Any Transport over MPLS

Any Transport over MPLS (AToM) transports Layer 2 packets over a Multiprotocol Label Switching (MPLS) backbone. AToM enables service providers to connect customer sites with existing data link layer (Layer 2) networks, by using a single, integrated, packet-based network infrastructure — a Cisco MPLS network. Instead of separate networks with network management environments, service providers can deliver Layer 2 connections over an MPLS backbone. AToM provides 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 AAL5 over MPLS
- ATM Cell Relay over MPLS
- Ethernet over MPLS (VLAN and port modes)
- Frame Relay over MPLS
- PPP over MPLS
- HDLC over MPLS

Feature Specifications for Any Transport over MPLS

Feature History	
Release	**Modification**
12.0(10)ST	Any Transport over MPLS: ATM AAL5 over MPLS was introduced on the Cisco 12000 series routers.
12.1(8a)E	Any Transport over MPLS: Ethernet over MPLS was introduced on the Cisco 7600 series Internet router.
12.0(21)ST	Ethernet over MPLS was introduced on the Cisco 12000 series routers. ATM AAL5 over MPLS was updated.
12.0(22)S	Ethernet over MPLS was integrated into this release. Support for the Cisco 10720 router was added. ATM AAL5 over MPLS was integrated into this release for the Cisco 12000 series routers.
12.0(23)S	The following new features were introduced: • ATM Cell Relay over MPLS (single cell relay, VC mode) • Frame Relay over MPLS • HDLC over MPLS • PPP over MPLS These features were supported on the Cisco 7200 and 7500 series routers. The Cisco 12000, 7200, and 7500 series routers supported the following features: • ATM AAL5 over MPLS • Ethernet over MPLS (VLAN mode) The Cisco 10720 Internet router continued support for Ethernet over MPLS.
12.2(14)S	This feature was integrated into Cisco IOS Release 12.2(14)S.
12.2(15)T	This feature was integrated into Cisco IOS Release 12.2(15)T.
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 CEF mode for Frame Relay, PPP, and HDLC over MPLS • Fast reroute with AToM • Tunnel selection • Traffic policing • QoS support

Feature History	
Release	**Modification**
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.)
12.0(27)S	The following new features were introduced: • ATM Cell Relay over MPLS: Packed Cell Relay for VC, VP, 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.
Supported Platforms	
Cisco 7200 series, Cisco 7500 series, Cisco 12000 series, Cisco 10720 Internet router See the sections that describe the features to determine the platforms that support the features. See Prerequisites for Any Transport over MPLS for the supported port adapters and line cards.	

Note Software images for Cisco 12000 series Internet routers have been deferred to Cisco IOS Release 12.0(27)S1.

Finding Support Information for Platforms and Cisco IOS Software Images

Use Cisco Feature Navigator to find information about platform support and Cisco IOS software image support. Access Cisco Feature Navigator at http://www.cisco.com/go/fn. You must have an account on Cisco.com. If you do not have an account or have forgotten your username or password, click **Cancel** at the login dialog box and follow the instructions that appear.

Contents

Prerequisites for Any Transport over MPLS

On the provider edge (PE) routers, AToM requires the hardware specified in the following sections:

Cisco 7200 and 7500 Series Routers: Required Chassis, Processors, and VIPs

- Cisco 7200 series routers
  - Chassis: All 7200-VXR chassis types
  - Processors: NPE-225, NPE-300, and NPE-400
- Cisco 7500 series routers
  - Chassis: All 7500 chassis types
  - Processors: RSP4, RSP4+, RSP8, and RSP16
  - VIPs: VIP2-50, VIP4-50, VIP4-80, and VIP6-80

Note The chassis, processors, and VIPs listed have been tested and are supported for use with MPLS AToM. All other chassis, processors, and VIPs have not been tested and therefore are not supported. In future releases, you will not be able to configure AToM on unsupported hardware.

Cisco 7200 and 7500 Series Routers: Supported Port Adapters

The following port adapters are supported for the Cisco 7200 and 7500 series routers for each transport type.

Transport Type	Supported Port Adapters
ATM AAL5 over MPLS	PA-A3-OC3 PA-A3-E3 **Note** AAL5 over MPLS is not supported on hardware version 1.0 of the PA-A3-OC3 and PA-A3-E3 line cards. PA-A3-DS3 PA-A3-OC12 PA-A3-8T1IMA PA-A3-8E1IMA
ATM Cell Relay over MPLS **Note** ATM Cell Relay over MPLS is not supported on the following port adapters: PA-A1-OC3 PA-A2-OC3	
ATM single cell relay: VC mode	PA-A3-OC3 PA-A3-E3 PA-A3-T3 PA-A3-8T1IMA PA-A3-8E1IMA **Note** ATM Cell Relay is not supported on hardware version 1.0 of the PA-A3-OC3, -E3, and -T3 port adapters.
ATM single cell relay: VP mode	PA-A3-OC3 PA-A3-E3 PA-A3-T3 PA-A3-8T1IMA PA-A3-8E1IMA **Note** ATM Cell Relay is not supported on hardware version 1.0 of the PA-A3- OC3, -E3, and -T3 port adapters.
ATM packed cell relay: VP and VC modes	PA-A3-OC3 PA-A3-E3 PA-A3-T3 **Note** ATM Cell Relay is not supported on hardware version 1.0 of these port adapters.

Transport Type	Supported Port Adapters
Ethernet over MPLS (Port and VLAN modes)	**7200 and 7500**
	PA-2FE
	PA-FE
	7200 only
	C7200-I/O-2FE
	C7200-I/O-GE+E (Only the Gigabit Ethernet port of this port adapter is supported.)
	c7200-I/O-FE
	PA-GE
	7500 only
	GEIP
	GEIP+
Frame Relay over MPLS	PA-MC-8T1
HDLC over MPLS	PA-MC-8E1
PPP over MPLS	PA-MC-2T3+
Note: Starting in Cisco IOS Release 12.0(25)S, channelized port adapters are supported for HDLC and PPP over MPLS.	PA-MC-T3
	PA-T3
	PA-2T3
	PA-T3+
	PA-4T+
	PA-2T3+
	PA-8T-V35
	PA-E3
	PA-2E3
	PA-MC-E3
	PA-MC-2E1
	PA-MC-4T1
	PA-MC-STM1
	PA-MC-8TE1+
	PA-POS-OC3
	PA-HSSI
	PA-2HSSI
	PA-4E1G120
	PA-8T-232
	PA-8T-X21

Cisco 12000 Series Routers: Supported Line Cards

The following line cards are supported for the Cisco 12000 series routers for each transport type.

Transport Type	Supported Line Cards
ATM AAL5 over MPLS	Label imposition: All Engine 0, 2 and 3 ATM line cards Label disposition: All line cards
ATM single cell relay over MPLS: VC mode	Label imposition: • All Engine 0 ATM line cards • Engine 2: 8-Port OC-3 STM-1 ATM line card • Engine 3: 4-Port OC-3X/STM-1 ATM ISE line card • Engine 3: 4-Port ATM ISE line cards Label disposition: All line cards
ATM single cell relay over MPLS: VP mode	Label imposition: • Engine 2: 8-Port OC-3 STM-1 ATM line card • Engine 3: 4-Port OC-3c/STM-1 ATM ISE line card • Engine 3: 4-Port ATM ISE line cards Label disposition: All line cards
ATM single cell relay over MPLS: port mode	Label imposition: • Engine 2: 8-Port OC-3 STM-1 ATM line card • Engine 3: 4-Port OC-3c/STM-1 ATM ISE line card • Engine 3: 4-Port ATM ISE line cards Label disposition: All line cards
ATM packed cell relay over MPLS: VP, VC, and port mode	Label imposition: • Engine 3: 4-Port ATM ISE line cards Label disposition: All line cards
Ethernet VLAN over MPLS	Label imposition: All Engine 2, 3, and 4+ Ethernet line cards Label disposition: All line cards
Ethernet Port Mode over MPLS	Label imposition: All Engine 2, 3, and 4+ Ethernet line cards Label disposition: All line cards
Frame Relay over MPLS	Label imposition: • All Engine 0 POS and channelized line cards • All Engine 2 POS line cards • All Engine 3 POS and channelized line cards Label disposition: All line cards

Transport Type	Supported Line Cards
HDLC over MPLS	Label imposition: • All Engine 0 POS and channelized line cards • All Engine 2 POS line cards • All Engine 3 POS and channelized line cards • All Engine 4+ POS line cards Label disposition: All line cards
PPP over MPLS	Label imposition: • All Engine 0 POS and channelized line cards • All Engine 2 POS line cards • All Engine 3 POS and channelized line cards Label disposition: All line cards

Restrictions for Any Transport over MPLS

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

- Sequencing: AToM does not support detecting of out-of-order packets.
- Address format: Configure the LDP router ID on all PE routers to be a loopback address with a /32 mask. Otherwise, some configurations might not properly function.

ATM AAL5 over MPLS Restrictions

The following restrictions pertain to the ATM AAL5 over MPLS feature:

- **PVC configuration:** You can configure ATM AAL5 over MPLS on permanent virtual circuits (PVCs) only. You cannot configure AAL5 over MPLS on main interfaces.
- **SDU mode:** AAL5 over MPLS is supported only in SDU mode.

ATM Cell Relay over MPLS Restrictions

The following restrictions pertain to the ATM Cell Relay over MPLS feature:

- **TE tunnels:** If you have TE tunnels running between the PE routers, you must enable label distribution protocol (LDP) on the tunnel interfaces.

Ethernet over MPLS Restrictions

The following restrictions pertain to the Ethernet over MPLS feature:

- **Packet format:** 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 customer edge (CE) routers.

Frame Relay over MPLS Restrictions

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

- **Traffic shaping:** Frame Relay traffic shaping is not supported with AToM switched VCs.

HDLC over MPLS Restrictions

The following restrictions pertain to the HDLC over MPLS feature:

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

PPP over MPLS Restrictions

The following restrictions pertain to the PPP over MPLS feature:

- **Zero hops on a PE router:** Zero hops on one router is not supported. However, you can have back-to-back PE routers.
- **Asynchronous interfaces:** 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:** Multilink PPP (MLP) is not supported.
- **Interface configuration:** You must configure PPP on router interfaces only. You cannot configure PPP on subinterfaces.

Restrictions Specific to the Cisco 12000 Series Routers

Fast Reroute

Fast Reroute uses three or more labels, depending on where the Traffic Engineering (TE) tunnel ends:

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

Engine 0 ATM line cards support three or more labels, although 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.

Frame Relay over MPLS

If you configure Frame Relay over MPLS 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 FECN, BECN, CR, and DE bit information is stripped from the PVC.

ATM Cell Relay over MPLS

If you configure the Engine 2 8-Port OC-3 STM-1 ATM line card for ATM single cell relay over MPLS, you cannot configure other Layer 3 features on those ports reserved for ATM cell relay over MPLS.

Information About Any Transport over MPLS

To configure AToM, you must understand the following concepts:

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 set up the connection, called a pseudowire, between the routers. You 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.
- Identifies a unique identifier that is shared between the two PE routers. The *vcid* is a 32-bit identifier.

