



## Configuring Ethernet over MPLS

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This chapter describes how to configure Ethernet over Multiprotocol Label Switching (EoMPLS) on the ML-Series card.

This chapter includes the following major sections:

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- [Configuring EoMPLS, page 18-4](#)
- [EoMPLS Configuration Example, page 18-11](#)
- [Monitoring and Verifying EoMPLS, page 18-13](#)
- [Understanding MPLS-TE, page 18-14](#)
- [Configuring MPLS-TE, page 18-15](#)
- [MPLS-TE Configuration Example, page 18-17](#)
- [Monitoring and Verifying MPLS-TE and IP RSVP, page 18-19](#)

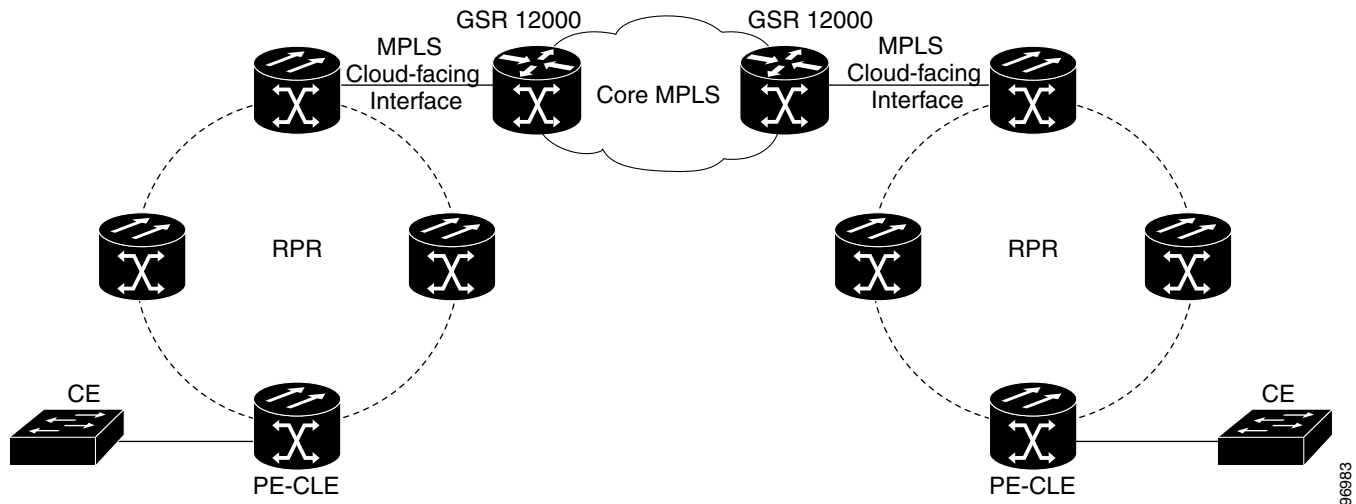
### Understanding EoMPLS

EoMPLS provides a tunneling mechanism for transporting Layer 2 Ethernet frames through an MPLS-enabled Layer 3 core network. It encapsulates Ethernet protocol data units (PDUs) inside MPLS packets and using label stacking forwards them across the MPLS network. EoMPLS is an Internet Engineering Task Force (IETF) standard-track protocol based on the Martini draft, specifically the draft-martini-l2circuit-encap-mpls-01 and draft-martini-l2circuit-transport-mpls-05 sections.

EoMPLS allows service providers to offer customers a virtual Ethernet line service or VLAN service using the service provider's existing MPLS backbone. It also simplifies service provider provisioning, since the provider edge customer-leading edge (PE-CLE) equipment only needs to provide Layer 2 connectivity to the connected customer edge (CE) equipment.

[Figure 18-1](#) shows an example of EoMPLS implemented on a service provider network. In the example, the ML-Series card acts as PE-CLE equipment connecting to the Cisco GSR 12000 Series through an RPR access ring. Point-to-point service is provided to CE equipment in different sites that connect through ML-Series cards to the ML-Series card RPR access ring.

Figure 18-1 EoMPLS Service Provider Network



Although Figure 18-1 shows RPR connecting the ML-Series cards on either side of the core MPLS, the ML-Series cards can also connect through POS ports that are not configured in RPR. In the non-RPR scenario, the ML-Series cards connect in a point-to-point configuration.

Implementing EoMPLS across a service provider's network requires setting up directed Label Distribution Protocol (LDP) sessions (LSPs) between the ingress and egress PE-CLE ML-Series cards to exchange information for a virtual circuit (VC). Each VC consists of two LSPs, one in each direction, since an LSP is a directed path to carry Layer 2 frames in one direction only.

EoMPLS uses a two-level label stack to transport Layer 2 frames, where the bottom/inner label is the VC label and the top/outer label is the tunnel label. The VC label is provided to the ingress PE-CLE by the egress PE-CLE of a particular LSP to direct traffic to a particular egress interface on the egress PE-CLE. A VC label is assigned by the egress PE-CLE during the VC setup and represents the binding between the egress interface and a unique and configurative VC ID. During a VC setup, the ingress and egress PE-CLE exchange VC label bindings for the specified VC ID.

An EoMPLS VC on the ML-Series card is one of two types, based on whether it transports an Ethernet port or an IEEE 802.1Q VLAN over the MPLS core. A VC type 5 tunnels an Ethernet port, and a VC type 4 transports a VLAN. In a VC type 5 session, the user can expect any traffic that is received on an ML-Series card PE-CLE port with an `mpls l2transport route` command to be tunneled to the remote egress interface on the far-end ML-Series card PE-CLE port. With a VC type 4, a user can expect the tunnel to act as an extension to that VLAN. The EoMPLS session commands are entered on a VLAN subinterface on the PE-CLE, and only VLAN-tagged traffic received on that port will be tunneled to the remote PE-CLE.

