



## **MPLS Basic MPLS Configuration Guide, Cisco IOS XE Release 2**

### **Americas Headquarters**

Cisco Systems, Inc.  
170 West Tasman Drive  
San Jose, CA 95134-1706  
USA  
<http://www.cisco.com>  
Tel: 408 526-4000  
800 553-NETS (6387)  
Fax: 408 527-0883

THE SPECIFICATIONS AND INFORMATION REGARDING THE PRODUCTS IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE. ALL STATEMENTS, INFORMATION, AND RECOMMENDATIONS IN THIS MANUAL ARE BELIEVED TO BE ACCURATE BUT ARE PRESENTED WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. USERS MUST TAKE FULL RESPONSIBILITY FOR THEIR APPLICATION OF ANY PRODUCTS.

THE SOFTWARE LICENSE AND LIMITED WARRANTY FOR THE ACCOMPANYING PRODUCT ARE SET FORTH IN THE INFORMATION PACKET THAT SHIPPED WITH THE PRODUCT AND ARE INCORPORATED HEREIN BY THIS REFERENCE. IF YOU ARE UNABLE TO LOCATE THE SOFTWARE LICENSE OR LIMITED WARRANTY, CONTACT YOUR CISCO REPRESENTATIVE FOR A COPY.

The Cisco implementation of TCP header compression is an adaptation of a program developed by the University of California, Berkeley (UCB) as part of UCB's public domain version of the UNIX operating system. All rights reserved. Copyright © 1981, Regents of the University of California.

NOTWITHSTANDING ANY OTHER WARRANTY HEREIN, ALL DOCUMENT FILES AND SOFTWARE OF THESE SUPPLIERS ARE PROVIDED "AS IS" WITH ALL FAULTS. CISCO AND THE ABOVE-NAMED SUPPLIERS DISCLAIM ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IN NO EVENT SHALL CISCO OR ITS SUPPLIERS BE LIABLE FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL, OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OR INABILITY TO USE THIS MANUAL, EVEN IF CISCO OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.

© 2011 Cisco Systems, Inc. All rights reserved.



## CONTENTS

### **MPLS Transport Profile 1**

Finding Feature Information 1

Restrictions for MPLS-TP 1

Information About MPLS-TP 2

How MPLS-TP Works 3

MPLS-TP Path Protection 3

Bidirectional LSPs 3

MPLS-TP OAM Support 3

MPLS-TP Static and Dynamic Multisegment Pseudowires 4

MPLS-TP L2VPN Pseudowire Redundancy for Static and Dynamic Multisegment Pseudowires 4

MPLS-TP OAM Status for Static and Dynamic Multisegment Pseudowires 5

MPLS-TP Links and Physical Interfaces 5

Tunnel Midpoints 5

How to Configure MPLS-TP 6

Configuring the MPLS Label Range 6

Configuring the Router ID and Global ID 7

Configuring Bidirectional Forwarding Detection Templates 8

Configuring Pseudowire OAM Attributes 9

Configuring the Pseudowire Class 10

Configuring the Pseudowire 12

Configuring the MPLS-TP Tunnel 13

Configuring MPLS-TP LSPs at Midpoints 17

Configuring MPLS-TP Links and Physical Interfaces 19

Configuring Static-to-Static Multisegment Pseudowires for MPLS-TP 21

Configuring a Template with Pseudowire Type-Length-Value Parameters 23

Configuring Static-to-Dynamic Multisegment Pseudowires for MPLS-TP 23

Example 27

Configuring the L2VPN Pseudowire Redundancy for Static Multisegment Pseudowires 27

Example 29

Verifying the MPLS-TP Configuration	30
Additional References	30
Feature Information for MPLS-TP	31
<b>Multiprotocol Label Switching (MPLS) on Cisco Routers</b>	<b>35</b>
Finding Feature Information	35
Restrictions for MPLS	35
Information About MPLS	35
MPLS Overview	36
Functional Description of MPLS	36
Label Switching Functions	36
Distribution of Label Bindings	36
Benefits of MPLS	37
How to Configure MPLS	38
Configuring a Router for MPLS Forwarding	38
Verifying Configuration of MPLS Forwarding	39
Additional References	39
Feature Information for MPLS on Cisco Routers	41
Glossary	42
<b>MPLS Infrastructure Changes Introduction of MFI and Removal of MPLS LSC and LC-ATM Features</b>	<b>45</b>
Finding Feature Information	45
Information About MPLS Infrastructure Changes	45
Introduction of the MPLS Forwarding Infrastructure	45
Introduction of IP Rewrite Manager	46
Removal of Support for MPLS LSC and LC-ATM Features	46
MPLS LSC and LC-ATM Configurations	46
Removal of Support for MPLS LSC and LC-ATM Commands	47
Additional References	48
Feature Information for MPLS Infrastructure Changes	48
<b>MPLS Static Labels</b>	<b>51</b>
Finding Feature Information	51
Restrictions for MPLS Static Labels	51
Prerequisites for MPLS Static Labels	52
Information About MPLS Static Labels	52
MPLS Static Labels Overview	52
Benefits of MPLS Static Labels	52

How to Configure MPLS Static Labels	52
Configuring MPLS Static Prefix Label Bindings	53
Verifying MPLS Static Prefix Label Bindings	54
Configuring MPLS Static Crossconnects	55
Verifying MPLS Static Crossconnect Configuration	56
Monitoring and Maintaining MPLS Static Labels	56
Configuration Examples for MPLS Static Labels	57
Example Configuring MPLS Static Prefixes Labels	57
Example Configuring MPLS Static Crossconnects	58
Additional References	59
Feature Information for MPLS Static Labels	60
Glossary	60
<b>MPLS--Multilink PPP Support</b>	<b>63</b>
Finding Feature Information	63
Prerequisites for MPLS--Multilink PPP Support	63
Information About MPLS--Multilink PPP Support	64
MPLS Layer 3 Virtual Private Network Features Supported for Multilink PPP	64
MPLS Quality of Service Features Supported for Multilink PPP	65
MPLS--Multilink PPP Support and PE-to-CE Links	66
MPLS--Multilink PPP Support and Core Links	66
MPLS--Multilink PPP Support in a CSC Network	67
MPLS--Multilink PPP Support in an Interautonomous System	68
How to Configure MPLS--Multilink PPP Support	68
Enabling Cisco Express Forwarding Switching	68
Creating a Multilink Bundle for MPLS--Multilink PPP Support	70
Assigning an Interface to a Multilink Bundle for MPLS--Multilink PPP Support	71
Disabling PPP Multilink Fragmentation	74
Verifying the Multilink PPP Configuration	76
Configuration Examples for MPLS--Multilink PPP Support	79
Example Sample Multilink PPP Configuration on an MPLS CSC PE Router	79
Example Enabling Cisco Express Forwarding	80
Example Creating a Multilink Bundle for MPLS--Multilink PPP Support	80
Additional References	81
Feature Information for MPLS--Multilink PPP Support	82
Glossary	82





# MPLS Transport Profile

---

The Multiprotocol Label Switching (MPLS) Transport Profile (TP) enables you to create tunnels that provide the transport network service layer over which IP and MPLS traffic traverse. MPLS-TP tunnels enable a transition from Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) time-division multiplexing (TDM) technologies to packet switching to support services with high bandwidth requirements, such as video.

- [Finding Feature Information, page 1](#)
- [Restrictions for MPLS-TP, page 1](#)
- [Information About MPLS-TP, page 2](#)
- [How to Configure MPLS-TP, page 6](#)
- [Additional References, page 30](#)
- [Feature Information for MPLS-TP, page 31](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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

## Restrictions for MPLS-TP

- MPLS-TPpenultimate hop popping is not supported. Only ultimate hop popping is supported, because label mappings are configured at the MPLS-TP endpoints.
- Ethernet subinterfaces are not supported.
- IPV6 addressing is not supported.

### L2VPN Restrictions

- L2VPN interworking is not supported.
- Local switching with AToM pseudowire as a backup is not supported.
- L2VPN pseudowire redundancy to an AToM pseudowire by one or more attachment circuits is not supported.

- PW ID Forward Equivalence Class (FEC) (type 128) is supported, but generalized ID FEC (type 129) is not supported.
- Static Pseudowire Operations, Administration, and Maintenance (OAM) protocol and BFD VCCV attachment circuit (AC) status signaling are mutually exclusive protocols. BFD VCCV in failure detection mode can be used with Static Pseudowire OAM protocol.
- BFD VCCV AC status signaling cannot be used in pseudowire redundancy configurations. You can use Static Pseudowire OAM instead.

### Ping and Trace Restrictions

- Ping for Static Pseudowires over MPLS-TP tunnels is not supported.
- Pseudowire ping and traceroute functionality for multisegment pseudowires that have one or more static pseudowire segments is not supported.
- The following packet format is supported:
  - A labeled packet with Generic Associated Channel Label (GAL) at the bottom of the label stack.
  - ACH channel is IP (0x21).
  - RFC 4379-based IP, UDP packet payload with valid source.
  - Destination IP address and UDP port 3503.
- Default reply mode for (1) is 4—Reply via application level control channel. An echo reply consists of the following elements:
  - A labeled packet with a GAL label at the bottom of the label stack.
  - ACH channel is IP (0x21).
  - RFC 4379-based IP, UDP packet payload with valid source.
  - Destination IP address and UDP port 3503.
- The optional “do not reply” mode may be set.
- The following reply modes are not allowed and are disabled in CLI:
  - 2—Reply via an IPv4/IPv6 UDP packet
  - 3—Reply via an IPv4/IPv6 UDP packet with Router Alert
- Force-explicit-null is not supported with ping and trace.
- Optional Reverse Path Connectivity verification is not supported. See *LSP-Ping Extensions for MPLS-TP* (draft-nitinb-mpls-tp-lsp-ping-extensions-01.txt).

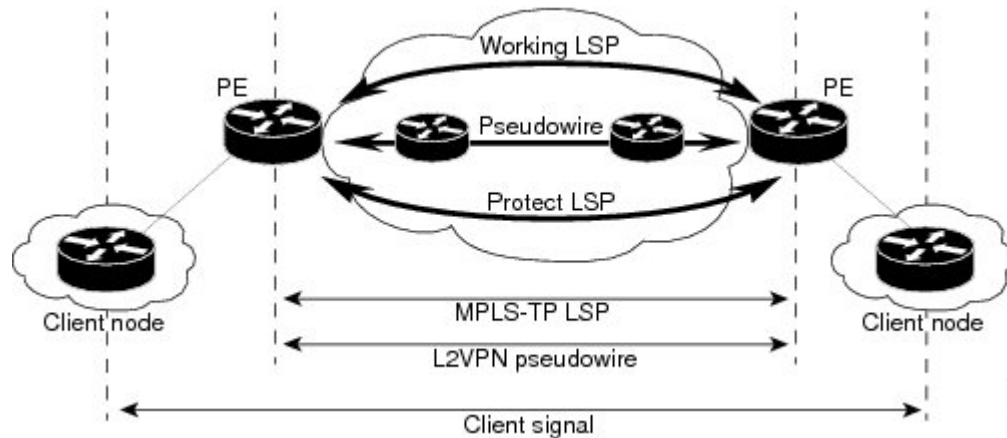
## Information About MPLS-TP

- [How MPLS-TP Works, page 3](#)
- [MPLS-TP Path Protection, page 3](#)
- [Bidirectional LSPs, page 3](#)
- [MPLS-TP OAM Support, page 3](#)
- [MPLS-TP Static and Dynamic Multisegment Pseudowires, page 4](#)
- [MPLS-TP L2VPN Pseudowire Redundancy for Static and Dynamic Multisegment Pseudowires, page 4](#)
- [MPLS-TP OAM Status for Static and Dynamic Multisegment Pseudowires, page 5](#)
- [MPLS-TP Links and Physical Interfaces, page 5](#)
- [Tunnel Midpoints, page 5](#)



## How MPLS-TP Works

MPLS-TP tunnels provide the transport network service layer over which IP and MPLS traffic traverse. MPLS-TP tunnels help transition from SONET/SDH TDM technologies to packet switching to support services with high bandwidth utilization and lower cost. Transport networks are connection oriented, statically provisioned, and have long-lived connections. Transport networks usually avoid control protocols that change identifiers (like labels). MPLS-TP tunnels provide this functionality through statically provisioned bidirectional label switched paths (LSPs), as shown in the figure below.



## MPLS-TP Path Protection

MPLS-TP LSPs support 1-to-1 path protection. You can configure the working and protect LSPs as part of configuring the MPLS-TP tunnel. The working LSP is the primary LSP used to route traffic. The protect LSP is a backup for a working LSP. If the working LSP fails, traffic is switched to the protect LSP until the working LSP is restored, at which time forwarding reverts back to the working LSP.

## Bidirectional LSPs

MPLS-TP LSPs are bidirectional and co-routed and are comprised of two unidirectional LSPs that are supported by the MPLS forwarding infrastructure. A TP tunnel consists of a pair of unidirectional tunnels providing a bidirectional LSP. Each unidirectional tunnel can optionally be protected with a protect LSP that activates automatically upon failure conditions.

## MPLS-TP OAM Support

Several OAM protocols and messages support the provisioning and maintenance of MPLS-TP tunnels and bidirectional LSPs:

- **MPLS-TP OAM: GACH:** Generic Associated Channel (G-ACh) is the control channel mechanism associated with MPLS LSPs in addition to MPLS pseudowire. The G-ACh Label (GAL) (Label 13) is a generic alert label to identify the presence of the G-ACh in the label packet. It is taken from the reserved MPLS label space.

G-ACh/GAL is used to support in-band OAMs of MPLS LSPs and PWs. The OAM messages are used for fault management, connection verification, continuity check and other functions.

The following OAM messages are forwarded along the specified MPLS LSP:

- ◦ OAM Fault Management: AIS, LDI and LKR messages. (GAL with fault-OAM channel)
- ◦ OAM Connection Verification: ping and traceroute messages. (GAL with IP channel by default)
- ◦ OAM Continuity Check: BFD (non-IP BFD and IP BFD) messages. (GAL with BFD channel or IP channel depending on message format)

The following messages are forwarded along the specified PW:

- ◦ Static PW OAM messages (static PW status)
  - PW ping and traceroute messages
  - PW BFD messages
- MPLS-TP OAM: Fault Management: Link Down Indication (LDI), Alarm Indication Signal (AIS), and Lock Report (LKR) messages. LDI messages are generated at midpoint nodes when a failure is detected. At the midpoint, an LDI message will be sent to the endpoint that is reachable with the existing failure. Similarly, LKR messages will be sent from a midpoint node to the reachable endpoint when an interface is administratively shut. AIS messages are not generated by Cisco, but are processed if received. By default, reception of LDI and LKR on the active LSP at an endpoint will cause a path protection switchover, while AIS will not.
- MPLS-TP OAM: Fault Management: Emulated Protection Switching for LSP Lockout. Cisco implements a form of Emulated Protection Switching in support of LSP Lockout using customized Fault messages. When a Cisco Lockout message is sent, it does not cause the LSP to be administratively down. The Cisco Lockout message causes a path protection switchover and prevents data traffic from using the LSP. The LSP remains up so that BFD and other OAM messages can continue to traverse it. Maintenance of the LSP can take place (such as reconfiguring or replacing a midpoint LSR). The LSP is shown as UP and OAM can verify connectivity before the LSP is put back into service by removing the lockout. Lockout of the working LSP is not allowed if no protect LSP is configured. Alternatively, lockout of the protect LSP is allowed if no working LSP is configured.
- LSP ping and trace: For MPLS-TP connectivity verification, you can use **ping mpls tp** and **trace mpls tp** commands. You can specify that the echo requests be sent along either the working LSP, the protect LSP, or the active LSP. You can also specify that the echo request be sent on a locked out MPLS-TP tunnel LSP (either working or protect) if the working or protect LSP is explicitly specified.
- MPLS-TP OAM: Continuity Check via BFD: You can configure BFD sessions running over MPLS-TP LSPs. BFD sessions run on both the working LSP and the protect LSP. In order to perform a path protection switchover within 60 msec on an MPLS-TP endpoint, the BFD Hardware Offload feature enables the router hardware to construct and send BFD messages, which removes the task from the software path. You do not need to configure the BFD Hardware Offload feature. It works automatically on supported platforms. You must enable BFD.