  The combination of the peer-router-id and the VC ID must be a unique combination on the router. Two circuits cannot use the same combination of peer-router-id and VC ID.
- Specifies the tunneling method used to encapsulate data in the pseudowire. For AToM, the tunneling method used to encapsulate data is **mpls.**

```
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. See the "How to Configure the Pseudowire-Class" section on page 13 for more information.

Compatibility with Previous Releases of AToM

In previous releases of AToM, the command used to configure AToM circuits was **mpls l2 transport route.** This command has been replaced with the **xconnect** command.

No new CLI enhancements will be made to the **mpls l2transport route** command. CLI enhancements will be made to either the **xconnect** command or **pseudowire-class** command. Therefore, we recommend that you use the **xconnect** command to configure AToM circuits.

Configurations from previous releases 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 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 on page 76 for the specific standards that AToM follows.) This benefits the service provider who 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.

How to Configure Any Transport over MPLS

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

Prerequisites

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

- Configure IP routing in the core so that the 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 IP CEF or IP CEF distributed 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 TE tunnel.

How to Configure 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 characteristics of the tunneling mechanism, including:

- Encapsulation type
- Control protocol
- Payload-specific options

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

http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s24/l2tpv3.htm

Once you specify the **encapsulation mpls** command, you cannot remove it using the **no encapsulation mpls** command. Nor can you change the command's setting using the **encapsulation l2tpv3** command. Those methods result in the following error message:

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

To remove the command, you must delete the pseudowire with the **no pseudowire-class** command. To change the type of encapsulation, remove the pseudowire with the **no pseudowire-class** command and re-establish the pseudowire and specify the new encapsulation type.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **pseudowire-class** *name*
4. **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class** *name* **Example:** `Router(config)# pseudowire-class atom`	Establishes a pseudowire class with a name that you specify.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation. For AToM, the encapsulation type is **mpls**.

Configuration Guidelines

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

```
% Incomplete command.
```

How to Configure ATM AAL5 over MPLS

ATM AAL5 over MPLS encapsulates ATM AAL5 SDUs in MPLS packets and forwards them across the MPLS network. Each ATM AAL5 SDU is transported as a single packet. Perform this task to enable ATM AAL5 over MPLS.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface atm***slot/port*
4. **pvc** *vpi/vci* **l2transport**
5. **encapsulation aal5**
6. **xconnect** *peer-router-id vcid* **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface atm***slot/port* **Example:** `Router(config)# interface atm1/0`	Specifies an ATM interface.
Step 4	**pvc** *vpi/vci* **l2transport** **Example:** `Router(config-if)# pvc 1/200 l2transport`	Assigns a virtual path identifier (VPI) and virtual circuit identifier (VCI). The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC. You can configure ATM AAL5 on PVCs only. You cannot configure AAL5 over MPLS on main interfaces.
Step 5	**encapsulation aal5** **Example:** `Router(config-if-atm-l2trans-pvc)# encapsulation aal5`	Specifies ATM AAL5 encapsulation for the PVC. Make sure you specify the same encapsulation type on the PE and CE routers.
Step 6	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if-atm-l2trans-pvc)# xconnect 13.13.13.13 100 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.

Configuring OAM Cell Emulation for ATM AAL5 over MPLS

Supported Platforms:

- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 12000 series routers

Overview of OAM Cell Emulation

If a PE router does not support the transport of OAM cells across an LSP, you can use OAM cell emulation to locally terminate or loopback 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** command and the **oam-pvc manage** command 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:

- 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.

Enabling OAM Cell Emulation for ATM AAL5 over MPLS

To enable OAM cell emulation on the PE routers, issue the **oam-ac emulation-enable** and **oam-pvc manage** commands in AToM VC configuration mode.

Specifying the Rate at Which AIS Cells Are Sent

The **oam-ac emulation-enable** command 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.

Configuration Examples for OAM Cell Emulation

The following example enables OAM cell emulation on an ATM PVC:

```
Router# interface ATM 1/0/0
Router(config-if)# pvc 1/200 l2transport
Router(config-if-atm-l2trans-pvc)# oam-ac emulation-enable
Router(config-if-atm-l2trans-pvc)# oam-pvc manage
```

The following example sets the rate at which an AIS cell is sent to every 30 seconds:

```
Router# interface ATM 1/0/0
Router(config-if)# pvc 1/200 l2transport
Router(config-if-atm-l2trans-pvc)# oam-ac emulation-enable 30
Router(config-if-atm-l2trans-pvc)# oam-pvc manage
```

Verifying OAM Cell Emulation

The following **show atm pvc** command shows that OAM cell emulation is enabled and working 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
InPkts: 564, OutPkts: 560, InBytes: 19792, OutBytes: 19680
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
```

How to Configure ATM Cell Relay over MPLS

This section contains the following concepts and procedures:

Varieties of ATM Cell Relay over MPLS

ATM cell relay over MPLS provides several configuration options:

- Virtual circuit (VC) mode, which enables you to configure ATM circuits on the permanent virtual circuits.
- Virtual path (VP) mode, which enables you to configure ATM circuits on the permanent virtual paths.
- Port mode, which enables you to configure ATM circuits on an interface.
- Single cell relay, which contains one ATM cell per packet.
- Packed cell relay, which contains multiple concatenated ATM cells per MPLS packet.

Table 1 shows the platforms that support the new ATM cell relay features. The following sections explain how to configure each feature.

Table 1 Platforms that Support the ATM Cell Relay Features

Transport Type	7200	7500	12000
VC mode, single cell relay	Y	Y	Y
VP mode, single cell relay	Y	Y	Y
Port Mode, single cell relay	N	N	Y
VC mode, packed cell relay	Y	Y	Y
VP mode, packed cell relay	Y	Y	Y
Port mode, packed cell relay	N	N	Y

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 are no longer needed. You no longer 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. That is no longer true. Only one port is reserved now.

In addition, in Cisco IOS Release 12.0(25)S, if you configured an 8-port OC-3 STM-1 ATM port for ATM AAL5 over MPLS and then configured ATM single cell relay over MPLS on that port, the VCs and 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 virtual path (VP) and virtual circuit (VC) mode and ATM AAL5 over MPLS on the same port.

Configuring ATM Cell Relay over MPLS: VC Mode

Supported Platforms:

- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 12000 series routers

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**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface atm***slot/port* **Example:** `Router(config)# interface atm1/0`	Specifies an ATM interface.
Step 4	**pvc** *vpi/vci* **l2transport** **Example:** `Router(config-if)# pvc 0/100 l2transport`	Assigns a virtual path identifier (VPI) and virtual circuit identifier (VCI). The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.

	Command or Action	Purpose
Step 5	**encapsulation aal0** **Example:** `Router(config-if-atm-l2trans-pvc)# encapsulation aal0`	For ATM Cell Relay, this command specifies raw cell encapsulation for the interface. Make sure you specify the same encapsulation type on the PE and CE routers.
Step 6	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if-atm-l2trans-pvc)# xconnect 13.13.13.13 100 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.

VC Mode Configuration Example

Example 1 shows the configuration for carrying single ATM cells over PVCs.

Example 1 VC Mode Configuration Example

PE1	PE2

`mpls label protocol ldp`
` mpls ldp router-id Loopback0 force`
`!`
`interface Loopback0`
` ip address 12.12.12.12 255.255.255.255`
`!`
`interface ATM4/0`
` pvc 0/100 l2transport`
`  encapsulation aal0`
`  xconnect 13.13.13.13 100 encapsulation mpls`
`!`
`interface ATM4/0.300 point-to-point`
` no ip directed-broadcast`
` no atm enable-ilmi-trap`
` pvc 0/300 l2transport`
`  encapsulation aal0`
`  xconnect 13.13.13.13 300 encapsulation mpls`
	`mpls label protocol ldp`
	` mpls ldp router-id Loopback0 force`
	`!`
	`interface Loopback0`
	` ip address 13.13.13.13 255.255.255.255`
	
	`interface ATM4/0`
	`  pvc 0/100 l2transport`
	`  encapsulation aal0`
	`  xconnect 12.12.12.12 100 encapsulation mpls`
	`!`
	`interface ATM4/0.300 point-to-point`
	` no ip directed-broadcast`
	` no atm enable-ilmi-trap`
	` pvc 0/300 l2transport`
	`  encapsulation aal0`
	`  xconnect 12.12.12.12 300 encapsulation mpls`

Verifying ATM Cell Relay VC Mode

The following **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, VCmode: 0x0
OAM Cell Emulation: not configured
InBytes: 0, OutBytes: 0
Status: UP
```

Configuring ATM Cell Relay over MPLS: VP Mode

Supported Platforms:

- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 12000 series routers

Virtual Path (VP) mode allows cells coming into a predefined permanent virtual path (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 is for transporting cell relay cells.
- The IP address of the peer PE router and the VC ID.

Perform this task to transport ATM cells over a PVP.

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**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface atm***slot/port* **Example:** `Router(config)# interface atm1/0`	Defines the interface.

	Command or Action	Purpose
Step 4	**atm pvp** *vpi* **l2transport** **Example:** `Router(config-if)# atm pvp vpi 1 l2transport`	Specifies that the PVP is dedicated to transporting ATM cells. The **l2transport** keyword indicates that the PVP is for cell relay. Once you enter this command, you enter l2transport PVP submode. This submode is for Layer 2 transport only; it is not for regular PVPs.
Step 5	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(cfg-if-atm-l2trans-pvp)# xconnect 10.0.0.1 123 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.

VP Mode Configuration Guidelines

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 in this release. 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.

VP Mode Configuration Example

The following example transports single ATM cells over a virtual path:

```
pseudowire-class vp-cell-relay
  encapsulation mpls

int atm 5/0
    atm pvp 1 l2transport
        xconnect 10.0.0.1 123 pw-class vp-cell-relay
```

Verifying ATM Cell Relay VP Mode

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

```
Router# show atm vp 1

ATM5/0  VPI: 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

TotalInPkts: 0, TotalOutPkts: 0, TotalInFast: 0, TotalOutFast: 0,
TotalBroadcasts: 0 TotalInPktDrops: 0, TotalOutPktDrops: 0
```

Configuring ATM Cell Relay over MPLS: Port Mode

Supported Platforms:

- Cisco 12000 series routers

Port mode cell relay allows a single cell 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, you issue the **xconnect** command from an ATM main interface and specify the destination address and the VC ID. The syntax and semantics of the **xconnect** command are the same as for all other transport types. Each ATM port is associated with one unique pseudowire VC label.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface atm***slot/port*
4. **xconnect** *peer-router-id vcid* **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

Step 3	**interface atm***slot/port* **Example:** `Router(config)# interface atm1/0`	Specifies an ATM interface.
Step 4	**xconnect** *peer-router-id vcid* **encapsulation mpls** `Router(config-if)# xconnect 10.0.0.1 123 encapsulation mpls`	Binds the attachment circuit to the interface.

Port Mode Configuration Guidelines

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.
- 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.
- OAM Support: 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.

Port Mode Configuration Example

The following example shows interface 5/0 is set up 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
```

Verifying the Port Mode Feature

The **show atm route** command displays port mode cell relay states. 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 also shows configuration information.

```
Router# show mpls l2transport vc

Local intf     Local circuit        Dest address    VC ID      Status
-------------  -------------------- --------------- ---------- ----------
AT1/0          ATM CELL ATM1/0      100.1.1.121     1121       UP
```

