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Any Transport over MPLS

This document describes the Any Transport over MPLS (AToM) feature, which provides the following capabilities:

- Transport data link layer (Layer2) packets over a Multiprotocol Label Switching (MPLS) backbone.
- Enable service providers to connect customer sites with existing Layer 2 networks by using a single, integrated, packet-based network infrastructure—a Cisco MPLS network. Instead of using separate networks with network management environments, service providers can deliver Layer 2 connections over an MPLS backbone.
- Provide a common framework to encapsulate and transport supported Layer 2 traffic types over an MPLS network core.

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

- ATM Adaptation Layer Type-5 (AAL5) over MPLS
- ATM Cell Relay over MPLS
- Ethernet over MPLS (VLAN and port modes)
- Frame Relay over MPLS
- PPP over MPLS
- High-Level Data Link Control (HDLC) over MPLS

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 Any Transport over MPLS

Before configuring AToM, ensure that the network is configured as follows:

- Configure IP routing in the core so that the provider edge (PE) routers can reach each other via IP.
- Configure MPLS in the core so that a label-switched path (LSP) exists between the PE routers.
- Enable Cisco Express Forwarding or distributed Cisco Express Forwarding before configuring any Layer 2 circuits.
- Configure a loopback interface for originating and terminating Layer 2 traffic. Make sure the PE routers can access the other router’s loopback interface. Note that the loopback interface is not needed in all cases. For example, tunnel selection does not need a loopback interface when AToM is directly mapped to a traffic engineering (TE) tunnel.
- AToM is supported on the Cisco 7200 and 7500 series routers. For details on supported hardware, see the following documents:
  - Cross-Platform Release Notes for Cisco IOS Release 12.0S
- AToM is supported on the Cisco 7600 routers. For details on supported shared port adapters and line cards, see the following documents:
  - Guide to Supported Hardware for Cisco 7600 Series Routers with Release 12.2SR
  - Cross-Platform Release Notes for Cisco IOS Release 12.2SR for the Cisco 7600 Series Routers
- The Cisco 7600 router has platform-specific instructions for configuring some AToM features. Platform-specific configuration information is included in the following documents:
  - The “Configuring PFC3BXL and PFC3B Mode Multiprotocol Label Switching” module of the Cisco 7600 Series Cisco IOS Software Configuration Guide, Release 12.2SR
  - The “Configuring Multiprotocol Label Switching on the Optical Services Modules” module of the OSM Configuration Note, Release 12.2SR
  - The “Configuring Multiprotocol Label Switching on FlexWAN and Enhanced FlexWAN Modules” module of the FlexWAN and Enhanced FlexWAN Modules Installation and Configuration Guides of Cisco 7600 Series Routers
  - The “Configuring Any Transport over MPLS on a SIP” section of the Cisco 7600 Series Router SIP, SSC, and SPA Software Configuration Guide
  - The “Configuring AToM VP Cell Mode Relay Support” section of the Cisco 7600 Series Router SIP, SSC, and SPA Software Configuration Guide
  - The Cross-Platform Release Notes for Cisco IOS Release 12.2SR
- AToM is supported on the Cisco 10000 series routers. For details on supported hardware, see the “Configuring Any Transport over MPLS” section of the Cisco 10000 Series Router Software Configuration Guide.
- The Cisco 10000 series router has platform-specific instructions for configuring some AToM features. Platform-specific configuration information is contained in the “Configuring Any Transport over MPLS” section of the Cisco 10000 Series Router Broadband Aggregation, Leased-Line, and MPLS Configuration Guide.
- AToM is supported on the Cisco 12000 series routers. For information about hardware requirements, see the Cross-Platform Release Notes for Cisco IOS Release 12.0S.
Restrictions for Any Transport over MPLS

General Restrictions

The following general restrictions pertain to all transport types under AToM:

- **Address format:** Configure the Label Distribution Protocol (LDP) router ID on all PE routers to be a loopback address with a /32 mask. Otherwise, some configurations might not function properly.
- **Layer 2 virtual private networks (L2VPN) features (AToM and Layer 2 Tunnel Protocol Version 3 (L2TPv3)) are not supported on an ATM interface.**
- **Distributed Cisco Express Forwarding is the only forwarding model supported on the Cisco 12000 series routers and is enabled by default. Disabling distributed Cisco Express Forwarding on the Cisco 12000 series routers disables forwarding.**
- **Distributed Cisco Express Forwarding mode is supported on the Cisco 7500 series routers for Frame Relay, HDLC, and PPP. In distributed Cisco Express Forwarding mode, the switching process occurs on the Versatile Interface Processors (VIPs) that support switching. When distributed Cisco Express Forwarding is enabled, VIP port adapters maintain identical copies of the Forwarding Information Base (FIB) and adjacency tables. The port adapters perform the express forwarding between port adapters, relieving the Route Switch Processor (RSP) from performing the switching. Distributed Cisco Express Forwarding uses an interprocess communications (IPC) mechanism to ensure synchronization of FIBs and adjacency tables between the RSP and port adapters.**
- **To convert an interface with L2TPv3 xconnect to AToM xconnect, remove the L2TPv3 configuration from the interface and then configure AToM. Some features may not work if AToM is configured when L2TPv3 configuration is not removed properly.**

ATM Cell Relay over MPLS Restrictions

The following restrictions pertain to ATM Cell Relay over MPLS:

- **For ATM Cell Relay over MPLS, if you have TE tunnels running between the PE routers, you must enable LDP on the tunnel interfaces.**
- **Configuring ATM Relay over MPLS with the Cisco 12000 Series Router engine 2 8-port OC-3 STM-1 ATM line card: In Cisco IOS Release 12.0(25)S, there were special instructions for configuring ATM cell relay on the Cisco 12000 series router with an engine 2 8-port OC-3 STM-1 ATM line card. The special configuration instructions do not apply to releases later than Cisco IOS Release 12.0(25)S and you do not need to use the `atm mode cell-relay` command.**

In Cisco IOS Release 12.0(25)S, when you configured the Cisco 12000 series 8-port OC-3 STM-1 ATM line card for ATM Cell Relay over MPLS, two ports were reserved. In releases later than Cisco IOS Release 12.0(25)S, only one port is reserved.

In addition, in Cisco IOS Release 12.0(25)S, if you configured an 8-port OC-3 STM-1 ATM port for ATM Adaptation Layer 5 (AAL5) over MPLS and then configured ATM single cell relay over MPLS on that port, the Virtual Circuits (VCs) and Virtual Paths (VPs) for AAL5 on the port and its corresponding port were removed. Starting in Cisco IOS Release 12.0(26)S, this behavior no longer occurs. ATM AAL5 over MPLS and ATM single cell relay over MPLS are supported on the same port. The Cisco 12000 series 8-port OC-3 STM-1 ATM line cards now support, by default, the ATM single cell relay over MPLS feature in both VP and VC modes and ATM AAL5 over MPLS on the same port.

- **The F4 end-to-end Operation, Administration, and Maintenance (OAM) cells are transparently transported along with the ATM cells. When a permanent virtual path (PVP) or Permanent Virtual Circuit (PVC) is down on one PE router, the label associated with that PVP or PVC is withdrawn.**
Subsequently, the peer PE router detects the label withdrawal and sends an F4 AIS/RDI signal to its corresponding customer edge (CE) router. The PVP or PVC on the peer PE router remains in the up state.

**Ethernet over MPLS (EoMPLS) Restrictions**

The following restrictions pertain to the Ethernet over MPLS feature:

- Ethernet over MPLS supports VLAN packets that conform to the IEEE 802.1Q standard. The 802.1Q specification establishes a standard method for inserting VLAN membership information into Ethernet frames. The Inter-Switch Link (ISL) protocol is not supported between the PE and CE routers.
- The AToM control word is supported. However, if the peer PE does not support a control word, the control word is disabled. This negotiation is done by LDP label binding.
- Ethernet packets with hardware-level cyclic redundancy check (CRC) errors, framing errors, and runt packets are discarded on input.
- In Cisco IOS Release 12.2(25)S, the behavior of the `mpls mtu` command changed. If the interface MTU is less than 1524 bytes, you can set the maximum MPLS MTU to 24 bytes more than the interface MTU. For example, if the interface MTU is set to 1510 bytes, then you can set the maximum MPLS MTU to 1534 bytes (1510 + 24).

⚠️ **Caution**

Although you can set the MPLS MTU to a value greater than the interface MTU, you must set the MPLS MTU to a value less than or equal to the interface MTU to prevent data corruption, dropped packets, and high CPU rates.

If the interface MTU is greater than or equal to 1524 bytes, then you can set the maximum MPLS MTU as high as the interface MTU. For example, if the interface MTU is set to 1600 bytes, then you can set the MPLS MTU to a maximum of 1600 bytes. If you set the MPLS MTU to a value higher than the interface MTU, traffic is dropped.

For interfaces that do not allow you to configure the interface MTU value and for interfaces where the interface MTU is 1500 bytes, the MPLS MTU range is 64 to 1524 bytes.

If you upgrade to Cisco IOS Release 12.2(25)S from an earlier release and you have an MPLS MTU setting that does not conform to these guidelines, the command is rejected. See the Maximum Transmission Unit Guidelines for Estimating Packet Size, page 7 for more information.

**Frame Relay over MPLS Restrictions**

The following restrictions pertain to the Frame Relay over MPLS feature:

- Frame Relay traffic shaping is not supported with AToM switched VCs.
- If you configure Frame Relay over MPLS on the Cisco 12000 series router and the core-facing interface is an engine 4 or 4+ line card and the edge-facing interface is an engine 0 or 2 line card, then the BECN, FECN, control word (CW), and DE bit information is stripped from the PVC.

---

**Information About Any Transport over MPLS**

- How AToM Transports Layer 2 Packets, page 5
- AToM Configuration Commands Prior to Cisco IOS Release 12.0(25)S, page 5
- Benefits of AToM, page 6
- MPLS Traffic Engineering Fast Reroute, page 6
How AToM Transports Layer 2 Packets

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

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

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

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

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

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

Step 2 specifies the encapsulation type for the interface, such as dot1q:

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

Step 3 does the following:

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

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

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

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

As an alternative, you can set up a pseudowire class to specify the tunneling method and other characteristics. For more information, see the Configuring the Pseudowire Class, page 15.

AToM Configuration Commands Prior to Cisco IOS Release 12.0(25)S

In releases of AToM before Cisco IOS 12.0(25)S, the `mpls l2 transport route` command was used to configure AToM circuits. This command has been replaced with the `xconnect` command.

No enhancements will be made to the `mpls l2transport route` command. Enhancements will be made to either the `xconnect` command or the `pseudowire-class` command. Therefore, Cisco recommends that you use the `xconnect` command to configure AToM circuits.
Configurations from releases before Cisco IOS 12.0(25)S that use the `mpls l2transport route` command are still supported.

**Benefits of AToM**

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

- The AToM product set accommodates many types of Layer 2 packets, including Ethernet and Frame Relay, across multiple Cisco router platforms, such as the Cisco 7200 and Cisco 7500 series routers. This enables the service provider to transport all types of traffic over the backbone and accommodate all types of customers.
- AToM adheres to the standards developed for transporting Layer 2 packets over MPLS. (See the "Standards" section for the specific standards that AToM follows.) This benefits the service provider that wants to incorporate industry-standard methodologies in the network. Other Layer 2 solutions are proprietary, which can limit the service provider’s ability to expand the network and can force the service provider to use only one vendor’s equipment.
- Upgrading to AToM is transparent to the customer. Because the service provider network is separate from the customer network, the service provider can upgrade to AToM without disruption of service to the customer. The customers assume that they are using a traditional Layer 2 backbone.

**MPLS Traffic Engineering Fast Reroute**

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

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

MPLS Traffic Engineering (TE)--Link and Node Protection, with RSVP Hellos Support

---

**Note**

The AToM VC independence feature was introduced in Cisco IOS Release 12.0(31)S. This feature enables the Cisco 12000 series router to perform fast reroute in fewer than 50 milliseconds, regardless of the number of VCs configured. In previous releases, the fast reroute time depended on the number of VCs inside the protected TE tunnel.

For the Cisco 12000 series routers, fast reroute uses three or more labels, depending on where the TE tunnel ends:

- If the TE tunnel is from a PE router to a PE router, three labels are used.
- If the TE tunnel is from a PE router to the core router, four labels are used.

Engine 0 ATM line cards support three or more labels, but the performance degrades. Engine 2 Gigabit Ethernet line cards and engine 3 line cards support three or more labels and can work with the fast reroute feature.

You can issue the `debug mpls l2transport fast-reroute` command to debug fast reroute with AToM.
This command does not display output on platforms where AToM fast reroute is implemented in the forwarding code. The command does display output on Cisco 10720 Internet router line cards and Cisco 12000 series line cards. This command does not display output for the Cisco 7500 (both Route Processor (RP) and Versatile Interface Processor (VIP)) series routers, Cisco 7200 series routers, and Cisco 12000 series RP.

In the following example, the primary link is disabled, which causes the backup tunnel (Tunnel 1) to become the primary path. In the following example, bolded output shows the status of the tunnel:

```
Router# execute-on slot 3 debug mpls l2transport fast-reroute
========= Line Card (Slot 3) =========
AToM fast reroute debugging is on
SLOT 3:Sep 16 17:58:56.346: AToM SMGR: Processing TFIB FRR event for 10.4.0.1
SLOT 3:Sep 16 17:58:56.346: AToM SMGR: Finished processing TFIB FRR event for 10.4.0.1
SLOT 3:Sep 16 17:58:56.346: AToM SMGR: Processing TFIB FRR event for Tunnel41
SLOT 3:Sep 16 17:58:56.346: AToM SMGR: Finished processing TFIB FRR event for Tunnel41
Sep 16 17:58:58.342: %LINK-3-UPDOWN: Interface POS0/0, changed state to down
Sep 16 17:58:59.342: %OSPF-5-ADJCHG: Process 1, Nbr 10.0.0.1 on POS0/0 from FULL to DOWN, Neighbor Down: Interface down or detached
Sep 16 17:58:59.342: %LINEPROTO-5-UPDOWN: Line protocol on Interface POS0/0, changed state to down
```

### Maximum Transmission Unit Guidelines for Estimating Packet Size

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

\[
\text{Core MTU} \geq (\text{Edge MTU} + \text{Transport header} + \text{AToM header} + (\text{MPLS label stack} \times \text{MPLS label size}))
\]

The following sections describe the variables used in the equation:

**Edge MTU**

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

**Transport Header**

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

#### Table 1  Header Size of Packets

<table>
<thead>
<tr>
<th>Transport Type</th>
<th>Packet Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL5</td>
<td>0-32 bytes</td>
</tr>
<tr>
<td>Ethernet VLAN</td>
<td>18 bytes</td>
</tr>
<tr>
<td>Ethernet Port</td>
<td>14 bytes</td>
</tr>
<tr>
<td>Frame Relay DLCI</td>
<td>2 bytes for Cisco encapsulation, 8 bytes for Internet Engineering Task Force (IETF) encapsulation</td>
</tr>
<tr>
<td>HDLC</td>
<td>4 bytes</td>
</tr>
<tr>
<td>Transport Type</td>
<td>Packet Size</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>PPP</td>
<td>4 bytes</td>
</tr>
</tbody>
</table>

**AToM Header**

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

**MPLS Label Stack**

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

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

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

- Example Estimating Packet Size, page 8
- mpls mtu Command Changes, page 9

**Example Estimating Packet Size**

The size of packets is estimated in the following example, which uses the following assumptions:

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

$$\text{Edge MTU} + \text{Transport header} + \text{AToM header} + (\text{MPLS label stack} \times \text{MPLS label}) = \text{Core MTU}$$

$$1500 + 18 + 0 + (2 \times 4) = 1526$$

You must configure the P and PE routers in the core to accept packets of 1526 bytes.
Once you determine the MTU size to set on your P and PE routers, you can issue the `mtu` command on the routers to set the MTU size. The following example specifies an MTU of 1526 bytes:

```
Router(config-if)# mtu 1526
```

### mpls mtu Command Changes

Some interfaces (such as FastEthernet) require the `mpls mtu` command to change the MTU size. In Cisco IOS Release 12.2(25)S, the behavior of the `mpls mtu` command changed.

If the interface MTU is fewer than 1524 bytes, you can set the maximum MPLS MTU to 24 bytes more than the interface MTU. For example, if the interface MTU is set to 1510 bytes, then you can set the maximum MPLS MTU to 1534 bytes (1510 + 24).

**Caution**

Although you can set the MPLS MTU to a value greater than the interface MTU, you must set the MPLS MTU value to less than or equal to the interface MTU to prevent data corruption, dropped packets, and high CPU rates.

If the interface MTU is greater than or equal to 1524 bytes, then you can set the maximum MPLS MTU value to as high as the interface MTU value. For example, if the interface MTU is set to 1600 bytes, then you can set the MPLS MTU to a maximum of 1600 bytes. If you set the MPLS MTU value to higher than the interface MTU, traffic is dropped.

For interfaces that do not allow you to configure the interface MTU value and for interfaces where the interface MTU is 1500 bytes, the MPLS MTU range is 64 to 1524 bytes.

For GRE tunnel interfaces you can set the MPLS MTU value to either the default value or the maximum value that is supported by the platform for the interface.

You can set the MPLS MTU value to the maximum value by using the `max` keyword along with the `mpls mtu` command. The `mpls mtu max` command allows the previously dropped packets to pass through the GRE tunnel by fragmentation on the underlying physical interface.

Note that the MPLS MTU value cannot be greater than the interface MTU value for non-GRE tunnels.

If you upgrade to Cisco IOS Release 12.2(25)S and you have an MPLS MTU setting that does not conform to these guidelines, the command is rejected.

For Cisco IOS Release 12.2(27)SBC, 12.2(33)SRA, 12.4(11)T, 12.2(33)SXH, and later releases, you cannot set the MPLS MTU to a value greater than the interface MTU. This eliminates problems, such as dropped packets, data corruption, and high CPU rates. See the MPLS MTU Command Changes document for more information.

### Frame Relay over MPLS and DTE DCE and NNI Connections

You can configure an interface as a DTE device or a DCE switch, or as a switch connected to a switch with network-to-network interface (NNI) connections. Use the following command in interface configuration mode:

```
frame-relay intf-type [dce | dte | nni]
```

The keywords are explained in the table below.
Table 2  frame-relay intf-type Command Keywords

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dce</td>
<td>Enables the router or access server to function as a switch connected to a router.</td>
</tr>
<tr>
<td>dte</td>
<td>Enables the router or access server to function as a DTE device. DTE is the default.</td>
</tr>
<tr>
<td>nni</td>
<td>Enables the router or access server to function as a switch connected to a switch.</td>
</tr>
</tbody>
</table>

- Local Management Interface and Frame Relay over MPLS, page 10

Local Management Interface and Frame Relay over MPLS

Local Management Interface (LMI) is a protocol that communicates status information about PVCs. When a PVC is added, deleted, or changed, the LMI notifies the endpoint of the status change. LMI also provides a polling mechanism that verifies that a link is up.

- How LMI Works, page 10

How LMI Works

To determine the PVC status, LMI checks that a PVC is available from the reporting device to the Frame Relay end-user device. If a PVC is available, LMI reports that the status is “Active,” which means that all interfaces, line protocols, and core segments are operational between the reporting device and the Frame Relay end-user device. If any of those components is not available, the LMI reports a status of “Inactive.”

Note

Only the DCE and NNI interface types can report the LMI status.

The figure below is a sample topology that helps illustrate how LMI works.

Figure 1  Sample Topology

In the figure above, note the following:

- CE1 and PE1 and PE2 and CE2 are Frame Relay LMI peers.
- CE1 and CE2 can be Frame Relay switches or end-user devices.
- Each Frame Relay PVC comprises multiple segments.
- The DLCI value is local to each segment and is changed as traffic is switched from segment to segment. Two Frame Relay PVC segments exist in the figure; one is between PE1 and CE1 and the other is between PE2 and CE2.

The LMI protocol behavior depends on whether you have DLCI-to-DLCI or port-to-port connections.
DLCI-to-DLCI Connections

If you have DLCI-to-DLCI connections, LMI runs locally on the Frame Relay ports between the PE and CE devices:

- CE1 sends an active status to PE1 if the PVC for CE1 is available. If CE1 is a switch, LMI checks that the PVC is available from CE1 to the user device attached to CE1.
- PE1 sends an active status to CE1 if the following conditions are met:
  - A PVC for PE1 is available.
  - PE1 received an MPLS label from the remote PE router.
  - An MPLS tunnel label exists between PE1 and the remote PE.

For DTE or DCE configurations, the following LMI behavior exists: The Frame Relay device accessing the network (DTE) does not report the PVC status. Only the network device (DCE) or NNI can report the status. Therefore, if a problem exists on the DTE side, the DCE is not aware of the problem.

Port-to-Port Connections

If you have port-to-port connections, the PE routers do not participate in the LMI status-checking procedures. LMI operates only between the CE routers. The CE routers must be configured as DCE-DTE or NNI-NNI.

For information about LMI, including configuration instructions, see the “Configuring the LMI” section of the Configuring Frame Relay document.

QoS Features Supported with AToM

For information about configuring QoS features on Cisco 12000 series routers, see the following feature module:

Any Transport over MPLS (AToM): Layer 2 QoS for the Cisco 12000 Series Router (Quality of Service)

The tables below list the QoS features supported by AToM on the Cisco 7200 and 7500 series routers.

Table 3  QoS Features Supported with Ethernet over MPLS on the Cisco 7200 and 7500 Series Routers

<table>
<thead>
<tr>
<th>QoS Feature</th>
<th>Ethernet over MPLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service policy</td>
<td>Can be applied to:</td>
</tr>
<tr>
<td></td>
<td>• Interface (input and output)</td>
</tr>
<tr>
<td></td>
<td>• Subinterface (input and output)</td>
</tr>
<tr>
<td>Classification</td>
<td>Supports the following commands:</td>
</tr>
<tr>
<td></td>
<td>• match cos (on interfaces and subinterfaces)</td>
</tr>
<tr>
<td></td>
<td>• match mpls experimental (on interfaces and subinterfaces)</td>
</tr>
<tr>
<td></td>
<td>• match qos-group (on interfaces) (output policy)</td>
</tr>
</tbody>
</table>
## QoS Feature

### Ethernet over MPLS

Supports the following commands:
- `set cos` (output policy)
- `set discard-class` (input policy)
- `set mpls experimental` (input policy) (on interfaces and subinterfaces)
- `set qos-group` (input policy)

### Policing

Supports the following:
- Single-rate policing
- Two-rate policing
- Color-aware policing
- Multiple-action policing

### Queueing and shaping

Supports the following:
- Distributed Low Latency Queueing (dLLQ)
- Distributed Weighted Random Early Detection (dWRED)
- Byte-based WRED

### Frame Relay over MPLS

<table>
<thead>
<tr>
<th>QoS Feature</th>
<th>Frame Relay over MPLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service policy</td>
<td>Can be applied to:</td>
</tr>
<tr>
<td></td>
<td>Interface (input and output)</td>
</tr>
<tr>
<td></td>
<td>PVC (input and output)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classification</th>
<th>Supports the following commands:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>match fr-de</code> (on interfaces and VCs)</td>
</tr>
<tr>
<td></td>
<td><code>match fr-dlci</code> (on interfaces)</td>
</tr>
<tr>
<td></td>
<td><code>match qos-group</code></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marking</th>
<th>Supports the following commands:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>frame-relay congestion management</code> (output)</td>
</tr>
<tr>
<td></td>
<td><code>set discard-class</code></td>
</tr>
<tr>
<td></td>
<td><code>set fr-de</code> (output policy)</td>
</tr>
<tr>
<td></td>
<td><code>set fr-fecn-becn</code> (output)</td>
</tr>
<tr>
<td></td>
<td><code>set mpls experimental</code></td>
</tr>
<tr>
<td></td>
<td><code>set qos-group</code></td>
</tr>
<tr>
<td></td>
<td><code>threshold ecn</code> (output)</td>
</tr>
</tbody>
</table>
### QoS Feature

#### Frame Relay over MPLS

- **Policing**
  - Single-rate policing
  - Two-rate policing
  - Color-aware policing
  - Multiple-action policing

- **Queueing and shaping**
  - dLLQ
  - dWRED
  - Distributed traffic shaping
  - Distributed class-based weighted fair queueing (dCBWFQ)
  - Byte-based WRED
  - `random-detect discard-class-based` command

### Table 5  QoS Features Supported with ATM Cell Relay and AAL5 over MPLS on the Cisco 7200 and 7500 Series Routers

<table>
<thead>
<tr>
<th>QoS Feature</th>
<th>ATM Cell Relay and AAL5 over MPLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service policy</td>
<td>Can be applied to:</td>
</tr>
<tr>
<td></td>
<td>• Interface (input and output)</td>
</tr>
<tr>
<td></td>
<td>• Subinterface (input and output)</td>
</tr>
<tr>
<td></td>
<td>• PVC (input and output)</td>
</tr>
<tr>
<td>Classification</td>
<td>Supports the following commands:</td>
</tr>
<tr>
<td></td>
<td>• <code>match mpls experimental</code> (on VCs)</td>
</tr>
<tr>
<td></td>
<td>• <code>match qos-group</code> (output)</td>
</tr>
<tr>
<td>Marking</td>
<td>Supports the following commands:</td>
</tr>
<tr>
<td></td>
<td>• <code>random-detect discard-class-based</code> (input)</td>
</tr>
<tr>
<td></td>
<td>• <code>set clp</code> (output) (on interfaces, subinterfaces, and VCs)</td>
</tr>
<tr>
<td></td>
<td>• <code>set discard-class</code> (input)</td>
</tr>
<tr>
<td></td>
<td>• <code>set mpls experimental</code> (input) (on interfaces, subinterfaces, and VCs)</td>
</tr>
<tr>
<td></td>
<td>• <code>set qos-group</code> (input)</td>
</tr>
</tbody>
</table>
### QoS Feature

<table>
<thead>
<tr>
<th>QoS Feature</th>
<th>ATM Cell Relay and AAL5 over MPLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policing</td>
<td>Supports the following:</td>
</tr>
<tr>
<td></td>
<td>• Single-rate policing</td>
</tr>
<tr>
<td></td>
<td>• Two-rate policing</td>
</tr>
<tr>
<td></td>
<td>• Color-aware policing</td>
</tr>
<tr>
<td></td>
<td>• Multiple-action policing</td>
</tr>
<tr>
<td>Queueing and shaping</td>
<td>Supports the following:</td>
</tr>
<tr>
<td></td>
<td>• dLLQ</td>
</tr>
<tr>
<td></td>
<td>• dWRED</td>
</tr>
<tr>
<td></td>
<td>• dCBWFQ</td>
</tr>
<tr>
<td></td>
<td>• Byte-based WRED</td>
</tr>
<tr>
<td></td>
<td>• random-detect discard-class-based command</td>
</tr>
<tr>
<td></td>
<td>• Class-based shaping support on ATM PVCs</td>
</tr>
</tbody>
</table>

### How to Configure Any Transport over MPLS

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

- Configuring the Pseudowire Class, page 15
- Configuring ATM AAL5 over MPLS on PVCs, page 16
- Configuring ATM AAL5 over MPLS in VC Class Configuration Mode, page 18
- Configuring OAM Cell Emulation for ATM AAL5 over MPLS, page 21
- Configuring ATM Cell Relay over MPLS in VC Mode, page 27
- Configuring ATM Cell Relay over MPLS in VC Mode Using VC Class Configuration Mode, page 29
- Configuring ATM Cell Relay over MPLS in PVP Mode, page 31
- Configuring ATM Cell Relay over MPLS in Port Mode, page 34
- Configuring ATM Single Cell Relay over MPLS, page 36
- Configuring ATM Packed Cell Relay over MPLS, page 38
- Configuring Ethernet over MPLS in VLAN Mode, page 51
- Configuring Ethernet over MPLS in Port Mode, page 52
- Configuring Ethernet over MPLS with VLAN ID Rewrite, page 54
- Configuring Ethernet over MPLS with VLAN ID Rewrite for Cisco 12k Routers for 12.0(29)S and Earlier Releases, page 54
- Configuring Ethernet over MPLS with VLAN ID Rewrite for Cisco 12k Routers for 12.0(30)S and Later Releases, page 55
- Configuring per-Subinterface MTU for Ethernet over MPLS, page 58
- Configuring Frame Relay over MPLS with DLCI-to-DLCI Connections, page 61
- Configuring Frame Relay over MPLS with Port-to-Port Connections, page 63
- Configuring HDLC and PPP over MPLS, page 64
- Configuring Tunnel Selection, page 66
- Setting Experimental Bits with AToM, page 70
- Setting the Frame Relay Discard Eligibility Bit on the Cisco 7200 and 7500 Series Routers, page 75
Configuring the Pseudowire Class

The successful transmission of the Layer 2 frames between PE routers is due to the configuration of the PE routers. You set up the connection, called a pseudowire, between the routers.

**Note**

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

The pseudowire-class configuration group specifies the following characteristics of the tunneling mechanism:

- Encapsulation type
- Control protocol
- Payload-specific options

For more information about the `pseudowire-class` command, see the following feature module: Layer 2 Tunnel Protocol Version 3.

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

```
% Incomplete command.
```

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `pseudowire-class name`
4. `encapsulation mpls`
5. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 <code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

**Example:**

```
Router> enable
```
### Configuring ATM AAL5 over MPLS on PVCs

ATM AAL5 over MPLS for PVCs encapsulates ATM AAL5 service data unit (SDUs) in MPLS packets and forwards them across the MPLS network. Each ATM AAL5 SDU is transported as a single packet.

**Note**

AAL5 over MPLS is supported only in SDU mode.

---

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> pseudowire-class name</td>
<td>Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# pseudowire-class atom</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> encapsulation mpls</td>
<td>Specifies the tunneling encapsulation.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pw-class)# encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> end</td>
<td>Exits pseudowire class configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pw-class)# end</td>
<td></td>
</tr>
</tbody>
</table>

To change the type of encapsulation, remove the pseudowire with the **no pseudowire-class** command, reestablish the pseudowire, and specify the new encapsulation type.

Once you specify the **encapsulation mpls** command, you can neither remove it using the **no encapsulation mpls** command nor change the command setting using the **encapsulation 12tpv3** command. If you try to remove or change the encapsulation type using the above-mentioned commands, you will get the following error message:

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

To remove a pseudowire, use the **clear xconnect** command in privileged EXEC mode. You can remove all pseudowires or specific pseudowires on an interface or peer router.
SUMMARY STEPS

1. enable
2. configure terminal
3. interface typeslot/port
4. pvc [name] vpi/vci l2transport
5. encapsulation aal5
6. xconnect peer-router-id vc id encapsulation mpls
7. exit
8. exit
9. exit
10. show mpls l2transport vc

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Step 2 configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Step 3 interface typeslot/port</td>
<td>Specifies the interface by type, slot, and port number, and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>Router(config)# interface atm1/0</td>
</tr>
<tr>
<td>Step 4 pvc [name] vpi/vci l2transport</td>
<td>Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• The l2transport keyword indicates that the PVC is a switched PVC instead of a terminated PVC.</td>
</tr>
<tr>
<td>Step 5 encapsulation aal5</td>
<td>Specifies the ATM ALL5 encapsulation for the PVC.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Make sure that you specify the same encapsulation type on the PE and CE routers.</td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 6</td>
<td><code>xconnect peer-router-id vcid encapsulation mpls</code></td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
</tbody>
</table>

**Example:**

```
Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls
```

| Step 7 | `exit` | Exits L2transport PVC configuration mode. |

**Example:**

```
Router(config-if-atm-l2trans-pvc)# exit
```

| Step 8 | `exit` | Exits interface configuration mode. |

**Example:**

```
Router(config-if)# exit
```

| Step 9 | `exit` | Exits global configuration mode. |

**Example:**

```
Router(config)# exit
```

| Step 10 | `show mpls l2transport vc` | Displays output that shows ATM AAL5 over MPLS is configured on a PVC. |

**Example:**

```
Router# show mpls l2transport vc
```

### Examples

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

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

### Configuring ATM AAL5 over MPLS in VC Class Configuration Mode

You can create a VC class that specifies the AAL5 encapsulation and then attach the encapsulation type to an interface, subinterface, or PVC. The following task creates a VC class and attaches it to a main interface.
Note

AAL5 over MPLS is supported only in SDU mode.

> 

**SUMMARY STEPS**

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

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
• Enter your password if prompted. |
| Example:           |         |
| Router> enable     |         |
| **Step 2** configure terminal | Enters global configuration mode. |
| Example:           |         |
| Router# configure terminal |         |
| **Step 3** vc-class atm vc-class-name | Creates a VC class and enters VC class configuration mode. |
| Example:           |         |
| Router(config)# vc-class atm aal5class |         |
### Command or Action

### Purpose

**Step 4** encapsulation layer-type  
Configures AAL and the encapsulation type.

**Example:**
```
Router(config-vc-class)# encapsulation aal5
```

**Step 5** exit  
Exits VC class configuration mode.

**Example:**
```
Router(config-vc-class)# exit
```

**Step 6** interface typeslot/port  
Specifies the interface by type, slot, and port number, and enters interface configuration mode.