## MPLS-TP Static and Dynamic Multisegment Pseudowires

MPLS-TP supports the following combinations of static and dynamic multisegment pseudowires:

- Static-static
- Static-dynamic
- Dynamic-static

## MPLS-TP L2VPN Pseudowire Redundancy for Static and Dynamic Multisegment Pseudowires

MPLS-TP supports one-to-one L2VPN pseudowire redundancy for the following combinations of static and dynamic pseudowires:

- Static pseudowire with a static backup pseudowire
- Static pseudowire with a dynamic backup pseudowire
- Dynamic pseudowire with a static backup pseudowire

## MPLS-TP OAM Status for Static and Dynamic Multisegment Pseudowires

With static pseudowires, status notifications can be provided by BFD over VCCV or static pseudowire OAM protocol. However, BFD over VCCV sends only attachment circuit status code notifications. Hop-by-hop notifications of other pseudowire status codes are not supported. Therefore, static pseudowire OAM protocol is preferred. You can acquire per pseudowire OAM for attachment circuit/pseudowire notification over VCCV channel with or without the control word.

## MPLS-TP Links and Physical Interfaces

MPLS-TP link numbers may be assigned to physical interfaces only. Bundled interfaces and virtual interfaces are not supported for MPLS-TP link numbers.

The MPLS-TP link is used to create a level of indirection between the MPLS-TP tunnel and midpoint LSP configuration and the physical interface. The **mpls tp link** command is used to associate an MPLS-TP link number with a physical interface and next-hop node. On point-to-point interfaces or Ethernet interfaces designated as point-to-point using the **medium p2p** command, the next-hop can be implicit, so the **mpls tp link** command just associates a link number to the interface.

Multiple tunnels and LSPs may then refer to the MPLS-TP link to indicate they are traversing that interface. You can move the MPLS-TP link from one interface to another without reconfiguring all the MPLS-TP tunnels and LSPs that refer to the link.

Link numbers must be unique on the router or node.

See [Configuring MPLS-TP Links and Physical Interfaces](#), page 19 for more information.

## Tunnel Midpoints

Tunnel LSPs, whether endpoint or midpoint, use the same identifying information. However, it is entered differently.

- At the midpoint, all the information for the LSP is specified with the **mpls tp lsp** command, which enters the submode for configuring forward and reverse information for forwarding.
- At the midpoint, determining which end is source and which is destination is arbitrary. That is, if you are configuring a tunnel between your router and a coworker's router, then your router is the source. However, your coworker considers his or her router to be the source. At the midpoint, either router could be considered the source. At the midpoint, the forward direction is from source to destination, and the reverse direction is from destination to source.
- At the endpoint, the local information (source) either comes from the global router ID and global ID, or from locally configured information using the **tp source** command after you enter the command **interface tunnel-tp number** command, where *number* is the local/source tunnel-number.
- At the endpoint, the remote information (destination) is configured using the **tp destination** command after you enter the command **interface tunnel-tp number**. The **tp destination** command includes the destination node ID, optionally the global ID, and optionally the destination tunnel number. If you do not specify the destination tunnel number, the source tunnel number is used.
- At the endpoint, the LSP number is configured in working-lsp or protect-lsp submode. The default is 0 for the working LSP and 1 for the protect LSP.

- When configuring the LSPs at the midpoint routers, make that the configuration does not reflect traffic back to the originating node.

## How to Configure MPLS-TP

- [Configuring the MPLS Label Range, page 6](#)
- [Configuring the Router ID and Global ID, page 7](#)
- [Configuring Bidirectional Forwarding Detection Templates, page 8](#)
- [Configuring Pseudowire OAM Attributes, page 9](#)
- [Configuring the Pseudowire Class, page 10](#)
- [Configuring the Pseudowire, page 12](#)
- [Configuring the MPLS-TP Tunnel, page 13](#)
- [Configuring MPLS-TP LSPs at Midpoints, page 17](#)
- [Configuring MPLS-TP Links and Physical Interfaces, page 19](#)
- [Configuring Static-to-Static Multisegment Pseudowires for MPLS-TP, page 21](#)
- [Configuring a Template with Pseudowire Type-Length-Value Parameters, page 23](#)
- [Configuring Static-to-Dynamic Multisegment Pseudowires for MPLS-TP, page 23](#)
- [Configuring the L2VPN Pseudowire Redundancy for Static Multisegment Pseudowires, page 27](#)
- [Verifying the MPLS-TP Configuration, page 30](#)

## Configuring the MPLS Label Range

You must specify a static range of MPLS labels using the **mpls label range** command with the **static** keyword.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label range** *minimum-value maximum-value* {**static** *minimum-static-value maximum-static-value*}

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>configure terminal</b>  <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.

Command or Action	Purpose
<b>Step 3</b> <b>mpls label range</b> <i>minimum-value maximum-value</i> { <b>static</b> <i>minimum-static-value maximum-static-value</i> }  <b>Example:</b>  Router(config)# mpls label range 1001 1003 static 10000 25000	Specifies a static range of MPLS labels

## Configuring the Router ID and Global ID

### SUMMARY STEPS

1. enable
2. configure terminal
3. mpls tp
4. router-id *node-id*
5. global-id *num*

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b>  Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>configure terminal</b>  <b>Example:</b>  Router# configure terminal	Enters global configuration mode.
<b>Step 3</b> <b>mpls tp</b>  <b>Example:</b>  Router(config)# mpls tp	Enters MPLS-TP configuration mode, from which you can configure MPLS-TP parameters for the router.

Command or Action	Purpose
<b>Step 4</b> <code>router-id node-id</code>  <b>Example:</b>  <pre>Router(config-mpls-tp)# router-id 10.10.10.10</pre>	Specifies the default MPLS-TP router ID, which is used as the default source node ID for all MPLS-TP tunnels configured on the router.
<b>Step 5</b> <code>global-id num</code>  <b>Example:</b>  <pre>Router(config-mpls-tp)# global-id 1</pre>	<p>(Optional) Specifies the default global ID used for all endpoints and midpoints. This command makes the router ID globally unique in a multiprovider tunnel. Otherwise, the router ID is only locally meaningful. The global ID is an autonomous system number, which is a controlled number space by which providers can identify each other.</p> <p>The router ID and global ID are also included in fault messages by routers at tunnel midpoints to help isolate the location of faults.</p>

## Configuring Bidirectional Forwarding Detection Templates

The **bfd-template** command allows you to create a BFD template and enter BFD configuration mode. The template can be used to specify a set of BFD interval values. You invoke the template as part of the MPLS-TP tunnel. On platforms that support the BFD Hardware Offload feature and can provide 60-ms cutover for MPLS-TP tunnels, it is recommended to use the higher resolution timers in the BFD template.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **bfd-template single-hop *template-name***
4. **interval [microseconds] {both *time*| min-tx *time* min-rx *time*} [**multiplier** *multiplier-value*]**

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b>  <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b>  <pre>Router# configure terminal</pre>	Enters global configuration mode.

Command or Action	Purpose
<b>Step 3</b> <code>bfd-template single-hop <i>template-name</i></code>  <b>Example:</b> <pre>Router(config)# bfd-template single-hop mpls-bfd-1</pre>	Creates a BFD template and enter BFD configuration mode.
<b>Step 4</b> <code>interval [microseconds] {both <i>time</i> min-tx <i>time</i> min-rx <i>time</i>} [<i>multiplier multiplier-value</i>]</code>  <b>Example:</b> <pre>Router(config-bfd)# interval min-tx 99 min-rx 99 multiplier 3</pre>	Specifies a set of BFD interval values.

## Configuring Pseudowire OAM Attributes

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `pseudowire-static-oam class class-name`
4. `timeout refresh send seconds`

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b> <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b> <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b> <code>pseudowire-static-oam class <i>class-name</i></code>  <b>Example:</b> <pre>Router(config)# pseudowire-static-oam class oam-class1</pre>	Creates a pseudowire OAM class and enters pseudowire OAM class configuration mode.

Command or Action	Purpose
<b>Step 4</b> <code>timeout refresh send <i>seconds</i></code>  <b>Example:</b>  <pre>Router(config-st-pw-oam-class)# timeout refresh send 20</pre>	Specifies the OAM timeout refresh intervals.

## Configuring the Pseudowire Class

When you create the pseudowire class, you specify the parameters of the pseudowire, such as the use of the control word, preferred path, OAM class, and VCCV BFD template.

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `pseudowire-class class-name`
4. `encapsulation mpls`
5. `control-word`
6. `protocol {l2tpv2 | l2tpv3 | none} [l2tp-class-name]`
7. `preferred-path {interface tunnel tunnel-number | peer {ip-address | host-name}} [disable-fallback]`
8. `status protocol notification static class-name`
9. `vccv bfd template name [udp | raw-bfd]`

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b>  <pre>Router&gt; enable</pre>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b>  <pre>Router# configure terminal</pre>	Enters global configuration mode.
<b>Step 3</b> <code>pseudowire-class <i>class-name</i></code>  <b>Example:</b>  <pre>Router(config)# pseudowire-class mpls-tp-class1</pre>	Creates a pseudowire class and enters pseudowire class configuration mode.



Command or Action	Purpose
<p><b>Step 4</b> <b>encapsulation mpls</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# encapsulation mpls</pre>	Specifies the encapsulation type.
<p><b>Step 5</b> <b>control-word</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# control-word</pre>	Enables the use of the control word.
<p><b>Step 6</b> <b>protocol {l2tpv2   l2tpv3   none} [l2tp-class-name]</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# protocol none</pre>	Specifies the type of protocol.
<p><b>Step 7</b> <b>preferred-path {interface tunnel <i>tunnel-number</i>   peer {<i>ip-address</i>   <i>host-name</i>}} [disable-fallback]</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# preferred-path interface tunnel-tp2</pre>	Specifies the tunnel to use as the preferred path.
<p><b>Step 8</b> <b>status protocol notification static <i>class-name</i></b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# status protocol notification static oam-class1</pre>	Specifies the OAM class to use.
<p><b>Step 9</b> <b>vccv bfd template <i>name</i> [udp   raw-bfd]</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# vccv bfd template bfd-templ raw-bfd</pre>	Specifies the VCCV BFD template to use.

## Configuring the Pseudowire

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **xconnect** *peer-ip-address vc-id* {**encapsulation** {**l2tpv3** [**manual**] | **mpls** [**manual**]} | **pw-class** *pw-class-name*} [**pw-class** *pw-class-name*] [**sequencing** {**transmit** | **receive** | **both**}]
5. **mpls label** *local-pseudowire-label remote-pseudowire-label*
6. **mpls control-word**
7. **backup delay** {*enable-delay-period* | **never**} {*disable-delay-period* | **never**}
8. **backup peer** *peer-router-ip-addr vcid* [**pw-class** *pw-class-name*] [**priority** *value*]

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b> <b>interface</b> <i>type number</i>  <b>Example:</b> Router(config)# interface Ethernet 1/0	Specifies the interface and enters interface configuration mode.
<b>Step 4</b> <b>xconnect</b> <i>peer-ip-address vc-id</i> { <b>encapsulation</b> { <b>l2tpv3</b> [ <b>manual</b> ]   <b>mpls</b> [ <b>manual</b> ]}   <b>pw-class</b> <i>pw-class-name</i> } [ <b>pw-class</b> <i>pw-class-name</i> ] [ <b>sequencing</b> { <b>transmit</b>   <b>receive</b>   <b>both</b> }]  <b>Example:</b> Router(config-if)# xconnect 10.131.191.251 100 encapsulation mpls manual pw-class mpls-tp-class1	Binds the attachment circuit to a pseudowire VC and enters xconnect interface configuration mode.

Command or Action	Purpose
<p><b>Step 5</b> <code>mpls label local-pseudowire-label remote-pseudowire-label</code></p> <p><b>Example:</b></p> <pre>Router(config-if-xconn)# mpls label 100 150</pre>	Configures the static pseudowire connection by defining local and remote circuit labels.
<p><b>Step 6</b> <code>mpls control-word</code></p> <p><b>Example:</b></p> <pre>Router(config-if-xconn)# no mpls control-word</pre>	Specifies the control word.
<p><b>Step 7</b> <code>backup delay {enable-delay-period   never} {disable-delay-period   never}</code></p> <p><b>Example:</b></p> <pre>Router(config-if-xconn)# backup delay 0 never</pre>	Specifies how long a backup pseudowire virtual circuit (VC) should wait before resuming operation after the primary pseudowire VC goes down.
<p><b>Step 8</b> <code>backup peer peer-router-ip-addr vcid [pw-class pw-class-name] [priority value]</code></p> <p><b>Example:</b></p> <pre>Router(config-if-xconn)# backup peer 10.0.0.2 50</pre>	Specifies a redundant peer for a pseudowire virtual circuit (VC).

## Configuring the MPLS-TP Tunnel

On the endpoint routers, create an MPLS TP tunnel and configure its parameters. See the `interface tunnel-tp` command for information on the parameters.

**SUMMARY STEPS**

1. **enable**
2. **configure terminal**
3. **interface tunnel-tp** *number*
4. **description** *tunnel-description*
5. **tp tunnel-name** *name*
6. **tp bandwidth** *num*
7. **tp source** *node-id* [*global-id num*]
8. **tp destination** *node-id* [[**tunnel-tp** *num*] **global-id** *num*]
9. **bfd** *bfd-template*
10. **working-lsp**
11. **in-label** *num*
12. **out-label** *num* **out-link** *num*
13. **exit**
14. **protect-lsp**
15. **in-label** *num*
16. **out-label** *num* **out-link** *num*
17. **exit**

**DETAILED STEPS**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>interface tunnel-tp</b> <i>number</i>  <b>Example:</b> Router(config)# <b>interface tunnel-tp</b> 2	Enters tunnel interface configuration mode. Tunnel numbers from 0 to 999 are supported.

	Command or Action	Purpose
Step 4	<p><b>description</b> <i>tunnel-description</i></p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>description</b> headend tunnel</pre>	(Optional) Specifies a tunnel description.
Step 5	<p><b>tp tunnel-name</b> <i>name</i></p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>tp tunnel-name</b> tunnel22</pre>	Specifies the name of the MPLS-TP tunnel. The TP tunnel name is displayed in the <b>show mpls tp tunnel</b> command output. This command is useful for consistently identifying the tunnel at all endpoints and midpoints.
Step 6	<p><b>tp bandwidth</b> <i>num</i></p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>tp bandwidth</b> 10000</pre>	Specifies the tunnel bandwidth.
Step 7	<p><b>tp source</b> <i>node-id</i> [<i>global-id num</i>]</p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>tp source</b> 10.10.11.11 <b>global-id</b> 10</pre>	(Optional) Specifies the tunnel source and endpoint. This command is and not typically used, because the global router ID and global ID can be used to identify the tunnel source at the endpoint. All tunnels on the router generally use the same (globally specified) source information.
Step 8	<p><b>tp destination</b> <i>node-id</i> [[<b>tunnel-tp</b> <i>num</i>] <b>global-id</b> <i>num</i>]</p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>tp destination</b> 10.10.10.10</pre>	Specifies the destination node of the tunnel.
Step 9	<p><b>bfd</b> <i>bfd-template</i></p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>bfd</b> mpls-tp-bfd-2</pre>	Specifies the BFD template.
Step 10	<p><b>working-lsp</b></p> <p><b>Example:</b></p> <pre>Router(config-if)# <b>working-lsp</b></pre>	Specifies a working LSP, also known as the primary LSP. This LSP is used to route traffic. This command enters working LSP interface configuration mode (config-if-working).