The **show interface atm** command displays cell relay information, as shown in the following example. The fifth line shows that the encapsulation is AAL0 cell relay.

```
Router# show interface atm 1/0

ATM1/0 is up, line protocol is up
  Hardware is CM155 OC-3c ATM, address is 0003.a018.6440 (bia 0003.a018.6440)
  MTU 4470 bytes, sub MTU 4470, BW 155000 Kbit, DLY 80 usec, rely 255/255, load 1/255
  Encapsulation ATM, loopback not set
  Encapsulation(s): AAL0 - Cell Relay ! This line shows the encapsulation type.
  2048 maximum active VCs, 1024 VCs per VP, 1 current VCCs
  VC idle disconnect time: 300 seconds
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Queueing strategy: fifo
  Output queue 0/40, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     12099 packets input, 653328 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     12094 packets output, 725640 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

Troubleshooting Tips

The **debug atm l2transport** and **debug mpls l2transport vc** commands help in troubleshooting.

Configuring ATM Cell Relay over MPLS: Single Cell Relay

Supported Platforms:

- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 12000 series routers

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: VP Mode" section on page 21.

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**

DETAILED STEPS

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

Configuring ATM Cell Relay over MPLS: Packed Cell Relay

Supported Platforms:

- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 12000 series routers

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. You configure the packed cell relay feature in ATM VP, VC or port mode on the Cisco 12000 series routers. You can configured the packed cell relay feature in ATM VP or VC mode on the Cisco 7200 and 7500 series routers.

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

Step 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.

Step 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.

The following procedure allows you to enable the cell-packing feature in VC mode.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface atm***slot/port*
4. **atm mcpt-timers** [*timer1-timeout timer2-timeout timer3-timeout*]
5. **pvc** *vpi/vci* **l2transport**
6. **encapsulation aal0**
7. **xconnect** *peer-router-id vcid* **encapsulation mpls**
8. **cell-packing** *cells* **mcpt-timer** *timer*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface atm***slot/port* **Example:** `Router(config)# interface atm1/0`	Defines the interface.

	Command or Action	Purpose
Step 4	**atm mcpt-timers** [*timer1-timeout timer2-timeout timer3-timeout*] **Example:** `Router(config-if)# atm mcpt-timers 100 200 250`	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 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 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
Step 5	**pvc** *vpi/vci* **l2transport** **Example:** `Router(config-if)# pvc 1/100 l2transport`	Assigns a virtual path identifier (VPI) and virtual circuit identifier (VCI). The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC.
Step 6	**encapsulation aal0** **Example:** `Router(config-if-atm-l2trans-pvc)# encapsulation aal0`	For ATM Cell Relay, this command specifies raw cell encapsulation for the interface. Make sure you specify the same encapsulation type on the PE routers.
Step 7	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if-atm-l2trans-pvc)# xconnect 10.0.0.1 123 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.
Step 8	**cell-packing** *cells* **mcpt-timer** *timer* **Example:** `Router(config-if-atm-l2trans-pvc)# cell-packing 10 mcpt-timer 1`	Enables cell packing and specifies the cell packing parameters. The *cells* value represents the maximum number of cells to be packed into an MPLS packet. The range is from 2 to the maximum transmission unit (MTU) of the interface divided by 52. The default is MTU/52. The *timer* value allows you to specify which timer to use. The default is timer 1. See the **cell-packing** command for more information.

Packed Cell Relay Configuration Guidelines

When configuring packed cell relay, use the following guidelines:

- 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 concantenated 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 routers 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 PE 1 is allowed to pack 10 cells per MPLS packet and PE 2 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.

Packed Cell Relay Configuration Examples

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 usecs, 800 usecs, and 500 usecs, respectively. 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.

```
int atm 1/0
    atm mcpt-timer 1000 800 500
    pvc 1/100 l2transport
       encapsulation aal0
       xconnect 10.0.0.1 123 encapsulation mpls
       cell-packing 5 mcpt-timer 1
```

The following example shows packed cell relay enabled on an interface set up for VP 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.

```
int atm 1/0
    atm mcpt-timer 1000 800 500
    atm pvp 100 l2transport
        xconnect 10.0.0.1 234 encapsulation mpls
        cell-packing 10 mcpt-timer 2
```

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
    atm mcpt-timer 1000 800 500
    cell-packing 10 mcpt-timer 2
    xconnect 10.0.0.1 123 encapsulation mpls
```

Verifying Packed Cell Relay

Use the following commands to display status and statistics for the ATM packed cell relay feature:

- **random-detect discard-class-based**

- **show atm pvc**
- **show atm vc**
- **show atm vp**

These commands display 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

The **random-detect discard-class-based** command displays information about the VCs and VPs that have cell packing enabled:

```
Router# show atm cell-packing


                      average                 average
        circuit  local nbr of cells    peer    nbr of cells    MCPT
        type     MNCP  rcvd in one pkt MNCP    sent in one pkt (us)
================================================================================
atm 1/0 vc 1/200  20    15              30              20       60
atm 1/0 vp 2      25    21              30              24      100
```

The following **show atm vp** command 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

  VCD    VCI   Type   InPkts   OutPkts   AAL/Encap     Status
  6      3     PVC    0        0         F4 OAM        ACTIVE
  7      4     PVC    0        0         F4 OAM        ACTIVE

TotalInPkts: 0, TotalOutPkts: 0, TotalInFast: 0, TotalOutFast: 0,
TotalBroadcasts: 0 TotalInPktDrops: 0, TotalOutPktDrops: 0
Local MNCP: 5, average number of cells received: 3
Peer MNCP: 1, average number of cells sent: 1
Local MCPT: 100 us
```

Troubleshooting Tips

The **debug atm cell-packing** command helps you to debug ATM cell-packing.

OAM Support with ATM Cell Relay over MPLS

The F4 end-to-end OAM cells are transparently transported along with the ATM cells. When a PVP or PVC is down on PE1, the label associated with that PVP or PVC is withdrawn. Subsequently, PE2 detects the label withdrawal and sends an F4 AIS/RDI signal to CE2. The PVP or PVC on PE2 remains in the up state.

How to Configure Ethernet over MPLS

Ethernet over MPLS works by encapsulating Ethernet PDUs in MPLS packets and forwarding them across the MPLS network. Each PDU is transported as a single packet. There are various ways to configure Ethernet over MPLS:

- VLAN mode, which transports Ethernet traffic from a source 802.1Q VLAN to a destination 802.1Q VLAN over a core MPLS network.
- Port mode, which 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 is transported without the preamble or FCS as a single packet.
- VLAN ID Rewrite, which enables you to use VLAN interfaces with different VLAN IDs at both ends of the tunnel.

The following sections explain how to configure these features.

Configuring Ethernet over MPLS: VLAN Mode

Supported Platforms:

- Cisco 12000 series routers
- Cisco 10720 Internet router
- Cisco 7200 series routers
- Cisco 7500 series routers

A virtual LAN (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 virtual circuit (VC). Only the two PE routers at the ingress/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.

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

SUMMARY STEPS

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

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet***slot/interface.subinterface* **Example:** `Router(config)# interface gigabitethernet4/0.1`	Specifies the Gigabit Ethernet subinterface. Make sure the subinterface on the adjoining CE router is on the same VLAN as this PE router.
Step 4	**encapsulation dot1q** *vlan-id* **Example:** `Router(config-subif)# encapsulation dot1q 100`	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.
Step 5	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-subif)# xconnect 10.0.0.1 123 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.

Ethernet over MPLS VLAN Mode Configuration Guidelines

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

- 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.

Configuring Ethernet over MPLS: Port Mode

Supported Platforms:

- Cisco 12000 series routers
- Cisco 10720 Internet router
- Cisco 7200 series routers
- Cisco 7500 series routers

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, you use the **xconnect** command in main interface mode and specify the destination address and the VC ID. The syntax and semantics of the **xconnect** command are the same as for all other transport types. Each interface is associated with one unique pseudowire VC label.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet***x/x*
4. **xconnect** *peer-router-id vcid* **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet***slot/interface* **Example:** `Router(config-if)# interface gigabitethernet4/0`	Specifies the Gigabit Ethernet interface. Make sure the interface on the adjoining CE router is on the same VLAN as this PE router.
Step 4	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-subif)# xconnect 10.0.0.1 123 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.

Ethernet over MPLS Port Mode Configuration Guidelines

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

- The pseudowire VC type is set to Ethernet.
- 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.
- 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.

Ethernet over MPLS Port Mode Configuration Example

The following example configures 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
```

Verifying Ethernet over MPLS Port Mode

To determine if a VC is set up in VLAN mode or port mode, issue the **show mpls l2transport vc** command.

The following example shows two VCs set up for Ethernet over MPLS.

- VC 2 is set up in Ethernet VLAN mode.
- VC 8 is set up in Ethernet port mode.

```
Router# show mpls l2transport vc

Local intf     Local circuit        Dest address    VC ID      Status
-------------  -------------------- --------------- ---------- ----------
Gi4/0.1        Eth VLAN 2           11.1.1.1        2          UP
Gi8/0/1        Ethernet             11.1.1.1        8          UP
```

If you issue the **show mpls l2transport vc detail** command, the output is similar.

```
Router# show mpls l2transport vc detail
Local interface: Gi4/0.1 up, line protocol up, Eth VLAN 2 up
Destination address: 11.1.1.1, VC ID: 2, VC status: up

...
Local interface: Gi8/0/1 up, line protocol up, Ethernet up
  Destination address: 11.1.1.1, VC ID: 8, VC status: up
```

Configuring Ethernet over MPLS: VLAN ID Rewrite

Supported Platforms:

- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 10720 routers
- Cisco 12000 series routers

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

The Cisco 7200 and 7500 series routers and the Cisco 10720 routers automatically perform VLAN ID rewrite on the disposition PE router. There is no configuration required.

Configuring the VLAN ID Rewrite Feature for the Cisco 12000 Series Routers

The VLAN ID rewrite feature has the following guidelines for the Cisco 12000 series routers:

- 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 to be provisioned with the same line cards. Make sure that both edge-facing ends of the virtual circuit use either the Engine 2 or IP Service Engine (ISE)) Ethernet line card. The following example shows the system flow with the VLAN ID rewrite feature:

- The IP Service Engine (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 VLAN 2.

- 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 VLAN 2.

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.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface gigabitethernet***x/x*
4. **encapsulation dot1q** *vlan-id*
5. **xconnect** *peer-router-id vcid* **encapsulation mpls**
6. **remote circuit id** *remote-vlan-id*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface gigabitethernet***slot/interface.subinterface* **Example:** `Router(config)# interface gigabitethernet4/0.1`	Specifies the Gigabit Ethernet subinterface. Make sure the subinterface on the adjoining CE router is on the same VLAN as this PE router.
Step 4	**encapsulation dot1q** *vlan-id* **Example:** `Router(config-subif)# encapsulation dot1q 100`	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.
Step 5	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-subif)# xconnect 10.0.0.1 123 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.
Step 6	**remote circuit id** *remote-vlan-id* **Example:** `Router(config-subif-xconn)# remote circuit id 101`	Enables you to use VLAN interfaces with different VLAN IDs at both ends of the tunnel.

VLAN ID Rewrite Configuration Example for the Cisco 12000 Series Routers

The following example configures VLAN ID rewrite on peer PE routers:

PE1	PE2

`interface GigabitEthernet0/0.2`
`  encapsulation dot1Q 2`
`  no ip directed-broadcast`
`  no cdp enable`
`  xconnect 5.5.5.5 2 encapsulation mpls`
`  remote circuit id 3`
	`interface GigabitEthernet3/0.2`
	`  encapsulation dot1Q 3`
	`  no ip directed-broadcast`
	`  no cdp enable`
	`  xconnect 3.3.3.3 2 encapsulation mpls`
	`  remote circuit id 2`

Verifying Ethernet over MPLS VLAN ID Rewrite for the Cisco 12000 Series Routers

For the Cisco 12000 series routers, to determine if VLAN ID rewrite is enabled, issue the **show controllers eompls forwarding-table** command.

On PE1:

```
LC-Slot0# show controllers eompls forwarding-table 0 2

Port # 0, VLAN-ID # 2, Table-index 2
EoMPLS configured: 1
tag_rew_ptr             = D001BB58
Leaf entry?     = 1
FCR index       = 20
           **tagrew_psa_addr    = 0006ED60
           **tagrew_vir_addr    = 7006ED60
           **tagrew_phy_addr    = F006ED60
        [0-7] loq 8800 mtu 4458  oq 4000 ai 3 oi 04019110 (encaps size 4)
        cw-size 4 vlanid-rew 3
        gather A30 (bufhdr size 32 EoMPLS (Control Word) Imposition profile 81)
        2 tag: 18 18
        counters 1182, 10 reported 1182, 10.
    Local OutputQ (Unicast):    Slot:2  Port:0  RED queue:0  COS queue:0
    Output Q (Unicast):         Port:0          RED queue:0  COS queue:0
```

On PE2:

```
LC-Slot3# show controllers eompls forwarding-table 0 3

Port # 0, VLAN-ID # 3, Table-index 3
EoMPLS configured: 1
tag_rew_ptr             = D0027B90
Leaf entry?     = 1
FCR index       = 20
           **tagrew_psa_addr    = 0009EE40
           **tagrew_vir_addr    = 7009EE40
           **tagrew_phy_addr    = F009EE40
        [0-7] loq 9400 mtu 4458  oq 4000 ai 8 oi 84000002 (encaps size 4)
        cw-size 4 vlanid-rew 2
        gather A30 (bufhdr size 32 EoMPLS (Control Word) Imposition profile 81)
        2 tag: 17 18
        counters 1182, 10 reported 1182, 10.
    Local OutputQ (Unicast):    Slot:5  Port:0  RED queue:0  COS queue:0
    Output Q (Unicast):         Port:0          RED queue:0  COS queue:0
```

How to Configure Frame Relay over MPLS

How Frame Relay PDUs Move Between PE Routers

Frame Relay over MPLS encapsulates Frame Relay protocol data units (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.
- 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 FECN, BECN, and DE bits.