## EoMPLS Support

EoMPLS on the ML-Series card has the following characteristics:

- EoMPLS is supported over the following interface types:
  - POS with LEX encapsulation using GFP Framing
  - POS with LEX encapsulation using HDLC Framing
  - SPR using GFP-Framing

- SPR using HDLC-Framing
- MPLS tag switching is supported on SPR and POS interfaces.
- Class of service (CoS) values are mapped to the experimental (EXP) bits in the MPLS label, either statically or by using the IEEE 802.1p bits (default).
- Ingress PE-CLE ML-Series cards set the S bit of the VC label to 1 to indicate that the VC label is at the bottom of the stack.
- The Ethernet over MPLS feature is part of the Cisco Any Transport over MPLS (AToM) product set.
- The ML-Series card hosting the EoMPLS endpoint ports must be running the MPLS microcode image to support EoMPLS. For more information on multiple microcode images, see the “[Multiple Microcode Images](#)” section on page 3-11. Other ML-Series cards in the RPR are not restricted to the MPLS microcode image.

## EoMPLS Restrictions

EoMPLS on the ML-Series card has the following restrictions:

- Zero hop or hairpin VCs are not supported. A single ML-Series card cannot be both the source and destination for a VC.
- MPLS control word for sequencing of data transmission is not supported. Packets must be received and transmitted without control word.
- Sequence checking or resequencing of EoMPLS traffic is not supported. Both depend on the control word to function.
- Maximum transmission unit (MTU) fragmentation is not supported.
- Explicit-null label for back-to-back LDP sessions is not supported.
- The ML-Series card supports a maximum of 650 VCs in EoMPLS configuration.



**Caution**

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Since MTU fragmentation is not supported across the MPLS backbone, the network operator must make sure the MTU of all intermediate links between endpoints is sufficient to carry the largest Layer 2 PDU.

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**Caution**

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If the 650 VC maximum is exceeded, the user is not permitted to save the configuration file.

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## EoMPLS Quality of Service

The EXP is a 3-bit field and part of the MPLS header. It was created by the IETF on an experimental basis, but later became part of the standard MPLS header. The EXP bits in the MPLS header carry the packet priority. Each label switch router along the path honors the packet priority by queuing the packet into the proper queue and servicing the packet accordingly.

By default, the ML-Series card does not map the IEEE 802.1P bits in the VLAN tag header to the MPLS EXP bits. The MPLS EXP bits are set to a value of 0.

There is no straight copy between Layer 2 CoS and MPLS EXP, but the user can use the **set mpls experimental** action to set the MPLS EXP bit values based on a match to 802.1p bits. This mapping occurs at the entry point, the ingress of the network.

Quality of service (QoS) for EoMPLS traffic on ML-Series cards uses strict priority and/or weighted round robin scheduling in the egress interface of both imposition and disposition router. This requires selection of the service class queue that determines the type of scheduling. In the imposition router, the priority bits EXP or RPR CoS that are marked based on policing are used to select the service class queue and in the disposition router, the dot1p CoS bits (which are copied from EXP bits of the labels) are used to do the same. In addition to scheduling in the egress interface, the output policy action can also include remarking of EXP and RPR CoS bits.

EoMPLS on the ML-Series card uses the Cisco Modular Quality of Service Command-Line Interface (MQC), just like the standard QoS on the ML-Series card. But the full range of MQC commands are not available. [Table 18-1](#) lists the applicable MQC statements and actions for the ML-Series card interfaces.

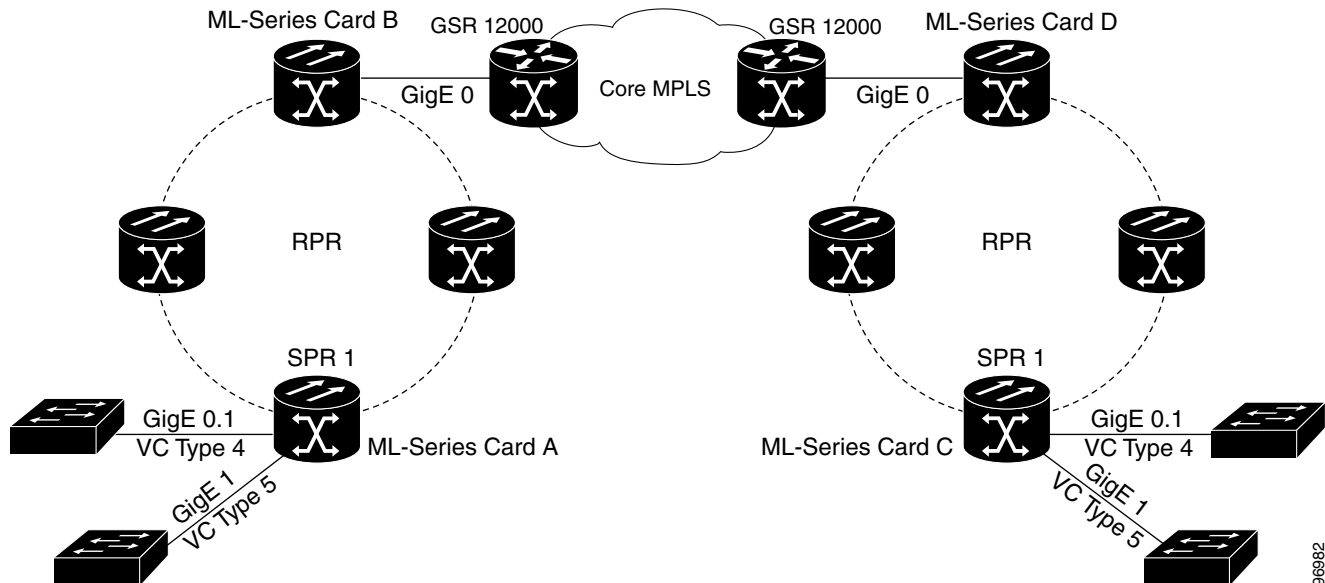
**Table 18-1** Applicable EoMPLS QoS Statements and Actions