Command or Action	Purpose
<p><b>Step 11</b> <code>in-label num</code></p> <p><b>Example:</b></p> <pre>Router(config-if-working)# in-label 111</pre>	<p>Specifies the in label.</p>
<p><b>Step 12</b> <code>out-label num out-link num</code></p> <p><b>Example:</b></p> <pre>Router(config-if-working)# out-label 112 out-link 1</pre>	<p>Specifies the out label and out link.</p>
<p><b>Step 13</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config-if-working)# exit</pre>	<p>Exits from working LSP interface configuration mode.</p>
<p><b>Step 14</b> <code>protect-lsp</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# protect-lsp</pre>	<p>Specifies a backup for a working LSP. If the working LSP fails, traffic is switched to the protect LSP until the working LSP is restored, at which time forwarding reverts back to the working LSP. This command enters protect LSP interface configuration mode (config-if-protect).</p>
<p><b>Step 15</b> <code>in-label num</code></p> <p><b>Example:</b></p> <pre>Router(config-if-protect)# in-label 100</pre>	<p>Specifies the in label.</p>
<p><b>Step 16</b> <code>out-label num out-link num</code></p> <p><b>Example:</b></p> <pre>Router(config-if-protect)# out-label 113 out-link 2</pre>	<p>Specifies the out label and out link.</p>
<p><b>Step 17</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config-if-protect)# exit</pre>	<p>Exits from protect LSP interface configuration mode.</p>

# Configuring MPLS-TP LSPs at Midpoints



**Note**

When configuring the LSPs at the midpoint routers, make that the configuration does not reflect traffic back to the originating node.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls tp lsp source** *node-id* [**global-id** *num*] **tunnel-tp** *num* **lsp**{*lsp-num* | **protect** | **working**} **destination** *node-id* [**global-id** *num*] **tunnel-tp** *num*
4. **forward-lsp**
5. **bandwidth** *num*
6. **in-label** *num* **out-label** *num* **out-link** *num*
7. **exit**
8. **reverse-lsp**
9. **bandwidth** *num*
10. **in-label** *num* **out-label** *num* **out-link** *num*

### DETAILED STEPS

	Command or Action	Purpose
Step 1	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
Step 2	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p><b>mpls tp lsp source</b> <i>node-id</i> [<b>global-id</b> <i>num</i>] <b>tunnel-tp</b> <i>num</i> <b>lsp</b>{<i>lsp-num</i>   <b>protect</b>   <b>working</b>} <b>destination</b> <i>node-id</i> [<b>global-id</b> <i>num</i>] <b>tunnel-tp</b> <i>num</i></p> <p><b>Example:</b></p> <pre>Router(config)# mpls tp lsp source 10.10.10.10 global-id 2 tunnel-tp 4 lsp protect destination 10.11.11.11 global-id 11 tunnel-tp 12</pre>	<p>Enables MPLS-TP midpoint connectivity and enters MPLS TP LSP configuration mode.</p>

Command or Action	Purpose
<p><b>Step 4</b> <code>forward-lsp</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp)# forward-lsp</pre>	<p>Enters MPLS-TP LSP forward LSP configuration mode.</p>
<p><b>Step 5</b> <code>bandwidth num</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp-forw)# bandwidth 100</pre>	<p>Specifies the bandwidth.</p>
<p><b>Step 6</b> <code>in-label num out-label num out-link num</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp-forw)# in-label 53 out-label 43 out-link 41</pre>	<p>Specifies the in label, out label, and out link numbers.</p>
<p><b>Step 7</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp-forw)# exit</pre>	<p>Exits MPLS-TP LSP forward LSP configuration mode.</p>
<p><b>Step 8</b> <code>reverse-lsp</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp)# reverse-lsp</pre>	<p>Enters MPLS-TP LSP reverse LSP configuration mode.</p>
<p><b>Step 9</b> <code>bandwidth num</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp-rev)# bandwidth 100</pre>	<p>Specifies the bandwidth.</p>
<p><b>Step 10</b> <code>in-label num out-label num out-link num</code></p> <p><b>Example:</b></p> <pre>Router(config-mpls-tp-lsp-rev)# in-label 33 out-label 23 out-link 44</pre>	<p>Specifies the in label, out label, and out link numbers.</p>



## Configuring MPLS-TP Links and Physical Interfaces

MPLS-TP link numbers may be assigned to physical interfaces only. Bundled interfaces and virtual interfaces are not supported for MPLS-TP link numbers.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type/num*
4. **ip address** *ip-address mask*
5. **mpls tp link** *link-num* { **ipv4** *ip-address* / **tx-mac** *mac-address* } **rx-mac** *mac-address*
6. **ip rsvp bandwidth** [**rdm** [**bc0** *interface-bandwidth*] [[*single-flow-bandwidth* [**bc1** *bandwidth* | **sub-pool** *bandwidth*]]] [*interface-bandwidth* [*single-flow-bandwidth* [**bc1** *bandwidth* | **sub-pool** *bandwidth*]] | **mam max-reservable-bw** [*interface-bandwidth* [*single-flow-bandwidth*] [**bc0** *interface-bandwidth* [**bc1** *bandwidth*]]] | **percent** *percent-bandwidth* [*single-flow-bandwidth*]]]
7. **exit**
8. **exit**
9. **show mpls tp link-numbers**

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b> <b>interface</b> <i>type/num</i>  <b>Example:</b> Router(config)# interface ethernet 1/0	Specifies the interface and enters interface configuration mode.

Command or Action	Purpose
<p><b>Step 4</b> <code>ip address ip-address mask</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# ip address 10.10.10.10 255.255.255.0</pre>	<p>Assigns an IP address to the interface.</p>
<p><b>Step 5</b> <code>mpls tp link link-num {ipv4 ip-address / tx-mac mac-address} rx-mac mac-address</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# mpls tp link 1 ipv4 10.0.0.2</pre>	<p>Associates an MPLS-TP link number with a physical interface and next-hop node. On point-to-point interfaces or Ethernet interfaces designated as point-to-point using the <b>medium p2p</b> command, the next-hop can be implicit, so the <b>mpls tp link</b> command just associates a link number to the interface.</p> <p>Multiple tunnels and LSPs can refer to the MPLS-TP link to indicate they are traversing that interface. You can move the MPLS-TP link from one interface to another without reconfiguring all the MPLS-TP tunnels and LSPs that refer to the link.</p> <p>Link numbers a must be unique on the router or node.</p>
<p><b>Step 6</b> <code>ip rsvp bandwidth [rdm [bc0 interface-bandwidth] [[single-flow-bandwidth [bc1 bandwidth   sub-pool bandwidth]]] [interface-bandwidth [single-flow-bandwidth [bc1 bandwidth   sub-pool bandwidth]]   mam max-reservable-bw [interface-bandwidth [single-flow-bandwidth] [bc0 interface-bandwidth [bc1 bandwidth]]]   percent percent-bandwidth [single-flow-bandwidth]]]</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# ip rsvp bandwidth 1158 100</pre>	<p>Enables Resource Reservation Protocol (RSVP) bandwidth for IP on an interface.</p> <p>For the Cisco 7600 platform, if you configure non-zero bandwidth for the TP tunnel or at a midpoint LSP, make sure that the interface to which the output link is attached has enough bandwidth available. For example, if three tunnel LSPs run over link 1 and each LSP was assigned 1000 with the <b>tp bandwidth</b> command, the interface associated with link 1 needs bandwidth of 3000 with the <b>ip rsvp bandwidth</b> command.</p>
<p><b>Step 7</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# exit</pre>	<p>Exits interface configuration mode.</p>
<p><b>Step 8</b> <code>exit</code></p> <p><b>Example:</b></p> <pre>Router(config)# exit</pre>	<p>Exits global configuration mode.</p>

Command or Action	Purpose
<b>Step 9</b> <code>show mpls tp link-numbers</code>  <b>Example:</b>  Router# <code>show mpls tp link-numbers</code>	Displays the configured links.

## Configuring Static-to-Static Multisegment Pseudowires for MPLS-TP

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `l2 vfi name point-to-point`
4. `neighbor ip-address vc-id {encapsulation mpls | pw-class pw-class-name}`
5. `mpls label local-pseudowire-label remote-pseudowire-label`
6. `mpls control-word`
7. `neighbor ip-address vc-id {encapsulation mpls | pw-class pw-class-name}`
8. `mpls label local-pseudowire-label remote-pseudowire-label`
9. `mpls control-word`

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1</b> <code>enable</code>  <b>Example:</b>  Router> <code>enable</code>	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b> <code>configure terminal</code>  <b>Example:</b>  Router# <code>configure terminal</code>	Enters global configuration mode.
<b>Step 3</b> <code>l2 vfi name point-to-point</code>  <b>Example:</b>  Router(config)# <code>l2 vfi atom point-to-point</code>	Creates a point-to-point Layer 2 virtual forwarding interface (VFI) and enters VFI configuration mode.

Command or Action	Purpose
<p><b>Step 4</b> <code>neighbor ip-address vc-id {encapsulation mpls   pw-class pw-class-name}</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)# neighbor 10.111.111.111 123 pw-class atom</pre>	<p>Sets up an emulated VC. Specify the IP address and the VC ID of the remote router. Also specify the pseudowire class to use for the emulated VC.</p> <p>Note: Only two <b>neighbor</b> commands are allowed for each I2 vfi point-to-point command.</p>
<p><b>Step 5</b> <code>mpls label local-pseudowire-label remote-pseudowire-label</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)# mpls label 101 201</pre>	<p>Configures the static pseudowire connection by defining local and remote circuit labels.</p>
<p><b>Step 6</b> <code>mpls control-word</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)# mpls control-word</pre>	<p>Specifies the control word.</p>
<p><b>Step 7</b> <code>neighbor ip-address vc-id {encapsulation mpls   pw-class pw-class-name}</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)#</pre>	<p>Sets up an emulated VC. Specify the IP address and the VC ID of the remote router. Also specify the pseudowire class to use for the emulated VC.</p>
<p><b>Step 8</b> <code>mpls label local-pseudowire-label remote-pseudowire-label</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)# Router(config-vfi)# mpls label 102 202</pre>	<p>Configures the static pseudowire connection by defining local and remote circuit labels.</p>
<p><b>Step 9</b> <code>mpls control-word</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)# mpls control-word</pre>	<p>Specifies the control word.</p>

## Configuring a Template with Pseudowire Type-Length-Value Parameters

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **pseudowire-tlv template *template-name***
4. **tlv [*type-name*] *type-value length* [**dec** | **hexstr** | **str**] *value***

### DETAILED STEPS

Command or Action	Purpose
<b>Step 1 enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2 configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3 pseudowire-tlv template <i>template-name</i></b>  <b>Example:</b> Router(config)# pseudowire-tlv template statictemp	Creates a template of pseudowire type-length-value (TLV) parameters
<b>Step 4 tlv [<i>type-name</i>] <i>type-value length</i> [<b>dec</b>   <b>hexstr</b>   <b>str</b>] <i>value</i></b>  <b>Example:</b> Router(config-pw-tlv-template)# tlv statictemp 2 4 hexstr 1	Specifies the TLV parameters.

## Configuring Static-to-Dynamic Multisegment Pseudowires for MPLS-TP

When you configure static-to-dynamic pseudowires, you configure the static pseudowire class with the **protocol none** command, create a dynamic pseudowire class, then invoke those pseudowire classes with the **neighbor** commands.

**SUMMARY STEPS**

1. **enable**
2. **configure terminal**
3. **pseudowire-class** *class-name*
4. **encapsulation mpls**
5. **control-word**
6. **protocol** {l2tpv2 | l2tpv3 | none} [*l2tp-class-name*]
7. **exit**
8. **pseudowire-class** *class-name*
9. **encapsulation mpls**
10. **exit**
11. **l2 vfi** *name* **point-to-point**
12. **neighbor** *ip-address* *vc-id* {**encapsulation mpls** | **pw-class** *pw-class-name*}
13. **neighbor** *ip-address* *vc-id* {**encapsulation mpls** | **pw-class** *pw-class-name*}
14. **mpls label** *local-pseudowire-label* *remote-pseudowire-label*
15. **mpls control-word**
16. **local interface** *pseudowire-type*
17. Do one of the following:
  - **tlv** [*type-name*] *type-value* *length* [**dec** | **hexstr** | **str**] *value*
  - 
  - **tlv template** *template-name*

**DETAILED STEPS**

	<b>Command or Action</b>	<b>Purpose</b>
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>pseudowire-class</b> <i>class-name</i>  <b>Example:</b> Router(config)# pseudowire-class mpls-tp-class1	Creates a pseudowire class and enters pseudowire class configuration mode.

	Command or Action	Purpose
Step 4	<p><b>encapsulation mpls</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# encapsulation mpls</pre>	Specifies the encapsulation type.
Step 5	<p><b>control-word</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# control-word</pre>	Enables the use of the control word.
Step 6	<p><b>protocol {l2tpv2   l2tpv3   none} [l2tp-class-name]</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# protocol none</pre>	Specifies the type of protocol. Use the <b>protocol none</b> command to specify a static pseudowire.
Step 7	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# exit</pre>	Exits pseudowire class configuration mode.
Step 8	<p><b>pseudowire-class class-name</b></p> <p><b>Example:</b></p> <pre>Router(config)# pseudowire-class mpls-tp-class1</pre>	Creates a pseudowire class and enters pseudowire class configuration mode.
Step 9	<p><b>encapsulation mpls</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# encapsulation mpls</pre>	Specifies the encapsulation type.
Step 10	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Router(config-pw-class)# exit</pre>	Exits pseudowire class configuration mode.

Command or Action	Purpose
<p><b>Step 11</b> <code>l2 vfi name point-to-point</code></p> <p><b>Example:</b></p> <pre>Router(config)# l2 vfi atom point-to-point</pre>	<p>Creates a point-to-point Layer 2 virtual forwarding interface (VFI) and enters VFI configuration mode.</p>
<p><b>Step 12</b> <code>neighbor ip-address vc-id {encapsulation mpls   pw-class pw-class-name}</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi)# neighbor 10.111.111.111 123 pw-class atom</pre>	<p>Sets up an emulated VC. Specify the IP address and the VC ID of the remote router. Also specify the pseudowire class to use for the emulated VC. Enters config-vfi-neighbor command mode.</p> <p>Note: Only two <b>neighbor</b> commands are allowed for each l2 vfi point-to-point command.</p>
<p><b>Step 13</b> <code>neighbor ip-address vc-id {encapsulation mpls   pw-class pw-class-name}</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi-neighbor)# neighbor 10.111.111.111 123 pw-class atom</pre>	<p>Sets up an emulated VC. Specify the IP address and the VC ID of the remote router. Also specify the pseudowire class to use for the emulated VC.</p> <p>Note: Only two <b>neighbor</b> commands are allowed for each l2 vfi point-to-point command.</p>
<p><b>Step 14</b> <code>mpls label local-pseudowire-label remote-pseudowire-label</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi-neighbor)# mpls label 101 201</pre>	<p>Configures the static pseudowire connection by defining local and remote circuit labels.</p>
<p><b>Step 15</b> <code>mpls control-word</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi-neighbor)# mpls control-word</pre>	<p>Specifies the control word.</p>
<p><b>Step 16</b> <code>local interface pseudowire-type</code></p> <p><b>Example:</b></p> <pre>Router(config-vfi-neighbor)# local interface 4</pre>	<p>Specifies the pseudowire type and enters VFI neighbor interface configuration mode.</p>



Command or Action	Purpose
<p><b>Step 17</b> Do one of the following:</p> <ul style="list-style-type: none"> <li>• <code>tlv [type-name] type-value length [dec   hexstr   str] value</code></li> <li>• <code>tlv template template-name</code></li> </ul> <p><b>Example:</b></p> <pre>Router(config-vfi-neighbor)# tlv statictemp 2 4 hexstr 1</pre>	Specifies the TLV parameters or invokes a previously configured TLV template.