Configuring Frame Relay over MPLS with DLCI-to-DLCI Connections

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. **connect** *connection-name interface dlci* **l2transport**
8. **xconnect** *peer-router-id vcid* **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**frame-relay switching** **Example:** `Router(config)# frame-relay switching`	Enables permanent virtual circuit (PVC) switching on a Frame Relay device.

	Command or Action	Purpose
Step 4	**interface serial***slot/port* **Example:** `Router(config)# interface Serial3/1`	Specifies a serial interface.
Step 5	**encapsulation frame-relay** [**cisco** | **ietf**] **Example:** `Router(config-if)# encapsulation frame-relay ietf`	Specifies Frame Relay encapsulation for the interface. You can specify different types of encapsulations. You can set one interface to Cisco encapsulation and the other interface to IETF encapsulation.
Step 6	**frame-relay intf-type dce** **Example:** `Router(config-if)# frame-relay intf-type dce`	Specifies that the interface is a DCE switch. You can also specify the interface to support NNI and DTE connections.
Step 7	**connect** *connection-name interface dlci* **l2transport** **Example:** `Router(config)# connect fr1 Serial5/0 1000 l2transport`	Defines connections between Frame Relay PVCs. Using the **l2transport** keyword specifies that the PVC will not be a locally switched PVC, but will be tunneled over the backbone network. The *connection-name* argument is a text string that you provide. The *interface* argument is the interface on which a PVC connection will be defined. The *dlci* argument is the DLCI number of the PVC that will be connected.
Step 8	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-fr-pw-switching)# xconnect 10.0.0.1 123 encapsulation mpls`	Creates the VC to transport the Layer 2 packets. In a DLCI-to DLCI connection type, Frame Relay over MPLS uses the **xconnect** command in connect submode.

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

When you set up a port-to-port connection between PE routers, you use HDLC mode to transport the Frame Relay encapsulated packets. 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**

DETAILED STEPS

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

Enabling Other PE Devices to Transport Frame Relay Packets

You can configure an interface as a data terminal equipment (DTE) device or a data circuit-terminating equipment (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 following table:

Keyword	Description
dce	Enables the router or access server to function as a switch connected to a router.
dte	Enables the router or access server to function as a DTE device. DTE is the default.
nni	Enables the router or access server to function as a switch connected to a switch.

Local Management Interface and Frame Relay over MPLS

Local Management Interface (LMI) is a protocol that communicates status information about permanent virtual circuits (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.

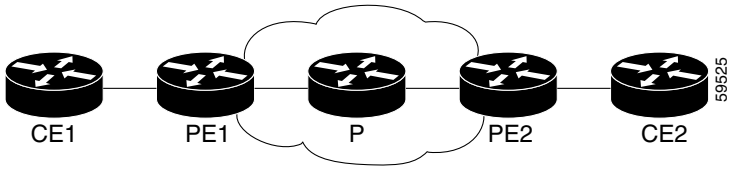
How LMI Works

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 LMI status.

Figure 1 is a sample topology that helps illustrate how LMI works.

Figure 1 Sample Topology



In Figure 1, 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 is composed of 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 Figure 1; one is between PE1 and CE1 and the other is between PE2 and CE2.

How the LMI protocol behaves 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/DCE configurations, the following LMI behavior exists:

The Frame Relay device accessing the network (DTE) does not report PVC status. Only the network device (DCE) or NNI can report 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 between the customer edge (CE) routers only. The CE routers must be configured as DCE-DTE or NNI-NNI.

For More Information About LMI

For information about LMI, including configuration instructions, see the following document:

Configuring Frame Relay, Configuring the LMI

http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fwan_c/wcffrely.htm#xtocid8

How to Configure 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 frame check sequence (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.

Configuring HDLC and PPP over MPLS

Perform this task to set up HDLC and PPP connections.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface serial***slot/port*
4. **encapsulation** *encapsulation-type*
5. **xconnect** *peer-router-id vcid* **encapsulation mpls**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**interface serial***slot/port* **Example:** `Router(config)# interface serial5/0`	Specifies a serial interface. You must configure HDLC and PPP over MPLS on router interfaces only. You cannot configure HDLC over MPLS on subinterfaces.

Step 4	For HDLC encapsulation:
	encapsulation hdlc
	
	Example:
	`Router(config-if)# encapsulation hdlc`
	
	For PPP encapsulation:
	encapsulation ppp
	
	Example:
	`Router(config-if)# encapsulation ppp`
		Specifies HDLC or PPP encapsulation.

Step 5	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-fr-pw-switching)# xconnect 10.0.0.1 123 encapsulation mpls`	Creates the VC to transport the Layer 2 packets.

How to Configure Distributed CEF Mode

Supported Platforms:

- Cisco 12000 series routers
- Cisco 7500 series routers

Note Distributed Cisco Express Forwarding (CEF) is the only forwarding model supported on the Cisco 12000 series routers and is enabled by default. Disabling distributed CEF on the Cisco 12000 series routers disables forwarding.

Distributed CEF mode is supported on the Cisco 7500 series routers for Frame Relay, HDLC, and PPP. In distributed CEF mode, the switching process occurs on the VIPs that support switching. When distributed CEF 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 CEF uses an interprocess communications (IPC) mechanism to ensure synchronization of FIBs and adjacency tables between the RSP and port adapters.

Enabling Distributed CEF

To enable distributed CEF on the Cisco 7500 series routers, issue the **ip cef distributed** command.

How to Configure MPLS Traffic Engineering Fast Reroute

Supported Platforms:

- Cisco 12000 series routers
- Cisco 10720 Internet router
- Cisco 7200 series routers
- Cisco 7500 series routers

This feature allows AToM to use MPLS Traffic Engineering (TE) tunnels with Fast Reroute support. AToM VCs can be rerouted around a failed link or node at the same time as MPLS and IP prefixes.

Configuring MPLS TE Fast Reroute

Enabling Fast Reroute on AToM does not require any special commands; you can use standard fast reroute 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:

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

http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s23/fs_frrnd.htm

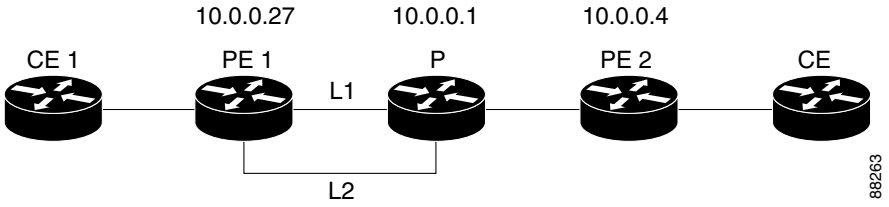
Fast Reroute Configuration Example

The following configuration example and Figure 2 show the configuration of Fast Reroute on AToM PE routers.

Routers PE1 and PE2 have the following characteristics:

- A TE tunnel called Tunnel41 is configured between PE1and 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 (Java)

```
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 1.4.0.1 disable-fallback
!
interface Loopback1
 ip address 1.0.0.27 255.255.255.255
!
interface Tunnel1
 ip unnumbered Loopback1
 tunnel destination 1.0.0.1
 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 1.0.0.4
 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 Chino_1
 tunnel mpls traffic-eng fast-reroute
!
interface POS0/0
 description Joe POS8/0/0
 ip address 1.1.0.2 255.255.255.252
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel1
 crc 16
 clock source internal
 pos ais-shut
 pos report lrdi
 ip rsvp bandwidth 155000 155000
!
interface POS0/3
 description Joe POS10/1/0
 ip address 1.1.0.14 255.255.255.252
 mpls traffic-eng tunnels
 crc 16
 clock source internal
 ip rsvp bandwidth 155000 155000
!
interface gigabitethernet3/0.1
 encapsulation dot1Q 203
 xconnect 1.0.0.4 2 pw-class IP1
!
interface gigabitethernet3/0.2
 encapsulation dot1Q 204
 xconnect 1.0.0.4 4 pw-class T41
!
router ospf 1
 network 1.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
!
ip classless
ip route 1.4.0.1 255.255.255.255 Tunnel41
!
ip explicit-path name Java_1 enable
 next-address 1.4.1.2
 next-address 1.1.0.10
```

P (Joe)

```
ip cef
mpls traffic-eng tunnels
!
interface Loopback1
 ip address 1.0.0.1 255.255.255.255
!
interface FastEthernet1/0/0
 ip address 1.4.1.2 255.255.255.0
 mpls traffic-eng tunnels
 ip rsvp bandwidth 10000 10000
!
interface POS8/0/0
 description Java POS0/0
 ip address 1.1.0.1 255.255.255.252
 mpls traffic-eng tunnels
 pos ais-shut
 pos report lrdi
 ip rsvp bandwidth 155000 155000
!
interface POS10/1/0
 description Java POS0/3
 ip address 1.1.0.13 255.255.255.252
 mpls traffic-eng tunnels
 ip rsvp bandwidth 155000 155000
!
router ospf 1
 network 1.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
```

PE2 (Chino)

```
ip cef
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
interface Loopback1
 ip address 1.0.0.4 255.255.255.255
!
interface loopback 2
ip address 1.4.0.1 255.255.255.255
!
interface Tunnel27
 ip unnumbered Loopback1
 tunnel destination 1.0.0.27
 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 Java_1
!
interface FastEthernet0/0.2
 encapsulation dot1Q 203
 xconnect 1.0.0.27 2 encapsulation mpls
!
interface FastEthernet0/0.3
 encapsulation dot1Q 204
 xconnect 1.0.0.27 4 encapsulation mpls
!
interface FastEthernet1/1
 ip address 1.4.1.1 255.255.255.0
```

```
 mpls traffic-eng tunnels
 ip rsvp bandwidth 10000 10000
!
router ospf 1
 network 1.0.0.0 0.255.255.255 area 0
 mpls traffic-eng router-id Loopback1
 mpls traffic-eng area 0
!
ip explicit-path name Java_1 enable
 next-address 1.4.1.2
 next-address 1.1.0.10
```

Verifying Fast Reroute

Issue the **show mpls traffic-eng tunnels** command to display status information about the tunnels.

```
Java# show mpls traffic-eng tunnels tunnel 41

Name: Java_t41                           (Tunnel41) Destination: 1.0.0.4
  Status:
    Admin: up         Oper: up     Path: valid       Signalling: connected
path option 1, type explicit Chino_1 (Basis for Setup, path weight 2)
Config Parameters:
    Bandwidth: 1000     kbps (Global)  Priority: 1  1   Affinity: 0x0/0xFFFF
    Metric Type: TE (default)
    AutoRoute:  disabled  LockDown: disabled  Loadshare: 1000     bw-based
    auto-bw: disabled
InLabel  :  -
  OutLabel : POS0/0, 35
  FRR OutLabel : Tunnel1, 35
  RSVP Signalling Info:
       Src 1.0.0.27, Dst 1.0.0.4, Tun_Id 41, Tun_Instance 48
    RSVP Path Info:
      My Address: 1.0.0.27
      Explicit Route: 1.1.0.1 1.4.1.2 1.4.1.1 1.0.0.4
      Record   Route:   NONE
      Tspec: ave rate=1000 kbits, burst=1000 bytes, peak rate=1000 kbits
    RSVP Resv Info:
      Record   Route:  1.4.1.2(35) 1.4.1.1(0)
      Fspec: ave rate=1000 kbits, burst=1000 bytes, peak rate=17179869 kbits
  Shortest Unconstrained Path Info:
    Path Weight: 2 (TE)
    Explicit Route: 1.1.0.1 1.4.1.2 1.4.1.1 1.0.0.4
  History:
    Tunnel:
      Time since created: 3 days, 7 hours, 49 minutes
      Time since path change: 3 days, 7 hours, 46 minutes
    Current LSP:
      Uptime: 3 days, 7 hours, 31 minutes
      Selection: reoptimation
    Prior LSP:
      ID: path option 1 [42]
      Removal Trigger: re-route path verification failed
```

Issue the **show mpls interfaces** command to display information about the TE tunnel.

```
Java# show mpls interfaces tunnel 41 detail

Interface Tunnel41:
        MPLS TE Tunnel Head
        IP labeling not enabled
        LSP Tunnel labeling not enabled
        BGP labeling not enabled
```

```
        MPLS not operational
        MTU = 4466
Tun hd Untagged    0          Tu41       point2point
        MAC/Encaps=4/8, MRU=4470, Tag Stack{28}, via PO0/0
        0F008847 0001C000
        No output feature configured
        Fast Reroute Protection via {Tu1, outgoing label 28}
```

Issue the **show mpls traffic-eng fast-reroute database** command to display information about the status of the tunnels.

```
Java# show mpls traffic-eng fast-reroute database
Tunnel head end item frr information:
Protected tunnel              In-label Out intf/label   FRR intf/label   Status
Tunnel41                      Tun hd   PO0/0:Untagged   Tu1:28           ready

Prefix item frr information:
Prefix            Tunnel      In-label Out intf/label   FRR intf/label   Status
1.4.0.1/32        Tu41        12313    PO0/0:Untagged   Tu1:28           ready
```

Troubleshooting Tips

You can issue the **debug mpls l2transport fast-reroute** command to debug Fast Reroute.