**Example:**
```
Router(config)# interface atm1/0
```

**Step 7** class-int vc-class-name  
Applies a VC class to the ATM main interface or subinterface.

**Note** You can also apply a VC class to a PVC.

**Example:**
```
Router(config-if)# class-int aal5class
```

**Step 8** pvc [name] vpi/vci l2transport  
Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode.

- The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.

**Example:**
```
Router(config-if)# pvc 1/200 l2transport
```

**Step 9** xconnect peer-router-id vcid encapsulation mpls  
Binds the attachment circuit to a pseudowire VC.

**Example:**
```
Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls
```

**Step 10** exit  
Exits L2transport PVC configuration mode.

**Example:**
```
Router(config-if-atm-l2trans-pvc)# exit
```
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 11 exit</td>
<td>Exits interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td>Step 12 exit</td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# exit</td>
<td></td>
</tr>
<tr>
<td>Step 13 show atm class-links</td>
<td>Shows the type of encapsulation and that the VC class was applied to an interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# show atm class-links</td>
<td></td>
</tr>
</tbody>
</table>

**Examples**

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

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

**Configuring OAM Cell Emulation for ATM AAL5 over MPLS**

If a PE router does not support the transport of Operation, Administration, and Maintenance (OAM) cells across a label switched path (LSP), you can use OAM cell emulation to locally terminate or loop back the OAM cells. You configure OAM cell emulation on both PE routers, which emulates a VC by forming two unidirectional LSPs. You use the `oam-ac emulation-enable` and `oam-pvc manage` commands on both PE routers to enable OAM cell emulation.

After you enable OAM cell emulation on a router, you can configure and manage the ATM VC in the same manner as you would a terminated VC. A VC that has been configured with OAM cell emulation can send loopback cells at configured intervals toward the local CE router. The endpoint can be either of the following:

- End-to-end loopback, which sends OAM cells to the local CE router.
- Segment loopback, which responds to OAM cells to a device along the path between the PE and CE routers.

The OAM cells include the following cells:

- Alarm indication signal (AIS)
Remote defect indication (RDI)

These cells identify and report defects along a VC. When a physical link or interface failure occurs, intermediate nodes insert OAM AIS cells into all the downstream devices affected by the failure. When a router receives an AIS cell, it marks the ATM VC down and sends an RDI cell to let the remote end know about the failure.

This section contains two tasks:

- Configuring OAM Cell Emulation for ATM AAL5 over MPLS on PVCs, page 22
- Configuring OAM Cell Emulation for ATM AAL5 over MPLS in VC Class Configuration Mode, page 25

Configuring OAM Cell Emulation for ATM AAL5 over MPLS on PVCs

Perform this task to configure OAM cell emulation for ATM AAL5 over MPLS on a PVC.

**Note**

For AAL5 over MPLS, you can configure the `oam-pvc manage` command only after you issue the `oam-ac emulation-enable` command.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface typeslot/port`
4. `pvc [name] vpi/vci l2transport`
5. `encapsulation aal5`
6. `xconnect peer-router-id vcid encapsulation mpls`
7. `oam-ac emulation-enable [ais-rate]`
8. `oam-pvc manage [frequency]`
9. `exit`
10. `exit`
11. `exit`
12. `show atm pvc`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

**Example:**

```
Router> enable
```
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface typeslot/port</td>
<td>Specifies the interface by type, slot, and port number, and enters</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>interface configuration mode.</td>
</tr>
<tr>
<td>Router(config)# interface atm1/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> pvc [name] vpi/vci l2transport</td>
<td>Creates or assigns a name to an ATM PVC and enters L2transport</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>PVC configuration mode.</td>
</tr>
<tr>
<td>Router(config-if)# pvc 1/200 l2transport</td>
<td>• The l2transport keyword indicates that the PVC is a switched</td>
</tr>
<tr>
<td></td>
<td>PVC instead of a terminated PVC.</td>
</tr>
<tr>
<td><strong>Step 5</strong> encapsulation aal5</td>
<td>Specifies ATM AAL5 encapsulation for the PVC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• Make sure you specify the same encapsulation type on the PE</td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)#</td>
<td>and CE routers.</td>
</tr>
<tr>
<td>encapsulation aal5</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> xconnect peer-router-id vcid encapsulation mpls</td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)#</td>
<td></td>
</tr>
<tr>
<td>xconnect 10.13.13.13 100 encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> oam-ac emulation-enable [ais-rate]</td>
<td>Enables OAM cell emulation for AAL5 over MPLS.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• The ais-rate argument lets you specify the rate at which AIS</td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)#</td>
<td>cells are sent. The default is one cell every second. The range is</td>
</tr>
<tr>
<td>oam-ac emulation-enable 30</td>
<td>0 to 60 seconds.</td>
</tr>
<tr>
<td><strong>Step 8</strong> oam-pvc manage [frequency]</td>
<td>Enables the PVC to generate end-to-end OAM loopback cells that</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>verify connectivity on the virtual circuit.</td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)#</td>
<td>• The optional frequency argument is the interval between</td>
</tr>
<tr>
<td>oam-pvc manage</td>
<td>transmission of loopback cells and ranges from 0 to 600</td>
</tr>
<tr>
<td>manage</td>
<td>seconds. The default value is 10 seconds.</td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 9</strong></td>
<td>exit</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-if-atm-l2trans-pvc)# exit</td>
</tr>
<tr>
<td><strong>Step 10</strong></td>
<td>exit</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-if)# exit</td>
</tr>
<tr>
<td><strong>Step 11</strong></td>
<td>exit</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config)# exit</td>
</tr>
<tr>
<td><strong>Step 12</strong></td>
<td>show atm pvc</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# show atm pvc</td>
</tr>
</tbody>
</table>

### Examples

The output of the `show atm pvc` command in the following example shows that OAM cell emulation is enabled on the ATM PVC:

```
Router# show atm pvc 5/500
ATM4/1/0.200: VCD: 6, VPI: 5, VCI: 500
UBR, PeakRate: 1
AAL5-LLC/SNAP, etype:0x0, Flags: 0x34000C20, VCmode: 0x0
OAM Cell Emulation: enabled, F5 End2end AIS Xmit frequency: 1 second(s)
OAM frequency: 0 second(s), OAM retry frequency: 1 second(s)
OAM up retry count: 3, OAM down retry count: 5
OAM Loopback status: OAM Disabled
OAM VC state: Not ManagedVerified
ILMI VC state: Not Managed
InProc: 0, OutProc: 0
InFast: 4, OutFast: 0, InAS: 560, OutAS: 560
InPktDrops: 0, OutPktDrops: 0
CrcErrors: 0, SarTimeOuts: 0, OversizedSDUs: 0
Out CLP=1 Pkts: 0
OAM cells received: 26
F5 InEndloop: 0, F5 InSegloop: 0, F5 InAIS: 0, F5 InRDI: 26
OAM cells sent: 77
F5 OutEndloop: 0, F5 OutSegloop: 0, F5 OutAIS: 77, F5 OutRDI: 0
OAM cell drops: 0
Status: UP
```
Configuring OAM Cell Emulation for ATM AAL5 over MPLS in VC Class Configuration Mode

The following steps explain how to configure OAM cell emulation as part of a VC class. You can then apply the VC class to an interface, a subinterface, or a VC. When you configure OAM cell emulation in VC class configuration mode and then apply the VC class to an interface, the settings in the VC class apply to all the VCs on the interface, unless you specify a different OAM cell emulation value at a lower level, such as the subinterface or VC level. For example, you can create a VC class that specifies OAM cell emulation and sets the rate of AIS cells to every 30 seconds. You can apply the VC class to an interface. Then, for one PVC, you can enable OAM cell emulation and set the rate of AIS cells to every 15 seconds. All the PVCs on the interface use the cell rate of 30 seconds, except for the one PVC that was set to 15 seconds.

Perform this task to enable OAM cell emulation as part of a VC class and apply it to an interface.

**Note**
For AAL5 over MPLS, you can configure the `oam-pvc manage` command only after you issue the `oam-ac emulation-enable` command.

**SUMMARY STEPS**

1. enable  
2. configure terminal  
3. vc-class atm `name`  
4. encapsulation `layer-type`  
5. oam-ac `emulation-enable` `[ais-rate]`  
6. oam-pvc manage `[frequency]`  
7. exit  
8. interface `typeslot/port`  
9. class-int `vc-class-name`  
10. `pvc` `[name]` `vpi/vci` `l2transport`  
11. xconnect peer-router-id `vciid` `encapsulation mpls`  
12. end

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step 3</th>
<th>vc-class atm name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Creates a VC class and enters VC class configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# vc-class atm oamclass</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>encapsulation layer-type</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Configures the AAL and encapsulation type.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-vc-class)# encapsulation aal5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
<th>oam-ac emulation-enable [ais-rate]</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Enables OAM cell emulation for AAL5 over MPLS.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The ais-rate argument lets you specify the rate at which AIS cells are sent. The default is one cell every second. The range is 0 to 60 seconds.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-vc-class)# oam-ac emulation-enable 30</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 6</th>
<th>oam-pvc manage [frequency]</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Enables the PVC to generate end-to-end OAM loopback cells that verify connectivity on the virtual circuit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The optional frequency argument is the interval between transmission of loopback cells and ranges from 0 to 600 seconds. The default value is 10 seconds.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-vc-class)# oam-pvc manage</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 7</th>
<th>exit</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Exits VC class configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-vc-class)# exit</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 8</th>
<th>interface typeslot/port</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Specifies the interface by type, slot, and port number, and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# interface atm1/0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 9</th>
<th>class-int vc-class-name</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Applies a VC class to the ATM main interface or subinterface.</td>
</tr>
<tr>
<td>Note</td>
<td>You can also apply a VC class to a PVC.</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-if)# class-int oamclass</td>
<td></td>
</tr>
</tbody>
</table>
### Configuring ATM Cell Relay over MPLS in VC Mode

Perform this task to configure ATM cell relay on the permanent virtual circuits.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface atm slot /port`
4. `pvc vpi/vci l2transport`
5. `encapsulation aal0`
6. `xconnect peer-router-id vcid encapsulation mpls`
7. `exit`
8. `exit`
9. `exit`
10. `show atm vc`

---

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 10</strong> <code>pvc [name] vpi/vci l2transport</code></td>
<td>Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode.</td>
</tr>
<tr>
<td></td>
<td>• The <code>l2transport</code> keyword indicates that the PVC is a switched PVC instead of a terminated PVC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if)# pvc 1/200 l2transport</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 11</strong> <code>xconnect peer-router-id vcid encapsulation mpls</code></td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 12</strong> <code>end</code></td>
<td>Exits L2transport PVC configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if-atm-l2trans-pvc)# end</code></td>
<td></td>
</tr>
</tbody>
</table>
### Detailed Steps

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface atm slot/port</td>
<td>Specifies an ATM interface and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface atm1/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> pvc vpi/vci l2transport</td>
<td>Assigns a virtual path identifier (VPI) and virtual circuit identifier (VCI) and enters L2transport PVC configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# pvc 0/100 l2transport</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> encapsulation aal0</td>
<td>For ATM cell relay, specifies raw cell encapsulation for the interface.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# encapsulation aal0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> xconnect peer-router-id vcid encapsulation mpls</td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> exit</td>
<td>Exits L2transport PVC configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# exit</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Step 8 exit</td>
<td>Exits interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td>Step 9 exit</td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# exit</td>
<td></td>
</tr>
<tr>
<td>Step 10 show atm vc</td>
<td>Verifies that OAM cell emulation is enabled on the ATM VC.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# show atm vc</td>
<td></td>
</tr>
</tbody>
</table>

**Examples**

The output of the `show atm vc` command shows that the interface is configured for VC mode cell relay:

```
Router# show atm vc 7
ATM3/0: VCD: 7, VPI: 23, VCI: 100
UBR, PeakRate: 149760
AAL0-Cell Relay, etype:0x10, Flags: 0x10000C2D, Vmode: 0x0
OAM Cell Emulation: not configured
InBytes: 0, OutBytes: 0
Status: UP
```

**Configuring ATM Cell Relay over MPLS in VC Mode Using VC Class Configuration Mode**

You can create a VC class that specifies the ATM cell relay encapsulation and then attach the VC class to an interface, subinterface, or VC. The following task creates a VC class that specifies the ATM cell relay encapsulation and attaches it to a main interface.

**Note**

You can configure VC class configuration mode only in VC mode. VC class configuration mode is not supported on VP or port mode.
### SUMMARY STEPS

1. enable  
2. configure terminal  
3. vc-class atm name  
4. encapsulation layer-type  
5. exit  
6. interface typeslot /port  
7. class-int vc-class-name  
8. pvc [name] vlpl/vci l2transport  
9. xconnect peer-router-id vc-id encapsulation mpls  
10. end

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
Example: Router> enable  
- Enter your password if prompted. |
| **Step 2** configure terminal | Enters global configuration mode.  
Example: Router# configure terminal |
| **Step 3** vc-class atm name | Creates a VC class and enters VC class configuration mode.  
Example: Router(config)# vc-class atm cellrelay |
| **Step 4** encapsulation layer-type | Configures the AAL and encapsulation type.  
Example: Router(config-vc-class)# encapsulation aal0 |
| **Step 5** exit | Exits VC class configuration mode.  
Example: Router(config-vc-class)# exit |
<table>
<thead>
<tr>
<th>Command or Action</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 6</strong> interface typeslot/port</td>
<td>Specifies the interface by type, slot, and port number, and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface atm1/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> class-int vc-class-name</td>
<td>Applies a VC class to the ATM main interface or subinterface.</td>
</tr>
<tr>
<td><strong>Note</strong></td>
<td>You can also apply a VC class to a PVC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# class-int cellrelay</td>
<td></td>
</tr>
<tr>
<td><strong>Step 8</strong> pvc [name] vpi/vci l2transport</td>
<td>Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# pvc 1/200 l2transport</td>
<td></td>
</tr>
<tr>
<td>• The <strong>l2transport</strong> keyword indicates that the PVC is a switched PVC instead of a terminated PVC.</td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong> xconnect peer-router-id vcid encapsulation mpls</td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# xconnect 10.13.13.13 100 encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 10</strong> end</td>
<td>Exits L2transport PVC configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# end</td>
<td></td>
</tr>
</tbody>
</table>

**Configuring ATM Cell Relay over MPLS in PVP Mode**

VP mode allows cells coming into a predefined PVP on the ATM interface to be transported over the MPLS backbone to a predefined PVP on the egress ATM interface. You can use VP mode to send single cells or packed cells over the MPLS backbone.

To configure VP mode, you must specify the following:

- The VP for transporting cell relay cells.
- The IP address of the peer PE router and the VC ID.

When configuring ATM cell relay over MPLS in VP mode, use the following guidelines:

- You do not need to enter the **encapsulation aal0** command in VP mode.
- One ATM interface can accommodate multiple types of ATM connections. VP cell relay, VC cell relay, and ATM AAL5 over MPLS can coexist on one ATM interface. On the Cisco 12000 series router, this is true only on the engine 0 ATM line cards.
- If a VPI is configured for VP cell relay, you cannot configure a PVC using the same VPI.
- VP trunking (mapping multiple VPs to one emulated VC label) is not supported. Each VP is mapped to one emulated VC.
- Each VP is associated with one unique emulated VC ID. The AToM emulated VC type is ATM VP cell transport.
- The AToM control word is supported. However, if a peer PE does not support the control word, it is disabled. This negotiation is done by LDP label binding.
- VP mode (and VC mode) drop idle cells.

Perform this task to configure ATM cell relay in PVP mode.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface atm slot/port`
4. `atm pvp vpi l2transport`
5. `xconnect peer-router-id vcid encapsulation mpls`
6. `exit`
7. `exit`
8. `exit`
9. `show atm vp`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td>- Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface atm slot/port</td>
<td>Defines the interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config)# interface atm1/0</code></td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 4</strong></td>
<td><strong>atm pvp vpi l2transport</strong></td>
<td>Specifies that the PVP is dedicated to transporting ATM cells and enters L2transport PVP configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-if)# atm pvp 1 l2transport</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>xconnect peer-router-id vcid encapsulation mpls</strong></td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-if-atm-l2trans-pvp)# xconnect 10.0.0.1 123 encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>exit</strong></td>
<td>Exits L2 transport PVP configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-if-atm-l2trans-pvP)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>exit</strong></td>
<td>Exits interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 8</strong></td>
<td><strong>exit</strong></td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong></td>
<td><strong>show atm vp</strong></td>
<td>Displays output that shows OAM cell emulation is enabled on the ATM VP.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# show atm vp</td>
<td></td>
</tr>
</tbody>
</table>

### Examples

The following **show atm vp** command in the following example shows that the interface is configured for VP mode cell relay:

```
Router# show atm vp 1
ATM5/0  VP1: 1, Cell Relay, PeakRate: 149760, CesRate: 0, DataVCs: 1, CesVCs: 0, Status: ACTIVE
   VCD  VCI  Type  InPkts  OutPkts  AAL/Encap  Status
       6    3    PVC       0       0    F4 OAM     ACTIVE
       7    4    PVC       0       0    F4 OAM     ACTIVE
```
Configuring ATM Cell Relay over MPLS in Port Mode

Port mode cell relay allows cells coming into an ATM interface to be packed into an MPLS packet and transported over the MPLS backbone to an egress ATM interface.

To configure port mode, issue the `xconnect` command from an ATM main interface and specify the destination address and the VC ID. The syntax of the `xconnect` command is the same as for all other transport types. Each ATM port is associated with one unique pseudowire VC label.

When configuring ATM cell relay over MPLS in port mode, use the following guidelines:

- The pseudowire VC type is set to ATM transparent cell transport (AAL0).
- The AToM control word is supported. However, if the peer PE does not support a control word, the control word is disabled. This negotiation is done by LDP label binding.

**Note**

The AToM control word is not supported for port mode cell relay on Cisco 7600 series routers.

- Port mode and VP and VC mode are mutually exclusive. If you enable an ATM main interface for cell relay, you cannot enter any PVP or PVC commands.
- If the pseudowire VC label is withdrawn due to an MPLS core network failure, the PE router sends a line AIS to the CE router.
- For the Cisco 7600 series routers, you must specify the interface ATM slot, bay, and port for the SIP400 or SIP200.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface atm slot/port
4. xconnect peer-router-id vcid encapsulation mpls
5. exit
6. exit
7. show atm route
8. show mpls l2transport vc

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

**Example:**

```
Router> enable
```
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface atm slot/port</td>
<td>Specifies an ATM interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>or interface atm slot/bay/port</td>
<td>• For the Cisco 7600 series routers, you must specify the interface ATM slot, bay, and port for the SIP400 or SIP200. In the example the slot is 4, the bay is 3, and the port is 0.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface atm1/0</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface atm4/3/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> xconnect peer-router-id vcid encapsulation mpls</td>
<td>Binds the attachment circuit to the interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# xconnect 10.0.0.1 123 encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> exit</td>
<td>Exits interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> exit</td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# exit</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action | Purpose
--- | ---
**Step 7** `show atm route` | Displays output that shows ATM cell relay in port mode has been enabled.

**Example:**

Router# `show atm route`

**Step 8** `show mpls l2transport vc` | Displays the attachment circuit and the interface.

**Example:**

Router# `show mpls l2transport vc`

### Examples

The `show atm route` command in the following example displays port mode cell relay state. The following example shows that atm interface 1/0 is for cell relay, the VC ID is 123 and the tunnel is down.

```
Router# `show atm route`
Input Intf  Output Intf  Output VC  Status
ATM1/0     ATOM Tunnel  123      DOWN
```

The `show mpls l2transport vc` command in the following example also shows configuration information:

```
Router# `show mpls l2transport vc`
Local intf  Local circuit  Dest address  VC ID  Status
------------- -------------------- --------------- ------ ----------
AT1/0        ATM CELL ATM1/0 10.1.1.121     1121   UP
```

- Troubleshooting Tips, page 36

### Troubleshooting Tips

The `debug atm l2transport` and `debug mpls l2transport vc` display troubleshooting information.

### Configuring ATM Single Cell Relay over MPLS

The single cell relay feature allows you to insert one ATM cell in each MPLS packet. You can use single cell relay in both VP and VC mode. The configuration steps show how to configure single cell relay in VC mode. For VP mode, see the Configuring ATM Cell Relay over MPLS in PVP Mode, page 31.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface atm slot/port
4. pvc vpi/vci l2transport
5. encapsulation aal0
6. xconnect peer-router-id vcid encapsulation mpls
7. end
### Detailed Steps

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
• Enter your password if prompted. |
| **Example:**  
Router> enable | |
| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:**  
Router# configure terminal | |
| **Step 3** interface atm slot/port | Specifies an ATM interface and enters interface configuration mode. |
| **Example:**  
Router(config)# interface atm1/0 | |
| **Step 4** pvc vpi/vci l2transport | Assigns a VPI and VCI and enters L2transport PVC configuration mode.  
• The *l2transport* keyword indicates that the PVC is a switched PVC instead of a terminated PVC. |
| **Example:**  
Router(config-if)# pvc 1/100 l2transport | |
| **Step 5** encapsulation aal0 | Specifies raw cell encapsulation for the interface.  
• Make sure you specify the same encapsulation type on the PE and CE routers. |
| **Example:**  
Router(config-if-atm-l2trans-pvc)# encapsulation aal0 | |
| **Step 6** xconnect peer-router-id vcid encapsulation mpls | Binds the attachment circuit to a pseudowire VC. |
| **Example:**  
Router(config-if-atm-l2trans-pvc)# xconnect 10.0.0.1 123 encapsulation mpls | |
| **Step 7** end | Exits L2transport PVC configuration mode and returns to privileged EXEC mode. |
| **Example:**  
Router(config-if-atm-l2trans-pvc)# end | |
Configuring ATM Packed Cell Relay over MPLS

The packed cell relay feature allows you to insert multiple concatenated ATM cells in an MPLS packet. The packed cell relay feature is more efficient than single cell relay, because each ATM cell is 52 bytes, and each AToM packet is at least 64 bytes.

At a high level, packed cell relay configuration consists of the following steps:

1. You specify the amount of time a PE router can wait for cells to be packed into an MPLS packet. You can set up three timers by default with different amounts of time attributed to each timer.
2. You enable packed cell relay, specify how many cells should be packed into each MPLS packet, and choose which timer to use during the cell packing process.

Restrictions

- The `cell-packing` command is available only if you use AAL0 encapsulation in VC mode. If the command is configured with ATM AAL5 encapsulation, the command is not valid.
- Only cells from the same VC, VP, or port can be packed into one MPLS packet. Cells from different connections cannot be concatenated into the same MPLS packet.
- When you change, enable, or disable the cell-packing attributes, the ATM VC, VP, or port and the MPLS emulated VC are reestablished.
- If a PE router does not support packed cell relay, the PE router sends only one cell per MPLS packet.
- The number of packed cells does not need to match between the PE routers. The two PE routers agree on the lower of the two values. For example, if PE1 is allowed to pack 10 cells per MPLS packet and PE2 is allowed to pack 20 cells per MPLS packet, the two PE routers would agree to send no more than 10 cells per packet.
- If the number of cells packed by the peer PE router exceeds the limit, the packet is dropped.
- Issue the `atm mcpt-timers` command on an ATM interface before issuing the `cell-packing` command.

See the following sections for configuration information:

Configuring ATM Packed Cell Relay over MPLS in VC Mode

Perform this task to configure the ATM packed cell relay over MPLS feature in VC mode.
**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface atm slot /port
4. shutdown
5. atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout]
6. no shutdown
7. pvc vpi/vci l2transport
8. encapsulation aal0
9. xconnect peer-router-id vcid encapsulation mpls
10. cell-packing cells mcpt-timer timer
11. end

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
  • Enter your password if prompted. |
<p>| <strong>Example:</strong> | |
| Router&gt; enable | |
| <strong>Step 2</strong> configure terminal | Enters global configuration mode. |
| <strong>Example:</strong> | |
| Router# configure terminal | |
| <strong>Step 3</strong> interface atm slot /port | Defines the interface and enters interface configuration mode. |
| <strong>Example:</strong> | |
| Router(config)# interface atm1/0 | |
| <strong>Step 4</strong> shutdown | Shuts down the interface. |
| <strong>Example:</strong> | |
| Router(config-if)# shutdown | |</p>
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 5** atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout] | Sets up the cell-packing timers, which specify how long the PE router can wait for cells to be packed into an MPLS packet.  
  - You can set up to three timers. For each timer, you specify the maximum cell-packing timeout (MCPT). This value gives the cell-packing function a limited amount of time to complete. If the timer expires before the maximum number of cells are packed into an AToM packet, the packet is sent anyway. The timeout’s default and range of acceptable values depends on the ATM link speed.  
  - The respective default values for the PA-A3 port adapters are:  
    - OC-3: 30, 60, and 90 microseconds  
    - T3: 100, 200, and 300 microseconds  
    - E3: 130, 260, and 390 microseconds  
  - You can specify either the number of microseconds or use the default.  
  - The respective range of values for the PA-A3 port adapters are:  
    - OC-3: 10 to 4095 microseconds  
    - T3: 30 to 4095 microseconds  
    - E3: 40 to 4095 microseconds |
| **Example:** |  
  Router(config-if)# atm mcpt-timers 100 200 250 |
| **Step 6** no shutdown | Enables the interface. |
| **Example:** |  
  Router(config-if)# no shutdown |
| **Step 7** pvc vpi/vci l2transport | Assigns a VPI and VCI and enters L2transport PVC configuration mode.  
  - The l2transport keyword indicates that the PVC is a switched PVC instead of a terminated PVC. |
| **Example:** |  
  Router(config-if)# pvc 1/100 l2transport |
| **Step 8** encapsulation aal0 | Specifies raw cell encapsulation for the interface.  
  - Make sure you specify the same encapsulation type on the PE routers. |
| **Example:** |  
  Router(config-if-atm-l2trans-pvc)# encapsulation aal0 |
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 9</strong> xconnect peer-router-id vcid encapsulation mpls</td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# xconnect 10.0.0.1 123 vcid 1 encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 10</strong> cell-packing cells mcpt-timer timer</td>
<td>Enables cell packing and specifies the cell-packing parameters.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# cell-packing 10 cells 1 mcpt-timer 1</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# cell-packing 10 cells 1 mcpt-timer 1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 11</strong> end</td>
<td>Exits L2transport PVC configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if-atm-l2trans-pvc)# end</td>
<td></td>
</tr>
</tbody>
</table>

### Configuring ATM Packed Cell Relay over MPLS in VC Mode Using VC Class Configuration Mode

You can create a VC class that specifies the ATM cell relay encapsulation and the cell packing parameters and then attach the VC class to an interface, subinterface, or VC. The following task creates a VC class that specifies the ATM cell relay encapsulation and cell packing and attaches it to a main interface.

#### Note

You can configure VC class configuration mode only in VC mode. VC class configuration mode is not supported on VP or port mode.

When you configure cell packing in VC class configuration mode and then apply the VC class to an interface, the settings in the VC class apply to all the VCs on the interface, unless you specify a different cell packing value at a lower level, such as the subinterface or VC level. For example, you can create a VC class that specifies three cells to be packed. You can apply the VC class to an interface. Then, for one PVC, you can specify two cells to be packed. All the PVCs on the interface pack three cells, except for the one PVC that was set to set two cells.
**SUMMARY STEPS**

1. enable
2. configure terminal
3. vc-class atm name
4. encapsulation layer-type
5. cell-packing cells mcpt-timer timer
6. exit
7. interface typeslot /port
8. shutdown
9. atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout]
10. no shutdown
11. class-int vc-class-name
12. pvc [name] vpi/vci l2transport
13. xconnect peer-router-id vcid encapsulation mpls
14. end

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> vc-class atm name</td>
<td>Creates a VC class and enters VC</td>
</tr>
<tr>
<td></td>
<td>class configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# vc-class atm cellpacking</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> encapsulation layer-type</td>
<td>Configures the AAL and</td>
</tr>
<tr>
<td></td>
<td>encapsulation type.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config-vc-class)# encapsulation aa10</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 5** cell-packing cells mcpt-timer timer | Enables cell packing and specifies the cell-packing parameters.  
  - The *cells* argument represents the maximum number of cells to be packed into an MPLS packet. The range is from 2 to the MTU of the interface divided by 52. The default is MTU/52.  
  - The *timer* argument allows you to specify which timer to use. The default is timer 1.  
  - See the **cell-packing** command page for more information. |
| Example: | |
| `Router(config-vc-class)# cell-packing 10 mcpt-timer 1` | |
| **Step 6** exit | Exits VC class configuration mode. |
| Example: | |
| `Router(config-vc-class)# exit` | |
| **Step 7** interface typeslot /port | Specifies the interface by type, slot, and port number, and enters interface configuration mode. |
| Example: | |
| `Router(config)# interface atm1/0` | |
| **Step 8** shutdown | Shuts down the interface. |
| Example: | |
| `Router(config-if)# shutdown` | |
### Step 9
**atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout]**

Sets up the cell-packing timers, which specify how long the PE router can wait for cells to be packed into an MPLS packet.

- You can set up to three timers. For each timer, you specify the MCPT. This value gives the cell-packing function a limited amount of time to complete. If the timer expires before the maximum number of cells are packed into an AToM packet, the packet is sent anyway. The timeout’s default and range of acceptable values depends on the ATM link speed.
- The respective default values for the PA-A3 port adapters are:
  - OC-3: 30, 60, and 90 microseconds
  - T3: 100, 200, and 300 microseconds
  - E3: 130, 260, and 390 microseconds
- You can specify either the number of microseconds or use the default.
- The respective range of values for the PA-A3 port adapters are:
  - OC-3: 10 to 4095 microseconds
  - T3: 30 to 4095 microseconds
  - E3: 40 to 4095 microseconds

**Example:**
```
Router(config-if)# atm mcpt-timers 100 200 250
```

### Step 10
**no shutdown**

Enables the interface.

**Example:**
```
Router(config-if)# no shutdown
```

### Step 11
**class-int vc-class-name**

Applies a VC class to the ATM main interface or subinterface.

**Note** You can also apply a VC class to a PVC.

**Example:**
```
Router(config-if)# class-int cellpacking
```

### Step 12
**pvc [name] vpi/vci l2transport**

Creates or assigns a name to an ATM PVC and enters L2transport PVC configuration mode.

- The l2transport keyword indicates that the PVC is a switched PVC instead of a terminated PVC.

**Example:**
```
Router(config-if)# pvc 1/200 l2transport
```
### Configuring ATM Packed Cell Relay over MPLS in VP Mode

Perform this task to configure the ATM cell-packing feature in VP mode.

#### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `interface atm slot /port`
4. `shutdown`
5. `atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout]`
6. `no shutdown`
7. `atm pvp vpi l2transport`
8. `xconnect peer-router-id vcid encapsulation mpls`
9. `cell-packing cells mcpt-timer timer`
10. `end`

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>

Example:

```
Router> enable
```
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface atm slot/port</td>
<td>Defines the interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface atm1/0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> shutdown</td>
<td>Shuts down the interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# shutdown</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout]</td>
<td>Sets up the cell-packing timers, which specify how long the PE router can wait for cells to be packed into an MPLS packet.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# atm mcpt-timers 100 200 250</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> no shutdown</td>
<td>Enables the interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# no shutdown</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Step 7 atm pvp vpi l2transport</td>
<td>Specifies that the PVP is dedicated to transporting ATM cells and enters L2transport PVP configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-if)# atm pvp 1 l2transport</td>
</tr>
<tr>
<td></td>
<td>• The l2transport keyword indicates that the PVP is for cell relay. This mode is for Layer 2 transport only; it is not for regular PVPs.</td>
</tr>
<tr>
<td>Step 8 xconnect peer-router-id vcid encapsulation mpls</td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(cfg-if-atm-l2trans-pvp)# xconnect 10.0.0.1 123 encapsulation mpls</td>
</tr>
<tr>
<td></td>
<td>• The syntax for this command is the same as for all other Layer 2 transports.</td>
</tr>
<tr>
<td>Step 9 cell-packing cells mcpt-timer timer</td>
<td>Enables cell packing and specifies the cell-packing parameters.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(cfg-if-atm-l2trans-pvp)# cell-packing 10 mcpt-timer 1</td>
</tr>
<tr>
<td></td>
<td>• The cells argument represents the maximum number of cells to be packed into an MPLS packet. The range is from 2 to the MTU of the interface divided by 52. The default is MTU/52.</td>
</tr>
<tr>
<td></td>
<td>• The timer argument allows you to specify which timer to use. The default is timer 1.</td>
</tr>
<tr>
<td></td>
<td>• See the cell-packing command page for more information.</td>
</tr>
<tr>
<td>Step 10 end</td>
<td>Exits L2transport PVC configuration mode and returns to privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-if-atm-l2trans-pvc)# end</td>
</tr>
</tbody>
</table>

**Configuring ATM Packed Cell Relay over MPLS in Port Mode**

Perform this task to configure ATM packed cell relay over MPLS in port mode.
SUMMARY STEPS

1. enable
2. configure terminal
3. interface atm slot/port
4. shutdown
5. atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout]
6. no shutdown
7. cell-packing cells mcpt-timer timer
8. xconnect peer-router-id vcid encapsulation mpls
9. exit
10. exit
11. show atm cell-packing
12. show atm vp

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td>Router&gt; enable</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
</tr>
<tr>
<td><strong>Step 3</strong> interface atm slot/port</td>
<td>Specifies an ATM interface and enters interface configuration mode.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td>Router(config)# interface atm1/0</td>
</tr>
<tr>
<td><strong>Step 4</strong> shutdown</td>
<td>Shuts down the interface.</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td>Router(config-if)# shutdown</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>------------------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| **Step 5** atm mcpt-timers [timer1-timeout timer2-timeout timer3-timeout] | Sets up the cell-packing timers, which specify how long the PE router can wait for cells to be packed into an MPLS packet.  
  • You can set up to three timers. For each timer, you specify the MCPT. This value gives the cell-packing function a limited amount of time to complete. If the timer expires before the maximum number of cells are packed into an AToM packet, the packet is sent anyway. The timeout’s default and range of acceptable values depends on the ATM link speed.  
  • The respective default values for the PA-A3 port adapters are:  
    ◦ OC-3: 30, 60, and 90 microseconds  
    ◦ T3: 100, 200, and 300 microseconds  
    ◦ E3: 130, 260, and 390 microseconds  
  • You can specify either the number of microseconds or use the default.  
  • The respective range of values for the PA-A3 port adapters are:  
    ◦ OC-3: 10 to 4095 microseconds  
    ◦ T3: 30 to 4095 microseconds  
    ◦ E3: 40 to 4095 microseconds |
| Example:  
  
  Router(config-if)# atm mcpt-timers 100 200 250 |  |
| **Step 6** no shutdown | Enables the interface.  
  Example:  
  
  Router(config-if)# no shutdown |  |
| **Step 7** cell-packing cells mcpt-timer timer | Enables cell packing and specifies the cell-packing parameters.  
  • The *cells* argument represents the maximum number of cells to be packed into an MPLS packet. The range is from 2 to the MTU of the interface divided by 52. The default is MTU/52.  
  • The *timer* argument allows you to specify which timer to use. The default is timer 1.  
  • See the cell-packing command page for more information.  
  Example:  
  
  Router(config-if)# cell-packing 10 mcpt-timer 1 |  |
| **Step 8** xconnect peer-router-id vcid encapsulation mpls | Binds the attachment circuit to the interface.  
  Example:  
  
  Router(config-if)# xconnect 10.0.0.1 123 encapsulation mpls |  |
### Command or Action | Purpose
--- | ---
**Step 9** exit | Exits interface configuration mode.

**Example:**

```
Router(config-if)# exit
```

**Step 10** exit | Exits global configuration mode.

**Example:**

```
Router(config)# exit
```

**Step 11** **show** atm **cell-packing** | Displays cell-packing statistics.

**Example:**

```
Router# show atm cell-packing
```

**Step 12** **show** atm **vp** | Displays cell-packing information.

**Example:**

```
Router# show atm vp
```

### Examples

The **show atm cell-packing** command in the following example displays the following statistics:

- The number of cells that are to be packed into an MPLS packet on the local and peer routers
- The average number of cells sent and received
- The timer values associated with the local router

```
Router# show atm cell-packing
```

<table>
<thead>
<tr>
<th>circuit</th>
<th>local</th>
<th>average</th>
<th>peer</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>MNCP</td>
<td>rcvd in one pkt</td>
<td>MNCP</td>
<td>sent in one pkt (us)</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-----------------</td>
<td>------</td>
<td>---------------------</td>
</tr>
<tr>
<td>atm 1/0 vc 1/200</td>
<td>20</td>
<td>15</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>atm 1/0 vp 2</td>
<td>25</td>
<td>21</td>
<td>30</td>
<td>24</td>
</tr>
</tbody>
</table>

The **show atm vp** command in the following example displays the cell packing information at the end of the output:

```
Router# show atm vp 12
```

**ATM5/0** VPI: 12, Cell Relay, PeakRate: 149760, CesRate: 0, DataVCs: 1, CesVCs: 0, Status: ACTIVE

<table>
<thead>
<tr>
<th>VCD</th>
<th>VCI</th>
<th>Type</th>
<th>InPkts</th>
<th>OutPkts</th>
<th>AAL/Encap</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3</td>
<td>PVC</td>
<td>0</td>
<td>0</td>
<td>F4 OAM</td>
<td>ACTIVE</td>
</tr>
</tbody>
</table>

TotalInPkts: 0, TotalOutPkts: 0, TotalInFast: 0, TotalOutFast: 0, TotalBroadcasts: 0, TotalInPktDrops: 0, TotalOutPktDrops: 0, Local MNCP: 5, average number of cells received: 3
Troubleshooting Tips

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

Configuring Ethernet over MPLS in VLAN Mode

A VLAN is a switched network that is logically segmented by functions, project teams, or applications regardless of the physical location of users. Ethernet over MPLS allows you to connect two VLAN networks that are in different locations. You configure the PE routers at each end of the MPLS backbone and add a point-to-point VC. Only the two PE routers at the ingress and egress points of the MPLS backbone know about the VCs dedicated to transporting Layer 2 VLAN traffic. All other routers do not have table entries for those VCs. Ethernet over MPLS in VLAN mode transports Ethernet traffic from a source 802.1Q VLAN to a destination 802.1Q VLAN over a core MPLS network.

**Note**
You must configure Ethernet over MPLS (VLAN mode) on the subinterfaces.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface gigabitethernet slot/subinterface`
4. `encapsulation dot1q vlan-id`
5. `xconnect peer-router-id vcid encapsulation mpls`
6. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
• Enter your password if prompted. |
| **Example:** | Router> enable |
| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:** | Router# configure terminal |
### Configuring Ethernet over MPLS in Port Mode

Port mode allows a frame coming into an interface to be packed into an MPLS packet and transported over the MPLS backbone to an egress interface. The entire Ethernet frame without the preamble or FCS is transported as a single packet. To configure port mode, use the `xconnect` command in interface configuration mode and specify the destination address and the VC ID. The syntax of the `xconnect` command is the same as for all other transport types. Each interface is associated with one unique pseudowire VC label.

When configuring Ethernet over MPLS in port mode, use the following guidelines:

- The pseudowire VC type is set to Ethernet.
- Port mode and Ethernet VLAN mode are mutually exclusive. If you enable a main interface for port-to-port transport, you cannot also enter commands on a subinterface.
- In Cisco IOS Release 12.2(33)SRE and later releases, L2VPN Routed Interworking using Ethernet over MPLS (EOMPLS) is no longer supported. When you configure the `interworking ip` command in pseudowire configuration mode, the `xconnect` command is disabled. To configure L2VPN Routed Interworking, use either Ethernet over MPLS (EOMPLS) or SVI (Switched Virtual Interface) based EOMPLS.

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 3** interface gigabitethernet slot / interface.subinterface | Specifies the Gigabit Ethernet subinterface and enters subinterface configuration mode.  
- Make sure the subinterface on the adjoining CE router is on the same VLAN as this PE router. |
| **Example:** |  
Router(config)# interface gigabitethernet4/0.1 |
| **Step 4** encapsulation dot1q vlan-id | Enables the subinterface to accept 802.1Q VLAN packets.  
- The subinterfaces between the CE and PE routers that are running Ethernet over MPLS must be in the same subnet. All other subinterfaces and backbone routers do not. |
| **Example:** |  
Router(config-subif)# encapsulation dot1q 100 |
| **Step 5** xconnect peer-router-id vcid encapsulation mpls | Binds the attachment circuit to a pseudowire VC.  
- The syntax for this command is the same as for all other Layer 2 transports. |
| **Example:** |  
Router(config-subif)# xconnect 10.0.0.1 123 encapsulation mpls |
| **Step 6** end | Exits L2transport PVC configuration mode and returns to privileged EXEC mode. |
| **Example:** |  
Router(config-if-atm-l2trans-pvc)# end |
### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `interface gigabitethernet slot/interface`
4. `xconnect peer-router-id vcid encapsulation mpls`
5. `exit`
6. `exit`
7. `show mpls l2transport vc`

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> <code>enable</code></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router&gt; enable</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> <code>configure terminal</code></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router# configure terminal</code></td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> <code>interface gigabitethernet slot/interface</code></td>
<td>Specifies the Gigabit Ethernet interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config)# interface gigabitethernet4/0</code></td>
<td>Make sure the interface on the adjoining CE router is on the same VLAN as this PE router.</td>
</tr>
<tr>
<td><strong>Step 4</strong> <code>xconnect peer-router-id vcid encapsulation mpls</code></td>
<td>Binds the attachment circuit to a pseudowire VC.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if)# xconnect 10.0.0.1 123 encapsulation mpls</code></td>
<td>The syntax for this command is the same as for all other Layer 2 transports.</td>
</tr>
<tr>
<td><strong>Step 5</strong> <code>exit</code></td>
<td>Exits interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td><code>Router(config-if)# exit</code></td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action | Purpose
---|---
**Step 6** | **exit**
Example:
```
Router(config)# exit
```
Exits router configuration mode.

**Step 7** | **show mpls l2transport vc**
Example:
```
Router# show mpls l2transport vc
```
Displays information about Ethernet over MPLS port mode.

### Examples
In the following example, the output of the `show mpls l2transport vc detail` command is displayed:

```
Router# show mpls l2transport vc detail
Local interface: Gi4/0.1 up, line protocol up, Eth VLAN 2 up
Destination address: 10.1.1.1, VC ID: 2, VC status: up

Local interface: Gi8/0/1 up, line protocol up, Ethernet up
Destination address: 10.1.1.1, VC ID: 8, VC status: up
```

### Configuring Ethernet over MPLS with VLAN ID Rewrite

The VLAN ID rewrite feature enables you to use VLAN interfaces with different VLAN IDs at both ends of the tunnel.

The Cisco 12000 series router requires you to configure VLAN ID rewrite manually, as described in the following sections.

The following routers automatically perform VLAN ID rewrite on the disposition PE router. No configuration is required:

- Cisco 7200 series routers.
- Cisco 7500 series routers.
- Cisco 10720 series routers.
- Routers supported on Cisco IOS Release 12.4(11)T. (Use Cisco Feature Navigator to find information about platform support and Cisco IOS and Catalyst OS software image support.)

The following sections explain how to configure the VLAN ID rewrite feature:

### Configuring Ethernet over MPLS with VLAN ID Rewrite for Cisco 12k Routers for 12.0(29)S and Earlier Releases

Use the following guidelines for the VLAN ID rewrite feature for the Cisco 12000 series routers in Cisco IOS releases earlier than 12.0(29)S:

- The IP Service Engine (ISE) 4-port Gigabit Ethernet line card performs the VLAN ID rewrite on the disposition side at the edge-facing line card.
The engine 2 3-port Gigabit Ethernet line card performs the VLAN ID rewrite on the imposition side at the edge-facing line card.

The VLAN ID rewrite functionality requires that both ends of the Ethernet over MPLS connections be provisioned with the same line cards. Make sure that both edge-facing ends of the virtual circuit use either the engine 2 or ISE Ethernet line card. The following example shows the system flow with the VLAN ID rewrite feature:

- The ISE 4-port Gigabit Ethernet line card:
  Traffic flows from VLAN1 on CE1 to VLAN2 on CE2. As the frame reaches the edge-facing line card of the disposition router PE2, the VLAN ID in the dot1Q header changes to the VLAN ID assigned to VLAN2.

- The engine 2 3-port Gigabit Ethernet line card:
  Traffic flows from VLAN1 on CE1 to VLAN2 on CE2. As the frame reaches the edge-facing line card of the imposition router PE1, the VLAN ID in the dot1Q header changes to the VLAN ID assigned to VLAN2.

For the Cisco 12000 series router engine 2 3-port Gigabit Ethernet line card, you must issue the `remote circuit id` command as part of the Ethernet over MPLS VLAN ID rewrite configuration.

### Configuring Ethernet over MPLS with VLAN ID Rewrite for Cisco 12k Routers for 12.0(30)S and Later Releases

In Cisco IOS Release 12.0(30)S, the following changes to VLAN ID rewrite were implemented:

- The ISE 4-port Gigabit Ethernet line card can perform VLAN ID rewrite at both the imposition and disposition sides of the edge-facing router.
- The `remote circuit id` command is not required as part of the Ethernet over MPLS VLAN ID rewrite configuration, as long as both PE routers are running Cisco IOS Release 12.0(30)S. The VLAN ID rewrite feature is implemented automatically when you configure Ethernet over MPLS.
- The VLAN ID rewrite feature in Cisco IOS Release 12.0(30)S can interoperate with routers that are running earlier releases. If you have a PE router at one end of the circuit that is using an earlier Cisco IOS release and the `remote circuit id` command, the other PE can run Cisco IOS Release 12.0(30)S and still perform VLAN ID rewrite.
- You can mix the line cards on the PE routers, as shown in the following table

#### Supported Line Cards for VLAN ID Rewrite Feature:

<table>
<thead>
<tr>
<th>If PE1 Has These Line Cards</th>
<th>Then PE2 Can Use These Line Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine 2 3-port Gigabit Ethernet line card or ISE 4-port Gigabit Ethernet line card</td>
<td>Engine 2 3-port Gigabit Ethernet line card or ISE 4-port Gigabit Ethernet line card</td>
</tr>
<tr>
<td>ISE 4-port Gigabit Ethernet line card</td>
<td>Any Cisco 12000 series router line card</td>
</tr>
</tbody>
</table>
SUMMARY STEPS

1. enable
2. configure terminal
3. interface gigabitethernet slot linterface.subinterface
4. encapsulation dot1q vlan-id
5. xconnect peer-router-id vcid encapsulation mpls
6. remote circuit id remote-vlan-id
7. exit
8. exit
9. exit
10. show controllers compls forwarding-table

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface gigabitethernet slot linterface.subinterface</td>
<td>Specifies the Gigabit Ethernet subinterface and enters subinterface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• Make sure the subinterfaces between the CE and PE routers that are running Ethernet over MPLS are in the same subnet. All other subinterfaces and backbone routers do not need to be in the same subnet.</td>
</tr>
<tr>
<td><strong>Step 4</strong> encapsulation dot1q vlan-id</td>
<td>Enables the subinterface to accept 802.1Q VLAN packets.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• Make sure the subinterface on the adjoining CE router is on the same VLAN as this PE router.</td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 5</strong> <code>xconnect peer-router-id vcid encapsulation mpls</code></td>
<td>Binds the attachment circuit to a pseudowire VC and enters xconnect configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• The syntax for this command is the same as for all other Layer 2 transports.</td>
</tr>
<tr>
<td></td>
<td>Router(config-subif)# xconnect 10.0.0.1 123 encapsulation mpls</td>
</tr>
<tr>
<td><strong>Step 6</strong> <code>remote circuit id remote-vlan-id</code></td>
<td>Enables you to use VLAN interfaces with different VLAN IDs at both ends of the tunnel.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>• This command is required only for the Cisco 12000 series router engine 2 3-port Gigabit Ethernet line card.</td>
</tr>
<tr>
<td></td>
<td>Router(config-subif-xconn)# remote circuit id 101</td>
</tr>
<tr>
<td><strong>Step 7</strong> <code>exit</code></td>
<td>Exits xconnect configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-subif-xconn)# exit</td>
</tr>
<tr>
<td><strong>Step 8</strong> <code>exit</code></td>
<td>Exits subinterface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config-subif)# exit</td>
</tr>
<tr>
<td><strong>Step 9</strong> <code>exit</code></td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router(config)# exit</td>
</tr>
<tr>
<td><strong>Step 10</strong> <code>show controllers eompls forwarding-table</code></td>
<td>Displays information about VLAN ID rewrite.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>Router# execute slot 0 show controllers eompls forwarding-table</td>
</tr>
</tbody>
</table>

**Examples**

**On PE1**

**On PE2**

The command output of the `show controllers eompls forwarding-table` command in the following example shows VLAN ID rewrite configured on the Cisco 12000 series routers with an engine 2 3-port...
Configuring per-Subinterface MTU for Ethernet over MPLS

Cisco IOS Release 12.2(33)SRC introduces the ability to specify MTU values in xconnect subinterface configuration mode. When you use xconnect subinterface configuration mode to set the MTU value, you establish a pseudowire connection for situations where the interfaces have different MTU values that cannot be changed.

If you specify an MTU value in xconnect subinterface configuration mode that is outside the range of supported MTU values (64 bytes to the maximum number of bytes supported by the interface), the command might be rejected. If you specify an MTU value that is out of range in xconnect subinterface configuration mode, the router enters the command in subinterface configuration mode.
Configuring the MTU value in xconnect subinterface configuration mode has the following restrictions:

- The following features do not support MTU values in xconnect subinterface configuration mode:
  - Layer 2 Tunnel Protocol Version 3 (L2TPv3)
  - Virtual Private LAN services (VPLS)
  - L2VPN Pseudowire Switching

- The MTU value can be configured in xconnect subinterface configuration mode only on the following interfaces and subinterfaces:
  - Ethernet
  - FastEthernet
  - Gigabit Ethernet

- The router uses an MTU validation process for remote VCs established through LDP, which compares the MTU value configured in xconnect subinterface configuration mode to the MTU value of the remote customer interface. If an MTU value has not been configured in xconnect subinterface configuration mode, then the validation process compares the MTU value of the local customer interface to the MTU value of the remote xconnect, either explicitly configured or inherited from the underlying interface or subinterface.

- When you configure the MTU value in xconnect subinterface configuration mode, the specified MTU value is not enforced by the dataplane. The dataplane enforces the MTU values of the interface (port mode) or subinterface (VLAN mode).

- Ensure that the interface MTU is larger than the MTU value configured in xconnect subinterface configuration mode. If the MTU value of the customer-facing subinterface is larger than the MTU value of the core-facing interface, traffic may not be able to travel across the pseudowire.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface gigabitethernet slot INTERFACE`
4. `mtu mtu-value`
5. `interface gigabitethernet slot INTERFACE.subinterface`
6. `encapsulation dot1q vlan-id`
7. `xconnect peer-router-id VC ID encapsulation mpls`
8. `mtu mtu-value`
9. `end`
10. `show mpls l2transport binding`
## DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
  • Enter your password if prompted. |
| **Example:** | Router> enable |
| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:** | Router# configure terminal |
| **Step 3** interface gigabitethernet slot interface | Specifies the Gigabit Ethernet interface and enters interface configuration mode. |
| **Example:** | Router(config)# interface gigabitethernet4/0 |
| **Step 4** mtu mtu-value | Specifies the MTU value for the interface.  
  • The MTU value specified at the interface level can be inherited by a subinterface. |
| **Example:** | Router(config-if)# mtu 2000 |
| **Step 5** interface gigabitethernet slot/interface.subinterface | Specifies the Gigabit Ethernet subinterface and enters subinterface configuration mode.  
  • Make sure the subinterface on the adjoining CE router is on the same VLAN as this PE router. |
| **Example:** | Router(config-if)# interface gigabitethernet4/0.1 |
| **Step 6** encapsulation dot1q vlan-id | Enables the subinterface to accept 802.1Q VLAN packets.  
  • The subinterfaces between the CE and PE routers that are running Ethernet over MPLS must be in the same subnet. All other subinterfaces and backbone routers need not be. |
| **Example:** | Router(config-subif)# encapsulation dot1q 100 |
| **Step 7** xconnect peer-router-id vcid encapsulation mpls | Binds the attachment circuit to a pseudowire VC.  
  • The syntax for this command is the same as for all other Layer 2 transports. Enters xconnect subinterface configuration mode. |
| **Example:** | Router(config-subif)# xconnect 10.0.0.1 123 encapsulation mpls |
### Configuring Frame Relay over MPLS with DLCI-to-DLCI Connections

Frame Relay over MPLS encapsulates Frame Relay PDUs in MPLS packets and forwards them across the MPLS network. For Frame Relay, you can set up data-link connection identifier (DLCI)-to-DLCI connections or port-to-port connections. With DLCI-to-DLCI connections, the PE routers manipulate the packet by removing headers, adding labels, and copying control word elements from the header to the PDU.

Perform this task to configure Frame Relay over MPLS with DLCI-to-DLCI connections.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `frame-relay switching`
4. `interface serial slot/port`
5. `encapsulation frame-relay [cisco | ietf]`
6. `frame-relay intf-type dce`
7. `exit`
8. `connect connection-name interface dlci l2transport`
9. `xconnect peer-router-id vcid encapsulation mpls`
10. `end`

---

#### Command or Action | Purpose
---|---
**Step 8** `mtu mtu-value` | Specifies the MTU for the VC.

**Example:**

```
Router(config-if-xconn)# mtu 1400
```

**Step 9** `end` | Exits xconnect subinterface configuration mode and returns to privileged EXEC mode.

**Example:**

```
Router(config-if-xconn)# end
```

**Step 10** `show mpls l2transport binding` | Displays the MTU values assigned to the local and remote interfaces.

**Example:**

```
Router# show mpls l2transport binding
```
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1 enable</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router&gt; enable</td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td><strong>Step 2 configure terminal</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3 frame-relay switching</strong></td>
<td>Enables PVC switching on a Frame Relay device.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# frame-relay switching</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4 interface serial slot/port</strong></td>
<td>Specifies a serial interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# interface serial3/1</td>
<td></td>
</tr>
<tr>
<td>**Step 5 encapsulation frame-relay [cisco</td>
<td>ietf]**</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-if)# encapsulation frame-relay ietf</td>
<td>• You can specify different types of encapsulations. You can set one interface to Cisco encapsulation and the other interface to IETF encapsulation.</td>
</tr>
<tr>
<td><strong>Step 6 frame-relay intf-type dce</strong></td>
<td>Specifies that the interface is a DCE switch.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-if)# frame-relay intf-type dce</td>
<td>• You can also specify the interface to support Network-to-Network Interface (NNI) and DTE connections.</td>
</tr>
<tr>
<td><strong>Step 7 exit</strong></td>
<td>Exits from interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config-if)# exit</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step 8</th>
<th><code>connect connection-name interface dlci l2transport</code></th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Defines connections between Frame Relay PVCs and enters connect configuration mode.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Using the <code>l2transport</code> keyword specifies that the PVC will not be a locally switched PVC, but will be tunneled over the backbone network.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The <code>connection-name</code> argument is a text string that you provide.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The <code>interface</code> argument is the interface on which a PVC connection will be defined.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The <code>dlci</code> argument is the DLCI number of the PVC that will be connected.</td>
<td></td>
</tr>
</tbody>
</table>

#### Example:

```
Router(config)# connect fr1 serial5/0 1000 l2transport
```

<table>
<thead>
<tr>
<th>Step 9</th>
<th><code>xconnect peer-router-id vcid encapsulation mpls</code></th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creates the VC to transport the Layer 2 packets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• In a DLCI-to-DLCI connection type, Frame Relay over MPLS uses the <code>xconnect</code> command in connect configuration mode.</td>
<td></td>
</tr>
</tbody>
</table>

#### Example:

```
Router(config-fr-pw-switching)# xconnect 10.0.0.1 123 encapsulation mpls
```

<table>
<thead>
<tr>
<th>Step 10</th>
<th><code>end</code></th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exits connect configuration mode and returns to privileged EXEC mode.</td>
<td></td>
</tr>
</tbody>
</table>

#### Example:

```
Router(config-fr-pw-switching)# end
```

---

**Configuring Frame Relay over MPLS with Port-to-Port Connections**

Frame Relay over MPLS encapsulates Frame Relay PDUs in MPLS packets and forwards them across the MPLS network. For Frame Relay, you can set up DLCI-to-DLCI connections or port-to-port connections. With port-to-port connections, you use HDLC mode to transport the Frame Relay encapsulated packets. In HDLC mode, the whole HDLC packet is transported. Only the HDLC flags and FCS bits are removed. The contents of the packet are not used or changed, including the backward explicit congestion notification (BECN), forward explicit congestion notification (FECN) and discard eligibility (DE) bits.

Perform this task to set up Frame Relay port-to-port connections.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface serial slot/port`
4. `encapsulation hdlc`
5. `xconnect peer-router-id vcid encapsulation mpls`
6. `end`

---

**Troubleshooting Tips**

MPLS: Layer 2 VPNs, Configuration Guide, Cisco IOS Release 12.4T
### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
  • Enter your password if prompted. |
| **Example:** |  
  Router> enable |
| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:** |  
  Router# configure terminal |
| **Step 3** interface serial *slot/port* | Specifies a serial interface and enters interface configuration mode. |
| **Example:** |  
  Router(config)# interface serial5/0 |
| **Step 4** encapsulation hdlc | Specifies that Frame Relay PDUs will be encapsulated in HDLC packets. |
| **Example:** |  
  Router(config-if)# encapsulation hdlc |
| **Step 5** xconnect *peer-router-id vcid encapsulation mpls* | Creates the VC to transport the Layer 2 packets. |
| **Example:** |  
  Router(config-if)# xconnect 10.0.0.1 123 encapsulation mpls |
| **Step 6** end | Exits interface configuration mode and enters privileged EXEC mode. |
| **Example:** |  
  Router(config-if)# end |

### Configuring HDLC and PPP over MPLS

With HDLC over MPLS, the whole HDLC packet is transported. The ingress PE router removes only the HDLC flags and FCS bits. The contents of the packet are not used or changed.

With PPP over MPLS, the ingress PE router removes the flags, address, control field, and the FCS.
The following restrictions pertain to the HDLC over MPLS feature:

- Asynchronous interfaces are not supported.
- You must configure HDLC over MPLS on router interfaces only. You cannot configure HDLC over MPLS on subinterfaces.

The following restrictions pertain to the PPP over MPLS feature:

- Zero hops on one router is not supported. However, you can have back-to-back PE routers.
- Asynchronous interfaces are not supported. The connections between the CE and PE routers on both ends of the backbone must have similar link layer characteristics. The connections between the CE and PE routers must both be synchronous.
- Multilink PPP (MLP) is not supported.
- You must configure PPP on router interfaces only. You cannot configure PPP on subinterfaces.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `interface serial slot/port`
4. Do one of the following:
   - `encapsulation ppp`
   - `encapsulation hdlc`
5. `xconnect peer-router-id vcid encapsulation mpls`
6. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td>• Enter your password if prompted.</td>
</tr>
</tbody>
</table>
|                        | **Example:**
|                        | `Router> enable`                               |
| Step 2 configure terminal | Enters global configuration mode.             |
| Example:               | **Example:**
|                        | `Router# configure terminal`                   |
### Command or Action

<table>
<thead>
<tr>
<th>Step 3</th>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>interface serial slot/port</td>
<td>Specifies a serial interface and enters interface configuration mode.</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface serial5/0</td>
<td>• You must configure HDLC and PPP over MPLS on router interfaces only. You cannot configure HDLC over MPLS on subinterfaces.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do one of the following:</td>
<td>Specifies HDLC or PPP encapsulation and enters connect configuration mode.</td>
<td></td>
</tr>
<tr>
<td>• encapsulation ppp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• encapsulation hdlc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# encapsulation ppp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# encapsulation hdlc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5</th>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>xconnect peer-router-id vcid encapsulation mpls</td>
<td>Creates the VC to transport the Layer 2 packets.</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Router(config-fr-pw-switching)# xconnect 10.0.0.1 123 encapsulation mpls</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 6</th>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>end</td>
<td>Exits connect configuration mode and returns to privileged EXEC mode.</td>
<td></td>
</tr>
</tbody>
</table>

### Configuring Tunnel Selection

The tunnel selection feature allows you to specify the path that traffic uses. You can specify either an MPLS TE tunnel or destination IP address or domain name server (DNS) name.
You also have the option of specifying whether the VCs should use the default path (the path LDP uses for signaling) if the preferred path is unreachable. This option is enabled by default; you must explicitly disable it.

You configure tunnel selection when you set up the pseudowire class. You enable tunnel selection with the `preferred-path` command. Then, you apply the pseudowire class to an interface that has been configured to transport AToM packets.

The following guidelines provide more information about configuring tunnel selection:

- The `preferred-path` command is available only if the pseudowire encapsulation type is MPLS.
- This tunnel selection feature is enabled when you exit from pseudowire mode.
- The selected path should be an LSP destined to the peer PE router.
- The selected tunnel must be an MPLS TE tunnel.
- If you select a tunnel, the tunnel tailend must be on the remote PE router.
- If you specify an IP address, that address must be the IP address of the loopback interface on the remote PE router. The address must have a /32 mask. There must be an LSP destined to that selected address. The LSP need not be a TE tunnel.

**SUMMARY STEPS**

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

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 3</strong> pseudowire-class <em>name</em></td>
<td>Establishes a pseudowire class with a name that you specify and enters pseudowire configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong> Router(config)# pseudowire-class ts1</td>
<td></td>
</tr>
</tbody>
</table>
| **Step 4** encapsulation mpls | Specifies the tunneling encapsulation.  
• For AToM, the encapsulation type is **mpls**. |
<p>| <strong>Example:</strong> Router(config-pw-class)# encapsulation mpls |
| <strong>Step 5</strong> preferred-path {interface tunnel <em>tunnel-number</em> | peer {ip-address | host-name} | disable-fallback} | Specifies the MPLS traffic engineering tunnel or IP address or hostname to be used as the preferred path. |
| <strong>Example:</strong> Router(config-pw-class)# preferred path peer 10.18.18.18 |
| <strong>Step 6</strong> exit | Exits from pseudowire configuration mode. |
| <strong>Example:</strong> Router(config-pw-class)# exit |
| <strong>Step 7</strong> interface <em>slot</em>/port | Specifies an interface and enters interface configuration mode. |
| <strong>Example:</strong> Router(config)# interface atm1/1 |
| <strong>Step 8</strong> encapsulation <em>encapsulation-type</em> | Specifies the encapsulation for the interface. |
| <strong>Example:</strong> Router(config-if)# encapsulation aal5 |
| <strong>Step 9</strong> xconnect peer-router-id <em>vcid</em> pw-class <em>name</em> | Binds the attachment circuit to a pseudowire VC. |
| <strong>Example:</strong> Router(config-if)# xconnect 10.0.0.1 123 pw-class ts1 |</p>
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 10 end</td>
<td>Exits interface configuration mode and returns to Privileged EXEC mode.</td>
</tr>
</tbody>
</table>

Example:

```
Router(config-if)# end
```

Examples

In the following example, the `show mpls l2transport vc` command shows the following information about the VCs:

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

In the following example, command output that is bolded shows the preferred path information.

```
Router# show mpls l2transport vc detail
Local interface: Gi0/0/0.1 up, line protocol up, Eth VLAN 222 up
Destination address: 10.16.16.16, VC ID: 101, VC status: up
  Preferred path: Tunnel1, active
  Default path: disabled
  Tunnel label: 3, next hop point2point
  Output interface: Tu1, imposed label stack (17 16)
Create time: 00:27:31, last status change time: 00:27:31
Signaling protocol: LDP, peer 10.16.16.16:0 up
  MPLS VC labels: local 25, remote 16
  Group ID: local 0, remote 6
  MTU: local 1500, remote 1500
  Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 10, send 10
    byte totals:   receive 1260, send 1300
    packet drops:  receive 0, send 0
Local interface: AT1/0/0 up, line protocol up, ATM AAL5 0/50 up
Destination address: 10.16.16.16, VC ID: 150, VC status: up
  Preferred path: 10.18.18.18, active
  Default path: ready
  Tunnel label: 3, next hop point2point
  Output interface: Tu2, imposed label stack (18 24)
Create time: 00:15:08, last status change time: 00:07:37
Signaling protocol: LDP, peer 10.16.16.16:0 up
  MPLS VC labels: local 26, remote 24
  Group ID: local 2, remote 0
  MTU: local 4470, remote 4470
  Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 0, send 0
    byte totals:   receive 0, send 0
    packet drops:  receive 0, send 0
```

- **Troubleshooting Tips, page 69**
You can use the `debug mpls l2transport vc event` command to troubleshoot tunnel selection. For example, if the tunnel interface that is used for the preferred path is shut down, the default path is enabled. The `debug mpls l2transport vc event` command provides the following output:

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

### Setting Experimental Bits with AToM

MPLS AToM uses the three experimental bits in a label to determine the queue of packets. You statically set the experimental bits in both the VC label and the LSP tunnel label, because the LSP tunnel label might be removed at the penultimate router. The following sections explain the transport-specific implementations of the EXP bits.

**Note**

For information about setting EXP bits on the Cisco 12000 series router for Cisco IOS Release 12.0(30)S, see the AToM: L2 QoS feature module.
The following restrictions apply to ATM AAL5 over MPLS with EXP bits:

- ATM AAL5 over MPLS allows you to statically set the experimental bits.
- If you do not assign values to the experimental bits, the priority bits in the header’s “tag control information” field are set to zero.
- On the Cisco 7500 series routers, distributed Cisco Express Forwarding must be enabled before you set the experimental bits.