Interface	Applicable MQC Match Statements	Applicable MQC Actions
Imposition Ingress	match cos match ip precedence match ip dscp match vlan	<b>police</b> <i>cir</i> <i>cir-burst</i> [ <i>pir-burst</i> <b>pir</b> <i>pir</i> <b>conform</b> [ <i>set-mpls-exp</i>   <b>exceed</b> [ <i>set-mpls-exp</i> ] <b>violate</b> <i>set-mpls-exp</i> ]
Imposition Egress	match mpls exp	<b>bandwidth</b> { <i>bandwidth-kbps</i>   <b>percent</b> <i>percent</i> } and <b>priority</b> <i>kbps</i> and [ <i>set-mpls-exp</i> ]
Disposition Ingress	Not applicable	Not applicable
Disposition Egress	match mpls exp	<b>bandwidth</b> { <i>bandwidth-kbps</i>   <b>percent</b> <i>percent</i> } and <b>priority</b> <i>kbps</i> and <b>set-cos</b> <i>cos-value</i>

## Configuring EoMPLS

Implementing EoMPLS on a service provider network requires ML-Series card interfaces to play three major roles. [Figure 18-2](#) illustrates EoMPLS on ML-Series cards and the interfaces that play these major roles.

Figure 18-2 EoMPLS Configuration Example



- ML-Series card interfaces connect the provider's network directly to the customer edge equipment and are known as the PE-CLE interfaces. This PE-CLE interface is configured to be an endpoint on the EoMPLS point-to-point session. The port on the ML-Series card connecting directly to the CE port is either Fast Ethernet on an ML100T-12 or Gigabit Ethernet on an ML1000-2.

The PE-CLE interface is either a VC type 4 or VC type 5. A VC type 4, which transport IEEE 802.1Q VLAN packets between two PE-CLE ML-Series cards, is configured on a subinterface, such as interface GigE 0.1 on card A and card C in Figure 18-2. A VC type 5, which transports the configured port's packets between two PE-CLE ML-Series cards, is configured on the main Fast Ethernet or Gigabit Ethernet interface. Interface GigE 1 on card A and card C plays the VC type 5 role in Figure 18-2.

For more information on the role of a VC type 4, see the “Understanding EoMPLS” section on page 18-1. For more information on the role of a VC type 5, see the “Understanding EoMPLS” section on page 18-1.

- An ML-Series card interface bridges the PE-CLE interface and the RPR network of ML-Series cards. This RPR/SPR interface contains POS ports and is configured for MPLS IP. To enable the RPR to act as an access ring for the MPLS cloud, you must provision the SPR interface on the same ML-Series card that hosts the EoMPLS PE-CLE FastEthernet or GigabitEthernet interfaces. Interface SPR 1 on card A and card C plays this role in Figure 18-2.

A POS interface is used in this role if the ML-Series cards on one side of the MPLS cloud use a point-to-point connection through POS interfaces instead of an RPR to connect. You provision the POS interface, instead of an SPR interface, to bridge the PE-CLE interface on the ML-Series card.

- An ML-Series card interface connects to the interface of a router that is part of the MPLS cloud. This interface is Gigabit Ethernet or Fast Ethernet and connects to the port of a Cisco GSR 12000 Series or similar device that is on the MPLS network. This MPLS cloud-facing interface bridges the SPR interface and the MPLS cloud. A bridge group must be created that contains this FastEthernet or GigabitEthernet port and the SPR interface. Interface GigE 0 on card B and card D plays this role in Figure 18-2.

A POS interface is used in the SPR interface role if the ML-Series cards on one side of the MPLS cloud use a point-to-point connection through POS interfaces instead of an RPR to connect. You provision the POS interface, instead of the SPR interface, as a member of the bridge group with MPLS cloud-facing interface on the ML-Series card.

Peer ML-Series card interface roles must be configured on both sides of the EoMPLS point-to-point service crossing the MPLS core.

## EoMPLS Configuration Guidelines

The ML-Series peer cards on both endpoints of the EoMPLS point-to-point service must be configured. Perform the following configuration tasks to enable EoMPLS:


- [VC Type 4 Configuration on PE-CLE Port, page 18-6](#) (Either VC type 4 or VC type 5 is required.)
- [VC Type 5 Configuration on PE-CLE Port, page 18-7](#) (Either VC type 4 or VC type 5 is required.)
- [EoMPLS Configuration on PE-CLE SPR Interface, page 18-8](#) (Optional)
- [EoMPLS Configuration on PE-CLE POS Interface, page 18-8](#) (Optional)
- [Bridge Group Configuration on MPLS Cloud-facing Port and SPR Interface, page 18-9](#) (Optional)
- [Bridge Group Configuration on MPLS Cloud-facing Port and POS Interface, page 18-10](#) (Optional)
- [Setting the Priority of Packets with the EXP, page 18-10](#) (Optional)

These are the guidelines for configuring EoMPLS:

- Loopback addresses are used to specify the peer ML-Series card's IP address.
- LDP configuration is required. The default Tag Distribution Protocol (TDP) will not work.
- EoMPLS uses LDP targeted session between the ML-Series cards to create the EoMPLS VCs.
- The MPLS backbone must use an Interior Gateway Protocol (IGP) routing protocol, for example, Open Shortest Path First (OSPF).