Note This command does not display output on platforms where AToM Fast Reroute is implemented in the forwarding code. This command does not display output for the Cisco 7500 (both RP and VIP) series routers, Cisco 7200 series routers, and Cisco 12000 series route processor. The command does display output on Cisco 10720 Internet router line cards and Cisco 12000 series line cards.

In the following example, the primary link is disabled, which causes the backup tunnel (Tunnel 1) to become the primary path.

```
Java# 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 1.4.0.1
SLOT 3:Sep 16 17:58:56.346: AToM SMGR: Finished processing TFIB FRR event for 1.4.0.1
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 17:58:58.342: %OSPF-5-ADJCHG: Process 1, Nbr 1.0.0.1 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
```

How to Configure Tunnel Selection

Supported Platforms:

- Cisco 12000 series routers
- Cisco 10720 Internet router
- Cisco 7200 series routers
- Cisco 7500 series routers

This feature allows you to specify the path that traffic uses. You can specify either an MPLS TE tunnel or destination IP address/DNS name.

You also have the option of specifying whether the VCs should use the default path (the path LDP used for signaling) if the preferred path is unreachable. This option is enabled by default; you must explicitly disable it.

Configuring Tunnel Selection

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.

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. **interface***slot/port*
7. **encapsulation** *encapsulation-type*
8. **xconnect** *peer-router-id vcid* **pw-class** *name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**pseudowire-class** *name* **Example:** `Router(config)# pseudowire-class ts1`	Establishes a pseudowire class with a name that you specify.
Step 4	**encapsulation mpls** **Example:** `Router(config-pw)# encapsulation mpls`	Specifies the tunneling encapsulation. For AToM, the encapsulation type is **mpls**.

	Command or Action	Purpose
Step 5	**preferred path** [**interface tunnel** *tunnel-number* | **peer** {*ip address* | *host name*}] [**disable-fallback**] **Example:** `Router(config-pw)# preferred path peer 16.18.18.18`	Specifies the MPLS traffic engineering tunnel or IP address or host name to be used as the preferred path.
Step 6	**interface***slot/port* **Example:** `Router(config)# interface atm1/1`	Specifies an interface.
Step 7	**encapsulation** *encapsulation-type* **Example:** `Router(config-if)# encapsulation aal5`	Specifies the encapsulation for the interface.
Step 8	**xconnect** *peer-router-id vcid* **pw-class** *name* `Router(config-if)# xconnect 10.0.0.1 123 pw-class ts1`	Binds the attachment circuit to a pseudowire VC.

Tunnel Selection Configuration Guidelines

The following guidelines provide more information about configuring tunnel selection.

- This command is available only if the pseudowire encapsulation type is MPLS.
- This feature is enabled when you exit from pseudowire submode.
- The selected path should be a label switched path (LSP) destined to the peer PE router.
- The selected tunnel must be an MPLS traffic engineering 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 does not have to be a TE tunnel.

Tunnel Selection Configuration Example

The following example sets 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:

```
mpls label protocol ldp
mpls 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 16.18.18.18
!
interface Loopback0
 ip address 75.2.2.2 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Tunnel1
 ip unnumbered Loopback0
 no ip directed-broadcast
 tunnel destination 16.16.16.16
 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 16.16.16.16
 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 16.16.16.16 101 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 l2transport
  encapsulation aal5
  xconnect 16.16.16.16 150 pw-class pw2
!
interface Ethernet2/0/1
 ip address 9.0.0.1 255.255.255.0
 no ip directed-broadcast
 tag-switching ip
 mpls traffic-eng tunnels
 ip rsvp bandwidth 15000 15000
!
router ospf 1
 log-adjacency-changes
 network 9.0.0.0 0.0.0.255 area 0
 network 75.2.2.2 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
!
ip route 16.18.18.18 255.255.255.255 Tunnel2
!
ip explicit-path name path-tu1 enable
 next-address 9.0.0.1
 index 3 next-address 11.0.0.1
```

PE2:

```
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback0
interface Loopback0
 ip address 16.16.16.16 255.255.255.255
 no ip directed-broadcast
 no ip mroute-cache
!
interface Loopback2
 ip address 16.18.18.18 255.255.255.255
 no ip directed-broadcast
!
interface Ethernet3/1
 ip address 11.0.0.2 255.255.255.0
 no ip directed-broadcast
 mpls traffic-eng tunnels
 mpls ip
 no cdp enable
 ip rsvp bandwidth 15000 15000
!
interface Ethernet3/3
 no ip address
 no ip directed-broadcast
 no cdp enable
!
interface Ethernet3/3.1
 encapsulation dot1Q 222
 no ip directed-broadcast
 no cdp enable
 mpls l2transport route 75.2.2.2 101
!
interface ATM5/0
 no ip address
 no ip directed-broadcast
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/50 l2transport
  encapsulation aal5
  xconnect 75.2.2.2 150 encapsulation mpls
!
router ospf 1
 log-adjacency-changes
 network 11.0.0.0 0.0.0.255 area 0
 network 16.16.16.16 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

Verifying Tunnel Selection

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.

```
Router# show mpls l2transport vc detail

Local interface: Gi0/0/0.1 up, line protocol up, Eth VLAN 222 up
  Destination address: 16.16.16.16, 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 16.16.16.16:0 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: 16.16.16.16, VC ID: 150, VC status: up
    Preferred path: 16.18.18.18, 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 16.16.16.16:0 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 Tunnel Selection

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 [75.2.2.2, 101]: Processing imposition update, vc_handle 62091860, update_action
3, remote_vc_label 16
AToM SMGR [75.2.2.2, 101]: selected route no parent rewrite: tunnel not up
AToM SMGR [75.2.2.2, 101]: Imposition Programmed, Output Interface: Et3/2
```

How to Estimate the Size of Packets Traveling Through the Core Network

The following calculation helps you determine the size of the packets traveling through the core network. You set the 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:

```
Core MTU >= (Edge MTU + Transport header + AToM header + (MPLS label stack * MPLS label
size))
```

The following sections describe the variables used in the equation.

Edge MTU

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

Transport header

The Transport header depends on the transport type. Table 2 lists the specific sizes of the headers.

Table 2 Header Size of Packets

Transport Type	Packet Size
AAL5	0–32 bytes
Ethernet VLAN	18 bytes
Ethernet Port	14 bytes
Frame Relay DLCI	2 bytes for Cisco encapsulation, 8 bytes for IETF encapsulation.
HDLC	4 bytes
PPP	4 bytes

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 1 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 2 (the LDP label and the VC label).
- If a TE tunnel instead of LDP is used between PE routers in the MPLS network, the label stack size is 2 (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 3 (TE label, LDP label, 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 4 (FRR label, TE label, LDP label, VC label).
- If AToM is used by the customer carrier in MPLS-VPN Carrier Supporting Carrier environment, you add a label to the stack. The maximum MPLS label stack in the provider carrier network is 5 (FRR label, TE label, LDP label, VPN label, VC label).
- If an AToM tunnel spans different service providers that exchange MPLS labels using IPv4 BGP (RFC 3107), you add a label to the stack. The maximum MPLS label stack is 5 (FRR label, TE label, BGP label, LDP label, VC label).

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

Example of Estimating Packet Size

Example 2 estimates the size of packets. The example 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.

Example 2 Estimating the MTU for Packets

```
Edge MTU + Transport header + AToM header + (MPLS label stack * MPLS Label) = Core MTU
1500     + 18                + 0          + (2                * 4          ) = 1526
```

You must configure the P and PE routers in the core to accept packets of 1526 bytes. See the following section for setting the MTU size on the P and PE routers.

Changing the MTU Size on the P and PE Routers

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
```

Note Some interfaces (such as FastEthernet interfaces) require the **mpls mtu** command to change the MTU size.

How to Configure QoS with AToM

This section explains how to configure QoS with AToM and includes the following procedures:

- How to Set Experimental Bits with AToM, page 55
- How to Configure QoS Features with the Cisco 12000 Series Routers, page 63
- How to Configure QoS Features with the Cisco 7200 and 7500 Series Routers, page 70

How to Set Experimental Bits with AToM

Supported Platforms:

- Cisco 12000 series routers
- Cisco 7200 series routers
- Cisco 7500 series routers
- Cisco 10720 Internet router for Ethernet over MPLS

For configuration steps and examples, see the "Setting the EXP Bits" section on page 57.

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.

ATM AAL5 over MPLS and 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, dCEF must be enabled before you set the experimental bits.

ATM Cell Relay over MPLS and EXP Bits

- ATM Cell Relay over MPLS allows you to statically set the experimental bits in VC, VP, 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, dCEF must be enabled before you set the experimental bits.

Ethernet over MPLS and EXP Bits

On the Cisco 12000 Series Routers

- Ethernet over MPLS allows you to either statically set the experimental bits or use the 802.1Q P bits to determine the experimental bit settings. To use the 802.1Q P bits, see the "Using 802.1Q P Bits to Determine the Experimental Bit Settings" section on page 61.
- In VLAN mode, 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.
- In port mode, if you do not assign values to the experimental bits, the experimental bits are set to zero.

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, dCEF must be enabled before you set the experimental bits.

On the Cisco 10720 Router

Table 3 lists the commands that are supported on the Cisco 10720 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.

Note The **match cos** command is supported only on subinterfaces, not main interfaces.

Table 3 Commands Supported on the Cisco 10720 Router for Ethernet over MPLS

Commands	Imposition		Disposition	
Traffic Matching Commands	**In**	**Out**	**In**	**Out**
match any	Y	Y	Y	Y
match input-interface	—	—	Y	Y
match qos-group	—	Y	—	Y
match mpls exp	—	Y	Y	—
match cos	Y	—	—	—
Traffic Action Commands				
set mpls exp	Y	—	—	—
set srp-priority	—	Y	—	—
set qos-group	Y	—	Y	—
set cos	—	—	—	Y

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, dCEF must be enabled before you set the experimental bits.

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 dCEF before setting the experimental bits.

Setting the EXP 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.