- [Example, page 27](#)

## Example

```
12 vfi atom point-to-point (static-dynamic MSPW)
neighbor 10.116.116.116 4294967295 pw-class dypw (dynamic)
neighbor 10.111.111.111 123 pw-class stpw (static)
mpls label 101 201
mpls control-word
local interface 4
tlv mtu 1 4 1500
tlv description 3 6 str abcd
tlv descr C 4 hexstr 0505
```

## Configuring the L2VPN Pseudowire Redundancy for Static Multisegment Pseudowires

Perform the following steps to configure the L2VPN pseudowire redundancy for static multisegment pseudowires that are backed up with static or dynamic multisegment pseudowires.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface ethernet** *type/num*
4. **service instance** *id ethernet*
5. **encapsulation dot1q** *vlan-id*
6. **xconnect** *peer-ip-address vc-id* { **encapsulation** { **l2tpv3** [ **manual** ] | **mpls** [ **manual** ] } | **pw-class** *pw-class-name* } [ **pw-class** *pw-class-name* ] [ **sequencing** { **transmit** | **receive** | **both** } ]
7. **mpls label** *local-pseudowire-label remote-pseudowire-label*
8. **mpls control-word**
9. **backup delay** { *enable-delay-period* | **never** } { *disable-delay-period* | **never** }
10. **backup peer** *peer-router-ip-addr vcid* [ **pw-class** *pw-class-name* ] [ **priority** *value* ]
11. **mpls label** *local-pseudowire-label remote-pseudowire-label*
12. **mpls control-word**

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
Step 2	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p><b>interface ethernet <i>type/num</i></b></p> <p><b>Example:</b></p> <pre>Router(config)# interface ethernet 1/0</pre>	<p>Specifies the interfaces and enters interface configuration mode.</p>
Step 4	<p><b>service instance <i>id</i> ethernet</b></p> <p><b>Example:</b></p> <pre>Router(config-if)# service instance 1 ethernet</pre>	<p>Specifies the service instance and enters service instance interface configuration mode.</p>
Step 5	<p><b>encapsulation dot1q <i>vlan-id</i></b></p> <p><b>Example:</b></p> <pre>Router(config-if-srv)# encapsulation dot1q 10</pre>	<p>Enables the interface to accept 802.1Q VLAN packets.</p>
Step 6	<p><b>xconnect <i>peer-ip-address</i> <i>vc-id</i> {encapsulation {12tpv3 [manual]   mpls [manual]}   pw-class <i>pw-class-name</i>} [pw-class <i>pw-class-name</i>] [sequencing {transmit   receive   both}]</b></p> <p><b>Example:</b></p> <pre>Router(config-if-srv)# xconnect 10.109.10.10 123encapsulation mpls manual pw-class stpw</pre>	<p>Binds the attachment circuit to a pseudowire VC and enters xconnect configuration mode.</p>
Step 7	<p><b>mpls label <i>local-pseudowire-label</i> <i>remote-pseudowire-label</i></b></p> <p><b>Example:</b></p> <pre>Router(cfg-if-ether-vc-xconn)# mpls label 100 150</pre>	<p>Configures the static pseudowire connection by defining local and remote circuit labels.</p>

	Command or Action	Purpose
Step 8	<b>mpls control-word</b>  <b>Example:</b> Router(cfg-if-ether-vc-xconn)# no mpls control-word	Specifies the control word.
Step 9	<b>backup delay</b> {enable-delay-period   <b>never</b> } {disable-delay-period   <b>never</b> }  <b>Example:</b> Router(cfg-if-ether-vc-xconn)# backup delay 0 never	Specifies how long a backup pseudowire virtual circuit (VC) should wait before resuming operation after the primary pseudowire VC goes down.
Step 10	<b>backup peer</b> peer-router-ip-addr vcid [pw-class pw-class-name] [priority value]  <b>Example:</b> Router(cfg-if-ether-vc-xconn)# backup peer 10.0.0.2 50	Specifies a redundant peer for a pseudowire virtual circuit (VC). Enters backup xconnect configuration mode.
Step 11	<b>mpls label</b> local-pseudowire-label remote-pseudowire-label  <b>Example:</b> Router(cfg-if-ether-vc-xconn-bkup)# mpls label 100 150	Configures the static pseudowire connection by defining local and remote circuit labels.
Step 12	<b>mpls control-word</b>  <b>Example:</b> Router(cfg-if-ether-vc-xconn-bkup)# no mpls control-word	Specifies the control word.

- [Example, page 29](#)

## Example

```
interface Ethernet1/0
  no ip address
  no shutdown
  service instance 1 ethernet
  encapsulation dot1q 10
  xconnect 10.113.113.113 123 encapsulation mpls manual pw-class stpw
  mpls label 0 101
  mpls control-word
  backup peer 1 0.120.120.120 124 pw-class stpw
  mpls label 0 105
  mpls control-word
```

## Verifying the MPLS-TP Configuration

When the entire tunnel is programmed, use the following commands to verify and help troubleshoot the configuration:

- **show mpls tp tunnel-tp lsps:** To ensure that both LSPs are up and working from a tunnel endpoint.
- **show mpls tp tunnel-tp *number* detail :** To help determine the cause if the tunnel is not up and working.
- **show bfd neighbors mpls-tp:** To display the state of BFD, which must be up for the endpoint LSPs to be up.
- **trace mpls tp** and **ping mpls tp:** To help isolate any connectivity issues.
- **debug mpls tp :** To enable the display of MPLS-TP error messages.
- **logging (MPLS-TP):** To enable the display of logging messages related to configuration changes or state changes.
- **show mpls l2transport static-oam:** To enable the display of MPLS-TP messages related to pseudowires.

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
MPLS commands	Cisco IOS MPLS Command Reference

### Standards

Standard	Title
draft-ietf-mpls-tp-gach-gal-xx	<i>MPLS Generic Associated Channel</i>

### MIBs

MIB	MIBs Link
None	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

<b>RFC</b>	<b>Title</b>
RFC 5921	<i>A Framework for MPLS in Transport Networks</i>
RFC 5885	<i>Bidirectional Forwarding Detection (BFD) for the Pseudowire Virtual Circuit Connectivity Verification (VCCV)</i>
RFC 5586	<i>MPLS Generic Associated Channel</i>

**Technical Assistance**

<b>Description</b>	<b>Link</b>
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for MPLS-TP

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

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

**Table 1**      **Feature Information for MPLS-TP**

Feature Name	Releases	Feature Information
MPLS Transport Profile	15.1(1)SA 15.3(1)S Cisco IOS XE Release 3.5S	<p>MPLS Transport Profile (TP) enables you to create tunnels that provide the transport network service layer over which IP and MPLS traffic traverse. MPLS-TP tunnels enable a transition from Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) time-division multiplexing (TDM) technologies to packet switching to support services with high bandwidth requirements, such as video.</p> <p>In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.</p> <p>The following commands were introduced or modified:</p> <p><b>debug mpls l2transport static-oam, debug mpls tp, interface tunnel-tp interval local interface logging (MPLS-TP) medium p2p mpls tp mpls tp link mpls tp lsp ping mpls tp pseudowire-static-oam class pseudowire-tlv template show mpls l2transport static-oam show mpls tp status protocol notification static timeout refresh tlv tlv template trace mpls tp</b></p>
L2VPN Static to Dynamic PW Interconnection & PW Preferred Path for MPLS-TP Tunnels	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
MPLS-TP: PW Redundancy for Static PWs	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
Bidirectional MPLS-TP LSP	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.

Feature Name	Releases	Feature Information
MPLS-TP Path Protection	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
MPLS-TP OAM: GACH	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
MPLS-TP OAM: Continuity Check via BFD	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
MPLS-TP OAM: Ping/Trace	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
MPLS-TP OAM: Fault Management	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.
MPLS TP: IP-less configuration of MPLS TP tunnels	Cisco IOS XE Release 3.5S	In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.







# Multiprotocol Label Switching (MPLS) on Cisco Routers

---

This document describes commands for configuring and monitoring Multiprotocol Label Switching (MPLS) functionality on Cisco routers and switches. This document is a companion to other feature modules describing other MPLS applications.

- [Finding Feature Information, page 35](#)
- [Restrictions for MPLS, page 35](#)
- [Information About MPLS, page 35](#)
- [How to Configure MPLS, page 38](#)
- [Additional References, page 39](#)
- [Feature Information for MPLS on Cisco Routers, page 41](#)
- [Glossary, page 42](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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

## Restrictions for MPLS

Label switching on a Cisco router requires that Cisco Express Forwarding be enabled on that router (see the “Configuration Tasks” section below).

## Information About MPLS

- [MPLS Overview, page 36](#)
- [Functional Description of MPLS, page 36](#)
- [Label Switching Functions, page 36](#)
- [Distribution of Label Bindings, page 36](#)

- [Benefits of MPLS, page 37](#)

## MPLS Overview

Multiprotocol label switching (MPLS) combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing. MPLS enables service providers to meet the challenges of explosive growth in network utilization while providing the opportunity to differentiate services without sacrificing the existing network infrastructure. The MPLS architecture is flexible and can be employed in any combination of Layer 2 technologies. MPLS support is offered for all Layer 3 protocols, and scaling is possible well beyond that typically offered in today's networks.

MPLS efficiently enables the delivery of IP services over an ATM switched network. MPLS supports the creation of different routes between a source and a destination on a purely router-based Internet backbone. By incorporating MPLS into their network architecture, service providers can save money, increase revenue and productivity, provide differentiated services, and gain competitive advantages.

## Functional Description of MPLS

Label switching is a high-performance packet forwarding technology that integrates the performance and traffic management capabilities of data link layer (Layer 2) switching with the scalability, flexibility, and performance of network layer (Layer 3) routing.

## Label Switching Functions

In conventional Layer 3 forwarding mechanisms, as a packet traverses the network, each router extracts all the information relevant to forwarding the packet from the Layer 3 header. This information is then used as an index for a routing table lookup to determine the next hop for the packet.

In the most common case, the only relevant field in the header is the destination address field, but in some cases, other header fields might also be relevant. As a result, the header analysis must be done independently at each router through which the packet passes. In addition, a complicated table lookup must also be done at each router.

In label switching, the analysis of the Layer 3 header is done only once. The Layer 3 header is then mapped into a fixed length, unstructured value called a *label*.

Many different headers can map to the same label, as long as those headers always result in the same choice of next hop. In effect, a label represents a *forwarding equivalence class* --that is, a set of packets which, however different they may be, are indistinguishable by the forwarding function.

The initial choice of a label need not be based exclusively on the contents of the Layer 3 packet header; for example, forwarding decisions at subsequent hops can also be based on routing policy.

Once a label is assigned, a short label header is added at the front of the Layer 3 packet. This header is carried across the network as part of the packet. At subsequent hops through each MPLS router in the network, labels are swapped and forwarding decisions are made by means of MPLS forwarding table lookup for the label carried in the packet header. Hence, the packet header does not need to be reevaluated during packet transit through the network. Because the label is of fixed length and unstructured, the MPLS forwarding table lookup process is both straightforward and fast.

## Distribution of Label Bindings

Each label switching router (LSR) in the network makes an independent, local decision as to which label value to use to represent a forwarding equivalence class. This association is known as a label binding. Each

LSR informs its neighbors of the label bindings it has made. This awareness of label bindings by neighboring routers is facilitated by the following protocols:

- Tag Distribution Protocol (TDP)--Used to support MPLS forwarding along normally routed paths
- Resource Reservation Protocol (RSVP)--Used to support MPLS traffic engineering
- Border Gateway Protocol (BGP)--Used to support MPLS virtual private networks (VPNs)

When a labeled packet is being sent from LSR A to the neighboring LSR B, the label value carried by the IP packet is the label value that LSR B assigned to represent the forwarding equivalence class of the packet. Thus, the label value changes as the IP packet traverses the network.

## Benefits of MPLS

MPLS provides the following major benefits to service provider networks:

**Scalable support for Virtual Private Networks (VPNs)**--MPLS enables VPN services to be supported in service provider networks, thereby greatly accelerating Internet growth.

The use of MPLS for VPNs provides an attractive alternative to the building of VPNs by means of either ATM or Frame Relay permanent virtual circuits (PVCs) or various forms of tunneling to interconnect routers at customer sites.

Unlike the PVC VPN model, the MPLS VPN model is highly scalable and can accommodate increasing numbers of sites and customers. The MPLS VPN model also supports “any-to-any” communication among VPN sites without requiring a full mesh of PVCs or the backhauling (suboptimal routing) of traffic across the service provider network. For each MPLS VPN user, the service provider’s network appears to function as a private IP backbone over which the user can reach other sites within the VPN organization, but not the sites of any other VPN organization.

From a user perspective, the MPLS VPN model enables network routing to be dramatically simplified. For example, rather than having to manage routing over a topologically complex virtual backbone composed of many PVCs, an MPLS VPN user can generally employ the service provider’s backbone as the default route in communicating with all of the other VPN sites.

**Explicit routing capabilities (also called constraint-based routing or traffic engineering)**--Explicit routing employs “constraint-based routing,” in which the path for a traffic flow is the shortest path that meets the resource requirements (constraints) of the traffic flow.

In MPLS traffic engineering, factors such as bandwidth requirements, media requirements, and the priority of one traffic flow versus another can be taken into account. These traffic engineering capabilities enable the administrator of a service provider network to

- Control traffic flow in the network
- Reduce congestion in the network
- Make best use of network resources

Thus, the network administrator can specify the amount of traffic expected to flow between various points in the network (thereby establishing a traffic matrix), while relying on the routing system to

- Calculate the best paths for network traffic
- Set up the explicit paths to carry the traffic

**Support for IP routing on ATM switches (also called IP and ATM integration)**--MPLS enables an ATM switch to perform virtually all of the functions of an IP router. This capability of an ATM switch stems from the fact that the MPLS forwarding paradigm, namely, label swapping, is exactly the same as the forwarding paradigm provided by ATM switch hardware.

The key difference between a conventional ATM switch and an ATM label switch is the control software used by the latter to establish its virtual channel identifier (VCI) table entries. An ATM label switch uses IP routing protocols and the Tag Distribution Protocol (TDP) to establish VCI table entries.

An ATM label switch can function as a conventional ATM switch. In this dual mode, the ATM switch resources (such as VCI space and bandwidth) are partitioned between the MPLS control plane and the ATM control plane. The MPLS control plane provides IP-based services, while the ATM control plane supports ATM-oriented functions, such as circuit emulation or PVC services.

## How to Configure MPLS

This section explains how to configure a router for MPLS forwarding by enabling Cisco Express Forwarding on the router.

Configuration tasks for other MPLS applications are described in the feature module documentation for the application.

- [Configuring a Router for MPLS Forwarding, page 38](#)
- [Verifying Configuration of MPLS Forwarding, page 39](#)

## Configuring a Router for MPLS Forwarding

MPLS forwarding on Cisco routers requires that Cisco Express Forwarding be enabled.



### Note

Cisco Express Forwarding is enabled by default on a Cisco ASR 1000 Series Aggregation Services Router and cannot be disabled.

For more information about Cisco Express Forwarding commands, see the Cisco IOS Switching Command Reference.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef distributed**

### DETAILED STEPS

	Command or Action	Purpose
Step 1	enable	Enables privileged EXEC mode.
	<b>Example:</b>	
	Router> enable	<ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>

	Command or Action	Purpose
Step 2	<b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
Step 3	<b>ip cef distributed</b>  <b>Example:</b> Router(config)# ip cef distributed	Enables Cisco Express Forwarding on the route processor card.