The following restrictions apply to ATM Cell Relay over MPLS with EXP bits:

- ATM Cell Relay over MPLS allows you to statically set the experimental bits in VC, PVP, and port modes.
- If you do not assign values to the experimental bits, the priority bits in the header’s “tag control information” field are set to zero.
- On the Cisco 7500 series routers, distributed Cisco Express Forwarding must be enabled before you set the experimental bits.

The following restrictions apply to Ethernet over MPLS with EXP bits:

**On the Cisco 7200 and 7500 Series Routers**

- Ethernet over MPLS allows you to set the EXP bits by using either of the following methods:
  - Writing the priority bits into the experimental bit field, which is the default.
  - Using the `match any` command with the `set mpls exp` command.
- If you do not assign values to the experimental bits, the priority bits in the 802.1Q header’s “tag control information” field are written into the experimental bit fields.
- On the Cisco 7500 series routers, distributed Cisco Express Forwarding must be enabled before you set the experimental bits.

**On the Cisco 10720 Internet Router**

The table below lists the commands that are supported on the Cisco 10720 Internet router for Ethernet over MPLS. The letter Y means that the command is supported on that interface. A dash (--) means that command is not supported on that interface.

<table>
<thead>
<tr>
<th>Traffic Matching Commands</th>
<th>Imposition</th>
<th>Disposition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>match any</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>match cos</td>
<td>Y</td>
<td>--</td>
</tr>
</tbody>
</table>

The `match cos` command is supported only on subinterfaces, not main interfaces.
### Commands

<table>
<thead>
<tr>
<th>Commands</th>
<th>Imposition</th>
<th>Disposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>match input-interface</td>
<td>--</td>
<td>Y</td>
</tr>
<tr>
<td>match mpls exp</td>
<td>--</td>
<td>Y</td>
</tr>
<tr>
<td>match qos-group</td>
<td>--</td>
<td>Y</td>
</tr>
</tbody>
</table>

#### Traffic Action Commands

<table>
<thead>
<tr>
<th>Commands</th>
<th>In</th>
<th>Out</th>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>set cos</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Y</td>
</tr>
<tr>
<td>set mpls exp</td>
<td>Y</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>set qos-group</td>
<td>Y</td>
<td>--</td>
<td>Y</td>
<td>--</td>
</tr>
<tr>
<td>set srp-priority</td>
<td>--</td>
<td>Y</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

The following restrictions apply to Frame Relay over MPLS and EXP bits:

- If you do not assign values to the experimental bits, the priority bits in the header’s “tag control information” field are set to zero.
- On the Cisco 7500 series routers, distributed Cisco Express Forwarding must be enabled before you set the experimental bits.

The following restrictions apply to HDLC over MPLS and PPP over MPLS and EXP bits:

- If you do not assign values to the experimental bits, zeros are written into the experimental bit fields.
- On the Cisco 7500 series routers, enable distributed Cisco Express Forwarding before setting the experimental bits.

Set the experimental bits in both the VC label and the LSP tunnel label. You set the experimental bits in the VC label, because the LSP tunnel label might be removed at the penultimate router. Perform this task to set the experimental bits.
SUMMARY STEPS

1. enable
2. configure terminal
3. class-map class-name
4. match any
5. exit
6. policy-map policy-name
7. class class-name
8. set mpls experimental value
9. exit
10. exit
11. interface slot/port
12. service-policy input policy-name
13. exit
14. exit
15. show policy-map interface interface-name \[vc [vpi/ vci] |dlci dlci] \[input | output\]

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| Step 1 enable     | Enables privileged EXEC mode.  
|                   | • Enter your password if prompted. |
| Example:          |         |
| Router> enable    |         |
| Step 2 configure terminal | Enters global configuration mode. |
| Example:          |         |
| Router# configure terminal |         |
| Step 3 class-map class-name | Specifies the user-defined name of the traffic class and enters class map configuration mode. |
| Example:          |         |
| Router(config)# class-map class1 |         |
| Step 4 match any | Specifies that all packets will be matched.  
<p>|                   | • Use only the any keyword. Other keywords might cause unexpected results. |
| Example:          |         |
| Router(config-cmap)# match any |         |</p>
<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 5</strong> exit</td>
<td>Exits class map configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-cmap)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 6</strong> policy-map <em>policy-name</em></td>
<td>Specifies the name of the traffic policy to configure and enters policy-map configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# policy-map policy1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 7</strong> class <em>class-name</em></td>
<td>Specifies the name of the predefined traffic that was configured with the <em>class-map</em> command and was used to classify traffic to the traffic policy specified, and enters policy-map class configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pmap)# class class1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 8</strong> set mpls experimental <em>value</em></td>
<td>Designates the value to which the MPLS bits are set if the packets match the specified policy map.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pmap-c)# set mpls experimental ?</td>
<td></td>
</tr>
<tr>
<td><strong>Step 9</strong> exit</td>
<td>Exits policy-map class configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pmap-c)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 10</strong> exit</td>
<td>Exits policy-map configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pmap)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 11</strong> interface <em>slot/port</em></td>
<td>Specifies the interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface atm4/0</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 12</strong> service-policy input <em>policy-name</em></td>
<td>Attaches a traffic policy to an interface.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# service-policy input policy1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 13</strong> exit</td>
<td>Exits interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 14</strong> exit</td>
<td>Exits global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# exit</td>
<td></td>
</tr>
<tr>
<td><strong>Step 15</strong> show policy-map interface <em>interface-name</em> [vc [vpi] vci] [dlci dlci] [input</td>
<td>output]</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# show policy-map interface serial3/0</td>
<td></td>
</tr>
</tbody>
</table>

### Setting the Frame Relay Discard Eligibility Bit on the Cisco 7200 and 7500 Series Routers

You can use the DE bit in the address field of a Frame Relay frame to prioritize frames in congested Frame Relay networks. The Frame Relay DE bit has only one bit and can therefore only have two settings, 0 or 1. If congestion occurs in a Frame Relay network, frames with the DE bit set to 1 are discarded before frames with the DE bit set to 0. Therefore, important traffic should have the DE bit set to 0, and less important traffic should be forwarded with the DE bit set at 1. The default DE bit setting is 0. You can change the DE bit setting to 1 with the `set fr-de` command.

**Note**
The `set fr-de` command can be used only in an output service policy.

Perform this task to set the Frame Relay DE bit on the Cisco 7200 and 7500 series routers.
### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `policy-map policy-name`
4. `class class-name`
5. `set fr-de`
6. `end`

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** `enable` | Enables privileged EXEC mode.  
  • Enter your password if prompted. |
| **Example:** | Router> enable |
| **Step 2** `configure terminal` | Enters global configuration mode. |
| **Example:** | Router# configure terminal |
| **Step 3** `policy-map policy-name` | Specifies the name of the traffic policy to configure and enters policy-map configuration mode.  
  • Names can be a maximum of 40 alphanumeric characters. |
| **Example:** | Router(config)# policy-map policy1 |
| **Step 4** `class class-name` | Specifies the name of a predefined traffic class and enters policy-map class configuration mode. |
| **Example:** | Router(config-pmap)# class class1 |
| **Step 5** `set fr-de` | Sets the Frame Relay DE bit setting for all packets that match the specified traffic class from 0 to 1. |
| **Example:** | Router(config-pmap-c)# set fr-de |
Matching the Frame Relay DE Bit on the Cisco 7200 and 7500 Series Routers

You can use the `match fr-de` command to enable frames with a DE bit setting of 1 to be considered a member of a defined class and forwarded according to the specifications set in the service policy.

Perform this task to match frames with the FR DE bit set to 1.

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `class-map class-map-name`
4. `match fr-de`
5. `end`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1 enable</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2 configure terminal</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3 class-map class-map-name</strong></td>
<td>Specifies the name of a predefined traffic class and enters class-map configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# class-map de-bits</td>
<td></td>
</tr>
</tbody>
</table>
Enabling the Control Word

You can enable the control word for dynamic and static pseudowires under a pseudowire class. Use the `control-word` command to enable, disable, or set a control word to autosense mode. If you do not enable a control word, autosense is the default mode for the control word.

Perform this task to enable a control word.

**SUMMARY STEPS**

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

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Step 2</strong> configure terminal</th>
<th>Enters global configuration mode.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

**Step 3** pseudowire-class cw_enable

**Example:**

```
Router(config)# pseudowire-class cw_enable
```

Enters pseudowire class configuration mode.

**Step 4** encapsulation mpls

**Example:**

```
Router(config-pw-class)# encapsulation mpls
```

Specifies the tunneling encapsulation.
- For AToM, the encapsulation type is mpls.

**Step 5** control-word

**Example:**

```
Router(config-pw-class)# control-word
```

Enables the control word.

**Step 6** exit

**Example:**

```
Router(config-pw-class)# exit
```

Exits pseudowire class configuration mode and returns to global configuration mode.

**Step 7** exit

**Example:**

```
Router(config)# exit
```

Exits global configuration mode.

---

**Configuration Examples for Any Transport over MPLS**

- Example ATM AAL5 over MPLS, page 80
- Example OAM Cell Emulation for ATM AAL5 over MPLS, page 80
- Example ATM Cell Relay over MPLS, page 81
- Example ATM Single Cell Relay over MPLS, page 82
- Example Ethernet over MPLS, page 84
- Example Tunnel Selection, page 84
- Example Setting Frame Relay Discard Eligibility Bit on the Cisco 7200 and 7500 Series Routers, page 86
- Example Matching Frame Relay DE Bit on the Cisco 7200 and 7500 Series Routers, page 87
- Example ATM over MPLS, page 87
- Example Ethernet over MPLS with MPLS Traffic Engineering Fast Reroute, page 88
Example ATM AAL5 over MPLS

ATM AAL5 over MPLS on PVCs

The following example shows how to enable ATM AAL5 over MPLS on an ATM PVC:

```
enable
configure terminal
interface atm1/0
  pvc 1/0
  200 l2transport
  encapsulation aal5
  xconnect 10.13.13.13 100 encapsulation mpls
```

ATM AAL5 over MPLS in VC Class Configuration Mode

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

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

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

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

Example OAM Cell Emulation for ATM AAL5 over MPLS

OAM Cell Emulation for ATM AAL5 over MPLS on PVCs

The following example shows how to enable OAM cell emulation on an ATM PVC:

```
interface ATM 1/0/0
pvc 1/200 l2transport
encapsulation aal5
```
The following example shows how to set the rate at which an AIS cell is sent every 30 seconds:

```
interface ATM 1/0/0
pvc 1/200 l2transport
encapsulation aal5
xconnect 10.13.13.13 100 encapsulation mpls
oam-ac emulation-enable 30
oam-pvc manage
```

**OAM Cell Emulation for ATM AAL5 over MPLS in VC Class Configuration Mode**

The following example shows how to configure OAM cell emulation for ATM AAL5 over MPLS in VC class configuration mode. The VC class is then applied to an interface.

```
enable
configure terminal
vc-class atm oamclass
encapsulation aal5
oam-ac emulation-enable 30
oam-pvc manage
interface atm1/0
class-int oamclass
pvc 1/200 l2transport
xconnect 10.13.13.13 100 encapsulation mpls
```

The following example shows how to configure OAM cell emulation for ATM AAL5 over MPLS in VC class configuration mode. The VC class is then applied to a PVC.

```
enable
configure terminal
vc-class atm oamclass
encapsulation aal5
oam-ac emulation-enable 30
oam-pvc manage
interface atm1/0
pvc 1/200 l2transport
class-vc oamclass
xconnect 10.13.13.13 100 encapsulation mpls
```

The following example shows how to configure OAM cell emulation for ATM AAL5 over MPLS in VC class configuration mode. The VC class is then applied to an interface. One PVC is configured with OAM cell emulation at an AIS rate of 10. That PVC uses the AIS rate of 10 instead of 30.

```
enable
configure terminal
vc-class atm oamclass
encapsulation aal5
oam-ac emulation-enable 30
oam-pvc manage
interface atm1/0
class-int oamclass
pvc 1/200 l2transport
oam-ac emulation-enable 10
xconnect 10.13.13.13 100 encapsulation mpls
```

**Example ATM Cell Relay over MPLS**
ATM Cell Relay over MPLS in VC Mode Using VC Class Configuration Mode

The following example shows how to configure ATM cell relay over MPLS in VC class configuration mode. The VC class is then applied to an interface.

```
enable
configure terminal
vc-class atm cellrelay
encapsulation aal0
interface atm1/0
class-int cellrelay
pvc 1/200 l2transport
xconnect 10.13.13.13 100 encapsulation mpls
```

The following example shows how to configure ATM cell relay over MPLS in VC class configuration mode. The VC class is then applied to a PVC.

```
enable
configure terminal
vc-class atm cellrelay
encapsulation aal0
interface atm1/0
class-vc cellrelay
xconnect 10.13.13.13 100 encapsulation mpls
```

ATM Cell Relay over MPLS in PVP Mode

The following example shows how to transport single ATM cells over a virtual path:

```
pseudowire-class vp-cell-relay
encapsulation mpls
interface atm 5/0
atm pvp 1 l2transport
xconnect 10.0.0.1 123 pw-class vp-cell-relay
```

ATM Cell Relay over MPLS in Port Mode

The following example shows how to configure interface ATM 5/0 to transport ATM cell relay packets:

```
pseudowire-class atm-cell-relay
encapsulation mpls
interface atm 5/0
xconnect 10.0.0.1 123 pw-class atm-cell-relay
```

The following example shows how to configure interface ATM 9/0/0 to transport ATM cell relay packets on a Cisco 7600 series router, where you must specify the interface ATM slot, bay, and port:

```
pseudowire-class atm-cell-relay
encapsulation mpls
interface atm 9/0/0
xconnect 10.0.0.1 500 pw-class atm-cell-relay
```

Example ATM Single Cell Relay over MPLS

ATM Packed Cell Relay over MPLS in VC Mode

The following example shows that ATM PVC 1/100 is an AToM cell relay PVC. There are three timers set up, with values of 1000 milliseconds, 800 milliseconds, and 500 milliseconds, respectively. The cell-
The `cell-packing` command specifies that five ATM cells are to be packed into an MPLS packet. The `cell-packing` command also specifies that timer 1 is to be used.

```
interface atm 1/0
shut down
atm mcpt-timer 1000 800 500
no shut down
pvc 1/100 l2transport
encapsulation aal0
xconnect 10.0.0.1 123 encapsulation mpls
cell-packing 5 mcpt-timer 1
```

**ATM Packed Cell Relay over MPLS in VC Mode Using VC Class Configuration Mode**

The following example shows how to configure ATM cell relay over MPLS with cell packing in VC class configuration mode. The VC class is then applied to an interface.

```
enable
configure terminal
vc-class atm cellpacking
encapsulation aal0
cell-packing 10 mcpt-timer 1
interface atm1/0
shut down
atm mcpt-timers 100 200 250
no shut down
class-int cellpacking
pvc 1/200 l2transport
xconnect 10.13.13.13 100 encapsulation mpls
```

The following example shows how to configure ATM cell relay over MPLS in VC class configuration mode. The VC class is then applied to a PVC.

```
enable
configure terminal
vc-class atm cellpacking
encapsulation aal0
cell-packing 10 mcpt-timer 1
interface atm1/0
shut down
atm mcpt-timers 100 200 250
no shut down
pvc 1/200 l2transport
class-vc cellpacking
xconnect 10.13.13.13 100 encapsulation mpls
```

**ATM Packed Cell Relay over MPLS in VP Mode**

The following example shows packed cell relay enabled on an interface configured for PVP mode. The `cell-packing` command specifies that 10 ATM cells are to be packed into an MPLS packet. The `cell-packing` command also specifies that timer 2 is to be used.

```
interface atm 1/0
shut down
atm mcpt-timer 1000 800 500
no shut down
atm pvp 100 l2transport
xconnect 10.0.0.1 234 encapsulation mpls
cell-packing 10 mcpt-timer 2
```
ATM Packed Cell Relay over MPLS in Port Mode

The following example shows packed cell relay enabled on an interface set up for port mode. The `cell-packing` command specifies that 10 ATM cells are to be packed into an MPLS packet. The `cell-packing` command also specifies that timer 2 is to be used.

```
interface atm 5/0
shutdown
atm mcpt-timer 1000 800 500
no shutdown
cell-packing 10 mcpt-timer 2
xconnect 10.0.0.1 123 encapsulation mpls
```

Example Ethernet over MPLS

Ethernet over MPLS in Port Mode

The following example shows how to configure VC 123 in Ethernet port mode:

```
pseudowire-class ethernet-port
encapsulation mpls
int gigabitethernet1/0
xconnect 10.0.0.1 123 pw-class ethernet-port
```

Ethernet over MPLS with VLAN ID Rewrite

The following example shows how to configure VLAN ID rewrite on peer PE routers with Cisco 12000 series router engine 2 3-port Gigabit Ethernet line cards.

PE1

```
interface GigabitEthernet0/0.2
encapsulation dot1Q 2
no ip directed-broadcast
no cdp enable
xconnect 10.5.5.5 2 encapsulation mpls
remote circuit id 3
```

PE2

```
interface GigabitEthernet3/0.2
encapsulation dot1Q 3
no ip directed-broadcast
no cdp enable
xconnect 10.3.3.3 2 encapsulation mpls
remote circuit id 2
```

Example Tunnel Selection

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

PE1 Configuration

```
mls label protocol ldp
mls traffic-eng tunnels
tag-switching tdp router-id Loopback0
pseudowire-class pw1
encapsulation mpls
preferred-path interface Tunnel1 disable-fallback

pseudowire-class pw2
encapsulation mpls
preferred-path peer 10.18.18.18
```
interface Loopback0
  ip address 10.2.2.2 255.255.255.255
  no ip directed-broadcast
  no ip mroute-cache
!
interface Tunnel1
  ip unnumbered Loopback0
  no ip directed-broadcast
tunnel destination 10.16.16.16
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng priority 7 7
tunnel mpls traffic-eng bandwidth 1500
tunnel mpls traffic-eng path-option 1 explicit name path-tu1
!
interface Tunnel2
  ip unnumbered Loopback0
  no ip directed-broadcast
tunnel destination 10.16.16.16
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng priority 7 7
tunnel mpls traffic-eng bandwidth 1500
tunnel mpls traffic-eng path-option 1 dynamic
!
interface gigabitethernet0/0/0
  no ip address
  no ip directed-broadcast
  no negotiation auto
!
interface gigabitethernet0/0/0.1
  encapsulation dot1Q 222
  no ip directed-broadcast
  xconnect 10.16.16.16 101 pw-class pw1
!
interface ATM1/0/0
  no ip address
  no ip directed-broadcast
  no atm enable-ilmi-trap
  no atm ilmi-keepalive
  pvc 0/50 12transport
  encapsulation aal5
  xconnect 10.16.16.16 150 pw-class pw2
!
interface Ethernet2/0/1
  ip address 10.0.0.1 255.255.255.0
  no ip directed-broadcast
tag-switching ip
  mpls traffic-eng tunnels
  ip rsvp bandwidth 15000 15000
!
router ospf 1
  log-adjacency-changes
  network 10.0.0.0 0.0.0.255 area 0
  network 10.2.2.2 0.0.0.0 area 0
  mpls traffic-eng router-id Loopback0
  mpls traffic-eng area 0
!
ip route 10.18.18.18 255.255.255.255 Tunnel2
!
ip explicit-path name path-tu1 enable
  next-address 10.0.0.1
  index 3 next-address 10.0.0.1

PE2 Configuration

mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback0
interface Loopback0
  ip address 10.16.16.16 255.255.255.255
  no ip directed-broadcast
  no ip mroute-cache
!
Example Setting Frame Relay Discard Eligibility Bit on the Cisco 7200 and 7500 Series Routers

The following example shows how to configure the service policy called set-de and attach it to an interface. In this example, the class map called data evaluates all packets exiting the interface for an IP precedence value of 1. If the exiting packet has been marked with the IP precedence value of 1, the packet’s DE bit is set to 1.

class-map data
match ip precedence 1
policy-map set-de
class data
set fr-de
interface Serial0/0/0
encapsulation frame-relay
interface Serial0/0.1 point-to-point
ip address 192.168.249.194 255.255.255.252
frame-relay interface-dlci 100
service output set-de
Example Matching Frame Relay DE Bit on the Cisco 7200 and 7500 Series Routers

The following example shows how to configure the service policy called match-de and attach it to an interface. In this example, the class map called data evaluates all packets entering the interface for a DE bit setting of 1. If the entering packet has been a DE bit value of 1, the packet's EXP bit setting is set to 3.

```
class-map data
match fr-de
policy-map match-de
class data
set mpls exp 3
ip routing
ip cef distributed
mpls label protocol ldp
interface Loopback0
  ip address 10.20.20.20 255.255.255.255
interface Ethernet1/0/0
  ip address 10.0.0.2 255.255.255.0
  mpls ip
interface Serial4/0/0
  encapsulation frame-relay
service input match-de
connect 100 Serial4/0/0 100 l2transport
xconnect 10.10.10.10 100 encapsulation mpls
```

Example ATM over MPLS

The table below shows the configuration of ATM over MPLS on two PE routers.
Table 8  ATM over MPLS Configuration Example

<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>mpls label protocol ldp</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls ldp router-id Loopback0 force</td>
<td>mpls ldp router-id Loopback0 force</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface Loopback0</td>
<td>interface Loopback0</td>
</tr>
<tr>
<td>ip address 10.16.12.12 255.255.255.255</td>
<td>ip address 10.13.13.13 255.255.255.255</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface ATM4/0</td>
<td>interface ATM4/0</td>
</tr>
<tr>
<td>pvc 0/100 12transport</td>
<td>pvc 0/100 12transport</td>
</tr>
<tr>
<td>encapsulation aal0</td>
<td>encapsulation aal0</td>
</tr>
<tr>
<td>xconnect 10.13.13.13 100 encapsulation mpls</td>
<td>xconnect 10.16.12.12 100 encapsulation mpls</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface ATM4/0.300 point-to-point</td>
<td>interface ATM4/0.300 point-to-point</td>
</tr>
<tr>
<td>no ip directed-broadcast</td>
<td>no ip directed-broadcast</td>
</tr>
<tr>
<td>no atm enable-ilmi-trap</td>
<td>no atm enable-ilmi-trap</td>
</tr>
<tr>
<td>pvc 0/300 12transport</td>
<td>pvc 0/300 12transport</td>
</tr>
<tr>
<td>encapsulation aal0</td>
<td>encapsulation aal0</td>
</tr>
<tr>
<td>xconnect 10.13.13.13 300 encapsulation mpls</td>
<td>xconnect 10.16.12.12 300 encapsation mpls</td>
</tr>
</tbody>
</table>

Example Ethernet over MPLS with MPLS Traffic Engineering Fast Reroute

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

Routers PE1 and PE2 have the following characteristics:

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

**Figure 2** Fast Reroute Configuration

**PE1 Configuration**

```plaintext
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
pseudowire-class T41
  encapsulation mpls
  preferred-path interface Tunnel41 disable-fallback
!
pseudowire-class IP1
  encapsulation mpls
  preferred-path peer 10.4.0.1 disable-fallback
!
interface Loopback1
  ip address 10.0.0.27 255.255.255.255
!
interface Tunnel1
  ip unnumbered Loopback1
  tunnel destination 10.0.0.1
  tunnel mode mpls traffic-eng
  tunnel mpls traffic-eng priority 1 1
  tunnel mpls traffic-eng bandwidth 10000
  tunnel mpls traffic-eng path-option 1 explicit name FRR
!
interface Tunnel41
  ip unnumbered Loopback1
  tunnel destination 10.0.0.4
  tunnel mode mpls traffic-eng
  tunnel mpls traffic-eng priority 1 1
  tunnel mpls traffic-eng bandwidth 1000
  tunnel mpls traffic-eng path-option 1 explicit name-1
  tunnel mpls traffic-eng fast-reroute
!
interface POS0/0
  description pe1name POS8/0/0
  ip address 10.1.0.2 255.255.255.252
  mpls traffic-eng tunnels
  mpls traffic-eng backup-path Tunnel1
crc 16
  clock source internal
describe internal
  pos ais-shut
  pos report lrdi
  ip rsvp bandwidth 155000
!
interface POS0/3
  description pe1name POS10/1/0
  ip address 10.1.0.14 255.255.255.252
  mpls traffic-eng tunnels
crc 16
  clock source internal
  ip rsvp bandwidth 155000
!
interface gigabitethernet3/0.1
  encapsulation dot1Q 203
  xconnect 10.0.0.4 2 pw-class IP1
```

*Any Transport over MPLS*
interface gigabitethernet3/0.2
  encapsulation dot1Q 204
  xconnect 10.0.0.4 4 pw-class T41
router ospf 1
  network 10.0.0.0 0.255.255.255 area 0
  mpls traffic-eng router-id Loopback1
  mpls traffic-eng area 0
  ip classless
  ip route 10.4.0.1 255.255.255.255 Tunnel41
  ip explicit-path name xxxx-1 enable
  next-address 10.4.1.2
  next-address 10.1.0.10

P Configuration

ip cef
mpls traffic-eng tunnels
interface Loopback1
  ip address 10.0.0.1 255.255.255.255
interface FastEthernet1/0/0
  ip address 10.4.1.2 255.255.255.0
  mpls traffic-eng tunnels
  ip rsvp bandwidth 10000 10000
interface POS8/0/0
  description xxxx POS0/0
  ip address 10.1.0.1 255.255.255.252
  mpls traffic-eng tunnels
  pos ais-shut
  pos report lrdi
  ip rsvp bandwidth 155000 155000
interface POS10/1/0
  description xxxx POS0/3
  ip address 10.1.0.13 255.255.255.252
  mpls traffic-eng tunnels
  ip rsvp bandwidth 155000 155000
router ospf 1
  network 10.0.0.0 0.255.255.255 area 0
  mpls traffic-eng router-id Loopback1
  mpls traffic-eng area 0

PE2 Configuration

ip cef
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
interface Loopback1
  ip address 10.0.0.4 255.255.255.255
interface loopback 2
  ip address 10.4.0.1 255.255.255.255
interface Tunnel27
  ip unnumbered Loopback1
tunnel destination 10.0.0.27
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng priority 1 1
tunnel mpls traffic-eng bandwidth 1000
tunnel mpls traffic-eng path-option 1 explicit name xxxx-1

Example Configuring per-Subinterface MTU for Ethernet over MPLS

The figure below shows a configuration that enables matching MTU values between VC endpoints.

As shown in the figure below, PE1 is configured in xconnect subinterface configuration mode with an MTU value of 1500 bytes in order to establish an end-to-end VC with PE2, which also has an MTU value of 1500 bytes. If PE1 was not set with an MTU value of 1500 bytes, in xconnect subinterface configuration mode, the subinterface would inherit the MTU value of 2000 bytes set on the interface. This would cause a mismatch in MTU values between the VC endpoints, and the VC would not come up.

The following examples show the router configurations in the figure above:

**CE1 Configuration**

interface gigabitethernet0/0
mtu 1500
no ip address

**PE1 Configuration**

interface gigabitethernet0/0
mtu 2000
no ip address
interface gigabitethernet0/0.1
  encapsulation dot1Q 100
  xconnect 10.1.1.152 100 encapsulation mpls
    mtu 1500

interface gigabitethernet0/0.2
  encapsulation dot1Q 200
  ip address 10.151.100.1 255.255.255.0
  mpls ip

PE2 Configuration

interface gigabitethernet1/0
  mtu 2000
  no ip address

interface gigabitethernet1/0.2
  encapsulation dot1Q 200
  ip address 10.100.152.2 255.255.255.0
  mpls ip

interface fastethernet0/0
  no ip address

interface fastethernet0/0.1
  description default MTU of 1500 for FastEthernet
  encapsulation dot1Q 100
  xconnect 10.1.1.151 100 encapsulation mpls

CE2 Configuration

interface fastethernet0/0
  no ip address

interface fastethernet0/0.1
  encapsulation dot1Q 100
  ip address 10.181.182.2 255.255.255.0

The show mpls l2transport binding command, issued from router PE1, shows a matching MTU value of 1500 bytes on both the local and remote routers:

Router# show mpls l2transport binding
Destination Address: 10.1.1.152, VC ID: 100
  Local Label: 100
    Cbit: 1, VC Type: Ethernet, GroupID: 0
    MTU: 1500, Interface Desc: n/a
    VCCV: CC Type: CW [1], RA [2]
    CV Type: LSPV [2]
  Remote Label: 202
    Cbit: 1, VC Type: Ethernet, GroupID: 0
    MTU: 1500, Interface Desc: n/a
    VCCV: CC Type: RA [2]
    CV Type: LSPV [2]

Router# show mpls l2transport vc detail
Local interface: Gi0/0.1 up, line protocol up, Eth VLAN 100 up
  Destination address: 10.1.1.152, VC ID: 100, VC status: up
  Output interface: Gi0/0.2, imposed label stack {202}
  Preferred path: not configured
  Default path: active
  Next hop: 10.151.152.2
  Create time: 1d11h, last status change time: 1d11h
  Signaling protocol: LDP, peer 10.1.1.152:0 up
  Targeted Hello: 10.1.1.151(LDP Id) -> 10.1.1.152
  MPLS VC labels: local 100, remote 202
  Group ID: local 0, remote 0
  MTU: local 1500, remote 1500
  Remote interface description:
Sequencing: receive disabled, send disabled
VC statistics:
  packet totals: receive 41, send 39
  byte totals: receive 4460, send 5346
  packet drops: receive 0, send 0

In the following example, you are specifying an MTU of 1501 in xconnect subinterface configuration mode, and that value is out of range, the router enters the command in subinterface configuration mode, where it is accepted:

Router# configure terminal
router(config)# interface gigabitethernet0/2.1
router(config-subif)# xconnect 10.10.10.1 100 encapsulation mpls
router(config-subif-xconn)# mtu ?
<64 – 1500> MTU size in bytes
router(config-subif-xconn)# mtu 1501
router(config-subif-xconn)# mtu ?
<64 – 17940> MTU size in bytes

If the MTU value is not accepted in either xconnect subinterface configuration mode or subinterface configuration mode, then the command is rejected, as shown in the following example:

Router# configure terminal
router(config)# interface gigabitethernet0/2.1
router(config-subif)# xconnect 10.10.10.1 100 encapsulation mpls
router(config-subif-xconn)# mtu ?
<64 – 1500> MTU size in bytes
router(config-subif-xconn)# mtu 63
% Invalid input detected at ^ marker

Example Configuring MTU Values in xconnect Configuration Mode for L2VPN Interworking

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

PE1 Configuration

pseudowire-class atom-iplw
  encapsulation mpls
  interworking ip
  !
interface Loopback0
  ip address 10.1.1.151 255.255.255.255
  !
interface Serial2/0
  mtu 1492
  no ip address
  encapsulation ppp
  no fair-queue
  serial restart-delay 0
  xconnect 10.1.1.152 123 pw-class atom-iplw
  !
interface Serial4/0
  ip address 10.151.100.1 255.255.255.252
  encapsulation ppp
  mpls ip
  serial restart-delay 0
  !
router ospf 1
  log-adjacency-changes

Example Configuring MTU Values in xconnect Configuration Mode for L2VPN Interworking

Configuration Examples for Any Transport over MPLS

MPLS: Layer 2 VPNs, Configuration Guide, Cisco IOS Release 12.4T
network 10.1.1.151 0.0.0.0 area 0
network 10.151.100.0 0.0.0.3 area 0

mpls ldp router-id Loopback0

**PE2 Configuration**

pseudowire-class atom-ipiw
encapsulation mpls
interworking ip
!
interface Loopback0
  ip address 10.1.1.152 255.255.255.255
!
interface Ethernet0/0
  no ip address
  xconnect 10.1.1.151 123 pw-class atom-ipiw
  mtu 1492
!
interface Serial4/0
  ip address 10.100.152.2 255.255.255.252
  encapsulation ppp
  mpls ip
  serial restart-delay 0
!
router ospf 1
  log-adjacency-changes
network 10.1.1.152 0.0.0.0 area 0
network 10.100.152.0 0.0.0.3 area 0
!
mpls ldp router-id Loopback0

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

**PE1 Configuration**

Router# `show mpls l2transport binding`

Destination Address: 10.1.1.152, VC ID: 123
  Local Label: 105
    Cbit: 1, VC Type: PPP, GroupID: 0
    MTU: 1492, Interface Desc: n/a
    VCCV: CC Type: CW [1], RA [2]
    CV Type: LSPV [2]
  Remote Label: 205
    Cbit: 1, VC Type: Ethernet, GroupID: 0
    MTU: 1492, Interface Desc: n/a
    VCCV: CC Type: RA [2]
    CV Type: LSPV [2]