## VC Type 4 Configuration on PE-CLE Port


To provision a VC type 4, perform the following procedure on the CE facing port, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>mpls label protocol ldp</b>	Specifies LDP as the label distribution protocol.  LDP must be specified. The ML-Series card does not operate EoMPLS with the default TDP as the label distribution protocol.
Step 2	Router(config)# <b>mpls label range 16 1039</b>	Restricts the MPLS label range to correspond to the 1024 subinterfaces supported on the ML-Series card.   <b>Caution</b> Failure to restrict the MPLS label range allows the creation of MPLS labels outside the supported range. In certain circumstances, this may result in traffic loss.

	Command	Purpose
Step 3	Router(config)# <b>interface loopback0</b>	Enters loopback interface configuration mode.
Step 4	Router(config-if)# <b>ip address ip-address 255.255.255.255</b>	Assigns an IP address to the loopback interface. This loopback IP addresses is used to identify the peer in the EoMPLS point-to-point session.
Step 5	Router(config)# <b>interface {GigabitEthernet   FastEthernet} interface-number.sub-interface-number</b>	Specifies the Ethernet subinterface for the imposition interface. Make sure the subinterface on the adjoining CE equipment is on the same VLAN as this subinterface.
Step 6	Router(config-subif)# <b>no ip address</b>	Disables the IP address if an IP address is assigned.
Step 7	Router(config-subif)# <b>encapsulation dot1Q vlan-id</b>	Enables the subinterface to accept 802.1q VLAN packets. Make sure the VLAN ID is the same as the VLAN ID on the adjoining CE equipment.
Step 8	Router(config-subif)# <b>mpls l2transport route destination vc-id</b>	<p>Specifies the VC to use to transport the VLAN packets. Initiates a remote LDP session with the peer point-to-point endpoint interface.</p> <p>The argument destination specifies the loopback address of the remote ML-Series at the other end of the VC (PE-CLE).</p> <p>The argument vc-id is a value you supply. It must be unique for each VC. The VC ID is used to connect the endpoints of the VC. Specify the same VC ID on both ends of the VC.</p>

## VC Type 5 Configuration on PE-CLE Port

To provision a VC type 5, perform the following procedure on the customer facing port, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>mpls label protocol ldp</b>	<p>Specifies LDP as the label distribution protocol.</p> <p>LDP must be specified. The ML-Series card does not operate EoMPLS with the default TDP as the label distribution protocol.</p>
Step 2	Router(config)# <b>mpls label range 16 1039</b>	<p>Restricts the MPLS label range to correspond to the 1024 subinterfaces supported on the ML-Series card.</p> <p> <b>Caution</b> Failure to restrict the MPLS label range allows the creation of MPLS labels outside the supported range. In certain circumstances this may result in traffic loss.</p>
Step 3	Router(config)# <b>interface loopback0</b>	Enters loopback interface configuration mode.
Step 4	Router(config-if)# <b>ip address ip-address 255.255.255.255</b>	Assigns an IP address to the loopback interface. This loopback IP addresses is used to identify the peer in the EoMPLS point-to-point session.

	Command	Purpose
Step 5	Router(config)# <b>interface</b> {GigabitEthernet   FastEthernet} <i>interface-number</i>	Specifies the Ethernet interface for the imposition interface.
Step 6	Router(config-if)# <b>no ip address</b>	Disables the IP address if an IP address is assigned.
Step 7	Router(config-if)# <b>mpls l2transport route destination vc-id</b>	Specifies the VC to use to transport the VLAN packets. Initiates a remote LDP session with the peer point-to-point endpoint interface.  destination specifies the loopback address of the remote ML-Series card at the other end of the VC (PE-CLE).  vc-id is a common identifier used by the endpoints to identify the created EoMPLS VC. It must be unique for each VC and the same VC ID must be used on both ends of the VC.

## EoMPLS Configuration on PE-CLE SPR Interface

To provision the SPR interface for MPLS, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>mpls label protocol ldp</b>	Specifies LDP as the label distribution protocol.  LDP must be specified. The ML-Series card does not operate EoMPLS with the default TDP as the label distribution protocol.
Step 2	Router(config)# <b>interface spr 1</b>	Enters RPR interface configuration mode.
Step 3	Router(config-if)# <b>ip address ip-address mask</b>	Assigns an IP address to the RPR interface for MPLS.
Step 4	Router(config-if)# <b>mpls ip</b>	Implements tag switching on the SPR interface.
Step 5	Router(config-if)# <b>end</b>	Exits interface configuration mode.
Step 6	Router# <b>copy running-config startup-config</b>	Saves the running configuration file to the startup configuration file.

## EoMPLS Configuration on PE-CLE POS Interface

You can also configure a POS interface on the same ML-Series card that hosts the EoMPLS PE-CLE Fast Ethernet or Gigabit Ethernet interfaces. To provision the POS interface for MPLS, perform the following procedure, beginning in global configuration mode:



	Command	Purpose
Step 1	Router(config)# <b>mpls label protocol ldp</b>	Specifies LDP as the label distribution protocol. LDP must be specified. The ML-Series card does not operate EoMPLS with the default TDP as the label distribution protocol.
Step 2	Router(config)# <b>interface pos0</b>	Enters POS interface configuration mode.
Step 3	Router(config-if)# <b>ip address ip-address mask</b>	Assigns an IP address to the RPR interface for MPLS.
Step 4	Router(config-if)# <b>mpls ip</b>	Implements tag switching on the SPR interface.
Step 5	Router(config-if)# <b>end</b>	Exits interface configuration mode.
Step 6	Router# <b>copy running-config startup-config</b>	Saves the running configuration file to the startup configuration file.