## Verifying Configuration of MPLS Forwarding

To verify that Cisco Express Forwarding has been configured properly, issue the **show ip cef summary** command, which generates output similar to that shown below:

### SUMMARY STEPS

1. show ip cef summary

### DETAILED STEPS

---

```
show ip cef summary
```

#### Example:

```
Router# show ip cef summary
IP CEF with switching (Table Version 49), flags=0x0
 43 routes, 0 resolve, 0 unresolved (0 old, 0 new)
 43 leaves, 49 nodes, 56756 bytes, 45 inserts, 2 invalidations
 2 load sharing elements, 672 bytes, 2 references
 1 CEF resets, 4 revisions of existing leaves
 4 in-place modifications
 refcounts: 7241 leaf, 7218 node
Adjacency Table has 18 adjacencies
Router#
```

---

## Additional References

**Related Documents**

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
MPLS commands	<i>Cisco IOS Multiprotocol Label Switching Command Reference</i>

**Standards**

Standard	Title
The supported standards applicable to the MPLS applications appear in the respective feature module for the application.	--

**MIBs**

MIB	MIBs Link
The supported MIBs applicable to the MPLS applications appear in the respective feature module for the application.	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

RFC	Title
The supported RFCs applicable to the MPLS applications appear in the respective feature module for the application.	--

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for MPLS on Cisco Routers

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

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

**Table 2**      **Feature Information for MPLS on Cisco Routers**

Feature Name	Releases	Feature Information
MPLS (Multiprotocol Label Switching)	Cisco IOS XE Release 2.1 Cisco IOS XE Release 3.5S	<p>Multiprotocol label switching (MPLS) combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing. MPLS enables service providers to meet the challenges of explosive growth in network utilization while providing the opportunity to differentiate services without sacrificing the existing network infrastructure.</p> <p>In Cisco IOS XE Release 2.1, this feature was introduced.</p> <p>In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.</p> <p>The following commands were introduced or modified: <b>interface atm</b>, <b>mpls atm control-vc</b>, <b>mpls atm vpi</b>, <b>mpls ip</b> (global configuration), <b>mpls ip</b> (interface configuration), <b>mpls ip default-route</b>, <b>mpls ip propagate-ttl</b>, <b>mpls ip ttl-expiration pop</b>, <b>mpls label range</b>, <b>mpls mtu</b>, <b>show mpls forwarding-table</b>, <b>show mpls interfaces</b>, <b>show mpls label range</b>, <b>debug mpls adjacency</b>, <b>debug mpls events</b>, <b>debug mpls lfib cef</b>, <b>debug mpls lfib enc</b>, <b>debug mpls lfib lsp</b>, <b>debug mpls lfib state</b>, <b>debug mpls lfib struct</b>, <b>debug mpls packets</b>.</p>

## Glossary

**ATM edge LSR** --A router that is connected to the ATM-LSR cloud through LC-ATM interfaces. The ATM edge LSR adds labels to unlabeled packets and strips labels from labeled packets.

**ATM-LSR** --A label switch router with a number of LC-ATM interfaces. The router forwards the cells among these interfaces using labels carried in the VPI/VCI field of the ATM cell header.



- CoS** --Class of service. A feature that provides scalable, differentiated types of service across an MPLS network.
- IP precedence** --A 3-bit value in a ToS byte used for assigning precedence to IP packets.
- label** --A short fixed-length label that tells switching nodes how to forward data (packets or cells).
- label-controlled ATM interface (LC-ATM interface)** --An interface on a router or switch that uses label distribution procedures to negotiate label VCs.
- label edge router (LER)** --A router that performs label imposition.
- label imposition** --The action of putting the first label on a packet.
- label switch** --A node that forwards units of data (packets or cells) on the basis of labels.
- label switched path (LSP)** --A sequence of hops (Router 0...Router n) in which a packet travels from R0 to Rn by means of label switching mechanisms. A label switched path can be chosen dynamically, based on normal routing mechanisms, or it can be configured manually.
- label switched path (LSP) tunnel** --A configured connection between two routers, in which label switching techniques are used for packet forwarding.
- label switching router (LSR)** --A Layer 3 router that forwards a packet based on the value of a label encapsulated in the packet.
- label VC (LVC)** --A n ATM virtual circuit that is set up through ATM LSR label distribution procedures.
- LFIB** --Label Forwarding Information Base. The data structure used by switching functions to switch labeled packets.
- LIB** --Label information base. A database used by an LSR to store labels learned from other LSRs, as well as labels assigned by the local LSR.
- MPLS** --Multiprotocol label switching. An emerging industry standard that defines support for MPLS forwarding of packets along normally routed paths (sometimes called MPLS hop-by-hop forwarding).
- QoS** --quality of service. A measure of performance for a transmission system that reflects its transmission quality and service availability.
- tailend** --The downstream, received end of a tunnel.
- TDP** --Tag Distribution Protocol. The protocol used to distribute label bindings to LSRs.
- traffic engineering** --The techniques and processes used to cause routed traffic to travel through the network on a path other than the one that could have been chosen if standard routing methods had been applied.
- traffic engineering tunne l**--A label-switched tunnel that is used for traffic engineering. Such a tunnel is set up through means other than normal Layer 3 routing; it is used to direct traffic over a path different from the one that Layer 3 routing could cause the tunnel to take.
- VPN** --Virtual Private Network. Enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.



# MPLS Infrastructure Changes Introduction of MFI and Removal of MPLS LSC and LC-ATM Features

---

This document explains the new MPLS Forwarding Infrastructure (MFI) and removal of support for MPLS label switch controller (LSC) and label-controlled ATM (LC-ATM) features and commands.

- [Finding Feature Information, page 45](#)
- [Information About MPLS Infrastructure Changes, page 45](#)
- [Additional References, page 48](#)
- [Feature Information for MPLS Infrastructure Changes, page 48](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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

## Information About MPLS Infrastructure Changes

- [Introduction of the MPLS Forwarding Infrastructure, page 45](#)
- [Introduction of IP Rewrite Manager, page 46](#)
- [Removal of Support for MPLS LSC and LC-ATM Features, page 46](#)
- [MPLS LSC and LC-ATM Configurations, page 46](#)
- [Removal of Support for MPLS LSC and LC-ATM Commands, page 47](#)

## Introduction of the MPLS Forwarding Infrastructure

The MPLS control plane software is enhanced to make MPLS more scalable and flexible. The MFI, which manages MPLS data structures used for forwarding, replaces the Label Forwarding Information Base (LFIB).

**Note**

The MFI and LFIB do not coexist in the same image. For a list of supported releases, see the "Feature Information for MPLS Forwarding Infrastructure."

## Introduction of IP Rewrite Manager

Cisco software introduces a module called the MPLS IP Rewrite Manager (IPRM) that manages the interactions between Cisco Express Forwarding, the IP Label Distribution Modules (LDMs), and the MFI. MPLS IPRM is enabled by default. You need not configure or customize the IPRM. These commands are related to IPRM:

- **clear mpls ip iprm counters**
- **debug mpls ip iprm**
- **debug mpls ip iprm cef**
- **debug mpls ip iprm events**
- **debug mpls ip iprm ldm**
- **debug mpls ip iprm mfi**
- **show mpls ip iprm counters**
- **show mpls ip iprm ldm**

For information about these commands, see the *Cisco IOS Debug Command Reference* and the *Cisco IOS MPLS Command Reference*.

## Removal of Support for MPLS LSC and LC-ATM Features

The following MPLS LSC and LC-ATM features are no longer supported, starting with Cisco IOS Release 12.4(20)T:

- MPLS LSC
- LC-ATM
- MPLS Scalability Enhancements for LSC and ATM LSR
- MPLS LSC Redundancy
- MPLS--OAM Insertion and Loop Detection on LC-ATM
- MPLS CoS Multi-VC Mode for PA-A3
- MPLS over ATM: Virtual Circuit Merge
- MPLS Diff-Serv Aware Traffic Engineering over ATM
- VSI Master MIB

## MPLS LSC and LC-ATM Configurations

Before upgrading to Cisco IOS Release 12.4(20)T, remove all the MPLS LSC and LC-ATM configurations from the routers in your network. If your core network has ATM links, you can use packet-based MPLS. See the MPLS Label Distribution Protocol Overview for more information. If you provide ATM access to customers, you can use the Any Transport over MPLS: ATM over MPLS feature. See Any Transport over MPLS for more information.

If you have MPLS LSC or LC-ATM features configured and you upgrade to Cisco IOS Release 12.4(20)T, the configuration is not accepted. The system displays "unrecognized command" errors for any commands that are no longer supported.

## Removal of Support for MPLS LSC and LC-ATM Commands

The following commands are no longer supported, starting with Cisco IOS Release 12.4(20)T:

- `debug mpls atm-cos`
- `debug mpls atm-ldp api`
- `debug mpls atm-ldp failure`
- `debug mpls atm-ldp routes`
- `debug mpls atm-ldp states`
- `debug mpls xmpls cross-connect`
- `debug mpls xmpls errors`
- `debug mpls xmpls events`
- `debug mpls xmpls vc`
- `debug mpls xtagatm cross-connect`
- `debug mpls xtagatm errors`
- `debug mpls xtagatm events`
- `debug mpls xtagatm vc`
- `debug vsi api`
- `debug vsi errors`
- `debug vsi events`
- `debug vsi packets`
- `debug vsi param-groups`
- `extended-port`
- `interface xtagatm`
- `mpls atm control-vc`
- `mpls atm cos`
- `mpls atm disable-headend-vc`
- `mpls atm multi-vc`
- `mpls atm vpi`
- `mpls atm vp-tunnel`
- `mpls cos-map`
- `mpls ldp atm control-mode`
- `mpls ldp atm vc-merges`
- `mpls prefix-map`
- `mpls request-labels for`
- `mpls traffic-eng atm cos global-pool`
- `mpls traffic-eng atm cos sub-pool`
- `show controllers vsi control-interface`
- `show controllers vsi descriptor`
- `show controllers vsi session`
- `show controllers vsi status`
- `show controllers vsi traffic`
- `show controllers xmpls`
- `show controllers xtagatm`
- `show interface xtagatm`
- `show mpls atm-ldp bindings`

- `show mpls atm-ldp bindwait`
- `show mpls atm-ldp capability`
- `show mpls atm-ldp summary`
- `show mpls cos-map`
- `show mpls prefix-map`
- `show xtagatm cos-bandwidth-allocation`
- `show xtagatm cross-connect`
- `show xtagatm vc`
- `snmp-server enable traps vsimaster`
- `tag-control-protocol vsi`

## Additional References

### Related Documents

Related Topic	Document Title
MPLS commands	<i>Cisco IOS MPLS Command Reference</i>
MPLS Label Distribution Protocol	MPLS Label Distribution Protocol Overview
Layer 2 VPN features over MPLS	Any Transport over MPLS

### Technical Assistance

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

## Feature Information for MPLS Infrastructure Changes

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

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

**Table 3**      **Feature Information for MPLS Infrastructure Changes**

Feature Name	Releases	Feature Information
MPLS Infrastructure Changes	12.4(20)T Cisco IOS XE Release 3.5S	In Cisco IOS Release 12.4(20)T, this feature was introduced.  In Cisco IOS XE Release 3.5S, support was added for the Cisco ASR 903 Router.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.







## MPLS Static Labels

---

This document describes the Cisco MPLS Static Labels feature. The MPLS Static Labels feature provides the means to configure statically:

- The binding between a label and an IPv4 prefix
- The contents of an LFIB crossconnect entry
- [Finding Feature Information, page 51](#)
- [Restrictions for MPLS Static Labels, page 51](#)
- [Prerequisites for MPLS Static Labels, page 52](#)
- [Information About MPLS Static Labels, page 52](#)
- [How to Configure MPLS Static Labels, page 52](#)
- [Configuration Examples for MPLS Static Labels, page 57](#)
- [Additional References, page 59](#)
- [Feature Information for MPLS Static Labels, page 60](#)
- [Glossary, page 60](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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

## Restrictions for MPLS Static Labels

- The trouble shooting process for MPLS static labels is complex.
- On a provider edge (PE) router for MPLS VPNs, there is no mechanism for statically binding a label to a customer network prefix (VPN IPv4 prefix).
- MPLS static crossconnect labels remain in the LFIB even if the router to which the entry points goes down.
- MPLS static crossconnect mappings remain in effect even with topology changes.
- MPLS static labels are not supported for label-controlled Asynchronous Transfer Mode (lc-atm).
- MPLS static bindings are not supported for local prefixes.

## Prerequisites for MPLS Static Labels

The network must support the following Cisco IOS features before you enable MPLS static labels:

- Multiprotocol Label Switching (MPLS)
- Cisco Express Forwarding

## Information About MPLS Static Labels

- [MPLS Static Labels Overview, page 52](#)
- [Benefits of MPLS Static Labels, page 52](#)

## MPLS Static Labels Overview

Generally, label switching routers (LSRs) dynamically learn the labels they should use to label-switch packets by means of label distribution protocols that include:

- Label Distribution Protocol (LDP), the Internet Engineering Task Force (IETF) standard, used to bind labels to network addresses
- Resource Reservation Protocol (RSVP) used to distribute labels for traffic engineering (TE)
- Border Gateway Protocol (BGP) used to distribute labels for Multiprotocol Label Switching (MPLS) Virtual Private Networks (VPNs)

To use a learned label to label-switch packets, an LSR installs the label into its Label Forwarding Information Base (LFIB).

The MPLS Static Labels feature provides the means to configure statically:

- The binding between a label and an IPv4 prefix
- The contents of an LFIB crossconnect entry

## Benefits of MPLS Static Labels

### Static Bindings Between Labels and IPv4 Prefixes

Static bindings between labels and IPv4 prefixes can be configured to support MPLS hop-by-hop forwarding through neighbor routers that do not implement LDP label distribution.

### Static Crossconnects

Static crossconnects can be configured to support MPLS Label Switched Path (LSP) midpoints when neighbor routers do not implement either the LDP or RSVP label distribution, but do implement an MPLS forwarding path.

## How to Configure MPLS Static Labels

- [Configuring MPLS Static Prefix Label Bindings, page 53](#)

- [Verifying MPLS Static Prefix Label Bindings, page 54](#)
- [Configuring MPLS Static Crossconnects, page 55](#)
- [Verifying MPLS Static Crossconnect Configuration, page 56](#)
- [Monitoring and Maintaining MPLS Static Labels, page 56](#)

## Configuring MPLS Static Prefix Label Bindings

To configure MPLS static prefix/label bindings, use the following commands beginning in global configuration mode:

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls label range** *min-label max-label* [**static** *min-static-label max-static-label*]
4. **mpls static binding ipv4** *prefix mask* [**input**| **output** *nexthop*] *label*

### DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <b>enable</b></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <b>mpls label range</b> <i>min-label max-label</i> [<b>static</b> <i>min-static-label max-static-label</i>]</p> <p><b>Example:</b></p> <pre>Router(config)# mpls label range 200 100000 static 16 199</pre>	<p>Specifies a range of labels for use with MPLS Static Labels feature.</p> <p>(Default is no labels reserved for static assignment.)</p>
<p><b>Step 4</b> <b>mpls static binding ipv4</b> <i>prefix mask</i> [<b>input</b>  <b>output</b> <i>nexthop</i>] <i>label</i></p> <p><b>Example:</b></p> <pre>Router(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 55</pre>	<p>Specifies static binding of labels to IPv4 prefixes.</p> <p>Bindings specified are installed automatically in the MPLS forwarding table as routing demands.</p>

## Verifying MPLS Static Prefix Label Bindings

To verify the configuration for MPLS static prefix/label bindings, use this procedure:

### SUMMARY STEPS

1. Enter **show mpls label range** command. The output shows that the new label ranges do not take effect until a reload occurs:
2. Enter the **show mpls static binding ipv4** command to show the configured static prefix/label bindings:
3. Use the **show mpls forwarding-table** command to determine which static prefix/label bindings are currently in use for MPLS forwarding.