Router# `show mpls l2transport vc detail`

Local interface: Se2/0 up, line protocol up, PPP up
  MPLS VC type is PPP, interworking type is IP
  Destination address: 10.1.1.152, VC ID: 123, VC status: up
  Output interface: Se4/0, imposed label stack (1003 205)
  Preferred path: not configured
  Default path: active
  Next hop: point2point
  Create time: 00:25:29, last status change time: 00:24:54
  Signaling protocol: LDP, peer 10.1.1.152:0 up
  Targeted Hello: 10.1.1.151(LDP Id) -> 10.1.1.152
  Status TLV support (local/remote) : enabled/supported
    Label/status state machine : established, LruRru
    Last local dataplane status rcvd: no fault
    Last local SSS circuit status rcvd: no fault
    Last local SSS circuit status sent: no fault
    Last local LDP TLV status sent: no fault
    Last remote LDP TLV status rcvd: no fault
  MPLS VC labels: local 105, remote 205
  Group ID: local n/a, remote 0
MTU: local 1492, remote 1492
Remote interface description:
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 30, send 29
byte totals: receive 2946, send 3364
packet drops: receive 0, send 0

PE2 Configuration

Router# show mpls l2transport binding
Destination Address: 10.1.1.151, VC ID: 123
Local Label: 205
 Cbit: 1, VC Type: Ethernet, GroupID: 0
MTU: 1492, Interface Desc: n/a
VCCV: CC Type: RA [2]
CV Type: LSPV [2]
Remote Label: 105
 Cbit: 1, VC Type: Ethernet, GroupID: 0
MTU: 1492, Interface Desc: n/a
VCCV: CC Type: CW [1], RA [2]
CV Type: LSPV [2]

Router# show mpls l2transport vc detail
Local interface: Et0/0 up, line protocol up, Ethernet up
MPLS VC type is Ethernet, interworking type is IP
Destination address: 10.1.1.151, VC ID: 123, VC status: up
Output interface: Se4/0, imposed label stack {1002 105}
Preferred path: not configured
Default path: active
Next hop: point2point
Create time: 00:25:19, last status change time: 00:25:19
Signaling protocol: LDP, peer 10.1.1.151:0 up
Targeted Hello: 10.1.1.152(LDP Id) -> 10.1.1.151
Status TLV support (local/remote) : enabled/supported
Label/status state machine : established, LruRru
Last local dataplane status rcvd: no fault
Last local SSS circuit status rcvd: no fault
Last local SSS circuit status sent: no fault
Last local LDP TLV status sent: no fault
Last remote LDP TLV status rcvd: no fault
MPLS VC labels: local 205, remote 105
Group ID: local n/a, remote 0
MTU: local 1492, remote 1492
Remote interface description:
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 29, send 30
byte totals: receive 2900, send 3426
packet drops: receive 0, send 0

Example Removing a Pseudowire

The following example shows how to remove all xconnects:

Router# clear xconnect all
02:13:56: Xconnect[ac:Et1/0.1(Eth VLAN)]: provisioning fwder with fwd_type=1, sss_role=1
02:13:56: Xconnect[mpls:10.1.1.2:1234000]: provisioning fwder with fwd_type=2, sss_role=2
02:13:56: Xconnect[ac:Et1/0.2(Eth VLAN)]: provisioning fwder with fwd_type=1, sss_role=2
02:13:56: Xconnect[mpls:10.1.1.2:1234001]: provisioning fwder with fwd_type=2, sss_role=1
02:13:56: Xconnect[ac:Et1/0.3(Eth VLAN)]: provisioning fwder with fwd_type=1, sss_role=1
02:13:56: Xconnect[mpls:10.1.1.2:1234002]: provisioning fwder with fwd_type=2, sss_role=1
02:13:56: Xconnect[ac:Et1/0.4(Eth VLAN)]: provisioning fwder with fwd_type=1, sss_role=2
02:13:56: Xconnect[mpls:10.1.1.2:1234003]: provisioning fwder with fwd_type=2, sss_role=1
02:13:56: MPLS peer 10.1.1.2 vcld 1234000, VC DOWN, VC state DOWN
02:13:56: MPLS peer 10.1.1.2 vcld 1234001, VC DOWN, VC state DOWN
02:13:56: MPLS peer 10.1.1.2 vcld 1234002, VC DOWN, VC state DOWN
02:13:56: MPLS peer 10.1.1.2 vcld 1234003, VC DOWN, VC state DOWN
02:13:56: XC AUTH [Et1/0.1, 1001]: Event: start xconnect authorization, state changed
from IDLE to AUTHORIZING
02:13:56: XC AUTH [Et1/0.1, 1001]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:13:56: XC AUTH [Et1/0.3, 1003]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:13:56: XC AUTH [10.1.1.2, 1234001]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:13:56: XC AUTH [10.1.1.2, 1234001]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:13:56: XC AUTH [10.1.2.2, 1234003]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:13:56: XC AUTH [10.1.2.2, 1234003]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:13:56: XC AUTH [Et1/0.1, 1003]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:13:56: XC AUTH [Et1/0.1, 1003]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:13:56: XC AUTH [Et1/0.3, 1001]: Event: free xconnect authorization request, state changed from DONE to END
02:13:56: XC AUTH [Et1/0.3, 1001]: Event: free xconnect authorization request, state changed from DONE to END
02:13:56: XC AUTH [10.1.1.2, 1234001]: Event: free xconnect authorization request, state changed from DONE to END
02:13:56: XC AUTH [10.1.1.2, 1234001]: Event: free xconnect authorization request, state changed from DONE to END
02:13:56: MPLS peer 10.1.1.2 vcid 1234001, VC UP, VC state UP
02:13:56: MPLS peer 10.1.2.2 vcid 1234003, VC UP, VC state UP
02:13:56: MPLS peer 10.1.2.2 vcid 1234002, VC UP, VC state UP
02:13:56: MPLS peer 10.1.2.2 vcid 1234001, VC DOWN, VC state DOWN
02:13:56: MPLS peer 10.1.1.2 vcid 1234001, VC DOWN, VC state DOWN
02:13:56: MPLS peer 10.1.1.2 vcid 1234000, VC UP, VC state UP
02:13:56: MPLS peer 10.1.2.2 vcid 1234002, VC UP, VC state UP

The following example shows how to remove all the xconnects associated with peer router 10.1.1.2:

Router# clear xconnect peer 10.1.1.2 all
02:14:08: Xconnect[ac:Et1/0.1(Eth VLAN)]: provisioning fwdr with fwd_type=1, sss_role=1
02:14:08: Xconnect[mpls:10.1.1.2:1234000]: provisioning fwdr with fwd_type=2, sss_role=2
02:14:08: Xconnect[ac:Et1/0.2(Eth VLAN)]: provisioning fwdr with fwd_type=1, sss_role=2
02:14:08: Xconnect[mpls:10.1.1.2:1234001]: provisioning fwdr with fwd_type=2, sss_role=1
02:14:08: MPLS peer 10.1.1.2 vcid 1234000, VC DOWN, VC state DOWN
02:14:08: MPLS peer 10.1.1.2 vcid 1234001, VC UP, VC state UP
02:14:08: MPLS peer 10.1.1.2 vcid 1234000, VC UP, VC state UP
02:14:08: MPLS peer 10.1.1.2 vcid 1234001, VC DOWN, VC state DOWN
02:14:08: XC AUTH [Et1/0.1, 1001]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:14:08: XC AUTH [Et1/0.1, 1001]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:14:08: XC AUTH [Et1/0.2, 1002]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:14:08: XC AUTH [Et1/0.2, 1002]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:14:08: XC AUTH [Et1/0.1, 1001]: Event: free xconnect authorization request, state changed from DONE to END
02:14:08: XC AUTH [Et1/0.1, 1001]: Event: free xconnect authorization request, state changed from DONE to END
02:14:08: MPLS peer 10.1.1.2 vcid 1234001, VC DOWN, VC state DOWN
02:14:08: MPLS peer 10.1.1.2 vcid 1234000, VC UP, VC state UP
02:14:08: MPLS peer 10.1.1.2 vcid 1234000, VC UP, VC state UP
02:14:08: MPLS peer 10.1.1.2 vcid 1234001, VC UP, VC state UP

The following example shows how to remove all the xconnects associated with peer router 10.1.1.2 and VC ID 1234001:

Router# clear xconnect peer 10.1.1.2 vcid 1234001
02:14:23: Xconnect[ac:Et1/0.1(Eth VLAN)]: provisioning fwdr with fwd_type=1, sss_role=1
02:14:23: Xconnect[mpls:10.1.1.2:1234000]: provisioning fwdr with fwd_type=2, sss_role=2
02:14:23: MPLS peer 10.1.1.2 vcid 1234000, VC DOWN, VC state DOWN
02:14:23: XC AUTH [Et1/0.2, 1002]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:14:23: XC AUTH [Et1/0.2, 1002]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:14:23: XC AUTH [Et1/0.2, 1002]: Event: free xconnect authorization request, state changed from DONE to END
02:14:23: MPLS peer 10.1.1.2 vcid 1234001, VC UP, VC state UP

The following example shows how to remove the xconnects associated with interface Ethernet 1/0.1:

Router# clear xconnect interface eth1/0.1
02:14:48: Xconnect[ac:Et1/0.1(Eth VLAN)]: provisioning fwdr with fwd_type=1, sss_role=2
02:14:48: Xconnect [mpls:10.1.1.2:1234000]: provisioning fwd with fwd_type=2, sss_role=1
02:14:48: MPLS peer 10.1.1.2 vcid 1234000, VC DOWN, VC state DOWN
02:14:48: XC AUTH [10.1.1.2, 1234000]: Event: start xconnect authorization, state changed from IDLE to AUTHORIZING
02:14:48: XC AUTH [10.1.1.2, 1234000]: Event: found xconnect authorization, state changed from AUTHORIZING to DONE
02:14:48: XC AUTH [10.1.1.2, 1234000]: Event: free xconnect authorization request, state changed from DONE to END

Additional References

Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
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<tr>
<td>Cisco IOS commands</td>
<td>Cisco IOS Master Commands List, All Releases</td>
</tr>
<tr>
<td>MPLS commands</td>
<td>Cisco IOS Multiprotocol Label Switching Command Reference</td>
</tr>
<tr>
<td>Any Transport over MPLS</td>
<td>“Overview” section of Cisco Any Transport over MPLS</td>
</tr>
<tr>
<td>Any Transport over MPLS for the Cisco 10000 series router</td>
<td>Cisco 10000 Series Router Broadband Aggregation, Leased-Line, and MPLS Configuration Guide</td>
</tr>
<tr>
<td>Layer 2 Tunnel Protocol Version 3 (L2TPv3)</td>
<td>Layer 2 Tunnel Protocol Version 3 (L2TPv3)</td>
</tr>
<tr>
<td>L2VPN interworking</td>
<td>L2VPN Interworking</td>
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</table>

Standards

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<tr>
<th>Standard</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>draft-martini-l2circuit-trans-mpls-08.txt</td>
<td>Transport of Layer 2 Frames Over MPLS</td>
</tr>
<tr>
<td>draft-martini-l2circuit-encap-mpls-04.txt</td>
<td>Encapsulation Methods for Transport of Layer 2 Frames Over MPLS</td>
</tr>
</tbody>
</table>
MIBs

MIB | MIBs Link
---|---
ATM AAL5 over MPLS and ATM Cell Relay over MPLS: | To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL:
- MPLS LDP MIB (MPLS-LDP-MIB.my)
- ATM MIB (ATM-MIB.my)
- CISCO AAL5 MIB (CISCO-AAL5-MIB.my)
- Cisco Enterprise ATM Extension MIB (CISCO-ATM-EXT-MIB.my)
- Supplemental ATM Management Objects (CISCO-IETF-ATM2-PVCTRAP-MIB.my)
- Interfaces MIB (IF-MIB.my)

Ethernet over MPLS:
- CISCO-ETHERLIKE-CAPABILITIES.my
- Ethernet MIB (ETHERLIKE-MIB.my)
- Interfaces MIB (IF-MIB.my)
- MPLS LDP MIB (MPLS-LDP-MIB.my)

Frame Relay over MPLS:
- Cisco Frame Relay MIB (CISCO-FRAME-RELAY-MIB.my)
- Interfaces MIB (IF-MIB.my)
- MPLS LDP MIB (MPLS-LDP-MIB.my)

HDLC and PPP over MPLS:
- MPLS LDP MIB (MPLS-LDP-MIB.my)
- Interfaces MIB (IF-MIB.my)

RFCs

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<th>RFC</th>
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<td>RFC 3032</td>
<td>MPLS Label Stack Encoding</td>
</tr>
<tr>
<td>RFC 3036</td>
<td>LDP Specification</td>
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Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td><a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a></td>
</tr>
</tbody>
</table>

Feature Information for Any Transport over MPLS

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

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Transport over MPLS</td>
<td>12.0(10)ST 12.0(21)ST 12.0(22)S</td>
<td>In Cisco IOS Release 12.0(10)ST, Any Transport over MPLS: ATM AAL5 over MPLS was</td>
</tr>
<tr>
<td></td>
<td>12.0(23)S 12.0(25)S 12.0(26)S</td>
<td>introduced on the Cisco 12000 series routers.</td>
</tr>
<tr>
<td></td>
<td>12.0(27)S 12.0(29)S 12.0(30)S</td>
<td>In Cisco IOS Release 12.1(8a)E, Ethernet over MPLS was introduced on the Cisco 7600</td>
</tr>
<tr>
<td></td>
<td>12.0(31)S 12.0(32)S 12.1(8a)E</td>
<td>series Internet router.</td>
</tr>
<tr>
<td></td>
<td>12.2(14)S 12.2(15)T 12.2(28)SB</td>
<td>In Cisco IOS Release 12.0(21)ST, Any Transport over MPLS: ATM AAL5 over MPLS was</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRB 12.2(33)SXH</td>
<td>introduced on the Cisco 12000 series routers.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRC 12.2(33)SRD</td>
<td>In Cisco IOS Release 12.0(22)S, Ethernet over MPLS was integrated into this release.</td>
</tr>
<tr>
<td></td>
<td>12.2(1)SRE 12.4(11)T 15.0(1)S</td>
<td>Support for the Cisco 10720 Internet router was added. ATML AAL5 over MPLS was</td>
</tr>
<tr>
<td></td>
<td>15.1(3)S</td>
<td>integrated into this release for the Cisco 12000 series routers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Cisco IOS Release 12.0(23)S, the following new features were introduced and support was added for them on the Cisco 7200 and 7500 series routers:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ATM Cell Relay over MPLS (single cell relay, VC mode)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Frame Relay over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• HDLC over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PPP over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cisco IOS Release 12.0(23)S also added support on the Cisco 12000, 7200, and 7500 series routers for the following features:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ATM AAL5 over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ethernet over MPLS (VLAN mode)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The AToM features were integrated into Cisco IOS Release 12.2(14)S.</td>
</tr>
</tbody>
</table>
The AToM features were integrated into Cisco IOS Release 12.2(15)T.

In Cisco IOS Release 12.0(25)S, the following new features were introduced:

- New commands for configuring AToM
- Ethernet over MPLS: port mode
- ATM Cell Relay over MPLS: packed cell relay
- ATM Cell Relay over MPLS: VP mode
- ATM Cell Relay over MPLS: port mode
- Distributed Cisco Express Forwarding mode for Frame Relay, PPP, and HDLC over MPLS
- Fast reroute with AToM
- Tunnel selection
- Traffic policing
- QoS support
In Cisco IOS Release 12.0(26)S, the following new features were introduced:

- Support for connecting disparate attachment circuits. See L2VPN Interworking for more information.
- QoS functionality with AToM for the Cisco 7200 series routers.

Support for FECN and BECN marking with Frame Relay over MPLS. (See BECN and FECN Marking for Frame Relay over MPLS for more information.)

In Cisco IOS Release 12.0(27)S, the following new features were introduced:

- ATM Cell Relay over MPLS: Packed Cell Relay for VC, PVP, and port mode for the Cisco 12000 series router.
- Support for ATM over MPLS on the Cisco 12000 series 4-port OC-12X/STM-4 ATM ISE line card.

This feature was integrated into Cisco IOS Release 12.2(25)S for the Cisco 7200 and 7500 series routers.

In Cisco IOS Release 12.0(29)S, the “Any Transport over MPLS Sequencing Support” feature was added for the Cisco 7200 and 7500 series routers.

In Cisco IOS Release 12.0(30)S, the following new features were introduced:

In Cisco IOS Release 12.0(31)S, the Cisco 12000 series router introduced the following enhancements:

- AToM VC Independence--With this enhancement, fast
reroute is accomplished in less than 50 milliseconds, regardless of the number of VCs configured.

- Support for ISE line cards on the 2.5G ISE SPA Interface Processor (SIP).

In Cisco IOS Release 12.0(32)S, the Cisco 12000 series router added engine 5 line card support for the following transport types:

- Ethernet over MPLS
- Frame Relay over MPLS
- HDLC over MPLS
- PPP over MPLS

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>reroute is accomplished in less than 50 milliseconds, regardless of the number of VCs configured.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Support for ISE line cards on the 2.5G ISE SPA Interface Processor (SIP).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Cisco IOS Release 12.0(32)S, the Cisco 12000 series router added engine 5 line card support for the following transport types:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ethernet over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Frame Relay over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• HDLC over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• PPP over MPLS</td>
</tr>
</tbody>
</table>
This feature was integrated into Cisco IOS Release 12.2(28)SB on the Cisco 10000 series routers. Platform-specific configuration information is contained in the “Configuring Any Transport over MPLS” section of the Cisco 10000 Series Router Broadband Aggregation, Leased-Line, and MPLS Configuration Guide.

Any Transport over MPLS was integrated into Cisco IOS Release 12.4(11)T with support for the following features:

- Any Transport over MPLS: Ethernet over MPLS: Port Mode
- Any Transport over MPLS: Ethernet over MPLS: VLAN Mode
- Any Transport over MPLS: Ethernet over MPLS: VLAN ID Rewrite
- Any Transport over MPLS: Frame Relay over MPLS
- Any Transport over MPLS: AAL5 over MPLS
- Any Transport over MPLS: ATM OAM Emulation

This feature was integrated into Cisco IOS Release 12.2(33)SRB to support the following features on the Cisco 7600 router:

- Any Transport over MPLS: Frame Relay over MPLS
- Any Transport over MPLS: ATM Cell Relay over MPLS: Packed Cell Relay
- Any Transport over MPLS: Ethernet over MPLS
- AToM Static Pseudowire Provisioning

Platform-specific configuration information is contained in the following documents:
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
</table>

- The “Configuring PFC3BXL and PFC3B Mode Multiprotocol Label Switching” module of the Cisco 7600 Series Cisco IOS Software Configuration Guide, Release 12.2SR

- The “Configuring Multiprotocol Label Switching on the Optical Services Modules” module of the OSM Configuration Note, Release 12.2SR

- The “Configuring Multiprotocol Label Switching on FlexWAN and Enhanced FlexWAN Modules” module of the FlexWAN and Enhanced FlexWAN Modules Configuration Guide

- The “Configuring Any Transport over MPLS on a SIP” section of the Cisco 7600 Series Router SIP, SSC, and SPA Software Configuration Guide

- The “Configuring AToM VP Cell Mode Relay Support” section of the Cisco 7600 Series Router SIP, SSC, and SPA Software Configuration Guide

- The Cross-Platform Release Notes for Cisco IOS Release 12.2SR for the Cisco 7600 Series Routers
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>This feature was integrated into Cisco IOS Release 12.2(33)SXH and supports the following features:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: Ethernet over MPLS: Port Mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: AAL5 over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: ATM OAM Emulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: Single Cell Relay--VC Mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: ATM Cell Relay over MPLS--VP Mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: Packed Cell Relay--VC/VP Mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Any Transport over MPLS: Ethernet over MPLS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ATM Port Mode Packed Cell Relay over AToM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• AToM Tunnel Selection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following features were integrated into Cisco IOS Release 12.2(33)SRC:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• AToM Tunnel Selection for the Cisco 7200 and Cisco 7300 routers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Per-Subinterface MTU for Ethernet over MPLS (EoMPLS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Cisco IOS Release 12.2(33)SRD, support for ATM Cell Relay over MPLS in port mode on Cisco 7600 series routers was added.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Per Subinterface MTU for Ethernet over MPLS (EoMPLS) was integrated into Cisco IOS Release 15.1(3)S.</td>
</tr>
<tr>
<td>Feature Name</td>
<td>Releases</td>
<td>Feature Information</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>MPLS L2VPN Clear Xconnect Command</td>
<td>12.2(1)SRE 15.0(1)S</td>
<td>These features are supported on Cisco 7600 routers in Cisco IOS Release 12.2(1)SRE and Cisco IOS Release 15.0(1)S. These features enable you to:&lt;ul&gt;&lt;li&gt;Reset a VC associated with an interface, a peer address, or on all the configured xconnect circuit attachments&lt;/li&gt;&lt;li&gt;Set the control word on dynamic pseudowires.&lt;/li&gt;&lt;li&gt;Enable ATM cell packing for static pseudowires.&lt;/li&gt;&lt;/ul&gt;The following commands were introduced or modified by these features: cell-packing, clear xconnect, control-word, encapsulation (Any Transport over MPLS), oam-ac emulation-enable.</td>
</tr>
<tr>
<td>MPLS MTU Command for GRE Tunnels</td>
<td>15.1(1)T 15.1(2)S</td>
<td>This feature allows you to reset the MPLS MTU size in GRE tunnels from default to the maximum. The maximum keyword was replaced with the max keyword. The following command was modified by this feature: mpls mtu.</td>
</tr>
<tr>
<td>ATM Port mode Packed Cell Relay over MPLS</td>
<td>15.2(1)S</td>
<td>This feature was integrated into Cisco IOS Release 12.2(1)S.</td>
</tr>
<tr>
<td>Any Transport over MPLS (AToM): ATM Cell Relay over MPLS: Packed Cell Relay</td>
<td>15.2(1)S</td>
<td>This feature was integrated into Cisco IOS Release 12.2(1)S.</td>
</tr>
</tbody>
</table>

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and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.
AToM Graceful Restart

The AToM Graceful Restart feature assists neighboring routers that have nonstop forwarding (NSF), stateful switchover (SSO) and graceful restart (GR) for Any Transport over MPLS (AToM) to recover gracefully from an interruption in service. AToM GR functions strictly in helper mode, which means it helps other routers that are enabled with the NSF/SSO: Any Transport over MPLS and AToM Graceful Restart feature to recover. If the router with AToM GR fails, its peers cannot help it recover. AToM GR is based on the MPLS Label Distribution Protocol (LDP) Graceful Restart feature.

Keep the following points in mind when reading this document:

- The AToM GR feature described in this document refers to helper mode.
- The NSF/SSO: Any Transport over MPLS and AToM Graceful Restart feature is supported in Cisco IOS Releases 12.2(25)S and 12.2(33)SRA. For brevity, the NSF/SSO: Any Transport over MPLS and AToM Graceful Restart feature is called AToM SSO/NSF in this document.

- Finding Feature Information, page 109
- Information About AToM Graceful Restart, page 109
- How to Configure AToM Graceful Restart, page 110
- Configuration Examples for AToM Graceful Restart, page 111
- Additional References, page 113
- Feature Information for AToM Graceful Restart, page 114

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.

Information About AToM Graceful Restart

- How AToM Graceful Restart Works, page 109

How AToM Graceful Restart Works

AToM GR works in strict helper mode, which means it helps a neighboring route processor that has AToM NSF/SSO to recover from a disruption in service without losing its MPLS forwarding state. The disruption
in service could result from a TCP or User Datagram Protocol (UDP) event or the stateful switchover of a route processor. AToM GR is based on the MPLS LDP Graceful Restart feature, which preserves forwarding information for AToM circuits during an LDP session interruption. When the neighboring router establishes a new session, the LDP bindings and MPLS forwarding state are recovered. For more information related to how the LDP Graceful Restart feature works, see the MPLS LDP Graceful Restart feature module.

How to Configure AToM Graceful Restart

- Configuring AToM Graceful Restart, page 110

Configuring AToM Graceful Restart

There is no AToM-specific configuration for AToM GR. You enable LDP GR to assist a neighboring router configured with AToM NSF/SSO to maintain its forwarding state while the LDP session is disrupted.

- See the MPLS LDP Graceful Restart document for information about how LDP GR works and how you can customize it for your network.
- Configure AToM. For information about setting up or configuring AToM, see the Any Transport over MPLS document.

Note

- AToM GR is supported in strict helper mode.
- AToM NSF/SSO is supported in Cisco IOS Release 12.2(25)S and 12.2(33)SRA.
- Tag Distribution Protocol (TDP) sessions are not supported. Only LDP sessions are supported.
- MPLS LDP GR cannot be configured on label-controlled ATM (LC-ATM) interfaces.

SUMMARY STEPS

1. enable
2. configure terminal
3. ip cef [distributed]
4. mpls ldp graceful-restart

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>
### Command or Action

<table>
<thead>
<tr>
<th>Step</th>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ip cef [distributed]</td>
<td>Enables Cisco Express Forwarding.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# ip cef distributed</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>mpls ldp graceful-restart</td>
<td>Enables the router to protect the LDP bindings and MPLS forwarding state during a disruption in service.</td>
</tr>
<tr>
<td></td>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Router(config)# mpls ldp graceful-restart</td>
<td>AToM GR is enabled globally. When you enable AToM GR, it has no effect on existing LDP sessions. New LDP sessions that are established can perform AToM GR.</td>
</tr>
</tbody>
</table>

### Configuration Examples for AToM Graceful Restart

- AToM Graceful Restart Configuration Example, page 111
- AToM Graceful Restart Recovering from an LDP Session Disruption Example, page 112

### AToM Graceful Restart Configuration Example

The following example shows an Ethernet VLAN over MPLS configuration. PE1 is configured with ATOM Graceful Restart. PE2 is configured with ATOM NSF/SSO. The commands for configuring ATOM GR and NSF/SSO are shown in bold.
PE1 with AToM GR

ip cef
!
mpls label protocol ldp
mpls ldp graceful-restart
mpls ldp router-id Loopback0
!
pseudowire-class atom
encapsulation mpls
!
interface Loopback0
  ip address 10.1.1.2 255.255.255.255
!
interface FastEthernet5/1/1
  no ip address
!
interface FastEthernet5/1/1.2
  description "xconnect to PE2"
encapsulation dot1Q 2 native
xconnect 10.2.2.2 1002 pw-class mpls
!
! IGP for MPLS
router ospf 10
log-adjacency-changes
auto-cost reference-bandwidth 1000
network 10.1.1.2 10.0.0.0 area 0
network 10.1.1.0 10.0.0.255 area 0

PE2 with AToM NSF/SSO

redundancy
  mode sso
ip cef
!
mpls label protocol ldp
mpls ldp graceful-restart
mpls ldp router-id Loopback0
!
pseudowire-class atom
encapsulation mpls
!
interface Loopback0
  ip address 10.2.2.2 255.255.255.255
!
interface Ethernet3/3
  no ip address
!
interface Ethernet3/3.2
  description "xconnect to PE1"
encapsulation dot1Q 2
xconnect 10.1.1.2 1002 pw-class mpls
!
! IGF for MPLS
router ospf 10
log-adjacency-changes
auto-cost reference-bandwidth 1000
network 10.2.2.2 10.0.0.0 area 0
network 10.1.1.0 10.0.0.255 area 0

AToM Graceful Restart Recovering from an LDP Session Disruption Example

The following examples show the output of the `show mpls l2transport vc` command during normal operation and when an LDP session is recovering from a disruption.

The following example shows the status of the VC on PE1 with AToM GR during normal operation:

```
Router# show mpls l2transport vc
Local intf Local circuit Dest address VC ID Status
------------ ----------- -------------- --------- -------
Fa5/1.2     Eth VLAN 2  10.2.2.2 1002  UP
```

The following example shows the status of the VC on PE1 with AToM GR while the VC is recovering from an LDP session disruption. The forwarding state for the circuit remains as it was before the disruption.

```
Router# show mpls l2transport vc
Local intf Local circuit Dest address VC ID Status
------------ ----------- -------------- --------- -------
Fa5/1.2     Eth VLAN 2  10.2.2.2 1002 RECOVERING
```

The following example shows the status of the VC on PE1 with AToM GR after the LDP session disruption was cleared. The AToM label bindings were advertised within the allotted time and the status returned to UP.

```
Router# show mpls l2transport vc
Local intf Local circuit Dest address VC ID Status
------------ ----------- -------------- --------- -------
Fa5/1.2     Eth VLAN 2  10.2.2.2 1002  UP
```

The following example shows the detailed status of the VC on PE1 with AToM GR during normal operation:

```
Router# show mpls l2transport vc detail
```

AToM Graceful Restart Recovering from an LDP Session Disruption Example

The following examples show the output of the `show mpls l2transport vc` command during normal operation and when an LDP session is recovering from a disruption.

The following example shows the status of the VC on PE1 with AToM GR during normal operation:

```
Router# show mpls l2transport vc
Local intf Local circuit Dest address VC ID Status
------------ ----------- -------------- --------- -------
Fa5/1.2     Eth VLAN 2  10.2.2.2 1002  UP
```

The following example shows the status of the VC on PE1 with AToM GR while the VC is recovering from an LDP session disruption. The forwarding state for the circuit remains as it was before the disruption.

```
Router# show mpls l2transport vc
Local intf Local circuit Dest address VC ID Status
------------ ----------- -------------- --------- -------
Fa5/1.2     Eth VLAN 2  10.2.2.2 1002 RECOVERING
```

The following example shows the status of the VC on PE1 with AToM GR after the LDP session disruption was cleared. The AToM label bindings were advertised within the allotted time and the status returned to UP.

```
Router# show mpls l2transport vc
Local intf Local circuit Dest address VC ID Status
------------ ----------- -------------- --------- -------
Fa5/1.2     Eth VLAN 2  10.2.2.2 1002  UP
```

The following example shows the detailed status of the VC on PE1 with AToM GR during normal operation:

```
Router# show mpls l2transport vc detail
```
Local interface: Fa5/1/1.2 up, line protocol up, Eth VLAN 2 up
Destination address: 10.2.2.2, VC ID: 1002, VC status: up
  Preferred path: not configured
  Default path: active
  Tunnel label: imp-null, next hop point2point
  Output interface: Se4/0/3, imposed label stack {16}
Create time: 1d00h, last status change time: 1d00h
Signaling protocol: LDP, peer 10.2.2.2:0 up
MPLS VC labels: local 21, remote 16
Group ID: local 0, remote 0
MTU: local 1500, remote 1500
Remote interface description: "xconnect to PE2"
Sequencing: receive disabled, send disabled
VC statistics:
  packet totals: receive 3466, send 12286
  byte totals: receive 4322368, send 5040220
  packet drops: receive 0, send 0

The following example shows the detailed status of the VC on PE1 with AToM GR while the VC is recovering.

Router# show mpls l2transport vc detail
Local interface: Fa5/1/1.2 up, line protocol up, Eth VLAN 2 up
Destination address: 10.2.2.2, VC ID: 1002, VC status: recovering
  Preferred path: not configured
  Default path: active
  Tunnel label: imp-null, next hop point2point
  Output interface: Se4/0/3, imposed label stack {16}
Create time: 1d00h, last status change time: 00:00:03
Signaling protocol: LDP, peer 10.2.2.2:0 down
MPLS VC labels: local 21, remote 16
Group ID: local 0, remote 0
MTU: local 1500, remote 1500
Remote interface description: "xconnect to PE2"
Sequencing: receive disabled, send disabled
VC statistics:
  packet totals: receive 20040, send 28879
  byte totals: receive 25073016, send 25992388
  packet drops: receive 0, send 0

Additional References

The following sections provide references related to AToM GR.

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS LDP graceful restart</td>
<td>MPLS LDP Graceful Restart</td>
</tr>
<tr>
<td>Configuring AToM</td>
<td>Any Transport over MPLS</td>
</tr>
<tr>
<td>Nonstop forwarding and stateful switchover for AToM</td>
<td>NSF/SSO—Any Transport over MPLS and AToM Graceful Restart</td>
</tr>
</tbody>
</table>
### Standards

<table>
<thead>
<tr>
<th>Standards</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.</td>
<td>—</td>
</tr>
</tbody>
</table>

### MIBs

<table>
<thead>
<tr>
<th>MIBs</th>
<th>MIBs Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS Label Distribution Protocol MIB Version 8 Upgrade</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
</tr>
</tbody>
</table>

### RFCs

<table>
<thead>
<tr>
<th>RFCs</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 3036</td>
<td><em>LDP Specification</em></td>
</tr>
<tr>
<td>RFC 3478</td>
<td><em>Graceful Restart Mechanism for Label Distribution</em></td>
</tr>
</tbody>
</table>

### Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></td>
</tr>
</tbody>
</table>

---

### Feature Information for AToM Graceful Restart

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.
Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

### Table 10  Feature Information for AToM Graceful Restart

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>AToM Graceful Restart</td>
<td>12.0(29)S</td>
<td>In 12.0(29)S, this feature was introduced.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRA</td>
<td>In 12.2(33)SRA, support was added for the Cisco 7600 series routers.</td>
</tr>
<tr>
<td></td>
<td>12.4(11)T</td>
<td>In 12.4(11)T, this feature was integrated into the release.</td>
</tr>
<tr>
<td></td>
<td>12.2(33)SXH</td>
<td>In 12.2(33)SXH, this feature was integrated into the release.</td>
</tr>
</tbody>
</table>

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Multilink Frame Relay over L2TPv3 AToM

This feature enables Multilink Frame Relay switching over Layer 2 Tunnel Protocol Version 3 (L2TPv3) and Any Transport over MPLS (AToM). The feature works with like-to-like interfaces and disparate interfaces (L2VPN interworking).