## Bridge Group Configuration on MPLS Cloud-facing Port and SPR Interface

To provision the MPLS cloud-facing port for EoMPLS, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>bridge 1 protocol {rstp   ieee}</b>	(Optional) Assigns a bridge group number and defines the appropriate spanning-tree type: either IEEE 802.1D Spanning Tree Protocol or IEEE 802.1W Rapid Spanning Tree.
Step 2	Router(config)# <b>interface {GigabitEthernet   FastEthernet} interface-number</b>	Enters interface configuration mode to configure the MPLS cloud-facing FastEthernet or GigabitEthernet interface of the ML-Series card.
Step 3	Router(config-if)# <b>bridge-group 1</b>	Assigns the network interface to bridge group 1.
Step 4	Router(config-if)# <b>no shutdown</b>	Changes the shutdown state to up and enables the interface.
Step 5	Router(config)# <b>interface spr 1.subinterface-number</b>	Enters SPR subinterface mode.
Step 6	Router(config-subif)# <b>encapsulation dot1q 1 native</b>	Enables the IEEE 802.1Q native VLAN on the subinterface. EoMPLS on the ML-Series card uses the native VLAN (VLAN 1).
Step 7	Router(config-if)# <b>bridge-group 1</b>	Assigns the network interface to bridge group 1.
Step 8	Router(config-if)# <b>end</b>	Returns to privileged EXEC mode.
Step 9	Router# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Bridge Group Configuration on MPLS Cloud-facing Port and POS Interface

To provision the MPLS cloud-facing port for EoMPLS, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>bridge 1 protocol {rstp   ieee}</b>	(Optional) Assigns a bridge group number and defines the appropriate spanning-tree type: either IEEE 802.1D Spanning Tree Protocol or IEEE 802.1W Rapid Spanning Tree.
Step 2	Router(config)# <b>interface {GigabitEthernet   FastEthernet} interface-number</b>	Enters interface configuration mode to configure the MPLS cloud-facing FastEthernet or GigabitEthernet interface of the ML-Series card.
Step 3	Router(config-if)# <b>bridge-group 1</b>	Assigns the network interface to bridge group 1.
Step 4	Router(config-if)# <b>no shutdown</b>	Changes the shutdown state to up and enables the interface.
Step 5	Router(config)# <b>interface pos interface-number.subinterface-number</b>	Enters POS subinterface mode.
Step 6	Router(config-subif)# <b>encapsulation dot1q 1 native</b>	Enables the IEEE 802.1Q native VLAN on the subinterface.  EoMPLS on the ML-Series card uses the native VLAN (VLAN 1).
Step 7	Router(config-if)# <b>bridge-group 1</b>	Assigns the network interface to bridge group 1.
Step 8	Router(config-if)# <b>end</b>	Returns to privileged EXEC mode.
Step 9	Router# <b>copy running-config startup-config</b>	(Optional) Saves your entries in the configuration file.

## Setting the Priority of Packets with the EXP

EoMPLS can provide QoS using the three EXP bits in a label to determine the priority of packets. Set the experimental bits in both the VC and tunnel labels to support QoS between ML-Series card endpoints.



### Note

The ML-Series card also supports MPLS-TE. See [Understanding MPLS-TE, page 18-14](#) for more information.

To set the experimental bits, perform the following procedure, beginning in global configuration mode:

	Command	Purpose
Step 1	Router(config)# <b>class-map class-name</b>	Specifies the user-defined name of the traffic class.
Step 2	Router(config-cmap)# <b>match any</b>	Specifies that all packets will be matched.
Step 3	Router(config-cmap)# <b>end</b>	Returns to global configuration mode.

	Command	Purpose
Step 4	Router(config)# <b>policy-map</b> <i>policy-name</i>	Specifies the name of the traffic policy to configure.
Step 5	Router(config-pmap)# <b>class</b> <i>class-name</i>	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	Router (config-pmap-c)# <b>set</b> <b>mpls experimental imposition</b> <i>value</i>	Designates the value to which the MPLS bits are set if the packets match the specified policy map.
Step 7	Router(config)# <b>interface</b> <b>GigabitEthernet</b> <i>interface-number</i>  or  <b>interface FastEthernet</b> <i>interface-number</i>	Enters interface configuration mode.
Step 8	Router(config-if)# <b>service-policy input</b> <i>policy-name</i>	Attaches a traffic policy to an interface.

## EoMPLS Configuration Example

Figure 18-2 on page 18-5 illustrates the sample network that the configuration commands reference. Examples 18-1, 18-2, 18-3, and 18-4 list relevant portions of the configuration files for enabling EoMPLS on ML-Series cards in a sample network.