Note Steps 1 through 5 are common to the Cisco 12000, 7200, and 7500 routers. Steps 6 and 7 are slightly different for the Cisco 12000 series routers. See "Examples of Setting the EXP Bits on the Cisco 12000 Series Routers" section on page 59 for examples.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **class-map** *class-name*
4. **match any**
5. **policy-map** *policy-name*
6. **class** *class-name*
7. **set mpls experimental** *value*
8. **interface***slot/port*
9. **service-policy input** *policy-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**class-map** *class-name* **Example:** `Router(config)# class-map jane`	Specifies the user-defined name of the traffic class.
Step 4	**match any** **Example:** `Router(config-cmap)# match any`	Specifies that all packets will be matched. In this release, use only the **any** keyword. Other keywords might cause unexpected results.
Step 5	**policy-map** *policy-name* **Example:** `Router(config-cmap)# policy-map doe`	Specifies the name of the traffic policy to configure.
Step 6	**class** *class-name* **Example:** `Router(config-pmap)# class jane`	Specifies the name of a predefined traffic class, which was configured with the **class-map** command, used to classify traffic to the traffic policy.

	Command or Action	Purpose
Step 7	**set mpls experimental** *value* **Example:** `Router(config-pmap-c)# set mpls experimental 7`	Designates the value to which the MPLS bits are set if the packets match the specified policy map.
Step 8	**interface***slot/port* `Router(config)# interface atm4/0`	Enters the interface.
Step 9	**service-policy input** *policy-name* **Example:** `Router(config-if)# service-policy input doe`	Attaches a traffic policy to an interface.

Displaying the Traffic Policy Assigned to an Interface

To display the traffic policy attached to an interface, use the **show policy-map interface** command.

Examples of Setting the EXP Bits on the Cisco 12000 Series Routers

The following examples set the EXP bits on the different transport types for the Cisco 12000 series routers.

Example 3 Setting the EXP Bits for ATM Single Cell Relay over MPLS

```
Class Map match-any atm-class
!
Policy Map exp7
    Class atm-class
      set mpls experimental 7
!
interface ATM4/0
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/110 l2transport
  xconnect 5.5.5.5 1145 encapsulation mpls
  service-policy input exp7
```

Example 4 Setting the EXP Bits for Frame Relay over MPLS

```
Class Map match-any fr-class
!
Policy Map exp7
    Class fr-class
      set mpls experimental 7
!
interface POS4/0.1 point-to-point
 no ip directed-broadcast
 switched-dlci 106
 service-policy input exp7
!
```

```
connect frompls101 POS4/0 106 l2transport
 xconnect 3.3.3.3 2034 encapsulation mpls
pvc 0/120 l2transport
  encapsulation aal0
  xconnect 5.5.5.5 1045 encapsulation mpls
  service-policy input exp7
```

Example 5 Setting the EXP Bits for Ethernet Port Mode over MPLS

```
Class Map match-any eport-class
!
Policy Map exp7
    Class eport-class
      set mpls experimental 7
!
int Gigaethernet4/0
    xconnect 5.5.5.5 1045 encapsulation mpls
    service-policy input exp7
```

Example 6 Setting the EXP Bits for HDLC over MPLS

```
Class Map match-any hdlc-class
!
Policy Map exp7
    Class hdlc-class
      set mpls experimental 7
!
interface POS4/0
    xconnect 5.5.5.5 1045 encapsulation mpls
    service-policy input exp7
```

Example 7 Setting the EXP Bits for Ethernet VLAN over MPLS

```
Class Map match-any evlan-class
!
Policy Map exp7
    Class evlan-class
      set mpls experimental 7
!
int Gigaethernet4/0.1
    encapsulation dot1Q 200
    xconnect 5.5.5.5 1045 encapsulation mpls
    service-policy input exp7
```

Example 8 Setting the EXP Bits for PPP over MPLS

```
Class Map match-any ppp-class
!
Policy Map exp7
    Class ppp-class
      set mpls experimental 7
!
interface POS4/0
    encapsulation ppp
    xconnect 5.5.5.5 1045 encapsulation mpls
    service-policy input exp7
```

Using 802.1Q P Bits to Determine the Experimental Bit Settings

The following configuration steps let you configure class maps and policy maps to control the setting of the EXP bit based on the 802.1Q P bit setting. This procedure applies only to Ethernet over MPLS in VLAN mode for the Cisco 12000 series routers.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **class-map match any** *class-map-name*
4. **match cos** *cos-value*
5. **policy-map** *policy-name*
6. **class** *class-name*
7. **set mpls experimental** *value*
8. **interface***slot/port*
9. **service-policy input** *policy-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**class-map match any** *class-map-name* **Example:** `Router(config)# class-map match any jane`	Specifies the user-defined name of the traffic class. The **match any** portion of the command allows a packet to be classified as a member of the traffic class if it matches any of the criteria.
Step 4	**match cos** *cos-value* **Example:** `Router(config-cmap)# match cos 7`	Specifies the CoS value against whose contents packets are checked to determine if they belong to the class. You can enter values 0 through 7.
Step 5	**policy-map** *policy-name* **Example:** `Router(config-cmap)# policy-map doe`	Specifies the name of the traffic policy to configure.

	Command or Action	Purpose
Step 6	**class** *class-name* **Example:** `Router(config-pmap)# class jane`	Assigns the class, which was configured with the **class-map** command, to the policy map.
Step 7	**set mpls experimental** *value* **Example:** `Router(config-pmap-c)# set mpls experimental 1`	Sets the MPLS bits if the packets match the criteria in the specified policy map.
Step 8	**interface***slot/port* **Example:** `Router(config)# interface gigabitethernet0/0.1`	Enters the interface.
Step 9	**service-policy input** *policy-name* **Example:** `Router(config-if)# service-policy input doe`	Attaches a traffic policy to an interface.

Example:

```
class-map match-any barney
  match cos  2
!
policy-map eompls1
  class barney
   set mpls experimental 1
!
int gig 0/0.1
    service-policy input eompls1
```

How to Configure QoS Features with the Cisco 12000 Series Routers

The following QoS features are supported by AToM on the Cisco 12000 series routers.

QoS Feature	Details
Traffic Policing	Supported on ATM AAL5, ATM Cell Relay (VC and VP modes), and Frame Relay over MPLS. See "Configuring Traffic Policing with the Cisco 12000 Series Routers" section on page 63 for more information.
Traffic Shaping	Supported on ATM AAL5 and ATM Cell Relay (VC and VP modes) For information about configuring and using Traffic Shaping on ATM interfaces on the Cisco 12000 series router, see the following information: • *8-Port OC-3 STM-1 ATM Line Card for Cisco 12000 Series Internet Routers* http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s22/8_oc3_lc.htm • *Traffic Shaping on ATM Line Cards for the Cisco 12000 Series* http://www.cisco.com/warp/public/121/atmlcshaping_12141.html • 4-Port ATM ISE Line Card for Cisco 12000 Series Routers http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s25/4atm_ise.htm

Configuring Traffic Policing with the Cisco 12000 Series Routers

Supported Platforms:

- Cisco 12000 series routers for ATM AAL5, ATM Cell Relay, and Frame Relay over MPLS

Traffic policing operates on incoming traffic. When enabled, policing prevents traffic congestion by treating traffic as either committed or excess. You specify the parameters for committed and excess traffic. Traffic that falls within the committed rate parameters is transmitted, whereas traffic that exceeds the parameters is dropped or transmitted with a different priority.

How traffic policing handles packets depends on the configuration of the committed information rate (CIR), peak information rate (PIR), burst committed (BC), and peak burst (BE) parameters and the conform, exceed, and violate actions.

Note Traffic policing is not supported in ATM Cell Relay port mode on the Cisco 12000 series routers.

How Traffic Policing Treats ATM Packets

Table 4 shows how ATM packets are handled on the Cisco 12000 series routers with traffic policing.

Table 4 How ATM AAL5 and ATM Cell Relay Packets Behave with Traffic Policing on Cisco 12000 Series Routers

If	Then
Traffic conforms to the specified rate.	The packets are transmitted.

Table 4 How ATM AAL5 and ATM Cell Relay Packets Behave with Traffic Policing on Cisco 12000 Series Routers

If	Then
Traffic exceeds the specified rate.	The packets are transmitted.
Traffic violates the specified rate.	The packets are dropped.

Traffic Policing on ATM AAL5 over MPLS with the Cisco 12000 Series Router Line Cards

On Cisco 12000 series routers, the policing function measures traffic in different ways for E2 and E0 ATM line cards. Therefore, when you display policing statistics, the results will be different for different line cards.

- On E2 ATM line cards, the policing function does not count the following items:
  - Four-byte AAL5 trailer
  - Four-byte AAL5 CRC
  - Bytes used for padding the AAL5 packet
- On E0 ATM line cards, the policing function counts the trailer, CRS, and padding bytes.

Further, arithmetic round-off errors can allow higher bursts of committed and excess traffic than you specified. To keep the burst traffic within the specified limits, specify a minimum excess burst.

How Traffic Policing Treats Frame Relay Packets

Table 5 shows how Frame Relay packets are handled on the Cisco 12000 series routers with traffic policing.

Table 5 How Frame Relay Packets Behave with Traffic Policing on Cisco 12000 Series Routers

If	Then
Traffic conforms to the specified rate.	The packets are transmitted.
Traffic exceeds the specified rate.	Sets the DE bit from 0 to 1 on the frame relay frame and transmits the packet.
Traffic violates the specified rate.	The packets are dropped.

Configuration Guidelines

To configure traffic policing, you create a traffic class and a traffic policy and attach the traffic policy to a specified VC or subinterface. You perform these tasks using the Modular QoS command-line interface (CLI). For information on the Modular QoS CLI, see *Modular Quality of Service Command Line Interface* in Cisco IOS Release 12.0(26)S.

The following list outlines guidelines specific to the Cisco 12000 series router and traffic policing:

- The Cisco 12000 series router supports the two-rate, three-color policer. For more information on this type of traffic policing, see *Two-Rate Policer.*
- The Cisco 12000 series router requires that you specify the committed information rate (CIR) and the peak information rate (PIR).

- The **switched-dlci** command is required only for Frame Relay over MPLS on the Cisco 12000 series routers.
- The **match fr-dlci** command is not supported on the Cisco 12000 series routers.
- The **set-clp-transmit** command is only supported on the Engine 2 8-Port OC-3 STM-1 ATM line card.
- Traffic policing is not supported for ATM Cell Relay over MPLS in port mode.

Configuring Traffic Policing for ATM AAL5 and ATM Cell Relay on the Cisco 12000 Series Routers

Perform this task to enable traffic policing for ATM Cell Relay and ATM AAL5.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **class-map match-any** *class-map-name*
4. **policy-map** *policy-name*
5. **class** *class-name*
6. **police cir** *cir* **bc** *bc* **pir** *pir* **be** *be* **conform-action** *action* **exceed-action** *action* **violate-action** *action*
7. **interface***slot/port*
8. **pvc** *vpi/vci* **l2transport**
9. **encapsulation aal5**

   or

   encapsulation aal0
10. **xconnect** *peer-router-id vcid* **encapsulation mpls**
11. **service-policy input** *policy-name*

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**class-map match-any** *class-map-name* **Example:** `Router(config)# class-map match-any jane`	Specifies that one of the match criterion must be met for traffic entering the traffic class to be classified as part of the traffic class.

	Command or Action	Purpose
Step 4	**policy-map** *policy-name* **Example:** `Router(config)# policy-map doe`	Specifies the name of the traffic policy to configure. Names can be a maximum of 40 alphanumeric characters.
Step 5	**class** *class-name* **Example:** `Router(config-pmap)# class jane`	Specifies the name of a predefined traffic class, which was configured with the **class-map** command, used to classify traffic to the traffic policy.
Step 6	**police cir** *cir* **bc** *bc* **pir** *pir* **be** *be* **conform-action** *action* **exceed-action** *action* **violate-action** *action* **Example:** `Router(config-pmap-c)# police cir 64000 bc 1000 pir 12800 be 2000 conform-action transmit exceed-action set-clp-transmit violate-action drop`	Specifies a maximum bandwidth usage by a traffic class. The police command polices traffic based on a token bucket algorithm. The variables in the token bucket algorithm are set in this command line.
Step 7	**interface***slot/port* **Example:** `Router(config)# interface atm4/0`	Enters the interface.
Step 8	**pvc** *vpi/vci* **l2transport** **Example:** `Router(config-if)# pvc 0/110 l2transport`	Assigns a virtual path identifier (VPI) and virtual circuit identifier (VCI). The **l2transport** keyword indicates that the PVC is a switched PVC instead of a terminated PVC. You can configure ATM AAL5 on permanent virtual circuits (PVCs) only. You cannot configure ATM AAL5 over MPLS on main interfaces.
Step 9	**encapsulation** *encapsulation-type* **Example:** `Router(config-if-atm-l2trans-pvc)#` **`encapsulation aal5`** or `Router(config-if-atm-l2trans-pvc)#` **`encapsulation aal0`**	Specifies AAL5 or AAL0 or encapsulation for the PVC. Make sure you specify the same encapsulation type on the PE and CE routers.
Step 10	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-if-atm-l2trans-pvc)# xconnect 10.0.0.1 123 encapsulation mpls`	Binds the attachment circuit to a pseudowire VC.
Step 11	**service-policy input** *policy-name* **Example:** `Router(config-atm-vc)# service-policy input doe`	Attaches a traffic policy to an VC.