Multilink Frame Relay is the logical grouping of one or more physical interfaces between two devices of the User-to-Network Interface/Network-to-Network Interface (UNI/NNI) as one single Frame Relay data link.

- Finding Feature Information, page 117
- Prerequisites for Configuring Multilink Frame Relay over L2TPv3 AToM, page 117
- Restrictions for Configuring Multilink Frame Relay over L2TPv3 AToM, page 118
- Information About Configuring Multilink Frame Relay over L2TPv3 AToM, page 118
- How to Configure Multilink Frame Relay over L2TPv3 AToM, page 119
- Configuration Examples for Multilink Frame Relay over L2TPv3 AToM, page 125
- Additional References, page 132
- Command Reference, page 133
- Feature Information for Multilink Frame Relay over L2TPv3 AToM, page 133

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 Configuring Multilink Frame Relay over L2TPv3 AToM

Before configuring Multilink Frame Relay over L2TPv3/AToM, you should understand how to configure Layer 2 virtual private networks (VPNs) and Multilink Frame Relay. See the Additional References, page 132 for pointers to the feature modules that explain how to configure and use those features.
Restrictions for Configuring Multilink Frame Relay over L2TPv3 AToM

- Only data-link connection identifier (DLCI)-to-DLCI switching, where each DLCI maps to its own pseudowire, is supported. Port-port mode (also known as HDLC mode), where the entire content of the port, including the Local Management Interface (LMI), is carried across a single pseudowire, is not supported.
- The following functionality is not supported:
  - UNI/NNI or end-to-end fragmentation
  - Nonstop forwarding/stateful switchover
  - Four-byte DLCIs
- On the Cisco 7500 series routers, all bundle links must reside on the same port adapter (PA) of the Versatile Interface Processor (VIP). Links spreading across PAs are not supported.
- Cisco 7500 series routers support the VIP6-80, VIP4-80, VIP4-50, VIP2-50, CH-STM1, CT3/CE3, CT1/CE1, PA-4T+, and PA-8T port adapters.
- On the Cisco 12000 series routers, Multilink Frame Relay is supported only on the following pluggable modules: Cisco 4-port channelized T3 (DSO) shared port adapter, Cisco 8-port channelized T1/E1 shared port adapter, and the Cisco 1-port channelize OC-3/STM-1 shared port adapter.

Information About Configuring Multilink Frame Relay over L2TPv3 AToM

- Multilink Frame Relay over L2TPv3 AToM, page 118
- Internetworking Support for Multilink Frame Relay, page 118
- Quality of Service Support for Multilink Frame Relay over L2TPv3 AToM, page 119

Multilink Frame Relay over L2TPv3 AToM

Multilink Frame Relay over L2TPv3/AToM supports the following functionality:

- Permanent virtual circuit (PVC) status signaling
- LMI types cisco, q933a, and ANSI
- Sequencing
- Frame Relay policing (nondistributed)
- Type of service (ToS) marking for L2TPv3

Internetworking Support for Multilink Frame Relay

Interworking support for Multilink Frame Relay interfaces supports the following functionality:

- Frame Relay to Ethernet/VLAN (Ethernet and IP interworking)
- Frame Relay to PPP and ATM (IP interworking)
- Cisco and Internet Engineering Task Force (IETF) encapsulation on the customer-edge (CE) router
- Sequencing
Quality of Service Support for Multilink Frame Relay over L2TPv3 AToM

L2VPN quality of service (QoS) features supported for Frame Relay are also supported with the Multilink Frame Relay over L2TPv3/AToM feature. You can attach an input service policy to the Multilink Frame Relay interface or individual DLCIs on the interface using the map-class mechanism to police or mark the traffic. You can attach an output policy to the Multilink Frame Relay (MFR) interface to perform class-based queueing, including per-DLCI queueing using the `match fr-dlci` command.

The following ingress QoS features are supported with the Multilink Frame Relay over L2TPv3/AToM feature:

- Interface input policy matching on the discard eligibility (DE) bit to set Multiprotocol Label Switching (MPLS) EXP or tunnel differentiated services code point (DSCP).
- Virtual circuit (VC) input policy configured with a color-aware, two-rate, three-color policer using the DE bit as input color and setting the MPLS EXP bit or tunnel DSCP bit based on color.

You cannot use the VC-level and interface-level input policies at the same time on the same interface.

The following egress QoS features are supported with the Multilink Frame Relay over L2TPv3/AToM feature:

- Egress queueing using tail drop or discard class-based weighted random early detection (WRED). You can use the latter with a core interface input policy to set the discard class based on the MPLS EXP or tunnel DSCP.
- Interface output policy matching on QoS group (selected by MPLS EXP or tunnel DSCP).
- Interface aggregate shaping policy with queueing policy.
- VC output shaping policy with tail drop or discard class-based WRED.
- Forward explicit congestion notification (FECN)/backward explicit congestion notification (BECN) marking.

You cannot use VC-level and interface-level output policies at the same time on the same interface.

Egress queueing and shaping policies are not supported with Multilink Frame Relay on the Cisco 7200 series routers.

How to Configure Multilink Frame Relay over L2TPv3 AToM

- Configuring a Multilink Frame Relay Bundle Interface, page 120
- Configuring a Multilink Frame Relay Bundle Link Interface, page 121
Configuring a Multilink Frame Relay Bundle Interface

Configure a bundle interface to aggregate bandwidth of multiple member links under a single interface to one virtual pipe. To configure a bundle interface for Multilink Frame Relay, perform the following steps.

**SUMMARY STEPS**

1. **enable**
2. **configure terminal**
3. **interface mfr number**
4. **frame-relay multilink bid name**

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface mfr number</td>
<td>Configures a multilink Frame Relay bundle interface and enters interface configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface mfr 1</td>
<td></td>
</tr>
</tbody>
</table>
Configuring a Multilink Frame Relay Bundle Link Interface

Configuring a Multilink Frame Relay bundle link interface allows you to combine bandwidth of multiple lower-speed serial links into a single large pipe and avoid the need of upgrading or purchasing new hardware. To configure a bundle link interface for Multilink Frame Relay, perform the following steps.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface serial number
4. encapsulation frame-relay mfr number [name]
5. frame-relay multilink bid name
6. frame-relay multilink hello seconds
7. frame-relay multilink ack seconds
8. frame-relay multilink retry number

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td>Command or Action</td>
<td>Purpose</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> interface serial number</td>
<td>Configures an interface and enters interface configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# interface serial 1/1</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> encapsulation frame-relay mfr number [name]</td>
<td>Creates a multilink Frame Relay bundle link and associates the link with a bundle.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# encapsulation frame-relay mfr 1</td>
<td></td>
</tr>
<tr>
<td><strong>Tip</strong> To minimize latency that results from the arrival order of packets, we recommend bundling physical links of the same line speed in one bundle.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 5</strong> frame-relay multilink lid name</td>
<td>(Optional) Assigns a bundle link identification name with a multilink Frame Relay bundle link.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# frame-relay multilink lid four</td>
<td></td>
</tr>
<tr>
<td><strong>Note</strong> The bundle link identification (LID) will not go into effect until the interface has gone from the down state to the up state. One way to bring the interface down and back up again is by using the <strong>shutdown</strong> and <strong>no shutdown</strong> commands in interface configuration mode.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 6</strong> frame-relay multilink hello seconds</td>
<td>(Optional) Configures the interval at which a bundle link will send out hello messages. The default value is 10 seconds.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# frame-relay multilink hello 20</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 7</strong> frame-relay multilink ack seconds</td>
<td>(Optional) Configures the number of seconds that a bundle link will wait for a hello message acknowledgment before resending the hello message. The default value is 4 seconds.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-if)# frame-relay multilink ack 10</td>
<td></td>
</tr>
</tbody>
</table>
Connecting Frame Relay PVCs Between Routers

By connecting Frame Relay PVCs between routers, you can integrate Frame Relay over a Level 2 VPN backbone, which allows you to use your existing Frame Relay network without upgrading. To connect Frame Relay PVCs between routers, perform the following steps.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. connect connection-name mfr number dlci l2transport
4. xconnect peer-router-id vcid encapsulation mpls

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1 enable</strong></td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2 configure terminal</strong></td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3 connect connection-name mfr number dlci l2transport</strong></td>
<td>Defines connections between Frame Relay PVCs.</td>
</tr>
<tr>
<td></td>
<td>• Using the l2transport keyword specifies that the PVC will not be a locally switched PVC, but will be tunneled over the backbone network.</td>
</tr>
<tr>
<td></td>
<td>• The connection-name argument is a text string that you provide.</td>
</tr>
<tr>
<td></td>
<td>• The dlci argument is the DLCI number of the PVC that will be connected.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router(config)# connect fr1 mfr 1 100 l2transport</td>
<td>Enters connect configuration submode.</td>
</tr>
</tbody>
</table>
Verifying Multilink Frame Relay over L2TPv3 AToM

To verify the configuration of Multilink Frame Relay, perform the following steps. The tunnel and session should be in the established (est) state.

**SUMMARY STEPS**

1. `show l2tunnel`
2. `show mpls forwarding`

**DETAILED STEPS**

**Step 1** `show l2tunnel`

On both PE routers, use the following command to verify the configuration of Multilink Frame Relay over L2TPv3:

```
PE1# show l2tunnel
```

**Example:**

```
Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name State Remote Address Port Sessions L2TPclass
35788 41451 FRWI1 est 10.9.9.9 0 1 l2tp_default_cl
LocID RemID TunID Username, Intf/ State Vcid, Circuit
8161 54072 35788 6, MF1:206 est
```

```
PE2# show l2tunnel
```

**Example:**

```
Tunnel and Session Information Total tunnels 1 sessions 1
LocID RemID Remote Name State Remote Address Port Sessions L2TPclass
41451 35788 FRWI3 est 10.8.8.8 0 1
LocID RemID TunID Username, Intf/ State Vcid, Circuit
54072 8161 41451 6, Fa0/1.6:6 est
```

**Step 2** `show mpls forwarding`

On both PE routers, use the following command to verify the configuration of Multilink Frame Relay over MPLS:

```
```

**Example:**

```
```
Example:

PE1# show mpls forwarding

<table>
<thead>
<tr>
<th>Local</th>
<th>Outgoing</th>
<th>Prefix</th>
<th>Bytes</th>
<th>tag</th>
<th>Outgoing</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>switched</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Pop tag</td>
<td>10.0.0.0/24</td>
<td>0</td>
<td>16</td>
<td>PO4/1/0</td>
<td>point2point</td>
</tr>
<tr>
<td>17</td>
<td>Untagged</td>
<td>12ckt(5)</td>
<td>0</td>
<td>17</td>
<td>MF1</td>
<td>point2point</td>
</tr>
<tr>
<td>18</td>
<td>Untagged</td>
<td>12ckt(6)</td>
<td>0</td>
<td>18</td>
<td>MF1</td>
<td>point2point</td>
</tr>
<tr>
<td>19</td>
<td>17</td>
<td>10.9.9.9/32</td>
<td>0</td>
<td>PO4/1/0</td>
<td>point2point</td>
<td></td>
</tr>
</tbody>
</table>

PE2# show mpls forwarding

<table>
<thead>
<tr>
<th>Local</th>
<th>Outgoing</th>
<th>Prefix</th>
<th>Bytes</th>
<th>tag</th>
<th>Outgoing</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>switched</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>10.8.8.8/32</td>
<td>0</td>
<td>PO2/0</td>
<td>point2point</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Pop tag</td>
<td>10.13.0.0/24</td>
<td>0</td>
<td>PO2/0</td>
<td>point2point</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Untagged</td>
<td>12ckt(5)</td>
<td>2244</td>
<td>MF2</td>
<td>point2point</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Untagged</td>
<td>12ckt(6)</td>
<td>510</td>
<td>MF2</td>
<td>point2point</td>
<td></td>
</tr>
</tbody>
</table>

Configuration Examples for Multilink Frame Relay over L2TPv3 AToM

- Frame Relay-to-Frame Relay over L2TPv3 on Multilink Frame Relay Interfaces Example, page 125
- Frame Relay-to-Ethernet VLAN Interworking over L2TPv3 on Multilink Frame Relay Interfaces Example, page 126
- Frame Relay-to-Ethernet Interworking over MPLS on Multilink Frame Relay Interfaces Example, page 127
- MQC Color-Aware Policing Example, page 128
- DE Bit Matching Example, page 129
- DLCI-Based queueing Example, page 129
- Discard Class-Based WRED Example, page 129
- Aggregate Shaping Example, page 130
- VC Shaping Example, page 131
- FECN BECN Marking Example, page 131

Frame Relay-to-Frame Relay over L2TPv3 on Multilink Frame Relay Interfaces Example

The following example sets up Multilink Frame Relay interfaces to transport Frame Relay data between PE routers:
Frame Relay-to-Ethernet VLAN Interworking over L2TPv3 on Multilink Frame Relay Interfaces Example

The following example sets up Multilink Frame Relay interfaces to perform Frame Relay-to-Ethernet VLAN interworking between PE routers. The example uses IP interworking, also referred to as routed interworking.
Frame Relay-to-Ethernet Interworking over MPLS on Multilink Frame Relay Interfaces Example

The following example sets up Multilink Frame Relay interfaces to perform Frame Relay-to-Ethernet interworking between PE routers. The example uses IP interworking, also referred to as routed interworking.
MQC Color-Aware Policing Example

Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.

The following example configures a VC input policy with a color-aware, two-rate, three-color policing method using a DE bit as input color and setting the tunnel Differentiated Services Code Point (DSCP) based on color. Packets in excess of peak rates are discarded.

class-map not-fr-de
match not fr-de
!
policy-map police
class class-default
police cir 64000 pir 256000
conform-color not-fr-de
conform-action set-dscp-tunnel-transmit af31
exceed-action set-dscp-tunnel-transmit af32
violate-action drop
!
DE Bit Matching Example

Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.

The following example shows the configuration of an interface input policy matching on the DE bit to set the tunnel DSCP:

```
class-map de
  match fr-de
!
policy-map de
  class de
    set ip dscp tunnel af32
  class class-default
    set ip dscp tunnel af31
!
interface MFR1
  service-policy input de
```

DLCI-Based queueing Example

Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.

The following example shows the configuration of an interface output policy matching on a QoS group based on the DLCI:

```
class-map dlci100
  match fr-dlci 100

class-map dlci200
  match fr-dlci 200
!
policy-map dlci
  class dlci100
    bandwidth percent 10
  class dlci200
    bandwidth percent 20
!
interface MFR1
  service-policy output dlci
```

Discard Class-Based WRED Example

Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.
The following example shows the configuration of an interface output policy matching on a QoS group based on the tunnel DSCP:

class-map conform
match ip dscp af31
match mpls experimental 4
class-map exceed
match ip dscp af32
match mpls experimental 3
class-map cos1
match qos-group 1
!
policy-map core
class conform
  set qos-group 1
  set discard-class 1
class exceed
  set qos-group 1
  set discard-class 2
!
policy-map wred
class cos1
  bandwidth percent 40
  random-detect discard-class-based
  random-detect discard-class 1 20 30 10
  random-detect discard-class 2 1 9 10
!
interface POS1/0
  service-policy input core
!
interface MFR1
  service-policy output wred

Aggregate Shaping Example

Note
Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.

The following example shows the configuration of an interface aggregate shaping policy with a DLCI-based queueing policy:

class-map dlic205
match fr-dlc 205
class-map dlic206
match fr-dlc 206
!
policy-map dlci
class dlic205
  bandwidth 128
class dlic206
  bandwidth 256
!
policy-map shape
class class-default
  shape average 512000 2048 2048
  service-policy dlic
!
interface MFR1
  service-policy output shape
VC Shaping Example

Note
Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.

The following example shows the configuration of a VC output shaping policy with discard class-based WRED:

```conf
class-map conform
match mpls experimental 4
class-map exceed
match mpls experimental 3
class-map cos1
match qos-group 1
!
policy-map core
class conform
set qos-group 1
set discard-class 1
class exceed
set qos-group 1
set discard-class 2
!
policy-map vc-wred
class class-default
bandwidth percent 40
random-detect discard-class-based
random-detect discard-class 1 20 30 10
random-detect discard-class 2 1 9 10
!
policy-map shape
class class-default
shape average 512000 2048 2048
service-policy vc-wred
!
interface POS4/1/0
service-policy input core
!
interface MFR1
frame-relay interface-dlci 206 switched
class shape
!
map-class frame-relay shape
service-policy output shape
```

FECN BECN Marking Example

Note
Quality of Service features are not supported in Cisco IOS Release 12.4(11)T.

The following example shows the configuration of an output policy that configures BECN and FECN bits:

```conf
policy-map dlci
class dlci100
  bandwidth percent 10
class dlci200
  bandwidth percent 20
set fr-fecn-becn 1
interface MFR1
frame-relay interface-dlci 206 switched
class shape
!
map-class frame-relay shape
service-policy output dci
frame-relay congestion-management
threshold ecn 20
```
## Additional References

The following sections provide references related to the Multilink Frame Relay over L2TPv3/AToM feature.

### Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilink Frame Relay</td>
<td>• For the Cisco 7500 series routers:</td>
</tr>
<tr>
<td></td>
<td>Distributed Multilink Frame Relay (FRF.16)</td>
</tr>
<tr>
<td></td>
<td>• For the Cisco 7200 series routers:</td>
</tr>
<tr>
<td></td>
<td>Multilink Frame Relay (FRF.16)</td>
</tr>
<tr>
<td>L2VPN interworking</td>
<td>L2VPN Interworking</td>
</tr>
<tr>
<td>Layer 2 Tunneling Protocol, Version 3</td>
<td>L2TPV3</td>
</tr>
<tr>
<td>Layer 2 local switching</td>
<td>Layer 2 Local Switching</td>
</tr>
</tbody>
</table>

### Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>draft-martini-l2circuit-trans-mpls-08.txt</td>
<td>Transport of Layer 2 Frames Over MPLS</td>
</tr>
<tr>
<td>draft-martini-l2circuit-encap-mpls-04.txt</td>
<td>Encapsulation Methods for Transport of Layer 2 Frames Over MPLS</td>
</tr>
<tr>
<td>draft-ietf-l2tpext-l2tp-base-03.txt</td>
<td>Layer Two Tunneling Protocol (Version 3)</td>
</tr>
</tbody>
</table>

### MIBs

<table>
<thead>
<tr>
<th>MIB</th>
<th>MIBs Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cisco Frame Relay MIB</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
</tr>
<tr>
<td>(CISCO-FRAME-RELAY-MIB.my)</td>
<td></td>
</tr>
<tr>
<td>• Interfaces MIB</td>
<td></td>
</tr>
<tr>
<td>(IF-MIB.my)</td>
<td></td>
</tr>
<tr>
<td>• MPLS LDP MIB</td>
<td></td>
</tr>
<tr>
<td>(MPLS-LDP-MIB.my)</td>
<td></td>
</tr>
</tbody>
</table>

### RFCs

<table>
<thead>
<tr>
<th>RFC</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFC 2661</td>
<td>Layer Two Tunneling Protocol</td>
</tr>
</tbody>
</table>
Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>pages of searchable technical content, including links to products,</td>
<td></td>
</tr>
<tr>
<td>technologies, solutions, technical tips, and tools. Registered Cisco.com</td>
<td></td>
</tr>
<tr>
<td>users can log in from this page to access even more content.</td>
<td></td>
</tr>
</tbody>
</table>

Command Reference

The following commands are introduced or modified in the feature or features documented in this module. For information about these commands, see the Cisco IOS Multiprotocol Label Switching Command Reference at http://www.cisco.com/en/US/docs/ios/mpls/command/reference/mp_book.html. For information about all Cisco IOS commands, go to the Command Lookup Tool at http://tools.cisco.com/Support/CLILookup or to the Cisco IOS Master Commands List.

- xconnect

Feature Information for Multilink Frame Relay over L2TPv3 AToM

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>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilink Frame Relay over L2TPv3/AToM</td>
<td>12.0(28)S</td>
<td>This feature was introduced in Cisco IOS Release 12.0(28)S for the Cisco 7200 and 7500 series routers.</td>
</tr>
<tr>
<td></td>
<td>12.2(25)S</td>
<td>This feature was integrated into Cisco IOS Release 12.2(25)S.</td>
</tr>
<tr>
<td></td>
<td>12.0(32)S</td>
<td>In Cisco IOS Release 12.0(32)S, this feature added support for the following pluggable modules for the Cisco 12000 series router: Cisco 4-port channelized T3 (DSO) shared port adapter, Cisco 8-port channelized T1/E1 shared port adapter, and the Cisco 1-port channelized OC-3/ STM-1 shared port adapter.</td>
</tr>
<tr>
<td></td>
<td>12.4(11)T</td>
<td>This feature was integrated into Cisco IOS Release 12.4(11)T.</td>
</tr>
</tbody>
</table>
L2VPN Interworking

Layer 2 Virtual Private Network (L2VPN) Interworking allows you to connect disparate attachment circuits. This feature module explains how to configure the following L2VPN Interworking features:

- Ethernet/VLAN to ATM AAL5 Interworking
- Ethernet/VLAN to Frame Relay Interworking
- Ethernet/VLAN to PPP Interworking
- Ethernet to VLAN Interworking
- Frame Relay to ATM AAL5 Interworking
- Frame Relay to PPP Interworking
- Ethernet/VLAN to ATM virtual channel identifier (VPI) and virtual channel identifier (VCI) Interworking
- L2VPN Interworking: VLAN Enable/Disable Option for AToM

Finding Feature Information, page 135
Prerequisites for L2VPN Interworking, page 135
Restrictions for L2VPN Interworking, page 136
Information About L2VPN Interworking, page 145
How to Configure L2VPN Interworking, page 148
Configuration Examples for L2VPN Interworking, page 155
Additional References, page 169
Feature Information for L2VPN Interworking, page 170

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.
On the Cisco 12000 series Internet router, before you configure Layer 2 Tunnel Protocol version 3 (L2TPv3) for L2VPN Interworking on an IP Services Engine (ISE/Engine 3) or Engine 5 interface, you must also enable the L2VPN feature bundle on the line card.

To enable the feature bundle, enter the **hw-module slot np mode feature** command in global configuration mode as follows:

```
Router# configure terminal
Router(config)# hw-module slot slot-number np mode feature
```

## Restrictions for L2VPN Interworking

- **General Restrictions**, page 136
- **Cisco 7600 Series Routers Restrictions**, page 136
- **Cisco 12000 Series Router Restrictions**, page 138
- **ATM AAL5 Interworking Restrictions**, page 141
- **Ethernet VLAN Interworking Restrictions**, page 141
- **Restrictions**, page 142
- **Frame Relay Interworking Restrictions**, page 144
- **PPP Interworking Restrictions**, page 144

### General Restrictions

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.

- The interworking type on one provider edge (PE) router must match the interworking type on the peer PE router.
- The following quality of service (QoS) features are supported with L2VPN Interworking:
  - Static IP type of service (ToS) or Multiprotocol Label Switching (MPLS) experimental bit (EXP) setting in tunnel header
  - IP ToS reflection in tunnel header (Layer 2 Tunnel Protocol Version 3 (L2TPv3) only)
  - Frame Relay policing
  - Frame Relay data-link connection identifier (DLCI)-based congestion management (Cisco 7500/ Versatile Interface Processor (VIP))
  - One-to-one mapping of VLAN priority bits to MPLS EXP bits
- Only ATM AAL5 VC mode is supported; ATM VP and port mode are not supported.
- In Cisco IOS Release 12.2(52)SE and Cisco IOS Release 12.2(33)SRE, the **encapsulation** command supports only the **mpls** keyword. The **l2tpv3** keyword is not supported. The **interworking** command supports only the **ethernet** and **vlan** keywords. The **ip** keyword is not supported.

### Cisco 7600 Series Routers Restrictions

The following line cards are supported on the Cisco 7600 series router. The first table below shows the line cards that are supported on the WAN (ATM, Frame Relay, or PPP) side of the interworking link. The second table below shows the line cards that are supported on the Ethernet side of the interworking link. For more details on the Cisco 7600 routers supported shared port adapters and line cards, see the following document:
• Release Notes for Cisco IOS Release 12.2SR for the Cisco 7600 Series Routers

**Table 12** Cisco 7600 Series Routers: Supported Line Cards for the WAN Side

<table>
<thead>
<tr>
<th>Interworking Type</th>
<th>Core-Facing Line Cards</th>
<th>Customer-Edge Line Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet (bridged) (ATM and</td>
<td>Any</td>
<td>EflexWAN SIP-200 SIP-400</td>
</tr>
<tr>
<td>Frame Relay)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP (routed) (ATM, Frame Relay,</td>
<td>Any</td>
<td>EflexWAN SIP-200 SIP-400</td>
</tr>
<tr>
<td>and PPP)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 13** Cisco 7600 Series Routers: Supported Line Cards for the Ethernet Side

<table>
<thead>
<tr>
<th>Interworking Type</th>
<th>Ethernet over MPLS Mode</th>
<th>Core-Facing Line Cards</th>
<th>Customer-Edge Line Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet (bridged)</td>
<td>Policy feature card</td>
<td>Any, except optical</td>
<td>Catalyst LAN SIP-600</td>
</tr>
<tr>
<td></td>
<td>(PFC) based</td>
<td>service module (OSM)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>and ES40</td>
<td></td>
</tr>
<tr>
<td>Ethernet (bridged)</td>
<td>Switched virtual</td>
<td>EflexWAN ES20 ES+40</td>
<td>Catalyst LAN</td>
</tr>
<tr>
<td></td>
<td>interface (SVI) based</td>
<td>SIP-200 SIP-400 SIP-</td>
<td>EflexWAN (with MPB) SIP-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>600</td>
<td>200 (with MPB)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(with MPB) SIP-400 SIP-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>600</td>
</tr>
<tr>
<td>Ethernet (bridged)</td>
<td>Scalable (with E-MPB)</td>
<td>Any, except OSM</td>
<td>ES20 SIP-600 and SIP-400</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with Gigabit Ethernet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(GE) SPA</td>
</tr>
<tr>
<td>IP (routed)</td>
<td>PFC-based</td>
<td>Catalyst LAN SIP-600</td>
<td>Catalyst LAN SIP-600</td>
</tr>
<tr>
<td>Note: PFC-based mode is not supported with routed interworking in Cisco IOS Release 12.2(33)SRD. Use SVI, Scalable, or Ethernet virtual connection (EVC) based Ethernet over MPLS (EoMPLS) instead.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP (routed)</td>
<td>SVI-based</td>
<td>Any, except Catalyst LAN and OSM.</td>
<td></td>
</tr>
<tr>
<td>Note: PFC-based mode is not supported with routed interworking in Cisco IOS Release 12.2(33)SRD. Use SVI, Scalable, or EVC-based EoMPLS instead.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following restrictions apply to the Cisco 7600 series routers and L2VPN Interworking:
• OAM Emulation is not required with L2VPN Interworking on the SIP-200, SIP-400, and Flexwan2 line cards.

• Cisco 7600 series routers support the L2VPN Interworking: VLAN Enable/Disable Option for AToM feature starting in Cisco IOS Release 12.2(33)SRE. This feature has the following restrictions:
  ◦ PFC-based EoMPLS is not supported.
  ◦ Scalable and SVI-based EoMPLS are supported with the SIP-400 line card.

• The Cisco 7600 series routers do not support L2VPN Interworking over L2TPv3.

• Cisco 7600 series routers support only the following interworking types:
  ◦ Ethernet/VLAN to Frame Relay (IP and Ethernet modes)
  ◦ Ethernet/VLAN to ATM AAL5SNAP (IP and Ethernet modes)
  ◦ Ethernet/VLAN to PPP (IP only)
  ◦ Ethernet to VLAN Interworking

• Cisco 7600 series routers do not support the following interworking types:
  ◦ Ethernet/VLAN to ATM AAL5MUX
  ◦ Frame Relay to PPP Interworking
  ◦ Frame Relay to ATM AAL5 Interworking

• Both ends of the interworking link must be configured with the same encapsulation and interworking type:
  ◦ If you use Ethernet encapsulation, you must use the Ethernet (bridged) interworking type. If you are not using Ethernet encapsulation, you can use a bridging mechanism, such as routed bridge encapsulation (RBE).
  ◦ If you use an IP encapsulation (such as ATM or Frame Relay), you must use the IP (routed) interworking type. The PE routers negotiate the process for learning and resolving addresses.
  ◦ You must use the same MTU size on the attachment circuits at each end of the pseudowire.

• PFC-based EoMPLS is not supported on ES40 line cards. SVI and EVC/scalable EoMPLS are the alternative options.

• PFC-based EoMPLS is not supported for Routed/IP interworking in Cisco IOS Release 12.2(33)SRD and later releases. The alternative Routed/IP interworking options are SVI and EVC or scalable EoMPLS. However, PFC-based EoMPLS is supported for Ethernet/Bridged interworking and for like-to-like over AToM.

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**Cisco 12000 Series Router Restrictions**

For more information about hardware requirements on the Cisco12000 series routers, see the Cross-Platform Release Notes for Cisco IOS Release 12.0S.

For QOS support on the Cisco 12000 series routers, see Any Transport over MPLS (AToM): Layer 2 QoS (Quality of Service) for the Cisco 12000 Series Router

**Frame Relay to PPP and High-Level Data Link Control Interworking**

The Cisco 12000 series Internet router does not support L2VPN Interworking with PPP and high-level data link control (HDLC) transport types in Cisco IOS releases earlier than Cisco IOS Release 12.0(32)S.

In Cisco IOS Release 12.0(32)S and later releases, the Cisco 12000 series Internet router supports L2VPN interworking for Frame Relay over MPLS and PPP and HDLC over MPLS only on the following shared port adapters (SPAs):

• ISE/Engine 3 SPAs:
SPA-2XCT3/DS0 (2-port channelized T3 to DS0)
SPA-4XCT3/DS0 (4-port channelized T3 to DS0)

• Engine 5 SPAs:
  • SPA-1XCHSTM1/OC-3 (1-port channelized STM-1c/OC-3c to DS0)
  • SPA-8XCHT1/E1 (8-port channelized T1/E1)
  • SPA-2XOC-48-POS/RPR (2-port OC-48/STM16 POS/RPR)
  • SPA-OC-192POS-LR (1-port OC-192/STM64 POS/RPR)
  • SPA-OC-192POS-XFP (1-port OC-192/STM64 POS/RPR)

L2VPN Interworking over L2TPv3

On the Cisco 12000 series Internet router, Ethernet (bridged) interworking is not supported for L2TPv3. Only IP (routed) interworking is supported.

IP (routed) interworking is not supported in an L2TPv3 pseudowire that is configured for data sequencing (using the sequencing command).

In Cisco IOS Release 12.0(32)SY and later releases, the Cisco 12000 series Internet router supports L2VPN Interworking over L2TPv3 tunnels in IP mode on ISE and Engine 5 line cards as follows:

• On an ISE interface configured for L2TPv3 tunneling, the following Layer 2 encapsulations are supported:
  • ATM adaptation layer type-5 (AAL5)
  • Ethernet
  • 802.1q (VLAN)
  • Frame Relay DLCI

• On an Engine 5 interface configured for L2TPv3 tunneling, the following Layer 2 encapsulations are supported:
  • Ethernet
  • 802.1q (VLAN)
  • Frame Relay DLCI

For more information, refer to Layer 2 Tunnel Protocol Version 3.

The only frame format supported for L2TPv3 interworking on Engine 5 Ethernet SPAs is Ethernet Version 2 (also known as Ethernet II) with the Ether type 0x0800 value set as Internet Protocol Payload and (optionally) 802.1q VLAN. Ethernet packets with other Ethernet frame formats are dropped.

Remote Ethernet Port Shutdown Support

The Cisco Remote Ethernet Port Shutdown feature (which minimizes potential data loss after a remote link failure) is supported only on the following Engine 5 Ethernet SPAs:

• SPA-8XFE (8-port Fast Ethernet)
• SPA-2X1GE (2-port Gigabit Ethernet)
• SPA-5X1GE (5-port Gigabit Ethernet)
• SPA-10X1GE (10-port Gigabit Ethernet)
• SPA-1X10GE (1-port 10-Gigabit Ethernet)

For more information about this feature, refer to Any Transport over MPLS (AToM): Remote Ethernet Port Shutdown.
L2VPN Any-to-Any Interworking on Engine 5 Line Cards

The table below shows the different combinations of transport types supported for L2VPN interworking on Engine 3 and Engine 5 SPA interfaces connected through an attachment circuit over MPLS or L2TPv3.