### Example 18-1 ML-Series Card A Configuration

```

microcode mpls
ip subnet-zero
no ip domain-lookup
!
mpls label protocol ldp
!
interface Loopback0

    ip address 10.10.10.10 255.255.255.255
    !
interface SPR1
    ip address 100.100.100.100 255.255.255.0
    no keepalive
spr station-id 1
mpls ip
    hold-queue 150 in
    !
interface GigabitEthernet0
    no ip address
    !
interface GigabitEthernet0.1
    encapsulation dot1Q 10
    mpls l2transport route 3.3.3.3 1
    !
interface GigabitEthernet1
    no ip address
    mpls l2transport route 4.4.4.4 2

```

```

!
interface POS0
  no ip address
  spr-intf-id 1
  crc 32
!
interface POS1
  no ip address
  spr-intf-id 1
  crc 32
router ospf 1
  log-adjacency-changes
  network 1.1.1.0 0.0.0.255 area 0
  network 10.10.10.0 0.0.0.255 area 0
!
ip classless
no ip http server

```

### **Example 18-2 ML-Series Card B Configuration**

```

bridge 10 protocol ieee
!
!
interface SPR1
  no ip address
  no keepalive
  bridge-group 10
  hold-queue 150 in
!
interface GigabitEthernet0
  no ip address
  bridge-group 10

```

### **Example 18-3 ML-Series Card C Configuration**

```

microcode mpls
ip subnet-zero
no ip domain-lookup
!
mpls label protocol ldp
!
interface Loopback0

  ip address 20.20.20.20 255.255.255.255
!
interface SPR1
  ip address 100.100.100.100 255.255.255.0
  no keepalive
  spr station-id 4
  mpls ip
  hold-queue 150 in
!
interface GigabitEthernet0
  no ip address
!
interface GigabitEthernet0.1
  encapsulation dot1Q 10
  mpls l2transport route 1.1.1.1 1
!
interface GigabitEthernet1
  no ip address
  mpls l2transport route 2.2.2.2 2

```

```

!
interface POS0
  no ip address
  spr-intf-id 1
  crc 32
!
interface POS1
  no ip address
  spr-intf-id 1
  crc 32
!
router ospf 1
  log-adjacency-changes
  network 1.1.1.0 0.0.0.255 area 0
  network 10.10.10.0 0.0.0.255 area 0
!
ip classless
no ip http server

```

#### Example 18-4 ML-Series Card D Configuration

```

bridge 20 protocol ieee
!
!
interface SPR1
  no ip address
  no keepalive
  bridge-group 20
  hold-queue 150 in
!
interface GigabitEthernet0
  no ip address
  bridge-group 20

```

## Monitoring and Verifying EoMPLS

Table 18-2 shows the privileged EXEC commands for monitoring and verifying EoMPLS.

**Table 18-2** Commands for Monitoring and Maintaining Tunneling

Command	Purpose
<code>show mpls l2transport vc</code>	Provides information about all EoMPLS tunnels.
<code>show mpls l2transport vc detail</code>	Provides detailed information about the EoMPLS tunnel.
<code>show mpls l2transport vc vc-id</code>	Provides information about a specific EoMPLS tunnel.

# Understanding MPLS-TE

MPLS traffic is normally routed to the least cost path as calculated by OSPF or another IGP routing protocol. This routing gives little or no consideration to varying bandwidth demands or link loads. MPLS traffic engineering (MPLS-TE) overcomes this by mapping traffic flows to paths that take bandwidth demands into account. These paths are known as MPLS-TE tunnels, and they may deviate from the normal IGP calculated routes.

MPLS-TE (RFC 2702) allow service providers to create traffic engineered tunnels to reserve bandwidth for specific types of traffic and to provide point-to-point services for end customers. The ML-Series card supports a maximum of 24 MPLS-TE tunnels. MPLS-TE tunnels can carry a VC type 5, which tunnels an Ethernet port, or a VC type 4, which tunnels an 802.1Q VLAN.

For the ML-Series card to use MPLS-TE, you need to configure three main components. First, you must implement an IGP routing protocol that conveys and distributes information about the link resources throughout the MPLS network. For this purpose, the ML-Series card supports OSPF and OSPF-TE extensions (RFC 2328 and RFC 2370). MPLS-TE extensions for other routing protocols, such as IS-IS, are not supported on the ML-Series card.

Second, you need to configure a signalling protocol to reserve needed resources and establish LSPs across the MPLS network. MPLS-TE tunnels use Resource Reservation Protocol (RSVP) messages (RFC 2205 and RFC 3209) to accomplish this. The ML-Series card supports RSVP and the RSVP extensions for LSP tunnels on both POS interfaces and RPR (SPR) interfaces.

For the third component, you need to set up an MPLS-TE tunnel on the appropriate ML-Series card interface. This requires creating an MPLS tunnel interface with an IP address, destination, encapsulation, bandwidth, and explicit or dynamic path.

## RSVP on the ML-Series Card

The ML-Series card uses RSVP to establish MPLS-TE tunnels and the associated tunnel labels. Targeted LDP is still used to establish the VC Labels. Also, RSVP is only used to guarantee the bandwidth on the intermediate nodes on the tunnel. On the ML-Series card, which will be the end-point of the MPLS-TE tunnel, RSVP is used only for bandwidth allocation.

You configure bandwidth guarantees on the ML-Series card ports using the Cisco Modular Quality of Service Command-Line Interface (MQC), just like the standard QoS on the ML-Series card. For more information, see the [“EoMPLS Quality of Service” section on page 18-3](#).

The ML-Series card does not use RSVP messages to carry the information for EoMPLS VCs. LDP sessions are still used to exchange VC information. Also RSVP does not guarantee bandwidth. It only allocates bandwidth.

The ML-Series card supports RSVP summary refresh and RSVP refresh reduction (RFC 2961). Refresh reduction is a set of extensions that reduce the messaging load imposed by RSVP. This helps RSVP scale to support larger numbers of flows. The global configuration command **ip rsvp signalling refresh reduction** enables this feature.

## Ethernet FCS Preservation

You can configure the ML-Series card to encapsulate and preserve the customer's Ethernet FCS. The ML-Series card will carry the Ethernet FCS end-to-end and unmodified across EoMPLS or EoMPLS-TE tunnels. This end-to-end preservation of the original Ethernet FCS is useful for troubleshooting.