Traffic Policing for ATM Cell Relay over MPLS Configuration Example

Example 9 shows an example of configuring traffic policing with ATM Cell Relay over MPLS.

Example 9 Traffic Policing for ATM Cell Relay over MPLS with the Cisco 12000 Series Routers

```
class map match-any atm-class
!
policy map atm-policy
    class atm-class
      police cir 64000 bc 1000 pir 128000 be 2000
conform-action transmit exceed-action set-clp-transmit violate-action drop
!
interface ATM4/0
 no ip address
 no ip directed-broadcast
 atm clock INTERNAL
 no atm enable-ilmi-trap
 no atm ilmi-keepalive
 pvc 0/110 l2transport
  xconnect 5.5.5.5 1145 encapsulation mpls
  service-policy input atm-policy
!
 pvc 0/120 l2transport
  encapsulation aal0
  xconnect 5.5.5.5 1045 encapsulation mpls
  service-policy input atm-policy
```

Configuring Traffic Policing for Frame Relay on the Cisco 12000 Series Routers

Perform this task to enable traffic policing for Frame Relay.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **class-map match-any** *class-name*
4. **policy-map** *policy-name*
5. **class** *class-name*
6. **police cir** *cir* **bc** *bc* **pir** *pir* **be** *be* **conform-action** *action* **exceed-action** *action* **violate-action** *action*
7. **interface***slot/port*
8. **encapsulation frame-relay** [**cisco** | **ietf**]
9. **interface***slot/port.subinterface*
10. **switched-dlci** *dlci*
11. **service-policy input** *policy-name*
12. **connect** *connection-name interface dlci* **l2transport**
13. **xconnect** *peer-router-id vcid* **encapsulation mpls**

DETAILED STEPS

	Command	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**class-map match-any** *class-name* **Example:** `Router(config)# class-map match-any jane`	Specifies that one of the match criterion must be met for traffic entering the traffic class to be classified as part of the traffic class.
Step 4	**policy-map** *policy-name* **Example:** `Router(config)# policy-map doe`	Specifies the name of the traffic policy to configure. Names can be a maximum of 40 alphanumeric characters.
Step 5	**class** *class-name* **Example:** `Router(config-pmap)# class jane`	Specifies the name of a predefined traffic class, which was configured with the **class-map** command, used to classify traffic to the traffic policy.
Step 6	**police cir** *cir* **bc** *bc* **pir** *pir* **be** *be* **conform-action** *action* **exceed-action** *action* **violate-action** *action* **Example:** `Router(config-pmap-c)# police cir 64000 bc 1000 pir 128000 be 2000 conform-action transmit exceed-action set-frde-transmit violate-action drop`	Specifies a maximum bandwidth usage by a traffic class. The police command polices traffic based on a token bucket algorithm. The variables in the token bucket algorithm are set in this command line.
Step 7	**interface***slot/port* **Example:** `Router(config)# interfacePOS4/1`	Specifies an interface.
Step 8	**encapsulation frame-relay** [**cisco** | **ietf**] **Example:** `Router(config-if)# encapsulation frame-relay ietf`	Specifies Frame Relay encapsulation for the interface. You can specify different types of encapsulations. You can set one interface to Cisco encapsulation and the other interface to IETF encapsulation.
Step 9	**interface***slot/port.subinterface* **Example:** `Router(config)# interfacePOS4/1.0`	Specifies a subinterface.

	Command	Purpose
Step 10	**switched-dlci** *dlci* **Example:** `Router(config-subif)# switched-dlci 106`	Establishes a link between the subinterface and the DLCI specified with the **connect** command.
Step 11	**service-policy input** *policy-name* **Example:** `Router(config-subif)# service-policy input doe`	Attaches a traffic policy to a subinterface.
Step 12	**connect** *connection-name interface dlci* **l2transport** **Example:** `Router(config)# connect newxc pos4/0 106 l2transport`	Defines connections between Frame Relay PVCs. Using the **l2transport** keyword specifies that the PVC will not be a locally switched PVC, but will be tunneled over the backbone network. The *connection-name* argument is a text string that you provide. The *interface* argument is the interface on which a PVC connection will be defined. The *dlci* argument is the DLCI number of the PVC that will be connected.
Step 13	**xconnect** *peer-router-id vcid* **encapsulation mpls** **Example:** `Router(config-fr-pw-switching)# xconnect 10.0.0.1 123 encapsulation mpls`	Creates the VC to transport the Layer 2 packets. In a DLCI-to DLCI connection type, Frame Relay over MPLS uses the **xconnect** command in connect submode.

Traffic Policing for Frame Relay over MPLS Configuration Example

Example 10 configures traffic policing for Frame Relay over MPLS on the Cisco 12000 series routers.

Example 10 Traffic Policing for Frame Relay over MPLS with the Cisco 12000 Series Routers

```
class map match-any fr-class
!
policy map frtp-policy
    class fr-class
      police cir 64000 bc 1000 pir 128000 be 2000
conform-action transmit exceed-action set-frde-transmit violate-action drop
!
interface POS4/0
 encapsulation frame-relay cisco
!
interface POS4/0.1 point-to-point
 no ip directed-broadcast
 switched-dlci 106
 service-policy input frtp-policy
connect frompls101 POS4/0 106 l2transport
 xconnect 3.3.3.3 2034 encapsulation mpls
```

How to Configure QoS Features with the Cisco 7200 and 7500 Series Routers

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

- Table 6 lists QoS Features Supported with Ethernet over MPLS on the Cisco 7200 and 7500 Series Routers
- Table 7 lists QoS Features Supported with Frame Relay over MPLS on the Cisco 7200 and 7500 Series Routers
- Table 7 lists QoS Features Supported with ATM Cell Relay and AAL5 over MPLS on the Cisco 7200 and 7500 Series Routers

Table 6 QoS Features Supported with Ethernet over MPLS on the Cisco 7200 and 7500 Series Routers

QoS Feature	Ethernet over MPLS
Service Policy	Can be applied to: • Interface (input and output) • Subinterface (input and output)
Classification	Supports the following commands: • **match cos** (on interfaces and subinterfaces) • **match mpls experimental** (on interfaces and subinterfaces) • **match qos-group** (on interfaces) (output policy)
Marking	Supports the following commands: • **set cos** (output policy) • **set mpls experimental** (input policy) (on interfaces and subinterfaces) • **set qos-group** (input policy) • **set discard-class** (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 (LLQ) • Distributed Weighted Random Early Detection (WRED) • Byte-based WRED

Table 7 QoS Features Supported with Frame Relay over MPLS on the Cisco 7200 and 7500 Series Routers

QoS Feature	Frame Relay over MPLS
Service Policy	Can be applied to: • Interface (input and output) • PVC (input and output)
Classification	Supports the following commands: • **match fr-de** (on interfaces and VCs) • **match fr-dlci** (on interfaces) • **match qos-group**
Marking	Supports the following commands: • **set fr-de** (output policy) • **set mpls experimental** • **set qos-group** • **set discard-class** • **set fr-fecn-becn** (output) • **frame-relay congestion management** (output) • **threshold ecn** (output)
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 (LLQ) • Distributed Weighted Random Early Detection (WRED) • Distributed traffic shaping • Distributed class-based weighted fair queueing (DCBWFQ) • Byte-based WRED • **random-detect discard-class-based** command

Table 8 QoS Features Supported with ATM Cell Relay and AAL5 over MPLS on the Cisco 7200 and 7500 Series Routers

QoS Feature	ATM Cell Relay and AAL5 over MPLS
Service Policy	Can be applied to: • Interface (input and output) • Subinterface (input and output) • PVC (input and output)
Classification	Supports the following commands: • **match mpls experimental** (on VCs) • **match qos-group** (output)
Marking	Supports the following commands: • **set mpls experimental** (input) (on interfaces, subinterfaces, and VCs) • **set qos-group** (input) • **random-detect discard-class-based** (input) • **set discard-class** (input) • **set clp** (output) (on interfaces, subinterfaces, and VCs)
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 (LLQ) • Distributed Weighted Random Early Detection (WRED) • Distributed class-based weighted fair queueing (DCBWFQ) • Byte-based WRED • **random-detect discard-class-based** command • Class based shaping support on ATM PVCs

Refer to the following documentation in Cisco IOS Release 12.0(26)S for more information:

- *BECN and FECN Marking for Frame Relay over MPLS*
- *Byte-Based Weighted Random Early Detection*
- *Class-Based Policing*
- *Class-Based Marking*
- *Class-Based Shaping*
- *Class-Based Weighted Fair Queueing and Weighted Random Early Detection*

- *Low Latency Queuing*
- *Modular Quality of Service Command Line Interface*
- *Packet Classification Using the Frame Relay DLCI*
- *Policer Enhancement: Multiple Actions*
- *QoS: Color-Aware Policer*
- *Two-Rate Policer*

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

You can use the discard eligibility (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, while 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 only be used in an output service policy.

Setting the Frame Relay DE Bit on the Cisco 7200 and 7500 Series Routers

Perform this task to set the Frame Relay DE bit to 1 on the Cisco7200 and 7500 series routers.

SUMMARY STEPS

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

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**policy-map** *policy-name* **Example:** `Router(config)# policy-map doe`	Specifies the name of the traffic policy to configure. Names can be a maximum of 40 alphanumeric characters.
Step 4	**class** *class-name* **Example:** `Router(config-pmap)# class jane`	Specifies the name of a predefined traffic class, which was configured with the **class-map** command, used to classify traffic to the traffic policy.
Step 5	**set fr-de** **Example:** `Router(config-pmap-c)# set fr-de`	Sets the Frame Relay DE bit setting for all packets that match the specified traffic class from 0 to 1.

Setting the Frame Relay DE Bit Configuration Example

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 Serial0/0/0.1 point-to-point
  ip address 161.222.249.194 255.255.255.252
   frame-relay interface-dlci 100
   service output SET-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.

Matching the Frame Relay DE Bit on the Cisco 7200 and 7500 Series Routers

Perform this task to classify 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**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**class-map** *class-map-name* **Example:** `Router(config)# class-map de-bits`	Specifies the name of a predefined traffic class, which was configured with the **class-map** command, used to classify traffic to the traffic policy.
Step 4	**match fr-de** **Example:** `Router(config-cmap)# match fr-de`	Classifies all frames with the DE bit set to 1.