### Table 14 Engine 3 and Engine 5 Line Cards/SPAs Supported for L2VPN Interworking

<table>
<thead>
<tr>
<th>Attachment Circuit 1 (AC1)</th>
<th>Attachment Circuit 2 (AC2)</th>
<th>Interworking Mode</th>
<th>AC1 Engine Type and Line Card/SPA</th>
<th>AC2 Engine Type and Line Card/SPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame Relay</td>
<td>Frame Relay</td>
<td>IP</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 3 ATM line cards</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>ATM</td>
<td>Ethernet</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 3 ATM line cards</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>ATM</td>
<td>IP</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 3 ATM line cards</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>Ethernet</td>
<td>Ethernet</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>Ethernet</td>
<td>IP</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>VLAN</td>
<td>Ethernet</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Frame Relay</td>
<td>VLAN</td>
<td>IP</td>
<td>Engine 5 POS and channelized</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Ethernet</td>
<td>Ethernet</td>
<td>Ethernet</td>
<td>Engine 5 Gigabit Ethernet</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Ethernet</td>
<td>Ethernet</td>
<td>IP</td>
<td>Engine 5 Gigabit Ethernet</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Ethernet</td>
<td>VLAN</td>
<td>Ethernet</td>
<td>Engine 5 Gigabit Ethernet</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>Ethernet</td>
<td>VLAN</td>
<td>IP</td>
<td>Engine 5 Gigabit Ethernet</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>ATM</td>
<td>Ethernet</td>
<td>Ethernet</td>
<td>Engine 3 ATM line cards</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
<tr>
<td>ATM</td>
<td>Ethernet</td>
<td>IP</td>
<td>Engine 3 ATM line cards</td>
<td>Engine 5 Gigabit Ethernet</td>
</tr>
</tbody>
</table>

On the Cisco 12000 series Engine 3 line card, Network Layer Protocol ID (NLPID) encapsulation is not supported in routed mode; and neither NLPID nor AAL5MUX is supported in bridged mode.

- On the Cisco 12000 series Internet router, Ethernet (bridged) interworking is not supported for L2TPv3.
In an L2VPN Interworking configuration, after you configure L2TPv3 tunnel encapsulation for a pseudowire using the `encapsulation l2tpv3` command, you cannot enter the `interworking ethernet` command.

- On Ethernet SPAs on the Cisco 12000 series Internet router, the only frame format supported for L2TPv3 interworking is Ethernet Version 2 (also known as Ethernet II) with the Ether type 0x0800 value set as Internet Protocol Payload and [optionally] 802.1q VLAN.

Ethernet packets with other Ethernet frame formats are dropped.

### ATM AAL5 Interworking Restrictions

The following restrictions apply to ATM AAL5 Interworking:

- Switched virtual circuits (SVCs) are not supported.
- Inverse Address Resolution Protocol (ARP) is not supported with IP interworking.
- Customer edge (CE) routers must use point-to-point subinterfaces or static maps.
- Both AAL5MUX and AAL5SNAP encapsulation are supported. In the case of AAL5MUX, no translation is needed.
- In the Ethernet end-to-end over ATM scenario, the following translations are supported:
  - Ethernet without LAN frame check sequence (FCS) (AAAA030080C2000700000)
  - Spanning tree (AAAA030080c2000E)

Everything else is dropped.

- In the IP over ATM scenario, the IPv4 (AAAA030000000800) translation is supported. Everything else is dropped.
- Operation, Administration, and Management (OAM) emulation for L2VPN Interworking is the same as like-to-like. The end-to-end F5 loopback cells are looped back on the PE router. When the pseudowire is down, an F5 end-to-end segment Alarm Indication Signal (AIS)/Remote Defect Identification (RDI) is sent from the PE router to the CE router.
- Interim Local Management Interface (ILMI) can manage virtual circuits (VCs) and permanent virtual circuits (PVCs).
- To enable ILMI management, configure ILMI PVC 0/16 on the PE router’s ATM interface. If a PVC is provisioned or deleted, an ilmiVCCChange trap is sent to the CE router.
- Only the user side of the User-Network Interface (UNI) is supported; the network side of the UNI is not supported.

### Ethernet VLAN Interworking Restrictions

The following restrictions apply to Ethernet/VLAN interworking:

- When you configure VLAN to Ethernet interworking, VLAN to Frame Relay (routed), or ATM using Ethernet (bridged) interworking, the PE router on the Ethernet side that receives a VLAN tagged frame from the CE router removes the VLAN tag. In the reverse direction, the PE router adds the VLAN tag to the frame before sending the frame to the CE router.

(If you enable the L2VPN Interworking: VLAN Enable/Disable Option for AToM feature with the `interworking vlan` command, VLAN ID is included as part of the Ethernet frame. See the VLAN Interworking, page 147 for more information.)

- In bridged interworking from VLAN to Frame Relay, the Frame Relay PE router does not strip off VLAN tags from the Ethernet traffic it receives.
• The Cisco 10720 Internet router supports Ethernet to VLAN Interworking Ethernet only over L2TPv3.
• Ethernet interworking for a raw Ethernet port or a VLAN trunk is not supported. Traffic streams are not kept separate when traffic is sent between transport types.
• In routed mode, only one CE router can be attached to an Ethernet PE router.
• There must be a one-to-one relationship between an attachment circuit and the pseudowire. Point-to-multipoint or multipoint-to-point configurations are not supported.
• 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 ARP (0806) packets and responds with its own MAC address (proxy ARP). Everything else is dropped.
• The Ethernet or VLAN 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 and one PE router should be on the Ethernet or VLAN 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 or VLAN 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 mode.
• This restriction applies if you configure interworking between Ethernet and VLAN with Catalyst switches as the CE routers. The spanning tree protocol is supported for Ethernet interworking. Ethernet interworking between an Ethernet port and a VLAN supports spanning tree protocol only on VLAN 1. Configure VLAN 1 as a nonnative VLAN.
• 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.

**Restrictions**

The following restrictions apply to the L2VPN Interworking: VLAN Enable/Disable Option for AToM feature, which allows the VLAN ID to be included as part of the Ethernet frame:

• The L2VPN Interworking: VLAN Enable/Disable Option for AToM feature is supported on the following releases:
  ◦ Cisco IOS release 12.2(52)SE for the Cisco Catalyst 3750 Metro switches
  ◦ Cisco IOS Release 12.2(33)SRE for the Cisco 7600 series routers
• L2VPN Interworking: VLAN Enable/Disable Option for AToM is not supported with L2TPv3. You can configure the feature only with AToM.
• If the interface on the PE router is a VLAN interface, it is not necessary to specify the **interworking vlan** command on that PE router.
• The L2VPN Interworking: VLAN Enable/Disable Option for AToM feature works only with the following attachment circuit combinations:
  ◦ Ethernet to Ethernet
  ◦ Ethernet to VLAN
- VLAN to VLAN

If you specify an interworking type on a PE router, that interworking type must be enforced. The interworking type must match on both PE routers. Otherwise, the VC may be in an incompatible state and remain in the down state. If the attachment circuit (AC) is VLAN, the PE router can negotiate (autosense) the VC type using Label Distribution Protocol (LDP).

For example, both PE1 and PE2 use Ethernet interfaces, and VLAN interworking is specified on PE1 only. PE2 is not configured with an interworking type and cannot autosense the interworking type. The result is an incompatible state where the VC remains in the down state.

On the other hand, if PE1 uses an Ethernet interface and VLAN interworking is enabled (which will enforce VLAN as the VC type), and PE2 uses a VLAN interface and interworking is not enabled (which causes PE2 to use Ethernet as its default VC type), PE2 can autosense and negotiate the interworking type and select VLAN as the VC type.

The table below summarizes shows the AC types, interworking options, and VC types after negotiation.

**Table 15**  **Negotiating Ethernet and VLAN Interworking Types**

<table>
<thead>
<tr>
<th>PE1 AC Type</th>
<th>Interworking Option</th>
<th>PE2 AC Type</th>
<th>Interworking Option</th>
<th>VC Type after Negotiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>none</td>
<td>Ethernet</td>
<td>none</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Vlan</td>
<td>none</td>
<td>Ethernet</td>
<td>none</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Ethernet</td>
<td>none</td>
<td>Vlan</td>
<td>none</td>
<td>Ethernet</td>
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<tr>
<td>Vlan</td>
<td>none</td>
<td>Vlan</td>
<td>none</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Ethernet</td>
<td>Vlan</td>
<td>Ethernet</td>
<td>none</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Vlan</td>
<td>Vlan</td>
<td>Ethernet</td>
<td>none</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Ethernet</td>
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<tr>
<td>Ethernet</td>
<td>none</td>
<td>Ethernet</td>
<td>Vlan</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Vlan</td>
<td>none</td>
<td>Ethernet</td>
<td>Vlan</td>
<td>Incompatible</td>
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<td>none</td>
<td>Vlan</td>
<td>Vlan</td>
<td>Incompatible</td>
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<td>Ethernet</td>
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<td>Ethernet</td>
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<tr>
<td>Vlan</td>
<td>Vlan</td>
<td>Vlan</td>
<td>Vlan</td>
<td>Vlan</td>
</tr>
</tbody>
</table>
Frame Relay Interworking Restrictions

The following restrictions apply to Frame Relay interworking:

- The attachment circuit maximum transmission unit (MTU) sizes must match when you connect them over MPLS. By default, the MTU size associated with a Frame Relay DLCI is the interface MTU. This may cause problems, for example, when connecting some DLCIs on a PoS interface (with a default MTU of 4470 bytes) to Ethernet or VLAN (with a default MTU of 1500 bytes) and other DLCIs on the same PoS interface to ATM (with a default MTU of 4470 bytes). To avoid reducing all the interface MTUs to the lowest common denominator (1500 bytes in this case), you can specify the MTU for individual DLCIs using the `mtu` command.
- Only DLCI mode is supported. Port mode is not supported.
- Configure Frame Relay switching to use DCE or Network-to-Network Interface (NNI). DTE mode does not report status in the Local Management Interface (LMI) process. If a Frame Relay over MPLS circuit goes down and the PE router is in DTE mode, the CE router is never informed of the disabled circuit. You must configure the `frame-relay switching` command in global configuration mode in order to configure DCE or NNI.
- Frame Relay policing is non-distributed on the Cisco 7500 series routers. If you enable Frame Relay policing, traffic is sent to the route switch processor for processing.
- Inverse ARP is not supported with IP interworking. CE routers must use point-to-point subinterfaces or static maps.
- The PE router automatically supports translation of both the Cisco encapsulations and the Internet Engineering Task Force (IETF) encapsulations that come 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.
- With Ethernet interworking, the following translations are supported:
  - Ethernet without LAN FCS (0300800080C20007 or 6558)
  - Spanning tree (0300800080C2000E or 4242)
- All other translations are dropped.
- With IP interworking, the IPv4 (03CC or 0800) translation is supported. All other translations are dropped.
- PVC status signaling works the same way as in like-to-like case. The PE router reports the PVC status to the CE router, based on the availability of the pseudowire. PVC status detected by the PE router will also be reflected into the pseudowire. LMI to OAM interworking is supported when you connect Frame Relay to ATM.

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.
- There must be a one-to-one relationship between a PPP session and a Frame Relay DLCI. Each Frame Relay PVC must have only one PPP session.
- 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.
- Proxy IPCP is automatically enabled on the PE router when IP interworking is configured on the pseudowire.
- 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.

Information About L2VPN Interworking

- Overview of L2VPN Interworking, page 145
- L2VPN Interworking Modes, page 145
- L2VPN Interworking Support Matrix, page 147
- Static IP Addresses for L2VPN Interworking for PPP, page 148

Overview of L2VPN Interworking

Layer 2 transport over MPLS and IP already exists for like-to-like attachment circuits, such as Ethernet-to-Ethernet or PPP-to-PPP. L2VPN Interworking builds on this functionality by allowing disparate attachment circuits to be connected. An interworking function facilitates the translation between the different Layer 2 encapsulations. The figure below is an example of Layer 2 interworking, where ATM and Frame Relay packets travel over the MPLS cloud.

Figure 4 ATM to Frame Relay Interworking Example

The L2VPN Interworking feature supports Ethernet, 802.1Q (VLAN), Frame Relay, ATM AAL5, and PPP attachment circuits over MPLS and L2TPv3. The features and restrictions for like-to-like functionality also apply to L2VPN Interworking.

L2VPN Interworking Modes

L2VPN Interworking works in either Ethernet (“bridged”) mode, IP (“routed”), or Ethernet VLAN mode. You specify the mode by issuing the \texttt{interworking} \{\texttt{ethernet} \mid \texttt{ip} \mid \texttt{vlan}\} command in pseudowire-class configuration mode.

- Ethernet (Bridged) Interworking, page 146
- IP (Routed) Interworking, page 146
- VLAN Interworking, page 147
Ethernet (Bridged) Interworking

The `ethernet` keyword causes Ethernet frames to be extracted from the attachment circuit and sent over the pseudowire. Ethernet end-to-end transmission is assumed. Attachment circuit frames that are not Ethernet are dropped. In the case of VLAN, the VLAN tag is removed, leaving an untagged Ethernet frame.

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 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. The enterprise wants LAN connectivity to all its sites. In this case, 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 Layer 2 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 (Routed) Interworking

The `ip` keyword causes IP packets to be extracted from the attachment circuit and sent over the pseudowire. Attachment circuit frames that do not contain IPv4 packets are dropped.

IP Interworking is also called routed interworking. The CE routers encapsulate IP on the link between the CE and PE routers. A new VC type is used to signal the IP pseudowire in MPLS and L2TPv3. Translation between the Layer 2 and IP encapsulations across the pseudowire is required. Special consideration needs to be given to address resolution and routing protocol operation, because these are handled differently on different Layer 2 encapsulations.

This mode is used to provide IP connectivity between sites, regardless of the Layer 2 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
• Frame Relay and ATM use 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.
**VLAN Interworking**

The `vlan` keyword allows the VLAN ID to be included as part of the Ethernet frame. In Cisco IOS Release 12.2(52)SE, you can configure Catalyst 3750 Metro switches to use Ethernet VLAN for Ethernet (bridged) interworking. You can specify the Ethernet VLAN (type 4) by issuing the `interworking vlan` command in pseudowire-class configuration mode. This allows the VLAN ID to be included as part of the Ethernet frame. In releases previous to Cisco IOS Release 12.2(52)SE, the only way to achieve VLAN encapsulation is to ensure the CE router is connected to the PE router through an Ethernet VLAN interface/subinterface.

**L2VPN Interworking Support Matrix**

The supported L2VPN Interworking features are listed in the table below.

<table>
<thead>
<tr>
<th>Feature</th>
<th>MPLS or L2TPv3 Support</th>
<th>IP or Ethernet Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet/VLAN to ATM AAL5</td>
<td>MPLS L2TPv3 (12000 series only)</td>
<td>IP Ethernet</td>
</tr>
<tr>
<td>Ethernet/VLAN to Frame Relay</td>
<td>MPLS L2TPv3</td>
<td>IP</td>
</tr>
<tr>
<td>Ethernet/VLAN to PPP</td>
<td>MPLS</td>
<td>IP</td>
</tr>
<tr>
<td>Ethernet to VLAN</td>
<td>MPLS L2TPv3</td>
<td>IP</td>
</tr>
<tr>
<td>L2VPN Interworking: VLAN Enable/Disable Option for AToM</td>
<td>MPLS</td>
<td>Ethernet VLAN</td>
</tr>
<tr>
<td>Frame Relay to ATM AAL5</td>
<td>MPLS L2TPv3 (12000 series only)</td>
<td>IP</td>
</tr>
<tr>
<td>Frame Relay to Ethernet or VLAN</td>
<td>MPLS L2TPv3</td>
<td>IP</td>
</tr>
<tr>
<td>Frame Relay to PPP</td>
<td>MPLS L2TPv3</td>
<td>IP</td>
</tr>
</tbody>
</table>

**Note**: On the Cisco 12000 series Internet router:

- Ethernet (bridged) interworking is not supported for L2TPv3.
- IP (routed) interworking is not supported in an L2TPv3 pseudowire configured for data sequencing (using the `sequencing` command).

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1 With the L2VPN Interworking: VLAN Enable/Disable Option for AToM feature, VLAN interworking can also be supported. For more information, see the “VLAN Interworking” section on page 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, you can configure the remote CE router’s IP address on the PE router. Issue 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 148
- Verifying the L2VPN Interworking Configuration, page 149
- Configuring L2VPN Interworking: VLAN Enable-Disable Option for AToM, page 153

Configuring L2VPN Interworking

L2VPN Interworking allows you to connect disparate attachment circuits. Configuring the 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 or L2TPv3 configuration. For specific instructions on configuring AToM or L2TPv3, see the following documents:

- Layer 2 Tunnel Protocol Version 3
- Any Transport over MPLS

**SUMMARY STEPS**

1. `enable`
2. `configure terminal`
3. `hw-module slot slot-number np mode feature`
4. `pseudowire-class name`
5. `encapsulation {mpls | l2tpv3}`
6. `interworking {ethernet | ip | vlan}`
DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| **Step 1** enable | Enables privileged EXEC mode.  
  • Enter your password if prompted. |
| **Example:**  
  Router> enable |
| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:**  
  Router# configure terminal |
| **Step 3** hw-module slot *slot-number* np mode feature | (Optional) Enables L2VPN Interworking functionality on the Cisco 12000 series router.  
  **Note** Enter this command only on a Cisco 12000 series Internet router if you use L2TPv3 for L2VPN Interworking on an ISE (Engine 3) or Engine 5 interface. In this case, you must first enable the L2VPN feature bundle on the line card by entering the `hw-module slot *slot-number* np mode feature` command. |
| **Example:**  
  Router(config)# hw-module slot 3 np mode feature |
| **Step 4** pseudowire-class *name* | Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode. |
| **Example:**  
  Router(config)# pseudowire-class class1 |
| **Step 5** encapsulation {mpls | l2tpv3} | Specifies the tunneling encapsulation, which is either mpls or l2tpv3. |
| **Example:**  
  Router(config-pw)# encapsulation mpls |
| **Step 6** interworking {ethernet | ip | vlan} | Specifies the type of pseudowire and the type of traffic that can flow across it.  
  **Note** On the Cisco 12000 series Internet router, Ethernet (bridged) interworking is not supported for L2TPv3. After you configure the L2TPv3 tunnel encapsulation for the pseudowire using the `encapsulation l2tpv3` command, you cannot enter the `interworking ethernet` command. |
| **Example:**  
  Router(config-pw)# interworking ip |

## Verifying the L2VPN Interworking Configuration

To verify the L2VPN Interworking configuration, you can use the following commands.
SUMMARY STEPS

1. enable
2. show l2tun session all (L2TPv3 only)
3. show arp
4. ping
5. show l2tun session interworking (L2TPv3 only)
6. show mpls l2transport vc detail (AToM only)

DETAILED STEPS

Step 1 enable
Enables privileged EXEC mode. Enter your password if prompted.

Step 2 show l2tun session all (L2TPv3 only)
For L2TPv3, you can verify the L2VPN Interworking configuration using the show l2tun session all command on the PE routers.
In the following example, the interworking type is shown in bold.
### PE1

**Router# show l2tun session all**

<table>
<thead>
<tr>
<th>Session Information</th>
<th>Total tunnels 1</th>
<th>sessions 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session id 15736 is up, tunnel id 35411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call serial number is 4035100045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote tunnel name is PE2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet address is 10.9.9.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session is L2TP signalled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session state is established, time since change 1d22h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Packets sent, 16 received</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1518 Bytes sent, 1230 received</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive packets dropped:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>out-of-order: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Send packets dropped:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>exceeded session MTU: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session vcid is 123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session Layer 2 circuit, type is Ethernet, name is FastEthernet1/1/0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit state is UP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote session id is 26570, remote tunnel id 46882</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF bit off, ToS reflect disabled, ToS value 0, TTL value 255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No session cookie information available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS cached header information:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>encaps size = 24 bytes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000 00000000 00000000 00000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000 00000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequencing is off</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### PE2

**Router# show l2tun session all**

<table>
<thead>
<tr>
<th>Session Information</th>
<th>Total tunnels 1</th>
<th>sessions 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session id 26570 is up, tunnel id 46882</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Call serial number is 4035100045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote tunnel name is PE1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet address is 10.8.8.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session is L2TP signalled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session state is established, time since change 1d22h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Packets sent, 16 received</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1230 Bytes sent, 1230 received</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive packets dropped:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>out-of-order: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Send packets dropped:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>exceeded session MTU: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total: 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session vcid is 123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session Layer 2 circuit, type is Ethernet, name is FastEthernet2/0.1:10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit state is UP, <strong>interworking type is Ethernet</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote session id is 15736, remote tunnel id 35411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DF bit off, ToS reflect disabled, ToS value 0, TTL value 255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No session cookie information available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS cached header information:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>encaps size = 24 bytes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000 00000000 00000000 00000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00000000 00000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequencing is off</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MPLS: Layer 2 VPNs, Configuration Guide, Cisco IOS Release 12.4T**

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

**Example:**

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

**Step 4 ping**

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

**Example:**

```
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
```

**Step 5 show l2tun session interworking (L2TPv3 only)**

For L2TPv3, you can verify that the interworking type is correctly set using the `show l2tun session interworking` command. Enter the command on the PE routers that are performing the interworking translation.

- In Example 1, the PE router performs the raw Ethernet translation. The command output displays the interworking type with a dash (`-`).
- In Example 2, the PE router performs the Ethernet VLAN translation. The command output displays the interworking type as ETH.

**Command Output for Raw Ethernet Translation**

```
Router# show l2tun session interworking
Session Information Total tunnels 1 sessions 1
LocID      TunID      Peer-address    Type IWrk Username, Intf/Vcid, Circuit
15736      35411      10.9.9.9         ETH   -   123,      Fa1/1/0
```

**Command Output for Ethernet VLAN Translation**

```
Router# show l2tun session interworking
Session Information Total tunnels 1 sessions 1
LocID      TunID      Peer-address    Type IWrk Username, Intf/Vcid, Circuit
26570      46882      10.8.8.8         VLAN ETH  123,      Fa2/0.1:10
```

**Step 6 show mpls l2transport vc detail (AToM only)**

You can verify the AToM configuration by using the `show mpls l2transport vc detail` command. In the following example, the interworking type is shown in bold.

```
Router# show mpls l2transport vc detail
Session Information Total tunnels 1 sessions 1
LocID      TunID      Peer-address    Type IWrk Username, Intf/Vcid, Circuit
26570      46882      10.8.8.8         VLAN ETH  123,      Fa2/0.1:10
```
<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Router# show mpls l2transport vc detail</strong></td>
<td><strong>Router# show mpls l2transport vc detail</strong></td>
</tr>
<tr>
<td>Local interface: Fa1/1/0 up, line protocol up, Ethernet up</td>
<td>Local interface: Fa2/0.3 up, line protocol up, Eth VLAN 10 up</td>
</tr>
<tr>
<td>Destination address: 10.9.9.9, VC ID: 123, VC status: up</td>
<td>MPLS VC type is Ethernet, <strong>interworking type is Ethernet</strong></td>
</tr>
<tr>
<td>Preferred path: not configured</td>
<td>Destination address: 10.8.8.8, VC ID: 123, VC status: up</td>
</tr>
<tr>
<td>Default path: active</td>
<td>Preferred path: not configured</td>
</tr>
<tr>
<td>Tunnel label: 17, next hop 10.1.1.3</td>
<td>Default path: active</td>
</tr>
<tr>
<td>Output interface: Fa4/0/0, imposed label stack {17 20}</td>
<td>Tunnel label: 16, next hop 10.1.1.3</td>
</tr>
<tr>
<td>Create time: 01:43:50, last status change time: 01:43:33</td>
<td>Output interface: Fa6/0, imposed label stack {16 16}</td>
</tr>
<tr>
<td>Create time: 00:00:26, last status change time: 00:00:06</td>
<td>Signaling protocol: LDP, peer 10.8.8.8:0 up</td>
</tr>
<tr>
<td>MPLS VC labels: local 16, remote 20</td>
<td>MPLS VC labels: local 20, remote 16</td>
</tr>
<tr>
<td>Group ID: local 0, remote 0</td>
<td>Group ID: local 0, remote 0</td>
</tr>
<tr>
<td>MTU: local 1500, remote 1500</td>
<td>MTU: local 1500, remote 1500</td>
</tr>
<tr>
<td>Remote interface description:</td>
<td>Remote interface description:</td>
</tr>
<tr>
<td>Sequencing: receive disabled, send disabled</td>
<td>Sequencing: receive disabled, send disabled</td>
</tr>
<tr>
<td>VC statistics:</td>
<td>VC statistics:</td>
</tr>
<tr>
<td>packet totals: receive 15, send 4184</td>
<td>packet totals: receive 5, send 0</td>
</tr>
<tr>
<td>byte totals: receive 1830, send 309248</td>
<td>byte totals: receive 340, send 0</td>
</tr>
<tr>
<td>packet drops: receive 0, send 0</td>
<td>packet drops: receive 0, send 0</td>
</tr>
</tbody>
</table>

**Configuring L2VPN Interworking: VLAN Enable-Disable Option for AToM**

You can specify the Ethernet VLAN (type 4) by issuing the `interworking vlan` command in pseudowire-class configuration mode. This allows the VLAN ID to be included as part of the Ethernet frame. In releases previous to Cisco IOS Release 12.2(52)SE and Cisco IOS Release 12.2(33)SRE, the only way to
achieve VLAN encapsulation is to ensure the CE router is connected to the PE router through an Ethernet link.

For complete instructions on configuring AToM, see "Any Transport over MPLS".

**SUMMARY STEPS**

1. enable
2. configure terminal
3. pseudowire-class name
4. encapsulation {mpls | l2tpv3}
5. interworking {ethernet | ip | vlan}
6. end
7. show mpls l2transport vc [vcid vc-id | vcid vc-id-min vc-id-max] [interface type number [local-circuit-id]] [destination ip-address | name] [detail]

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td>Example:</td>
<td><strong>Enters your password if prompted.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Router&gt; enable</strong></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td><strong>Enters global configuration mode.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Router# configure terminal</strong></td>
</tr>
<tr>
<td><strong>Step 3</strong> pseudowire-class name</td>
<td><strong>Establishes a pseudowire class with a name that you specify and enters pseudowire class configuration mode.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Router(config)# pseudowire-class class1</strong></td>
</tr>
<tr>
<td><strong>Step 4</strong> encapsulation {mpls</td>
<td>l2tpv3}</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Router(config-pw)# encapsulation mpls</strong></td>
</tr>
<tr>
<td><strong>Step 5</strong> interworking {ethernet</td>
<td>ip</td>
</tr>
<tr>
<td></td>
<td><strong>Example:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Router(config-pw)# interworking vlan</strong></td>
</tr>
</tbody>
</table>

L2VPN Interworking

How to Configure L2VPN Interworking

MPLS: Layer 2 VPNs, Configuration Guide, Cisco IOS Release 12.4T
### Configuration Examples for L2VPN Interworking

**Examples**

When the pseudowire on an interface is different from the VC type, the interworking type is displayed in the `show mpls l2transport vc detail` command output. In the following example, the pseudowire is configured on an Ethernet port and VLAN interworking is configured in the pseudowire class. The relevant output is shown in bold:

```
PE1# show mpls l2 vc 34 detail
Local interface: Et0/1 up, line protocol up, Ethernet up
MPLS VC type is Ethernet, interworking type is Eth VLAN
  Destination address: 10.1.1.2, VC ID: 34, VC status: down
  Output interface: if?-?0), imposed label stack {}
  Preferred path: not configured
  Default path: no route
  No adjacency
Create time: 00:00:13, last status change time: 00:00:13
Signaling protocol: LDP, peer unknown
  Targeted Hello: 10.1.1.1(LDP Id) -> 10.1.1.2
  Status TLV support (local/remote) : enabled/None (no remote binding)
  LDP route watch : enabled
  Label/status state machine : local standby, AC-ready, LnuRnd
  Last local dataplane status rcvd: No fault
  Last local SSS circuit status rcvd: No fault
  Last local SSS circuit status sent: Not sent
  Last local LDP TLV status sent: None
  Last remote LDP TLV status rcvd: None (no remote binding)
  Last remote LDP ADJ status rcvd: None (no remote binding)
  MPLS VC labels: local 2003, remote unassigned
  Group ID: local 0, remote unknown
  MTU: local 1500, remote unknown
  Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 0, send 0
    byte totals: receive 0, send 0
    packet drops: receive 0, seq error 0, send 0
```

**• Ethernet to VLAN over L2TPV3 (Bridged) Example, page 156**

---

**Command or Action** | **Purpose**
--- | ---
**Step 6** | **end**
**Example:**
```
Router(config-pw)# end
```
Exits pseudowire class configuration mode and enters privileged EXEC mode.

**Step 7** | `show mpls l2transport vc [vcid vc-id | vcid vc-id-min vc-id-max] [interface type number [local-circuit-id]] [destination ip-address | name] [detail]`
**Example:**
```
Router# show mpls l2transport vc detail
```
Displays information about AToM VCs.
Ethernet to VLAN over L2TPV3 (Bridged) Example

The following example shows the configuration of Ethernet to VLAN over L2TPv3:
Ethernet to VLAN over AToM (Bridged) Example

The following example shows the configuration of Ethernet to VLAN over AToM:
<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ip cef</td>
<td>ip cef</td>
</tr>
<tr>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>mpls label protocol ldp</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls ldp router-id Loopback0 force</td>
<td>mpls ldp router-id Loopback0 force</td>
</tr>
<tr>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>pseudowire-class atom-eth-iw</td>
<td>pseudowire-class atom</td>
</tr>
<tr>
<td>encapsulation mpls</td>
<td>encapsulation mpls</td>
</tr>
<tr>
<td>interworking ethernet</td>
<td>!</td>
</tr>
<tr>
<td>!</td>
<td>interface Loopback0</td>
</tr>
<tr>
<td>interface Loopback0</td>
<td>ip address 10.9.9.9 255.255.255.255</td>
</tr>
<tr>
<td>ip address 10.8.8.8 255.255.255.255</td>
<td>!</td>
</tr>
<tr>
<td>!</td>
<td>interface FastEthernet0/0</td>
</tr>
<tr>
<td>interface FastEthernet1/0.1</td>
<td>no ip address</td>
</tr>
<tr>
<td>encapsulation dot1q 100</td>
<td>!</td>
</tr>
<tr>
<td>xconnect 10.9.9.9 123 pw-class atom-eth-iw</td>
<td>interface FastEthernet1/0</td>
</tr>
<tr>
<td></td>
<td>xconnect 10.9.9.9 123 pw-class atom</td>
</tr>
</tbody>
</table>

Frame Relay to VLAN over L2TPV3 (Routed) Example

The following example shows the configuration of Frame Relay to VLAN over L2TPv3:
<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>configure terminal</td>
<td>configure terminal</td>
</tr>
<tr>
<td>ip cef</td>
<td>ip routing</td>
</tr>
<tr>
<td>frame-relay switching</td>
<td>ip cef</td>
</tr>
<tr>
<td>!</td>
<td>frame-relay switching</td>
</tr>
<tr>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>interface loopback 0</td>
<td>interface loopback 0</td>
</tr>
<tr>
<td>ip address 10.8.8.8 255.255.255.255</td>
<td>ip address 10.9.9.9 255.255.255.255</td>
</tr>
<tr>
<td>no shutdown</td>
<td>no shutdown</td>
</tr>
<tr>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>pseudowire-class ip</td>
<td>pseudowire-class ip</td>
</tr>
<tr>
<td>encapsulation l2tpv3</td>
<td>encapsulation l2tpv3</td>
</tr>
<tr>
<td>interworking ip</td>
<td>interworking ip</td>
</tr>
<tr>
<td>ip local interface loopback0</td>
<td>ip local interface loopback0</td>
</tr>
<tr>
<td>!</td>
<td>!</td>
</tr>
<tr>
<td>interface POS1/0</td>
<td>interface FastEthernet1/0/1</td>
</tr>
<tr>
<td>encapsulation frame-relay</td>
<td>speed 10</td>
</tr>
<tr>
<td>clock source internal</td>
<td>no shutdown</td>
</tr>
<tr>
<td>logging event dlcis-status-change</td>
<td>!</td>
</tr>
<tr>
<td>no shutdown</td>
<td>interface FastEthernet1/0/1.6</td>
</tr>
<tr>
<td>no fair-queue</td>
<td>encapsulation dot1Q 6</td>
</tr>
<tr>
<td>!</td>
<td>xconnect 10.8.8.8 6 pw-class ip</td>
</tr>
<tr>
<td>connect fr-vlan POS1/0 206 l2transport</td>
<td>no shutdown</td>
</tr>
<tr>
<td>xconnect 10.9.9.9 6 pw-class ip</td>
<td>!</td>
</tr>
<tr>
<td>!</td>
<td>router ospf 10</td>
</tr>
<tr>
<td>router ospf 10</td>
<td>network 10.0.0.2 0.0.0.0 area 0</td>
</tr>
<tr>
<td>network 10.0.0.2 0.0.0.0 area 0</td>
<td>network 10.9.9.9 0.0.0.0 area 0</td>
</tr>
<tr>
<td>network 10.8.8.8 0.0.0.0 area 0</td>
<td>network 10.8.8.8 0.0.0.0 area 0</td>
</tr>
</tbody>
</table>
### Frame Relay to VLAN over AToM (Routed) Example

The following example shows the configuration of Frame Relay to VLAN over AToM:

<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>configure terminal</td>
<td>configure terminal</td>
</tr>
<tr>
<td>ip cef</td>
<td>ip cef</td>
</tr>
<tr>
<td>frame-relay switching</td>
<td>frame-relay switching</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>mpls label protocol ldp</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls ldp router-id loopback0</td>
<td>mpls ldp router-id loopback0</td>
</tr>
<tr>
<td>mpls ip</td>
<td>mpls ip</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>pseudowire-class atom</td>
<td>pseudowire-class atom</td>
</tr>
<tr>
<td>encapsulation mpls</td>
<td>encapsulation mpls</td>
</tr>
<tr>
<td>interworking ip</td>
<td>interworking ip</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface loopback 0</td>
<td>interface loopback 0</td>
</tr>
<tr>
<td>ip address 10.8.8.8 255.255.255.255</td>
<td>ip address 10.9.9.9 255.255.255.255</td>
</tr>
<tr>
<td>no shutdown</td>
<td>no shutdown</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>connect fr-vlan POS1/0 206 l2transport</td>
<td></td>
</tr>
<tr>
<td>xconnect 10.9.9.9 6 pw-class atom</td>
<td>interface FastEthernet1/0/1.6</td>
</tr>
<tr>
<td></td>
<td>encapsulation dot1Q 6</td>
</tr>
<tr>
<td></td>
<td>xconnect 10.8.8.8 6 pw-class atom</td>
</tr>
<tr>
<td></td>
<td>no shutdown</td>
</tr>
</tbody>
</table>
Frame Relay to ATM AAL5 over AToM (Routed) Example

Note
Frame Relay to ATM AAL5 is available only with AToM in IP mode.