Ethernet FCS preservation is off by default on the ML-Series card. Configure Ethernet FCS preservation at the interface or sub-interface configuration level with the **[no] fcs-preservation-on** command. To operate correctly, both ends of the EoMPLS tunnel need to be configured for FCS preservation.

## Configuring MPLS-TE

Perform the following tasks on the MPLS network before you enable MPLS-TE on the ML-Series card:

- Turn on MPLS tunnels
- Turn on OSPF

To configure MPLS-TE on the ML-Series card, perform the tasks described in the following sections:

- [Configuring an ML-Series Card for Tunnels Support](#)
- [Configuring an Interface to Support RSVP-Based Tunnel Signalling and IGP Flooding](#)
- [Configuring OSPF and Refresh Reduction for MPLS-TE](#)
- [Configuring an MPLS-TE Tunnel](#)



**Note**

The ML-Series card does not support MPLS-TE with IS-IS.



**Note**

Cisco Express Forwarding (CEF) is on by default on the ML-Series card.

## Configuring an ML-Series Card for Tunnels Support

To configure an ML-Series card to support tunnels, use the following commands in global configuration mode:

	Command	Purpose
<b>Step 1</b>	Router(config)# <b>mpls traffic-eng tunnels</b>	Enables the MPLS-TE tunnel feature on a device.

## Configuring an Interface to Support RSVP-Based Tunnel Signalling and IGP Flooding

To configure an interface to support RSVP-based tunnel signalling and IGP flooding, use the following commands in interface configuration mode:



**Note**

You must enable the tunnel feature on interfaces or sub-interfaces that you want to support MPLS-TE.

**Note**

A VC type 4 requires one POS interface to be configured for MPLS-TE tunnel and the other POS interface configured for the 802.1Q tunnel.

	Command	Purpose
Step 1	Router(config-if)# <b>mpls traffic-eng tunnels</b>	Enables MPLS-TE tunnels on an RPR (SPR) interface or on a POS interface.
Step 2	Router(config-if)# <b>ip rsvp bandwidth</b> <i>bandwidth</i>	Enables RSVP for IP on an interface and specifies the amount of bandwidth that will be reserved.  For a description of the <b>ip rsvp</b> interface command syntax, see the <i>Cisco IOS Quality of Service Solutions Command Reference</i> .

## Configuring OSPF and Refresh Reduction for MPLS-TE

For a description of the OSPF commands (excluding the OSPF traffic engineering commands), see the *Cisco IOS IP Command Reference, Volume 2 of 3: Routing Protocols*

To configure OSPF and Refresh Reduction for MPLS-TE, use the following commands beginning in global configuration mode .

	Command	Purpose
Step 1	Router(config)# <b>router ospf</b> <i>process-id</i>	Configures an OSPF routing process for IP and places the router in configuration mode.  The <i>process-id</i> argument is an internally used identification parameter for an OSPF routing process. It is locally assigned and can be any positive integer. Assign a unique value for each OSPF routing process.
Step 2	Router(config-router)# <b>mpls traffic-eng area</b> <i>area-id</i>	Turns on MPLS-TE for a specified OSPF area.
Step 3	Router(config-router)# <b>mpls traffic-eng router-id</b> <i>loopback0</i>	Specifies that the traffic engineering router identifier for the node is the IP address associated with interface loopback0.
Step 4	Router(config)# <b>ip rsvp signalling refresh reduction</b>	Reduces the messaging load imposed by RSVP

## Configuring an MPLS-TE Tunnel

To configure an MPLS-TE tunnel, use the following commands, beginning in global configuration mode:

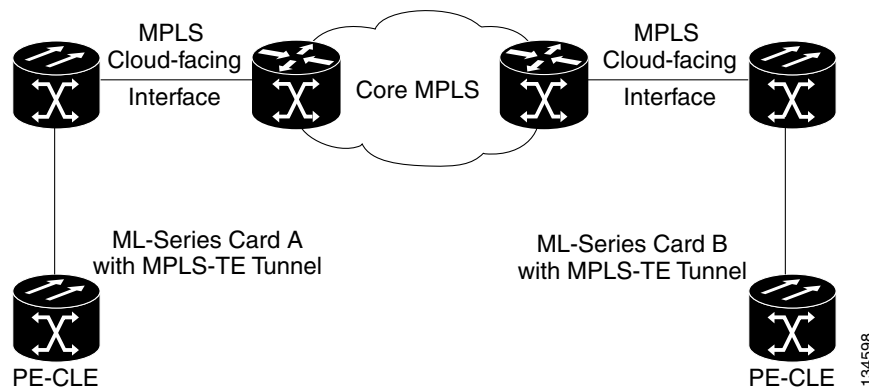


	Command	Purpose
Step 1	Router(config)# <b>interface tunnel</b>	Configures an interface type and enters interface configuration mode.
Step 2	Router(config)# <b>ip unnumbered loopback0</b>	Gives the tunnel interface an IP address. An MPLS-TE tunnel interface should be unnumbered because it represents a unidirectional link.
Step 3	Router(config-if)# <b>tunnel destination A.B.C.D</b>	Specifies the destination for a tunnel.
Step 4	Router(config-if)# <b>tunnel mode mpls traffic-eng</b>	Sets the tunnel encapsulation mode to MPLS-TE.
Step 5	Router(config-if)# <b>tunnel mpls traffic-eng autoroute announce</b>	Specifies IGP should use the tunnel (if the tunnel is up) in its enhanced shortest path first (SPF) calculation.
Step 6	Router(config-if)# <b>tunnel mpls traffic-eng bandwidth bandwidth</b>	Configures the bandwidth for the MPLS-TE tunnel.
Step 7	Router(config-if)# <b>tunnel mpls traffic-eng path-option number {dynamic   explicit}{name path-name   path-number} [lockdown]</b>	Configures the tunnel to use a named IP explicit path or a dynamic path.