Matching the Frame Relay DE Bit Configuration Example

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 20.20.20.20 255.255.255.255

interface Ethernet1/0/0
 ip address 91.0.0.2 255.255.255.0
 tag-switching 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
```

Additional References

The following sections provide information related to Any Transport over MPLS:

Related Documents

Related Topic	Document Title
Any Transport over MPLS	*Data Sheet: Any Transport over MPLS* *White Paper: Cisco Any Transport over MPLS* *Overview: Cisco Any Transport over MPLS*
Layer 2 Tunnel Protocol Version 3 (L2TPv3): Provides the ability to tunnel any Layer 2 payload over an IP core network using Layer 2 virtual private networks (L2VPNs).	*Layer 2 Tunnel Protocol Feature Summary* *Layer 2 Tunneling Protocol: A Feature in Cisco IOS Software* *Layer 2 Tunnel Protocol Version 3 (L2TPv3) Feature Module* *Unified VPN Suite*
L2VPN Interworking	*L2VPN Interworking*

Standards

Standards[1]	Title
draft-martini-l2circuit-trans-mpls-08.txt	*Transport of Layer 2 Frames Over MPLS*
draft-martini-l2circuit-encap-mpls-04.txt	*Encapsulation Methods for Transport of Layer 2 Frames Over MPLS*

1. Not all supported standards are listed.

MIBs

MIBs[1]	MIBs Link
ATM AAL5 over MPLS and ATM Cell Relay over MPLS: 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) Interface MIB (IF-MIB.my)	To locate and download MIBs for selected platforms, Cisco IOS releases, and feature sets, use Cisco MIB Locator found at the following URL: http://tools.cisco.com/go/mibs

1. Not all supported MIBs are listed.

RFCs

RFCs[1]	Title
RFC 3032	*MPLS Label Stack Encoding*
RFC 3036	*LDP Specification*

1. Not all supported RFC are listed.

Technical Assistance

Description	Link
Technical Assistance Center (TAC) home page, containing 30,000 pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/public/support/tac/home.shtml

Command Reference

This command reference includes the following sections:

Changed Commands

The following commands have been updated in Cisco IOS Release 12.0(27)S:

- show mpls l2transport binding
- show mpls l2transport hw-capability

show mpls l2transport binding

To display VC label binding information, use the **show mpls l2transport binding** command in EXEC mode.

show mpls l2transport binding [*vc-id* | *ip-address* | **local-label** *number* | **remote-label** *number*}

Syntax Description

vc-id	(Optional) Displays VC label binding information for the specified VC.
ip-address	(Optional) Displays VC label binding information for the specified VC destination.
local-label *number*	(Optional) Displays VC label binding information for the specified local assigned label.
remote-label *number*	(Optional) Displays VC label binding information for the specified remote assigned label.

Command Modes

EXEC

Command History

Release	Modification
12.0(23)S	This command was introduced.
12.2(14)S	This command was integrated into Cisco IOS Release 12.2(14)S.
12.2(15)T	This command was integrated into Cisco IOS Release 12.2(15)T.
12.0(27)S	This command was updated to display AToM Virtual Circuit Connection Verification (VCCV) information.
12.2(18)SXE	This command was integrated into Cisco IOS Release 12.2(18)SXE.
12.2(30)S	This command was updated to display Connectivity Verification (CV) type capabilities.

Examples

The following example shows the VC label binding information for Cisco IOS Releases 12.0(27)S and 12.2(18)SXE and later:

```
Router# show mpls l2transport binding

Destination Address: 10.0.0.203,  VC ID: 1
    Local Label:  16
        Cbit: 1,    VC Type: Ethernet,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV Capabilities: Type 1, Type 2
    Remote Label: 16
        Cbit: 1,    VC Type: Ethernet,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV Capabilities: Type 1, Type 2
```

The following examples shows the VC label binding information for Cisco IOS Release 12.2(30)S and later:

```
Router# show mpls l2transport binding

Destination Address: 5.5.5.51,  VC ID: 108
    Local Label:  16
        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: 16
        Cbit: 1,    VC Type: Ethernet,    GroupID: 0
        MTU: 1500,   Interface Desc: n/a
        VCCV: CC Type: RA [2]
              CV Type: LSPV [2]
```

The output of the command changed between Cisco IOS Releases. The following table maps the older output to the new output:

Output in Cisco IOS Releases 12.0(27)S and 12.2(18)SXE	Output In Cisco IOS Release 12.2(30)S
VCCV Capabilities	VCCV: CC Type
Type 1	CW [1]
Type 2	RA [2]

Table 9 describes the significant fields shown in the display.

Table 9 show mpls l2transport binding Field Descriptions

Field	Description
Destination Address	The IP address of the remote router's interface that is at the other end of the VC.
VC ID	The virtual circuit identifier assigned to one of the interfaces on the router.
Local Label	The VC label that a router signals to its peer router, which is used by the peer router during imposition.
Remote Label	The disposition VC label of the remote peer router.
Cbit	The control word bit. If it is set, the value is 1.
VC Type	The type of VC, such as Frame Relay, Ethernet, ATM, and so on.
Group ID	The group ID assigned to the local or remote VCs.
MTU	The maximum transmission unit assigned.
Interface Desc	Interface parameters, if applicable.

Table 9 show mpls l2transport binding Field Descriptions (continued)

Field	Description
VCCV Capabilities	(Cisco IOS Releases 12.0(27)S and 12.2(18)SXE and later) AToM VCCV information. This field displays how an AToM VCCV packet is identified. • Type 1—The Protocol ID field of in the AToM Control Word (CW) identified the AToM VCCV packet. • Type 2—An MPLS Router Alert (RA) Level above the VC label identified the AToM VCCV packet. Type 2 is used for VC types that do not support or do not interpret the AToM Control Word.
VCCV: CC Type	(Cisco IOS Releases 12.2(30)S and later) The types of Control Channel (CC) processing that are supported. The number indicates the position of the bit that was set in the received octet. The following values can be displayed: • CW [1]—Control Word • RA [2]—Router Alert • TTL [3]—Time to Live • Unkn [*x*]—Unknown
CV Type	(Cisco IOS Releases 12.2(30)S and later) The type of Connectivity Verification (CV) packets that can be processed in the control channel of the MPLS pseudowire. The number indicates the position of the bit that was set in the received octet. • ICMP [1]—Internet Control Management Protocol (ICMP) is used to verify connectivity. • LSPV [2]—LSP Ping is used to verify connectivity. • BFD [3]—Bidirectional Forwarding Detection is used to verify connectivity for more than one pseudowire. • Unkn [*x*]—A CV type was received that could not be interpreted.

Related Commands

Command	Description
show mpls l2transport hw-capability	Displays the transport types and their supported capabilities.

show mpls l2transport hw-capability

To display the transport types supported on an interface, use the **show mpls l2transport hw-capability** command in privileged EXEC mode.

show mpls l2transport hw-capability interface *type number*

Syntax Description

interface	Displays information for the specified interface.
type number	The type and number of the interface. For example, serial6/0.

Command Modes

Privileged EXEC

Command History

Release	Modification
12.0(23)S	This command was introduced.
12.2(14)S	This command was integrated into Cisco IOS Release 12.2(14)S.
12.2(15)T	This command was integrated into Cisco IOS Release 12.2(15)T.
12.0(27)S	This command was updated to display AToM Virtual Circuit Connection Verification (VCCV) information.
12.2(18)SXE	This command was integrated into Cisco IOS Release 12.2(18)SXE.
12.2(30)S	This command was updated to display VCCV type capabilities.

Usage Guidelines

This command can help you determine the interface to use for the various transport types. Use this command to check that core-facing and edge-facing interfaces can accommodate the different transport types.

Examples

The following is partial sample output from the **show mpls l2transport hw-capability** command for Cisco IOS Releases 12.0(23)S, 12.2(14)S, and 12.2(15)T and later. For more information on the fields, see Table 10.

```
Router# show mpls l2transport hw-capability interface serial5/1

Interface Serial5/1

Transport type FR DLCI
  Core functionality:
    MPLS label disposition supported
    Control word processing supported
    Sequence number processing not supported
  Edge functionality:
    MPLS label imposition supported
    Control word processing supported
    Sequence number processing not supported
.
.
.
```

Note These examples show only a portion of the output. The command displays the the capabilities of every transport type.

The following is partial sample output from the **show mpls l2transport hw-capability** command for Cisco IOS Releases 12.0(27)S and 12.2(18)SXE and later. This output shows VCCV data under the Core Functionality section. Type 1 means that the AToM Control Word identified the AToM VCCV packet. For more information on the fields, see Table 10.

```
Transport type FR DLCI
  Core functionality:
    MPLS label disposition supported
    Control word processing supported
    Sequence number processing not supported
    VCCV CC Type 1 processing supported

  Edge functionality:
    MPLS label imposition supported
    Control word processing supported
    Sequence number processing not supported
.
.
.
```

The following is partial sample output from the **show mpls l2transport hw-capability** command for Cisco IOS Releases 12.2(30)S and later. The VCCV output shows that AToM Control Word (CW) identified the AToM VCCV packet. For more information on the fields, see Table 10.

```
Transport type FR DLCI
  Core functionality:
    MPLS label disposition supported
    Control word processing supported
    Sequence number processing not supported
    VCCV CC Type CW [1] processing supported

  Edge functionality:
    MPLS label imposition supported
    Control word processing supported
    Sequence number processing not supported
.
.
.
```

The output of the command changed between Cisco IOS Releases. The following table maps the older output to the new output:

Output in Cisco IOS Releases 12.0(27)S and 12.2(18)SXE and later	Output In Cisco IOS Release 12.2(30)S
VCCV CC processing supported	VCCV CC processing supported
Type 1	Type CW [1]

Table 10 describes the significant fields shown in the display.

Table 10 show mpls l2transport hw-capability Field Descriptions

Field	Description
Transport type	Indicates the transport type.
Core functionality	Displays the functionalities that the core-facing interfaces support, such as label disposition, and control word and sequence number processing.
VCCV CC Type processing supported	Displays whether the core-facing interfaces support Control Word processing, or Router Alert Processing. (Cisco IOS Releases 12.0(27)S and 12.2(18)SXE and later) • Type 1—The Protocol ID field of in the AToM Control Word (CW) identified the AToM VCCV packet. (Cisco IOS Releases 12.2(30)S and later) • CW [1]—Control Word • Unkn [*x*]—Unknown. The number indicates the position of the bit that was set in the received octet.
Edge functionality	Displays the functionalities that the edge-facing interfaces support, such as label disposition, and control word and sequence number processing.

Obsolete and Replaced Commands

This section documents obsolete and replaced commands. Other commands used with this feature are documented in the previous releases of AToM feature modules:

- Cisco IOS Release 12.0(26)S: Any Transport over MPLS

  http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s26/atom26s.htm
- Cisco IOS Release 12.0(25)S: Any Transport over MPLS

  http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s25/atom25s.htm
- Cisco IOS Release 12.0(23)S: Any Transport over MPLS

  http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/120newft/120limit/120s/120s23/atom/index.htm

Table 11 lists commands that are obsolete or have been replaced.

Table 11 Obsolete or Replaced AToM Commands

Obsolete or Replaced Command	New Command
atm mode cell-relay	**No replacement**
atm route interface	**xconnect**
debug mpls atm-transport control	**No replacement**

Table 11 Obsolete or Replaced AToM Commands (continued)

Obsolete or Replaced Command	New Command
debug mpls atm-transport distributed	No replacement
debug mpls atm-transport switching	No replacement
mpls atm-transport	No replacement
mpls atm-transport cos-map	No replacement
mpls l2transport cos-map	No replacement
show atm route	No replacement
show mpls atm-transport cos-map	No replacement
show mpls atm-transport disposition	No replacement
show mpls atm-transport imposition	No replacement

atm mode cell-relay

The **atm mode cell-relay** command is obsolete. You no longer need to use this command to configure ATM Cell Relay over MPLS on the Cisco 12000 series router engine 2 8-port OC-3 STM-1 ATM line card.

atm route interface

The **atm route interface** command has been replaced. See the **xconnect** command for more information.

debug mpls atm-transport control

This command is obsolete. There is no replacement command.

debug mpls atm-transport distributed

This command is obsolete. There is no replacement command.

debug mpls atm-transport switching

This command is obsolete. There is no replacement command.

mpls atm-transport

This command is obsolete. There is no replacement command.

mpls atm-transport cos-map

This command is obsolete. There is no replacement command.

mpls l2transport cos-map

This command is obsolete. There is no replacement command.

show atm route

This command is obsolete. There is no replacement.

show mpls atm-transport cos-map

This command is obsolete. There is no replacement.

show mpls atm-transport disposition

This command is obsolete. There is no replacement.

show mpls atm-transport imposition

This command is obsolete. There is no replacement.