The following example shows the configuration of Frame Relay to ATM AAL5 over AToM:
### VLAN to ATM AAL5 over AToM (Bridged) Example

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

<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ip cef</td>
<td>ip cef</td>
</tr>
<tr>
<td>frame-relay switching</td>
<td>mpls ip</td>
</tr>
<tr>
<td>mpls ip</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls label protocol ldp</td>
<td>mpls ldp router-id loopback0 force</td>
</tr>
<tr>
<td>mpls ldp router-id loopback0 force</td>
<td>pseudowire-class fratmip</td>
</tr>
<tr>
<td>pseudowire-class fratmip</td>
<td>encapsulation mpls</td>
</tr>
<tr>
<td>encapsulation mpls</td>
<td>interworking ip</td>
</tr>
<tr>
<td>interworking ip</td>
<td>interface Loopback0</td>
</tr>
<tr>
<td>interface Loopback0</td>
<td>ip address 10.22.22.22 255.255.255.255</td>
</tr>
<tr>
<td>ip address 10.33.33.33 255.255.255.255</td>
<td>interface ATM 2/0</td>
</tr>
<tr>
<td>interface serial 2/0</td>
<td>pvc 0/203 l2transport</td>
</tr>
<tr>
<td>encapsulation frame-relay ietf</td>
<td>encapsulation aa5snap</td>
</tr>
<tr>
<td>frame-relay intf-type dce</td>
<td>xconnect 10.33.33.33 333 pw-class fratmip</td>
</tr>
<tr>
<td>connect fr-eth serial 2/0 100 l2transport</td>
<td>interface POS1/0</td>
</tr>
<tr>
<td>xconnect 10.22.22.22 333 pw-class fratmip</td>
<td>ip address 10.1.1.2 255.255.255.0</td>
</tr>
<tr>
<td>interface POS1/0</td>
<td>crc 32</td>
</tr>
<tr>
<td>ip address 10.1.7.3 255.255.255.0</td>
<td>clock source internal</td>
</tr>
<tr>
<td>crc 32</td>
<td>mpls ip</td>
</tr>
<tr>
<td>clock source internal</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls ip</td>
<td>router ospf 10</td>
</tr>
<tr>
<td>mpls label protocol ldp</td>
<td>passive-interface Loopback0</td>
</tr>
<tr>
<td>router ospf 10</td>
<td>network 10.22.22.22 0.0.0.0 area 10</td>
</tr>
<tr>
<td>passive-interface Loopback0</td>
<td>network 10.1.1.0 0.0.0.255 area 10</td>
</tr>
<tr>
<td>network 10.33.33.33 0.0.0.0 area 10</td>
<td>network 10.1.7.0 0.0.0.255 area 10</td>
</tr>
</tbody>
</table>
Frame Relay to PPP over L2TPv3 (Routed) Example

The following example shows the configuration of Frame Relay to PPP over L2TPv3:

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

Frame Relay to PPP over L2TPv3 (Routed) Example

The following example shows the configuration of Frame Relay to PPP over L2TPv3:
---

**PE1**

```text
ip cef
ip routing!
!
frame-relay switching
!
pseudowire-class ppp-fr
en encapsulation l2tpv3
interworking ip
ip local interface Loopback0
!
interface Loopback0
ip address 10.1.1.1 255.255.255.255
!
interface FastEthernet1/0/0
ip address 10.16.1.1 255.255.255.0
!
interface Serial3/0/0
no ip address
encapsulation ppp
ppp authentication chap
!
ip route 10.0.0.0 255.0.0.0 10.16.1.2
!
xconnect 10.2.2.2 1 pw-class ppp-fr
ppp ipcp address proxy 10.65.32.14
```

**PE2**

```text
ip cef
ip routing!
!
pseudowire-class ppp-fr
encapsulation l2tpv3
interworking ip
ip local interface Loopback0
!
interface Loopback0
ip address 10.2.2.2 255.255.255.255
!
interface FastEthernet1/0/0
ip address 10.16.2.1 255.255.255.0
!
interface Serial3/0/0
no ip address
encapsulation frame-relay
frame-relay intf-type dce
!
ip route 10.0.0.0 255.0.0.0 10.16.2.2
!
xconnect 10.1.1.1 100 pw-class ppp-fr
connect ppp-fr Serial3/0/0 100 l2transport
```
Frame Relay to PPP over AToM (Routed) Example

The following example shows the configuration of Frame Relay to PPP over AToM:
<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ip cef</td>
<td>ip cef</td>
</tr>
<tr>
<td>ip routing</td>
<td>ip routing</td>
</tr>
<tr>
<td>mpls label protocol ldp</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls ldp router-id loopback0 force</td>
<td>mpls ldp router-id loopback0 force</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>frame-relay switching</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>pseudowire-class ppp-fr</td>
<td>pseudowire-class ppp-fr</td>
</tr>
<tr>
<td>encapsulation mpls</td>
<td>encapsulation mpls</td>
</tr>
<tr>
<td>interworking ip</td>
<td>interworking ip</td>
</tr>
<tr>
<td>ip local interface Loopback0</td>
<td>ip local interface Loopback0</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface Loopback0</td>
<td>interface Loopback0</td>
</tr>
<tr>
<td>ip address 10.1.1.1 255.255.255.255</td>
<td>ip address 10.2.2.2 255.255.255.255</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface FastEthernet1/0/0</td>
<td>interface FastEthernet1/0/0</td>
</tr>
<tr>
<td>ip address 10.16.1.1 255.255.255.0</td>
<td>ip address 10.16.2.1 255.255.255.0</td>
</tr>
<tr>
<td>mpls ip</td>
<td>mpls ip</td>
</tr>
<tr>
<td>label protocol ldp</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface Serial3/0/0</td>
<td>interface Serial3/0/0</td>
</tr>
<tr>
<td>no ip address</td>
<td>no ip address</td>
</tr>
<tr>
<td>encapsulation ppp</td>
<td>encapsulation frame-relay</td>
</tr>
<tr>
<td>ppp authentication chap</td>
<td>frame-relay intf-type dce</td>
</tr>
<tr>
<td>xconnect 10.2.2.2 1 pw-class ppp-fr</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>ppp ipcp address proxy 10.65.32.14</td>
<td>ip route 10.0.0.0 255.0.0.0 10.16.2.2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>ip route 10.0.0.0 255.0.0.0 10.16.1.2</td>
<td>connect ppp-fr Serial3/0/0 100 l2transport</td>
</tr>
<tr>
<td></td>
<td>xconnect 10.1.1.1 100 pw-class ppp-fr</td>
</tr>
</tbody>
</table>
Ethernet VLAN to PPP over AToM (Routed) Example

The following example shows the configuration of Ethernet VLAN to PPP over AToM:
<table>
<thead>
<tr>
<th>PE1</th>
<th>PE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>configure terminal</td>
<td>configure terminal</td>
</tr>
<tr>
<td>mpls label protocol ldp</td>
<td>mpls label protocol ldp</td>
</tr>
<tr>
<td>mpls ldp router-id Loopback0</td>
<td>mpls ldp router-id Loopback0</td>
</tr>
<tr>
<td>mpls ip</td>
<td>mpls ip</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>pseudowire-class ppp-ether</td>
<td>pseudowire-class ppp-ether</td>
</tr>
<tr>
<td>encapsulation mpls</td>
<td>encapsulation mpls</td>
</tr>
<tr>
<td>interworking ip</td>
<td>interworking ip</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface Loopback0</td>
<td>interface Loopback0</td>
</tr>
<tr>
<td>ip address 10.8.8.8 255.255.255.255</td>
<td>ip address 10.9.9.9 255.255.255.255</td>
</tr>
<tr>
<td>no shutdown</td>
<td>no shutdown</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>interface POS2/0/1</td>
<td>interface vlan300</td>
</tr>
<tr>
<td>no ip address</td>
<td>mtu 4470</td>
</tr>
<tr>
<td>encapsulation ppp</td>
<td>no ip address</td>
</tr>
<tr>
<td>no peer default ip address</td>
<td>xconnect 10.8.8.8 300 pw-class ppp-ether</td>
</tr>
<tr>
<td>ppp ipcp address proxy 10.10.10.1</td>
<td>no shutdown</td>
</tr>
<tr>
<td>xconnect 10.9.9.9 300 pw-class ppp-ether</td>
<td>!</td>
</tr>
<tr>
<td>no shutdown</td>
<td>interface GigabitEthernet6/2</td>
</tr>
<tr>
<td></td>
<td>switchport</td>
</tr>
<tr>
<td></td>
<td>switchport trunk encapsulation dot1q</td>
</tr>
<tr>
<td></td>
<td>switchport trunk allowed vlan 300</td>
</tr>
<tr>
<td></td>
<td>switchport mode trunk</td>
</tr>
<tr>
<td></td>
<td>no shutdown</td>
</tr>
</tbody>
</table>
# Additional References

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

## Related Documents

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 2 Tunnel Protocol Version 3</td>
<td>Layer 2 Tunnel Protocol Version 3</td>
</tr>
<tr>
<td>Any Transport over MPLS</td>
<td>Any Transport over MPLS</td>
</tr>
<tr>
<td>Cisco 3270 series routers hardware support</td>
<td>Cisco IOS Software Releases 12.2SE Release Notes</td>
</tr>
</tbody>
</table>

## Standards

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

<table>
<thead>
<tr>
<th>MIBs</th>
<th>MIBs Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new or modified MIBs are supported by this feature, and support for existing MIBs has not been modified by this feature.</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
</tr>
</tbody>
</table>

RFCs

<table>
<thead>
<tr>
<th>RFCs</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.</td>
<td>--</td>
</tr>
</tbody>
</table>

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></td>
</tr>
</tbody>
</table>

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 17 | Feature Information for L2VPN Interworking

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2VPN Interworking</td>
<td>12.0(26)S</td>
<td>This feature allows disparate attachment circuits to be connected. An interworking function facilitates the translation between the different Layer 2 encapsulations. This feature was introduced in Cisco IOS Release 12.0(26)S.</td>
</tr>
<tr>
<td></td>
<td>12.0(30)S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.0(32)S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.0(32)SY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2(33)SXH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.4(11)T</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2(33)SE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.2(33)SRE</td>
<td></td>
</tr>
</tbody>
</table>

In Cisco IOS Release 12.0(30)S, support was added for Cisco 12000 series Internet routers.

In Cisco IOS Release 12.0(32)S, support was added on Engine 5 line cards (SIP-401, SIP-501, SIP-600, and SIP-601) in Cisco 12000 series routers for the following four transport types:

- Ethernet/VLAN to Frame Relay Interworking
- Ethernet/VLAN to ATM AAL5 Interworking
- Ethernet to VLAN Interworking
- Frame Relay to ATM AAL5 Interworking

On the Cisco 12000 series Internet router, support was added for IP Services Engine (ISE) and Engine 5 line cards that are configured for L2TPv3 tunneling.

In Cisco IOS Release 12.2(33)SRA, support was added for the Cisco 7600 series routers.

In Cisco IOS Release 12.4(11)T, support was added for the following transport types:

- Ethernet to VLAN Interworking
- Ethernet/VLAN to Frame Relay Interworking

This feature was integrated into Cisco IOS Release 12.2(33)SXH.

In Cisco IOS Release 12.2(33)SRD, support for routed
<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>and bridged interworking on SIP-400 was added for the Cisco 7600 series routers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Cisco IOS Release 12.2(52)SE, the L2VPN Internetworking: VLAN Enable/Disable option for AToM feature was added for the Cisco 3750 Metro switch.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In Cisco IOS Release 12.2(33)SRE, the L2VPN Internetworking: VLAN Enable/Disable option for AToM feature was added for the Cisco 7600 series router.</td>
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<tr>
<td></td>
<td></td>
<td>The following commands were introduced or modified:</td>
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<tr>
<td></td>
<td></td>
<td><strong>interworking</strong></td>
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Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.
L2VPN Pseudowire Redundancy

The L2VPN Pseudowire Redundancy feature lets you configure your network to detect a failure in the network and reroute the Layer 2 (L2) service to another endpoint that can continue to provide service. This feature provides the ability to recover from a failure either of the remote provider edge (PE) router or of the link between the PE and customer edge (CE) routers.

- Finding Feature Information, page 173
- Prerequisites for L2VPN Pseudowire Redundancy, page 173
- Restrictions for L2VPN Pseudowire Redundancy, page 174
- Information About L2VPN Pseudowire Redundancy, page 174
- How to Configure L2VPN Pseudowire Redundancy, page 176
- Configuration Examples for L2VPN Pseudowire Redundancy, page 181
- Additional References, page 183
- Feature Information for L2VPN Pseudowire Redundancy, page 184

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 Pseudowire Redundancy

- This feature module requires that you understand how to configure basic L2 virtual private networks (VPNs). You can find that information in the following documents:
  - Any Transport over MPLS
  - L2 VPN Interworking
- The L2VPN Pseudowire Redundancy feature requires that the following mechanisms be in place to enable you to detect a failure in the network:
  - Label-switched paths (LSP) Ping/Traceroute and Any Transport over MPLS Virtual Circuit Connection Verification (AToM VCCV)
  - Local Management Interface (LMI)
Restrictions for L2VPN Pseudowire Redundancy

General Restrictions

- The primary and backup pseudowires must run the same type of transport service. The primary and backup pseudowires must be configured with AToM.
- Only static, on-box provisioning is supported.
- If you use L2VPN Pseudowire Redundancy with L2VPN Interworking, the interworking method must be the same for the primary and backup pseudowires.
- Setting the experimental (EXP) bit on the Multiprotocol Label Switching (MPLS) pseudowire is supported.
- Different pseudowire encapsulation types on the MPLS pseudowire are not supported.
- The mpls l2transport route command is not supported. Use the xconnect command instead.
- The ability to have the backup pseudowire fully operational at the same time that the primary pseudowire is operational is not supported. The backup pseudowire becomes active only after the primary pseudowire fails.
- The AToM VCCV feature is supported only on the active pseudowire.
- More than one backup pseudowire is not supported.

Restrictions for Layer 2 Tunnel Protocol Version 3 (L2TPv3) Xconnect Configurations

- Interworking is not supported.
- Local switching backup by pseudowire redundancy is not supported.
- PPP, HDLC, and Frame-Relay attachment circuit (AC) types of L2TPv3 pseudowire redundancy are not supported.
- For the edge interface, only the Cisco 7600 series SPA Interface Processor-400 (SIP-400) linecard with the following shared port adapters (SPAs) is supported:
  - Cisco 2-Port Gigabit Ethernet Shared Port Adapter (SPA-2X1GE)
  - Cisco 5-Port Gigabit Ethernet Shared Port Adapter, Version 2 (SPA-5X1GE-V2)
  - Cisco 10-Port Gigabit Ethernet Shared Port Adapter, Version 2 (SPA-10X1GE-V2)
  - Cisco 2-Port OC3c/STM1c ATM Shared Port Adapter (SPA-2XOC3-ATM)
  - Cisco 4-Port OC3c/STM1c ATM Shared Port Adapter (SPA-4XOC3-ATM)
  - Cisco 1-Port OC12c/STM4c ATM Shared Port Adapter (SPA-1XOC12-ATM)
  - Cisco 1-Port OC-48c/STM-16 ATM Shared Port Adapter (SPA-1XOC48-ATM)

Information About L2VPN Pseudowire Redundancy

- Introduction to L2VPN Pseudowire Redundancy, page 174

Introduction to L2VPN Pseudowire Redundancy

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

Figure 5  Points of Potential Failure in an L2VPN Network

X1 = End-to-end routing failure
X2 = PE hardware or software failure
X3 = Attachment circuit failure from a line break
X4 = CE hardware or software failure

The L2VPN Pseudowire Redundancy feature provides the ability to ensure that the CE2 router in the figure
above can always maintain network connectivity, even if one or all the failures in the figure occur.

The L2VPN Pseudowire Redundancy feature enables you to set up backup pseudowires. You can configure
the network with redundant pseudowires (PWs) and redundant network elements, which are shown in the
three figures below.

The figure below shows a network with redundant pseudowires and redundant attachment circuits.

Figure 6  L2VPN Network with Redundant PWs and Attachment Circuits

The figure below shows a network with redundant pseudowires, attachment circuits, and CE routers.

Figure 7  L2VPN Network with Redundant PWs, Attachment Circuits, and CE Routers
The figure below shows a network with redundant pseudowires, attachment circuits, CE routers, and PE routers.

**Figure 8** L2VPN Network with Redundant PWs, Attachment Circuits, CE Routers, and PE Routers

---

**How to Configure L2VPN Pseudowire Redundancy**

The L2VPN Pseudowire Redundancy feature enables you to configure a backup pseudowire in case the primary pseudowire fails. When the primary pseudowire fails, the PE router can switch to the backup pseudowire. You can have the primary pseudowire resume operation after it comes back up.

The default Label Distribution Protocol (LDP) session hold-down timer will enable the software to detect failures in about 180 seconds. That time can be configured so that the software can detect failures more quickly. See the `mpls ldp holdtime` command for more information.

- Configuring the Pseudowire, page 176
- Configuring L2VPN Pseudowire Redundancy, page 177
- Forcing a Manual Switchover to the Backup Pseudowire VC, page 179
- Verifying the L2VPN Pseudowire Redundancy Configuration, page 180

**Configuring the Pseudowire**

The successful transmission of the Layer 2 frames between PE routers is due to the configuration of the PE routers. You set up the connection, called a pseudowire, between the routers.

The pseudowire-class configuration group specifies the characteristics of the tunneling mechanism, which are:

- Encapsulation type
- Control protocol
- Payload-specific options

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

```
% Incomplete command.
```

Perform this task to configure a pseudowire class.
### SUMMARY STEPS

1. enable
2. configure terminal
3. pseudowire-class name
4. encapsulation mpls
5. interworking {ethernet | ip}

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> configure terminal</td>
<td>Enters global configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router# configure terminal</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> pseudowire-class name</td>
<td>Establishes a pseudowire class with a name that you specify. Enters pseudowire class configuration mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config)# pseudowire-class atom</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> encapsulation mpls</td>
<td>Specifies the tunneling encapsulation. For AToM, the encapsulation type is mpls.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pw-class)# encapsulation mpls</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> interworking {ethernet</td>
<td>ip}</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router(config-pw-class)# interworking ip</td>
<td></td>
</tr>
</tbody>
</table>

### Configuring L2VPN Pseudowire Redundancy

Use the following steps to configure the L2VPN Pseudowire Redundancy feature.

For each transport type, the `xconnect` command is configured slightly differently. The following configuration steps use Ethernet VLAN over MPLS, which is configured in subinterface configuration.
mode. See *Any Transport over MPLS* to determine how to configure the `xconnect` command for other transport types.

**SUMMARY STEPS**

1. enable
2. configure terminal
3. interface gigabitethernet `slot | subslot | interface . subinterface`
4. encapsulation `dot1q` vlan-id
5. xconnect `peer-router-id vcid {encapsulation mpls| pw-class pw-class-name}`
6. backup peer `peer-router-ip-addr vcid [pw-class pw-class-name]`
7. backup delay `enable-delay {disable-delay | never}`

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td></td>
<td>• Enter your password if prompted.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

| **Step 2** configure terminal | Enters global configuration mode.                                        |
| Example:                     |                                                                         |
| Router# configure terminal   |                                                                         |

| **Step 3** interface gigabitethernet `slot | subslot | interface . subinterface` | Specifies the Gigabit Ethernet subinterface and enters subinterface configuration mode. |
| Example:                     | Make sure that the subinterface on the adjoining CE router is on the same VLAN as this PE router. |
| Router(config)# interface gigabitethernet0/0/0.1 |                                                                                      |

| **Step 4** encapsulation `dot1q` vlan-id | Enables the subinterface to accept 802.1Q VLAN packets. The subinterfaces between the CE and PE routers that are running Ethernet over MPLS must be in the same subnet. All other subinterfaces and backbone routers do not. |
| Example: |                                                                         |
| Router(config-subif)# encapsulation dot1q 100 |                                                                         |
## Command or Action

### Purpose

**Step 5**

```text
xconnect peer-router-id vcid {encapsulation mpls|
pw-class pw-class-name}
```

Binds the attachment circuit to a pseudowire VC.

The syntax for this command is the same as for all other Layer 2 transports.

Enters xconnect configuration mode.

**Example:**

```text
Router(config-subif)# xconnect 10.0.0.1 123 pw-class atom
```

**Step 6**

```text
backup peer peer-router-ip-addr vcid [pw-class pw-class-name]
```

Specifies a redundant peer for the pseudowire VC.

The pseudowire class name must match the name you specified when you created the pseudowire class, but you can use a different pw-class in the `backup peer` command than the name that you used in the primary `xconnect` command.

**Example:**

```text
Router(config-if-xconn)# backup peer 10.0.0.3 125 pw-class atom
```

**Step 7**

```text
backup delay e nable-delay {disable-delay | never}
```

Specifies how long (in seconds) the backup pseudowire VC should wait to take over after the primary pseudowire VC goes down. The range is 0 to 180.

Specifies how long the primary pseudowire should wait after it becomes active to take over for the backup pseudowire VC. The range is 0 to 180 seconds. If you specify the `never` keyword, the primary pseudowire VC never takes over for the backup.

**Example:**

```text
Router(config-if-xconn)# backup delay 5 never
```

---

## Forcing a Manual Switchover to the Backup Pseudowire VC

To force the router switch over to the backup or primary pseudowire, you can enter the `xconnect backup force switchover` command in privileged EXEC mode. You can specify either the interface of the primary attachment circuit (AC) to switch to or the IP-address and VC ID of the peer router.

A manual switchover can be made only if the interface or peer specified in the command is actually available and the xconnect will move to the fully active state when the command is entered.

### SUMMARY STEPS

1. **enable**
2. **xconnect backup force-switchover**

### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> enable</td>
<td>Enables privileged EXEC mode.</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td></td>
</tr>
<tr>
<td>Router&gt; enable</td>
<td></td>
</tr>
</tbody>
</table>

---

MPLS: Layer 2 VPNs, Configuration Guide, Cisco IOS Release 12.4T
### Command or Action

<table>
<thead>
<tr>
<th>Step 2</th>
<th>xconnect backup force-switchover [ interface interface-info ] peer ip-address vcid</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Specifies that the router should switch to the backup or to the primary pseudowire.</td>
<td></td>
</tr>
</tbody>
</table>

**Example:**

Router# xconnect backup force-switchover peer 10.10.10.1 123

### Verifying the L2VPN Pseudowire Redundancy Configuration

Use the following commands to verify that the L2VPN Pseudowire Redundancy feature is correctly configured.

**SUMMARY STEPS**

1. `show mpls l2transport vc`
2. `show xconnect all`
3. `xconnect logging redundancy`

**DETAILED STEPS**

#### Step 1

**show mpls l2transport vc**

In this example, the primary attachment circuit is up. The backup attachment circuit is available, but not currently selected. The `show` output displays as follows:

**Example:**

```
Router# show mpls l2transport vc
Local intf     Local circuit           Dest address    VC ID      Status
-------------  ----------------------- --------------- ---------- ----------
Et0/0.1        Eth VLAN 101            10.0.0.2        101        UP
Et0/0.1        Eth VLAN 101            10.0.0.3        201        DOWN
```

#### Step 2

**show xconnect all**

In this example, the topology is Attachment Circuit 1 to Pseudowire 1 with a Pseudowire 2 as a backup:

**Example:**

```
Router# show xconnect all
Legend: XC ST=Xconnect State, S1=Segment1 State, S2=Segment2 State
```
In this example, the topology is Attachment Circuit 1 to Attachment Circuit 2 with a Pseudowire backup for Attachment Circuit 2:

Example:

Router# show xconnect all
Legend: XC ST=Xconnect State, S1=Segment1 State, S2=Segment2 State
UP=Up, DN=Down, AD=Admin Down, IA=Inactive, NH=No Hardware
<table>
<thead>
<tr>
<th>XC ST</th>
<th>Segment 1</th>
<th>S1</th>
<th>Segment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>UP pri ac</td>
<td>Et0/0(Ethernet)</td>
<td>UP mpls 10.55.55.2:1000</td>
<td>UP</td>
</tr>
<tr>
<td>IA sec ac</td>
<td>Et0/0(Ethernet)</td>
<td>UP mpls 10.55.55.3:1001</td>
<td>DN</td>
</tr>
</tbody>
</table>

Step 3 xconnect logging redundancy
In addition to the `show mpls l2transport vc` command and the `show xconnect` command, you can use the `xconnect logging redundancy` command to track the status of the xconnect redundancy group:

Example:

Router(config)# xconnect logging redundancy
When this command is configured, the following messages will be generated during switchover events:

Activating the primary member:

Example:

00:01:07: %XCONNECT-5-REDUNDANCY: Activating primary member 10.55.55.2:1000

Activating the backup member:

Example:

00:01:05: %XCONNECT-5-REDUNDANCY: Activating secondary member 10.55.55.3:1001

Configuration Examples for L2VPN Pseudowire Redundancy

Each of the configuration examples refers to one of the following pseudowire classes:

- AToM (like-to-like) pseudowire class:

  pseudowire-class mpls
  encapsulation mpls

- L2VPN IP interworking:

  pseudowire-class mpls-ip
L2VPN Pseudowire Redundancy and AToM Like to Like Examples

The following example shows a High-Level Data Link Control (HDLC) attachment circuit xconnect with a backup pseudowire:

```
interface Serial4/0
  xconnect 10.55.55.2 4000 pw-class mpls
  backup peer 10.55.55.3 4001 pw-class mpls
```

The following example shows a Frame Relay attachment circuit xconnect with a backup pseudowire:

```
connect fr-fr-pw Serial6/0 225 l2transport
  xconnect 10.55.55.2 5225 pw-class mpls
  backup peer 10.55.55.3 5226 pw-class mpls
```

L2VPN Pseudowire Redundancy and L2VPN Interworking Examples

The following example shows an Ethernet attachment circuit xconnect with L2VPN IP interworking and a backup pseudowire:

```
interface Ethernet0/0
  xconnect 10.55.55.2 1000 pw-class mpls-ip
  backup peer 10.55.55.3 1001 pw-class mpls-ip
```

The following example shows an Ethernet VLAN attachment circuit xconnect with L2VPN IP interworking and a backup pseudowire:

```
interface Ethernet1/0.1
  encapsulation dot1Q 200
  no ip directed-broadcast
  xconnect 10.55.55.2 5200 pw-class mpls-ip
  backup peer 10.55.55.3 5201 pw-class mpls-ip
```

The following example shows a Frame Relay attachment circuit xconnect with L2VPN IP interworking and a backup pseudowire:

```
connect fr-ppp-pw Serial6/0 250 l2transport
  xconnect 10.55.55.2 8250 pw-class mpls-ip
  backup peer 10.55.55.3 8251 pw-class mpla-ip
```

The following example shows a PPP attachment circuit xconnect with L2VPN IP interworking and a backup pseudowire:

```
interface Serial7/0
  encapsulation ppp
  xconnect 10.55.55.2 2175 pw-class mpls-ip
  backup peer 10.55.55.3 2176 pw-class mpls-ip
```
L2VPN Pseudowire Redundancy with Layer 2 Local Switching Examples

The following example shows an Ethernet VLAN-VLAN local switching xconnect with a pseudowire backup for Ethernet segment E2/0.2. If the subinterface associated with E2/0.2 goes down, the backup pseudowire is activated.

```plaintext
connect vlan-vlan Ethernet1/0.2 Ethernet2/0.2
    backup peer 10.55.55.3 1101 pw-class mpls
```

The following example shows a Frame Relay-to-Frame Relay local switching connect with a pseudowire backup for Frame Relay segment S8/0 150. If data-link connection identifier (DLCI) 150 on S8/0 goes down, the backup pseudowire is activated.

```plaintext
connect fr-fr-ls Serial6/0 150 Serial8/0 150
    backup peer 10.55.55.3 7151 pw-class mpls
```

Additional References

<table>
<thead>
<tr>
<th>Related Topic</th>
<th>Document Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Transport over MPLS</td>
<td>Any Transport over MPLS</td>
</tr>
<tr>
<td>High Availability for ATom</td>
<td>ATOM Graceful Restart</td>
</tr>
<tr>
<td>L2VPN Interworking</td>
<td>L2VPN Interworking</td>
</tr>
<tr>
<td>Layer 2 local switching</td>
<td>Layer 2 Local Switching</td>
</tr>
<tr>
<td>PWE3 MIB</td>
<td>Pseudowire Emulation Edge-to-Edge MIBs for Ethernet and Frame Relay Services</td>
</tr>
<tr>
<td>Packet sequencing</td>
<td>Any Transport over MPLS (ATOM) Sequencing Support</td>
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</table>

Standards

<table>
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<tr>
<th>Standards</th>
<th>Title</th>
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MIBs

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<tr>
<th>MIBs</th>
<th>MIBs Link</th>
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<td>None</td>
<td>To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a></td>
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RFCs

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<th>Title</th>
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</thead>
<tbody>
<tr>
<td>None</td>
<td>--</td>
</tr>
</tbody>
</table>

Technical Assistance

<table>
<thead>
<tr>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.</td>
<td><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></td>
</tr>
</tbody>
</table>

Feature Information for L2VPN Pseudowire Redundancy

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

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.
### Table 18  Feature Information for L2VPN Pseudowire Redundancy

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Releases</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2VPN Pseudowire Redundancy</td>
<td>12.0(31)S 12.2(28)SB 12.4(11)T 12.2(33)SRB 12.2(22)SXI 15.0(1)S</td>
<td>This feature enables you to set up your network to detect a failure in the network and reroute the Layer 2 service to another endpoint that can continue to provide service. In Cisco IOS Release 12.0(31)S, the L2VPN Pseudowire Redundancy feature was introduced for Any Transport over MPLS (AToM) on the Cisco 12000 series routers. This feature was integrated into Cisco IOS Release 12.2(28)SB. This feature was integrated into Cisco IOS Release 12.4(11)T. This feature was integrated into Cisco IOS Release 12.2(33)SRB. This feature was integrated into Cisco IOS Release 12.2(33)SXI. The following commands were introduced or modified: <code>backup delay (L2VPN local switching)</code>, <code>backup peer</code>, <code>show xconnect</code>, <code>xconnect backup force-switchover</code>, <code>xconnect logging redundancy</code>.</td>
</tr>
<tr>
<td>L2VPN Pseudowire Redundancy for L2TPv3</td>
<td>12.2(33)SRE 15.0(1)S</td>
<td>This feature provides L2VPN pseudowire redundancy for L2TPv3 xconnect configurations. In Cisco IOS Release 12.2(33)SRE, this feature was implemented on the Cisco 7600 series routers. The following commands were introduced or modified: <code>aps hspw-icrm-grp</code>, <code>show hspw-aps-icrm</code>.</td>
</tr>
<tr>
<td>Resilient Pseudowire (RPW): PW Fast Recovery</td>
<td>15.2(1)S</td>
<td>This feature was integrated into Cisco IOS Release 15.2(1)S. The following commands were introduced or modified: <code>aps hspw-icrm-grp</code>, <code>show hspw-aps-icrm</code>.</td>
</tr>
</tbody>
</table>
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