## MPLS-TE Configuration Example

Figure 18-3 illustrates the sample network that the configuration commands reference. Example 18-5 lists relevant portions of the configuration files for enabling MPLS-TE on ML-Series card A in the sample network. ML-Series card A is configured with an explicit path.

Figure 18-3 MPLS-TE Configuration Example



### Example 18-5 ML-Series Card A Configuration

```

microcode mpls
ip subnet-zero
no ip domain-lookup
!
mpls label protocol ldp
mpls traffic-eng tunnels

```

```

no mpls traffic-eng auto-bw timers frequency 0
!
!
!
interface Loopback0
 ip address 222.222.222.222 255.255.255.255
!
interface Tunnel0
 ip unnumbered Loopback0
 tunnel destination 212.212.212.212
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng path-option 1 explicit identifier 1
!
interface Tunnel1
 ip unnumbered Loopback0
 tunnel destination 212.212.212.212
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng autoroute announce
 tunnel mpls traffic-eng path-option 2 explicit identifier 2
!
interface GigabitEthernet0
 no ip address
 shutdown
!
interface GigabitEthernet1
 no ip address
!
interface GigabitEthernet1.1
 encapsulation dot1Q 10
 fcs-preservation-on
 mpls l2transport route 212.212.212.212 222
!
interface GigabitEthernet1.2
 encapsulation dot1Q 20
 mpls l2transport route 212.212.212.212 223
!
interface GigabitEthernet1.3
 encapsulation dot1Q 30
 mpls l2transport route 212.212.212.212 224
!
interface POS0
 ip address 170.170.170.172 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 ip rsvp bandwidth 10000
!
interface POS1
 ip address 2.1.1.22 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 ip rsvp bandwidth 10000
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 log-adjacency-changes
 network 2.1.1.22 0.0.0.0 area 0
 network 170.170.170.172 0.0.0.0 area 0
 network 222.222.222.222 0.0.0.0 area 0
!
ip classless
no ip http server
!

```

```

!
ip explicit-path identifier 1 enable
  next-address 2.1.1.1
  next-address 192.168.3.2
  next-address 192.168.3.1
  next-address 2.2.1.1
  next-address 2.2.1.2
  next-address 212.212.212.212
!
ip explicit-path identifier 2 enable
  next-address 170.170.170.171
  next-address 192.168.3.2
  next-address 192.168.3.1
  next-address 2.2.1.1
  next-address 2.2.1.2
  next-address 212.212.212.212
!
!
!
!
control-plane
!
!
!
line con 0
  exec-timeout 0 0
line vty 0 4
  exec-timeout 0 0
  password xxx
  no login

```

## Monitoring and Verifying MPLS-TE and IP RSVP

Table 18-2 shows the privileged EXEC commands supported to monitor and verify the state of MPLS-TE tunnels on the ML-Series cards.

**Table 18-3** Commands for Monitoring and Verifying MPLS-TE

Command	Purpose
<code>show mpls traffic-eng autoroute</code>	Displays tunnels announced to the Interior Gateway Protocol (IGP), including interface, destination, and bandwidth
<code>show mpls traffic-eng link-management admission-control</code>	Displays which tunnels were admitted locally and their parameters (such as, priority, bandwidth, incoming and outgoing interface, and state).
<code>show mpls traffic-eng link-management advertisements</code>	Displays local link information that MPLS traffic engineering link management is currently flooding into the global traffic engineering topology.
<code>show mpls traffic-eng link-management bandwidth-allocation</code>	Displays current local link information.

**Table 18-3** *Commands for Monitoring and Verifying MPLS-TE (continued)*

Command	Purpose
<code>show mpls traffic-eng link-management igp-neighbors</code>	Displays IGP neighbors.
<code>show mpls traffic-eng link-management interfaces</code>	Displays interface resource and configuration information.
<code>show mpls traffic-eng link-management summary</code>	Displays a summary of link management information including link counts.
<code>show mpls traffic-eng topology</code>	Displays the MPLS-TE global topology as currently known at this node.
<code>show mpls traffic-eng tunnel</code>	Displays information about MPLS-TE tunnels, including LSP Tunnels Process and RSVP process.
<code>show mpls traffic-eng tunnel summary</code>	Displays condensed information about MPLS-TE tunnels.

Table 18-2 shows the privileged EXEC commands supported to monitor and verify the state of IP RSVP on the ML-Series cards.

**Table 18-4** *Commands for Monitoring and Verifying IP RSVP*

Command	Purpose
<code>show ip rsvp interface [interface-type interface-number]</code>	Displays Resource Reservation Protocol (RSVP)-related information.
<code>show ip rsvp installed [interface-type interface-number]</code>	Displays RSVP-related installed filters and corresponding bandwidth information.
<code>show ip rsvp neighbor [interface-type interface-number]</code>	Displays current RSVP neighbors.
<code>show ip rsvp sender [interface-type interface-number]</code>	Displays RSVP path-related sender information currently in the database.
<code>show ip rsvp request [interface-type interface-number]</code>	Displays RSVP-related request information being requested upstream
<code>show ip rsvp reservation [interface-type interface-number]</code>	Displays RSVP-related receiver information currently in the database

## RPRW Alarm

For information on the ONS 15454 RPRW alarm, refer to the online version of the *Cisco ONS 15454 Troubleshooting Guide, Release 5.0* at

<http://www.cisco.com/univercd/cc/td/doc/product/ong/15400/r50docs/r50tblsh/r50alts.htm>