### DETAILED STEPS

**Step 1** Enter **show mpls label range** command. The output shows that the new label ranges do not take effect until a reload occurs:

#### Example:

```
Router# show mpls label range

Downstream label pool: Min/Max label: 16/100000
 [Configured range for next reload: Min/Max label: 200/100000]
Range for static labels: Min/Max/Number: 16/199
```

The following output from the **show mpls label range** command, executed after a reload, indicates that the new label ranges are in effect:

#### Example:

```
Router# show mpls label range

Downstream label pool: Min/Max label: 200/100000
Range for static labels: Min/Max/Number: 16/199
```

**Step 2** Enter the **show mpls static binding ipv4** command to show the configured static prefix/label bindings:

#### Example:

```
Router# show mpls static binding ipv4
10.17.17.17/32: Incoming label: 251 (in LIB)
  Outgoing labels:
    10.0.0.1          18
10.18.18.18/32: Incoming label: 201 (in LIB)
  Outgoing labels:
    10.0.0.1    implicit-null
```

**Step 3** Use the **show mpls forwarding-table** command to determine which static prefix/label bindings are currently in use for MPLS forwarding.

#### Example:

```
Router# show mpls forwarding-table
```

Local tag	Outgoing tag or VC Pop tag	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
201	2/35	10.18.18.18/32	0	PO1/1/0	point2point
251	18	10.18.18.18/32	0	AT4/1/0.1	point2point
		10.17.17.17/32	0	PO1/1/0	point2point

## Configuring MPLS Static Crossconnects

To configure MPLS static crossconnects, use the following command beginning in global configuration mode:

### SUMMARY STEPS

1. enable
2. configure terminal
3. `mpls label range min-label max-label [static min-static-label max-static-label]`
4. `mpls static binding ipv4 prefix mask [input| output nexthop] label`

### DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> enable</p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> configure terminal</p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>mpls label range min-label max-label [static min-static-label max-static-label]</code></p> <p><b>Example:</b></p> <pre>Router(config)# mpls label range 200 100000 static 16 199</pre>	<p>Specifies a range of labels for use with MPLS Static Labels feature.</p> <p>(Default is no labels reserved for static assignment.)</p>

Command or Action	Purpose
<p><b>Step 4</b> <code>mpls static binding ipv4 prefix mask [input  output nexthop] label</code></p> <p><b>Example:</b></p> <pre>Router(config)# Router(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 55</pre>	<p>Specifies static binding of labels to IPv4 prefixes.</p> <p>Bindings specified are installed automatically in the MPLS forwarding table as routing demands.</p>

## Verifying MPLS Static Crossconnect Configuration

To verify the configuration for MPLS static crossconnects, use this procedure:

### SUMMARY STEPS

1. Use the `show mpls static crossconnect` command to display information about crossconnects that have been configured:

### DETAILED STEPS

---

Use the `show mpls static crossconnect` command to display information about crossconnects that have been configured:

**Example:**

```
Router# show mpls static crossconnect
Local   Outgoing   Outgoing   Next Hop
label   label      interface
34      22         pos3/0/0   point2point (in LFIB)
```

---

## Monitoring and Maintaining MPLS Static Labels

To monitor and maintain MPLS static labels, use one or more of the following commands:

### SUMMARY STEPS

1. `enable`
2. `show mpls forwarding-table`
3. `show mpls label range`
4. `show mpls static binding ipv4`
5. `show mpls static crossconnect`

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
Step 2	<p><b>show mpls forwarding-table</b></p> <p><b>Example:</b></p> <pre>Router# show mpls forwarding-table</pre>	<p>Displays the contents of the MPLS LFIB.</p>
Step 3	<p><b>show mpls label range</b></p> <p><b>Example:</b></p> <pre>Router# show mpls label range</pre>	<p>Displays information about the static label range.</p>
Step 4	<p><b>show mpls static binding ipv4</b></p> <p><b>Example:</b></p> <pre>Router# show mpls static binding ipv4</pre>	<p>Displays information about the configured static prefix/label bindings.</p>
Step 5	<p><b>show mpls static crossconnect</b></p> <p><b>Example:</b></p> <pre>Router# show mpls static crossconnect</pre>	<p>Displays information about the configured crossconnects.</p>

## Configuration Examples for MPLS Static Labels

- [Example Configuring MPLS Static Prefixes Labels, page 57](#)
- [Example Configuring MPLS Static Crossconnects, page 58](#)

### Example Configuring MPLS Static Prefixes Labels

In the following output, the **mpls label range** command reconfigures the range used for dynamically assigned labels from 16 to 100000 to 200 to 100000 and configures a static label range of 16 to 199.

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# mpls label range 200 100000 static 16 199
```

```
% Label range changes take effect at the next reload.
Router(config)# end
```

In the following output, the **show mpls label range** command indicates that the new label ranges do not take effect until a reload occurs:

```
Router# show mpls label range

Downstream label pool: Min/Max label: 16/100000
  [Configured range for next reload: Min/Max label: 200/100000]
Range for static labels: Min/Max/Number: 16/199
```

In the following output, the **show mpls label range** command, executed after a reload, indicates that the new label ranges are in effect:

```
Router# show mpls label range

Downstream label pool: Min/Max label: 200/100000
Range for static labels: Min/Max/Number: 16/199
```

In the following output, the **mpls static binding ipv4** commands configure static prefix/label bindings. They also configure input (local) and output (remote) labels for various prefixes:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 55
Router(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 output 10.0.0.66 2607
Router(config)# mpls static binding ipv4 10.6.0.0 255.255.0.0 input 17
Router(config)# mpls static binding ipv4 10.0.0.0 255.0.0.0 output 10.13.0.8 explicit-null
Router(config)# end
```

In the following output, the **show mpls static binding ipv4** command displays the configured static prefix/label bindings:

```
Router# show mpls static binding ipv4

10.0.0.0/8: Incoming label: none;
  Outgoing labels:
10.13.0.8      explicit-null
10.0.0.0/8: Incoming label: 55 (in LIB)
  Outgoing labels:
    10.0.0.66      2607
10.66.0.0/16: Incoming label: 17 (in LIB)
  Outgoing labels: None
```

## Example Configuring MPLS Static Crossconnects

In the following output, the **mpls static crossconnect** command configures a crossconnect from incoming label 34 to outgoing label 22 out interface pos3/0/0:

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# mpls static crossconnect 34 pos3/0/0 22
Router(config)# end
```

In the following output, the **show mpls static crossconnect** command displays the configured crossconnect:

```
Router# show mpls static crossconnect
Local  Outgoing  Outgoing  Next Hop
label  label      interface
34     22         pos3/0/0  point2point (in LFIB)
```



# Additional References

## Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
MPLS commands	<i>Multiprotocol Label Switching Command Reference</i>

## Standards

Standard	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

## MIBs

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

## RFCs

RFC	Title
No new or modified RFCs are supported by this feature, and support for existing RFCs has not been modified by this feature.	--

## Technical Assistance

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for MPLS Static Labels

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

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

**Table 4** Feature Information for MPLS Static Labels

Feature Name	Releases	Feature Information
MPLS Static Labels	Cisco IOS XE Release 2.1	<p>The MPLS Static Labels feature provides the means to configure the following items statically:</p> <ul style="list-style-type: none"> <li>The binding between a label and an IPv4 prefix</li> <li>The contents of an LFIB crossconnect entry</li> </ul> <p>The following commands were introduced or modified: <b>debug mpls static binding</b>, <b>mpls label range</b>, <b>mpls static binding ipv4</b>, <b>mpls static crossconnect</b>, <b>show mpls label range</b>, <b>show mpls static binding ipv4</b>, <b>show mpls static crossconnect</b></p>

## Glossary

**BGP** --Border Gateway Protocol. The predominant interdomain routing protocol used in IP networks.

**Border Gateway Protocol** --See BGP.

**FIB** --Forwarding Information Base. A table that contains a copy of the forwarding information in the IP routing table.

**Forwarding Information Base** --See FIB.

**label** --A short, fixed-length identifier that tells switching nodes how the data (packets or cells) should be forwarded.

**label binding** --An association between a label and a set of packets, which can be advertised to neighbors so that a label switched path can be established.

**Label Distribution Protocol** --See LDP.

**Label Forwarding Information Base** --See LFIB.

**label imposition** --The act of putting the first label on a packet.

**label switching router** --See LSR.

**LDP** --Label Distribution Protocol. The protocol that supports MPLS hop-by-hop forwarding by distributing bindings between labels and network prefixes.

**LFIB** --Label Forwarding Information Base. A data structure in which destinations and incoming labels are associated with outgoing interfaces and labels.

**LSR** --label switching router. A Layer 3 router that forwards a packet based on the value of an identifier encapsulated in the packet.

**MPLS** --Multiprotocol Label Switching. An industry standard on which label switching is based.

**MPLS hop-by-hop forwarding** --The forwarding of packets along normally routed paths using MPLS forwarding mechanisms.

**Multiprotocol Label Switching** --See MPLS.

**Resource Reservation Protocol** --See RSVP.

**RIB** --Routing Information Base. A common database containing all the routing protocols running on a router.

**Routing Information Base** --See RIB.

**RSVP** --Resource Reservation Protocol. A protocol for reserving network resources to provide quality of service guarantees to application flows.

**traffic engineering** --Techniques and processes used to cause routed traffic to travel through the network on a path other than the one that would have been chosen if standard routing methods were used.

**Virtual Private Network** --See VPN.

**VPN** --Virtual Private Network. A network that enables IP traffic to use tunneling to travel securely over a public TCP/IP network.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams,

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



## MPLS--Multilink PPP Support

---

The MPLS--Multilink PPP Support feature ensures that MPLS Layer 3 Virtual Private Networks (VPNs) with quality of service (QoS) can be enabled for bundled links. This feature supports Multiprotocol Label Switching (MPLS) over Multilink PPP (MLP) links in the edge (provider edge [PE]-to-customer edge [CE]) or in the MPLS core (PE-to-PE and PE-to-provider router [P]).

Service providers that use relatively low-speed links can use MLP to spread traffic across them in their MPLS networks. Link fragmentation and interleaving (LFI) should be deployed in the CE-to-PE link for efficiency, where traffic uses a lower link bandwidth (less than 768 kbps).

- [Finding Feature Information, page 63](#)
- [Prerequisites for MPLS--Multilink PPP Support, page 63](#)
- [Information About MPLS--Multilink PPP Support, page 64](#)
- [How to Configure MPLS--Multilink PPP Support, page 68](#)
- [Configuration Examples for MPLS--Multilink PPP Support, page 79](#)
- [Additional References, page 81](#)
- [Feature Information for MPLS--Multilink PPP Support, page 82](#)
- [Glossary, page 82](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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

## Prerequisites for MPLS--Multilink PPP Support

- Cisco Express Forwarding enabled
- MPLS enabled on PE and P routers
- Cisco Express Forwarding switching enabled on the interface with the **ip route-cache cef** command

## Information About MPLS--Multilink PPP Support

- [MPLS Layer 3 Virtual Private Network Features Supported for Multilink PPP](#), page 64
- [MPLS Quality of Service Features Supported for Multilink PPP](#), page 65
- [MPLS--Multilink PPP Support and PE-to-CE Links](#), page 66
- [MPLS--Multilink PPP Support and Core Links](#), page 66
- [MPLS--Multilink PPP Support in a CSC Network](#), page 67
- [MPLS--Multilink PPP Support in an Interautonomous System](#), page 68

## MPLS Layer 3 Virtual Private Network Features Supported for Multilink PPP

The table below lists MPLS Layer 3 VPN features supported for MLP and indicates if the feature is supported on CE-to-PE links, PE-to-P links, and Carrier Supporting Carrier (CSC) CE-to-PE links.

**Table 5** *MPLS Layer 3 VPN Features Supported for MLP*

MPLS L3 VPN Feature	CE-to-PE Links	PE-to-P Links	CSC CE-to-PE Links
Static routes	Supported	-- <sup>1</sup>	--
External Border Gateway Protocol (eBGP)	Supported	Not applicable to this configuration	Supported
Intermediate System-to-Intermediate System (IS-IS)	--	Supported	--
Open Shortest Path first (OSPF)	Supported	Supported	--
Enhanced Interior Gateway Routing Protocol (EIGRP)	Supported	Supported	--
Interprovider (Inter-AS) VPNs (with Label Distribution Protocol [LDP])	Not applicable to this configuration	Supported (MLP between Autonomous System Border routers {ASBRs})	Not applicable to this configuration
Inter-AS VPNs with IPv4 Label Distribution	Not applicable to this configuration	Supported (MLP between ASBRs)	Not applicable to this configuration
CSC VPNs (with LDP)	--	Not applicable to this configuration	Supported
CSC VPNs with IPv4 label distribution	Supported	Not applicable to this configuration	Supported

<sup>1</sup> An em dash (--) indicates that the configuration is not supported.

MPLS L3 VPN Feature	CE-to-PE Links	PE-to-P Links	CSC CE-to-PE Links
External and internal BGP (eBGP) Multipath	--	--	Not applicable to this configuration
Internal BGP (iBGP) Multipath	Not applicable to this configuration	--	Not applicable to this configuration
eBGP Multipath	--	--	--

## MPLS Quality of Service Features Supported for Multilink PPP

The table below lists the MPLS QoS features supported for MLP and indicates if the feature is supported on CE-to-PE links, PE-to-P links, and CSC-CE-to-CSC-PE links.

**Table 6** MPLS QoS Features Supported for MLP

MPLS QoS Feature	CE-to-PE Links	PE-to-P Links	CSC-CE-to-PE Links
Default copy of IP Precedence to EXP bits and the reverse	Supported	-- <sup>2</sup>	--
Set MPLS EXP bits using the modular QoS Command-Line Interface (MQC)	Supported	Supported	Supported
Matching on MPLS EXP using MQC	Supported	Supported	Supported
Low Latency Queueing (LLQ)/ Class-Based Weighted Fair Queueing (CBWFQ) support	Supported	Supported	Supported
Weighted Random Early Detection (WRED) based on EXP bits using MQC	Supported	Supported	Supported
Policer with EXP bit-marking using MQC-3 action	Supported	Supported	Supported
Support for EXP bits in MPLS accounting	Supported	Supported	Supported

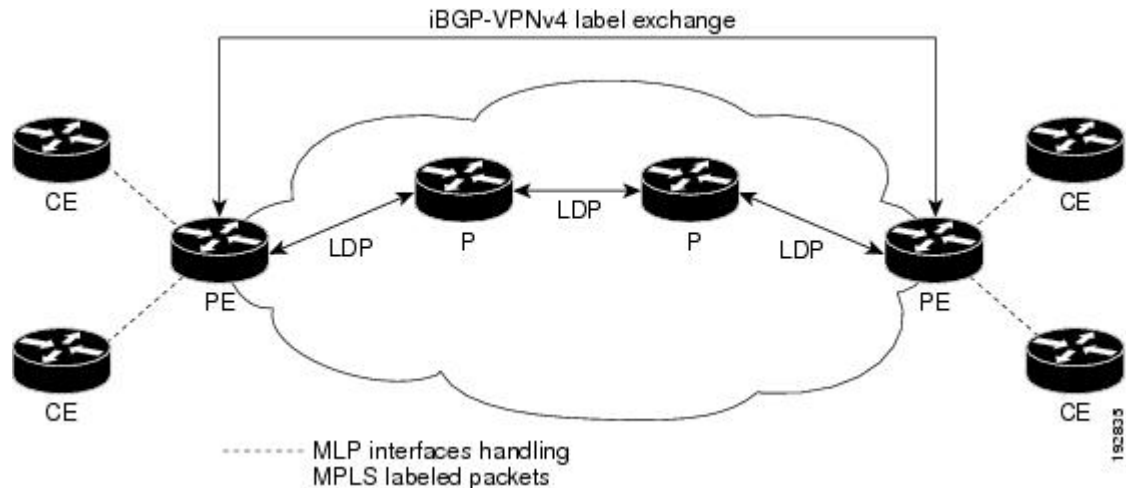
<sup>2</sup> An em dash (--) indicates that the configuration is not supported.

## MPLS--Multilink PPP Support and PE-to-CE Links

The figure below shows a typical MPLS network in which the PE router is responsible for label imposition (at ingress) and disposition (at egress) of the MPLS traffic.

In this topology, MLP is deployed on the PE-to-CE links. The VPN routing and forwarding instance (VRF) interface is in a multilink bundle. There is no MPLS interaction with MLP; all packets coming into the MLP bundle are IP packets.

**Figure 1** *MPL and Traditional PE-to-CE Links*



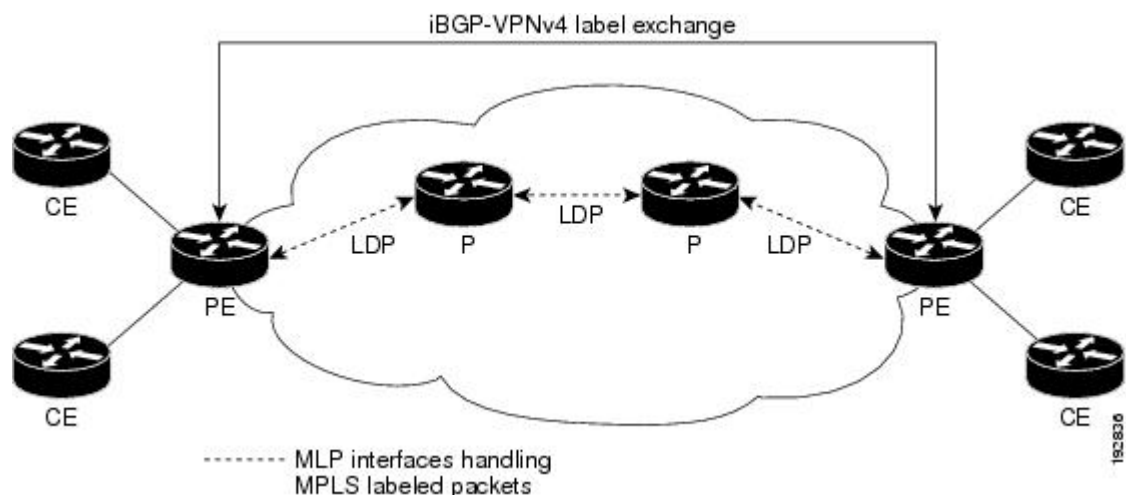
The PE-to-CE routing protocols that are supported for the MPLS--Multilink PPP Support feature are eBGP, OSPF, and EIGRP. Static routes are also supported between the CE and PE routers.

QoS features that are supported for the MPLS--Multilink PPP Support feature on CE-to-PE links are LFI, header compression, policing, marking, and classification.

## MPLS--Multilink PPP Support and Core Links

The figure below shows a sample topology in which MPLS is deployed over MLP on PE-to-P and P-to-P links. Enabling MPLS on MLP for PE-to-P links is similar to enabling MPLS on MLP for P-to-P links.

**Figure 2** *MPL on PE-to-P and P-to-P Links*





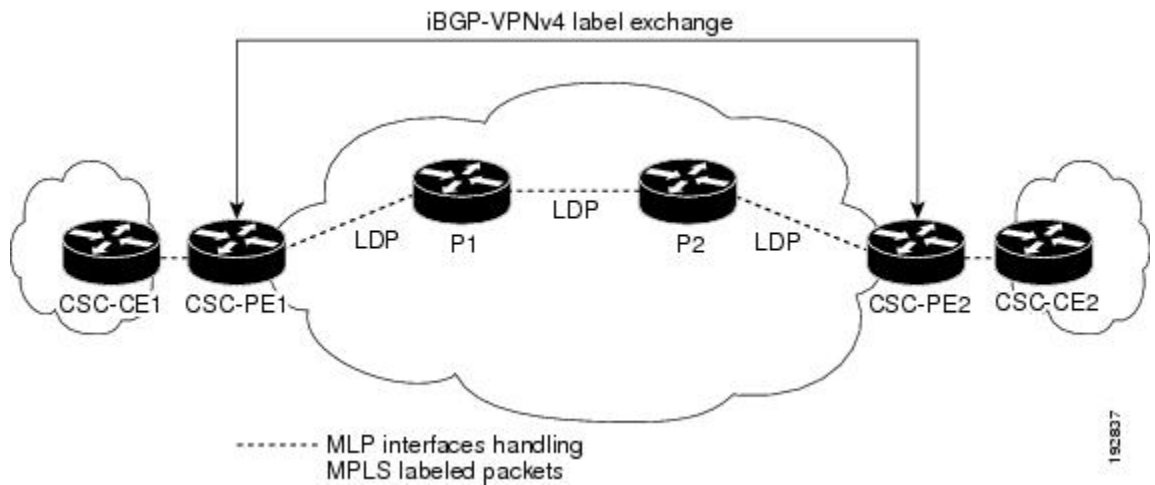
You employ MLP in the PE-to-P or P-to-P links primarily so that you can reduce the number of Interior Gateway Protocol (IGP) adjacencies and facilitate the load sharing of traffic.

In addition to requiring MLP on the PE-to-P links, the MPLS--Multilink PPP Support feature requires the configuration of an IGP routing protocol and LDP.

## MPLS--Multilink PPP Support in a CSC Network

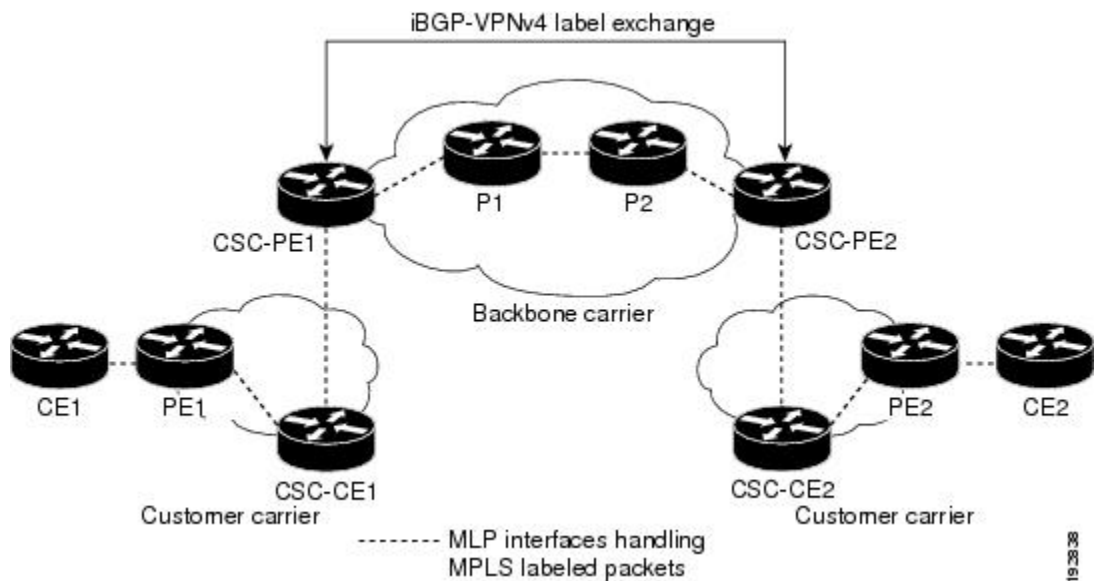
The figure below shows a typical MPLS VPN CSC network where MLP is configured on the CSC-CE-to-CSC-PE links.

**Figure 3** *MLP on CSC-CE-to-CSC-PE Links with MPLS VPN Carrier Supporting Carrier*



The MPLS--Multilink PPP Support feature supports MLP between CSC-CE and CSC-PE links with LDP or with EBGp IPv4 label distribution. This feature also supports LFI for an MPLS VPN CSC configuration. The figure below shows all MLP links that this feature supports for CSC configurations.

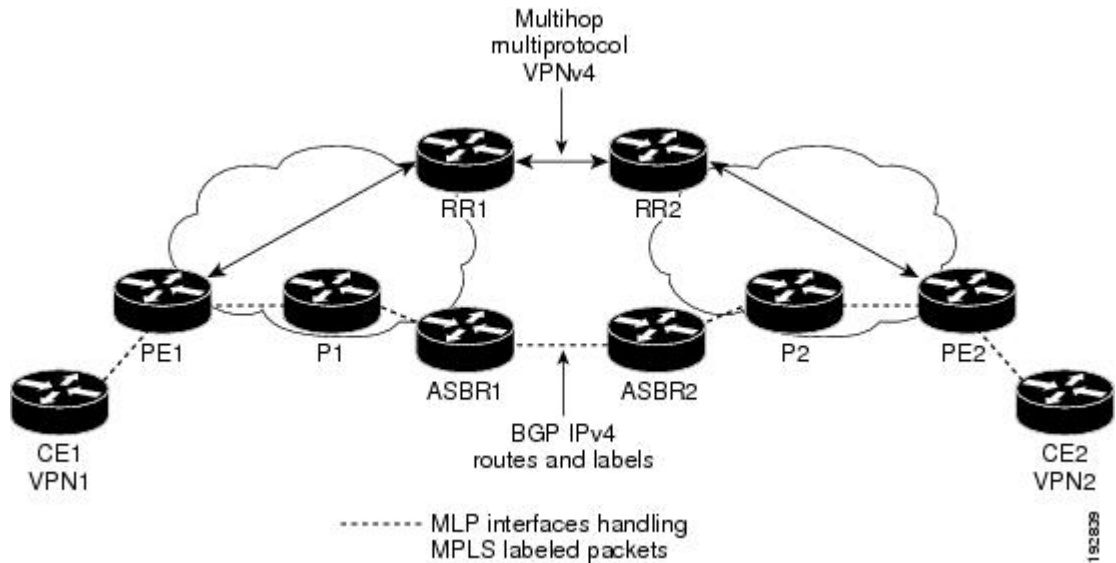
**Figure 4** *MLP Supported Links with MPLS VPN Carrier Supporting Carrier*



## MPLS--Multilink PPP Support in an Interautonomous System

The figure below shows a typical MPLS VPN interautonomous system (Inter-AS) network where MLP is configured on the PE-to-CE links.

**Figure 5** *MLP on ASBR-to-PE Links in an MPLS VPN Inter-AS Network*



The MPLS--Multilink PPP Support feature supports MLP between ASBR links for Inter-AS VPNs with LDP and with eBGP IPv4 label distribution.

## How to Configure MPLS--Multilink PPP Support

Service providers that use relatively low-speed links can use MLP to spread traffic across them in their MPLS networks. LFI should be deployed in the CE-to-PE link for efficiency, where traffic uses lower link bandwidth (less than 768 kbps). The MPLS--Multilink PPP Support Support feature can reduce the number of IGP adjacencies and facilitate load sharing of traffic.

The tasks in this section can be performed on CE-to-PE links, PE-to-P links, P-to-P links, and CSC CSC-CE-to-CSC-PE links.

- [Enabling Cisco Express Forwarding Switching, page 68](#)
- [Creating a Multilink Bundle for MPLS--Multilink PPP Support, page 70](#)
- [Assigning an Interface to a Multilink Bundle for MPLS--Multilink PPP Support, page 71](#)
- [Disabling PPP Multilink Fragmentation, page 74](#)
- [Verifying the Multilink PPP Configuration, page 76](#)

## Enabling Cisco Express Forwarding Switching

Perform the following task to enable Cisco Express Forwarding switching. Cisco Express Forwarding is required for the forwarding of MLP traffic.

Multilink PPP requires the configuration of standard Cisco Express Forwarding. To find out if Cisco Express Forwarding is enabled on your router, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like the following:

```
Router# show ip cef
Prefix          Next Hop          Interface
10.2.61.8/24    192.168.100.1    FastEthernet1/0/0
                192.168.101.1    FastEthernet6/1/0
```

If Cisco Express Forwarding is not enabled on your platform, the output for the **show ip cef** command looks like the following:

```
Router# show ip cef
%CEF not running
```

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip cef**
4. **exit**

### DETAILED STEPS

	Command or Action	Purpose
Step 1	<b>enable</b>  <b>Example:</b> Router> enable	Enables privileged EXEC mode. <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
Step 2	<b>configure terminal</b>  <b>Example:</b> Router# configure terminal	Enters global configuration mode.
Step 3	<b>ip cef</b>  <b>Example:</b> Router(config)# ip cef	Enables standard Cisco Express Forwarding switching.
Step 4	<b>exit</b>  <b>Example:</b> Router(config)# exit	Exits to privileged EXEC mode.

## Creating a Multilink Bundle for MPLS--Multilink PPP Support

Perform this task to create a multilink bundle for the MPLS--Multilink PPP Support feature. This can reduce the number of IGP adjacencies and facilitate load sharing of traffic.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface multilink** *group-number*
4. **ip address** *address mask* [**secondary**]
5. **encapsulation** *encapsulation-type*
6. **ppp multilink**
7. **end**

### DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <b>enable</b></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <b>interface multilink</b> <i>group-number</i></p> <p><b>Example:</b></p> <pre>Router(config)# interface multilink 1</pre>	<p>Creates a multilink bundle or enters multilink interface configuration mode.</p> <ul style="list-style-type: none"> <li>• The <i>group-number</i> argument is the number of the multilink bundle (a nonzero number).</li> </ul>
<p><b>Step 4</b> <b>ip address</b> <i>address mask</i> [<b>secondary</b>]</p> <p><b>Example:</b></p> <pre>Router(config-if)# ip address 10.0.0.0 255.255.0.0</pre>	<p>Sets a primary or secondary IP address for an interface.</p> <ul style="list-style-type: none"> <li>• The <i>address</i> argument is the IP address.</li> <li>• The <i>mask</i> argument is the mask for the associated IP subnet.</li> <li>• The <b>secondary</b> keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address.</li> </ul> <p>This command is used to assign an IP address to the multilink interface.</p>

Command or Action	Purpose
<p><b>Step 5</b> <code>encapsulation encapsulation-type</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# encapsulation ppp</pre>	<p>Sets the encapsulation method used by the interface.</p> <ul style="list-style-type: none"> <li>The <i>encapsulation-type</i> argument specifies the encapsulation type. The keyword <b>ppp</b> enables PPP encapsulation.</li> </ul>
<p><b>Step 6</b> <code>ppp multilink</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# ppp multilink</pre>	<p>Enables MLP on an interface.</p>
<p><b>Step 7</b> <code>end</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# end</pre>	<p>Exits to privileged EXEC mode.</p>

## Assigning an Interface to a Multilink Bundle for MPLS--Multilink PPP Support

### SUMMARY STEPS

1. `enable`
2. `configure terminal`
3. `controller {t1 | e1} slot / port`
4. `channel-group channel-number timeslots range`
5. `exit`
6. `interface serial slot / subslot / port [. subinterface]`
7. `ip route-cache [cef]`
8. `no ip address`
9. `keepalive [period [retries]]`
10. `encapsulation encapsulation-type`
11. `multilink-group group-number`
12. `ppp multilink`
13. `ppp authentication chap`
14. `end`

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<p><b>enable</b></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>Enter your password if prompted.</li> </ul>
Step 2	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
Step 3	<p><b>controller {t1   e1} slot / port</b></p> <p><b>Example:</b></p> <pre>Router# controller t1 1/3</pre>	<p>Configures a T1 or E1 controller and enters controller configuration mode.</p> <ul style="list-style-type: none"> <li>The <b>t1</b> keyword indicates a T1 line card.</li> <li>The <b>e1</b> keyword indicates an E1 line card.</li> <li>The <i>slot / port</i> arguments are the backplane slot number and port number on the interface. Refer to your hardware installation manual for the specific slot numbers and port numbers.</li> </ul>
Step 4	<p><b>channel-group channel-number timeslots range</b></p> <p><b>Example:</b></p> <pre>Router(config-controller)# channel-group 1 timeslots 1</pre>	<p>Defines the time slots that belong to each T1 or E1 circuit.</p> <ul style="list-style-type: none"> <li>The <i>channel-number</i> argument is the channel-group number. When a T1 data line is configured, channel-group numbers can be values from 0 to 23. When an E1 data line is configured, channel-group numbers can be values from 0 to 30.</li> <li>The <b>timeslots range</b> keyword-argument pair specifies one or more time slots or ranges of time slots belonging to the channel group. The first time slot is numbered 1. For a T1 controller, the time slot range is from 1 to 24. For an E1 controller, the time slot range is from 1 to 31. You can specify a time slot range (for example, 1-29), individual time slots separated by commas (for example 1, 3, 5), or a combination of the two (for example 1-14, 15, 17-31).</li> </ul>
Step 5	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Router(config-controller)# exit</pre>	<p>Exits to global configuration mode.</p>

	Command or Action	Purpose
Step 6	<p><b>interface serial</b> <i>slot / subslot / port</i> [<i>. subinterface</i>]</p> <p><b>Example:</b></p> <pre>Router(config)# interface serial 1/0/0:1</pre>	Configures a serial interface and enters interface configuration mode.
Step 7	<p><b>ip route-cache</b> [<b>cef</b>]</p> <p><b>Example:</b></p> <pre>Router(config-if)# ip route- cache cef</pre>	<p>Controls the use of switching methods for forwarding IP packets</p> <ul style="list-style-type: none"> <li>The <b>cef</b> keyword enables Cisco Express Forwarding operation on an interface after Cisco Express Forwarding operation was disabled.</li> </ul>
Step 8	<p><b>no ip address</b></p> <p><b>Example:</b></p> <pre>Router(config-if)# no ip address</pre>	Removes any specified IP address.
Step 9	<p><b>keepalive</b> [<i>period</i> [<i>retries</i>]]</p> <p><b>Example:</b></p> <pre>Router(config-if)# keepalive</pre>	<p>Enables keepalive packets and specifies the number of times that the Cisco IOS XE software tries to send keepalive packets without a response before bringing down the interface or before bringing the tunnel protocol down for a specific interface.</p> <ul style="list-style-type: none"> <li>The <i>period</i> argument is an integer value, in seconds, greater than 0. The default is 10.</li> <li>The <i>retries</i> argument specifies the number of times that the device will continue to send keepalive packets without response before bringing the interface down. Enter an integer value greater than 1 and less than 255. If you do not enter a value, the value that was previously set is used; if no value was specified previously, the default of 5 is used.</li> </ul> <p>If you are using this command with a tunnel interface, the command specifies the number of times that the device will continue to send keepalive packets without response before bringing the tunnel interface protocol down.</p>
Step 10	<p><b>encapsulation</b> <i>encapsulation-type</i></p> <p><b>Example:</b></p> <pre>Router(config-if)# encapsulation ppp</pre>	<p>Sets the encapsulation method used by the interface.</p> <ul style="list-style-type: none"> <li>The <i>encapsulation-type</i> argument specifies the encapsulation type. The keyword <b>ppp</b> enables PPP encapsulation.</li> </ul>

Command or Action	Purpose
<b>Step 11</b> <b>multilink-group</b> <i>group-number</i>  <b>Example:</b>  <pre>Router(config-if)# multilink- group 1</pre>	Designates an interface as part of a multilink leased line bundle. <ul style="list-style-type: none"> <li>The <i>group-number</i> argument is the number of the multilink bundle (a nonzero number).</li> </ul>
<b>Step 12</b> <b>ppp multilink</b>  <b>Example:</b>  <pre>Router(config-if)# ppp multilink</pre>	Enables MLP on an interface.
<b>Step 13</b> <b>ppp authentication chap</b>  <b>Example:</b>  <pre>Router(config-if)# ppp authentication chap</pre>	(Optional) Enables Challenge Handshake Authentication Protocol (CHAP) authentication on a serial interface.
<b>Step 14</b> <b>end</b>  <b>Example:</b>  <pre>Router(config-if)# end</pre>	Exits to privileged EXEC mode.

## Disabling PPP Multilink Fragmentation

Perform this task to disable PPP multilink fragmentation. PPP multilink fragmentation is enabled by default.

Enabling fragmentation reduces the delay latency among bundle links, but adds some load to the CPU. Disabling fragmentation might produce better throughput.

If your data traffic is consistently of a similar size, we recommend disabling fragmentation. In this case, the benefits of fragmentation can be outweighed by the added load on the CPU.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number*
4. **ppp multilink fragmentation disable**
5. **end**



## DETAILED STEPS

Command or Action	Purpose
<p><b>Step 1</b> <code>enable</code></p> <p><b>Example:</b></p> <pre>Router&gt; enable</pre>	<p>Enables privileged EXEC mode.</p> <ul style="list-style-type: none"> <li>• Enter your password if prompted.</li> </ul>
<p><b>Step 2</b> <code>configure terminal</code></p> <p><b>Example:</b></p> <pre>Router# configure terminal</pre>	<p>Enters global configuration mode.</p>
<p><b>Step 3</b> <code>interface type number</code></p> <p><b>Example:</b></p> <pre>Router(config)# interface serial 1/0/0</pre>	<p>Configures an interface type and enters interface configuration mode.</p> <ul style="list-style-type: none"> <li>• The <i>type</i> argument indicates the type of interface to be configured.</li> <li>• The <i>number</i> argument specifies the port, connector, or interface card number. The numbers are assigned at the factory at the time of installation or when the interface is added to a system, and can be displayed with the <b>show interfaces</b> command.</li> </ul>
<p><b>Step 4</b> <code>ppp multilink fragmentation disable</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# ppp multilink fragmentation disable</pre>	<p>Disables packet fragmentation.</p>
<p><b>Step 5</b> <code>end</code></p> <p><b>Example:</b></p> <pre>Router(config-if)# end</pre>	<p>Exits to privileged EXEC mode.</p>

## Verifying the Multilink PPP Configuration

### SUMMARY STEPS

1. **enable**
2. **show ip interface brief**
3. **show ppp multilink**
4. **show ppp multilink interface** *interface-bundle*
5. **show interface** *interface-name interface-number*
6. **show mpls forwarding-table**
7. **exit**

### DETAILED STEPS

#### Step 1 **enable**

Use this command to enable privileged EXEC mode. Enter your password if prompted. For example:

#### Example:

```
Router> enable
Router#
```

#### Step 2 **show ip interface brief**

Use this command to verify logical and physical MLP interfaces. For example:

#### Example:

```
Router# show ip interface brief
Locolrface      IP-Address      OK? Method Status Prot
FastEthernet1/0/0 10.3.62.106    YES NVRAM  up      up
FastEthernet0/0/1 unassigned      YES NVRAM  administratively down down
FastEthernet0/0/0 unassigned      YES NVRAM  administratively down down
FastEthernet0/0/1 unassigned      YES NVRAM  administratively down down
FastEthernet0/0/2 unassigned      YES NVRAM  administratively down down
FastEthernet0/1/0 unassigned      YES NVRAM  administratively down down
FastEthernet0/1/1 unassigned      YES NVRAM  administratively down down
FastEthernet0/1/2 unassigned      YES NVRAM  administratively down down
FastEthernet1/2/0 unassigned      YES NVRAM  administratively down down
FastEthernet1/0/1 unassigned      YES NVRAM  administratively down down
FastEthernet1/1/0 unassigned      YES NVRAM  administratively down down
FastEthernet1/1/1 unassigned      YES NVRAM  administratively down down
FastEthernet1/1/2 unassigned      YES NVRAM  administratively down down
Serial1/1/0:1     unassigned      YES NVRAM  administratively down down
Serial1/1/0:2     unassigned      YES NVRAM  administratively down down
Serial1/1/1:1     unassigned      YES NVRAM  up       up
Serial1/1/1:2     unassigned      YES NVRAM  up       down
Serial1/1/3:1     unassigned      YES NVRAM  up       up
Serial1/1/3:2     unassigned      YES NVRAM  up       up
Multilink6       10.30.0.2       YES NVRAM  up       up
Multilink8       unassigned      YES NVRAM  administratively down down
Multilink10      10.34.0.2       YES NVRAM  up       up
Loopback0        10.0.0.1        YES NVRAM  up       up
```

#### Step 3 **show ppp multilink**

Use this command to verify that you have created a multilink bundle. For example:

**Example:**

```
Router# show ppp multilink
Multilink1, bundle name is group 1
Bundle is Distributed
0 lost fragments, 0 reordered, 0 unassigned, sequence 0x0/0x0 rcvd/sent
0 discarded, 0 lost received, 1/255 load
Member links: 4 active, 0 inactive (max no set, min not set)
Serial1/0/0/:1
Serial1/0/0/:2
Serial1/0/0/:3
Serial1/0/0/:4
```

**Step 4****show ppp multilink interface interface-bundle**

Use this command to display information about a specific MLP interface. For example:

**Example:**

```
Router# show ppp multilink interface multilink6
Multilink6, bundle name is router
Bundle up for 00:42:46, 1/255 load
Receive buffer limit 24384 bytes, frag timeout 1524 ms
Bundle is Distributed
0/0 fragments/bytes in reassembly list
1 lost fragments, 48 reordered
0/0 discarded fragments/bytes, 0 lost received
0x4D7 received sequence, 0x0 sent sequence
Member links: 2 active, 0 inactive (max not set, min not set)
Sel/1/3:1, since 00:42:46, 240 weight, 232 frag size
Sel/1/3:2, since 00:42:46, 240 weight, 232 frag size
```

**Step 5****show interface interface-name interface-number**

Use this command to display information about serial interfaces in your configuration. For example:

**Example:**

```
Router# show interface serial 1/1/3:1
Serial1/1/3:1 is up, line protocol is up
Hardware is Multichannel T1
MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation PPP, LCP Open, multilink Open, crc 16, Data non-inverted
Last input 00:00:01, output 00:00:01, output hang never
Last clearing of "show interface" counters 00:47:13
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
722 packets input, 54323 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
697 packets output, 51888 bytes, 0 underruns
0 output errors, 0 collisions, 1 interface resets
0 output buffer failures, 0 output buffers swapped out
1 carrier transitions no alarm present
Timeslot(s) Used:1, subrate: 64Kb/s, transmit delay is 0 flags
Transmit queue length 25
Router# show interface serial 1/1/3:2
Serial1/1/3:2 is up, line protocol is up
Hardware is Multichannel T1
MTU 1500 bytes, BW 64 Kbit, DLY 20000 usec,
reliability 255/255, txload 1/255, rxload 1/255
Encapsulation PPP, LCP Open, multilink Open, crc 16, Data non-inverted
Last input 00:00:03, output 00:00:03, output hang never
Last clearing of "show interface" counters 00:47:16
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
```

```

Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
  725 packets input, 54618 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
  693 packets output, 53180 bytes, 0 underruns
  0 output errors, 0 collisions, 1 interface resets
  0 output buffer failures, 0 output buffers swapped out
  1 carrier transitions no alarm present
Timeslot(s) Used:2, subrate: 64Kb/s, transmit delay is 0 flags
Transmit queue length 26

```

You can also use the **show interface** command to display information about the multilink interface:

#### Example:

```

Router# show interface multilink6
Multilink6 is up, line protocol is up
Hardware is multilink group interface
Internet address is 10.30.0.2/8
MTU 1500 bytes, BW 128 Kbit, DLY 100000 usec,
  reliability 255/255, txload 1/255, rxload 1/255
Encapsulation PPP, LCP Open, multilink Open
Open: CDPCP, IPCP, TAGCP, loopback not set
DTR is pulsed for 2 seconds on reset
Last input 00:00:00, output never, output hang never
Last clearing of "show interface" counters 00:48:43
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)
30 second input rate 0 bits/sec, 0 packets/sec
30 second output rate 0 bits/sec, 0 packets/sec
  1340 packets input, 102245 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
  1283 packets output, 101350 bytes, 0 underruns
  0 output errors, 0 collisions, 1 interface resets
  0 output buffer failures, 0 output buffers swapped out
  0 carrier transitions

```

#### Step 6 show mpls forwarding-table

Use this command to display contents of the MPLS Label Forwarding Information Base (LFIB) and look for information on multilink interfaces associated with a point2point next hop. For example:

#### Example:

```

Router# show mpls forwarding-table
Local  Outgoing  Prefix          Bytes tag  Outgoing  Next Hop
tag    tag or VC  or Tunnel Id    switched  interface
16     Untagged  10.30.0.1/32    0         Mu6       point2point
17     Pop tag    10.0.0.3/32     0         Mu6       point2point
18     Untagged  10.0.0.9/32[V]  0         Mu10      point2point
19     Untagged  10.0.0.11/32[V] 6890      Mu10      point2point
20     Untagged  10.32.0.0/8[V]  530       Mu10      point2point
21     Aggregate 10.34.0.0/8[V]  0         Mu10      point2point
22     Untagged  10.34.0.1/32[V] 0         Mu10      point2point

```

Use the **show ip bgp vpnv4** command to display VPN address information from the Border Gateway Protocol (BGP) table:

#### Example:

```

Router# show ip bgp vpnv4 all summary

```

```

BGP router identifier 10.0.0.1, local AS number 100
BGP table version is 21, main routing table version 21
10 network entries using 1210 bytes of memory
10 path entries using 640 bytes of memory
2 BGP path attribute entries using 120 bytes of memory
1 BGP extended community entries using 24 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 1994 total bytes of memory
BGP activity 10/0 prefixes, 10/0 paths, scan interval 5 secs
10.0.0.3 4 100 MsgRc52 MsgSe52 TblV21 0 0 00:46:35 State/P5xRcd

```

**Step 7****exit**

Use this command to exit to user EXEC mode. For example:

**Example:**

```

Router# exit
Router>

```

## Configuration Examples for MPLS--Multilink PPP Support

- [Example Sample Multilink PPP Configuration on an MPLS CSC PE Router, page 79](#)
- [Example Enabling Cisco Express Forwarding, page 80](#)
- [Example Creating a Multilink Bundle for MPLS--Multilink PPP Support, page 80](#)

### Example Sample Multilink PPP Configuration on an MPLS CSC PE Router

The following is a sample configuration for an MPLS CSC PE router. The configuration of MLP on an interface is the same for PE-to-CE links, PE-to-P links, and P-to-P links. An eBGP session is configured between the PE and CE routers.

```

Router# show running-config interface Serial1/0/0:1
Building configuration...
!
mpls label protocol ldp
ip cef
ip vrf vpn2
  rd 200:1
  route-target export 200:1
  route-target import 200:1
!
controller T1 1/0
  framing esf
  clock source internal
  linecode b8zs
  channel-group 1 timeslots 1
  channel-group 2 timeslots 2
  no yellow generation
  no yellow detection
!
interface Serial1/0:1
  no ip address
  encapsulation ppp
  tx-ring-limit 26
  ppp multilink

```

```

    ppp multilink group 1
    !
interface Serial1/0:2
  no ip address
  encapsulation ppp
  tx-ring-limit 26
  ppp multilink
  ppp multilink group 1
  !
interface Multilink1
  ip vrf forwarding vpn2
  ip address 10.35.0.2 255.0.0.0
  no peer neighbor-route
  load-interval 30
  ppp multilink
  ppp multilink interleave
  ppp multilink group 1
  !
!
router ospf 200
  log-adjacency-changes
  auto-cost reference-bandwidth 1000
  redistribute connected subnets
  passive-interface Multilink1
  network 10.0.0.7 0.0.0.0 area 200
  network 10.31.0.0 0.255.255.255 area 200
  !
!
router bgp 200
  no bgp default ipv4-unicast
  bgp log-neighbor-changes
  neighbor 10.0.0.11 remote-as 200
  neighbor 10.0.0.11 update-source Loopback0
  !
  address-family vpnv4
  neighbor 10.0.0.11 activate
  neighbor 10.0.0.11 send-community extended
  bgp scan-time import 5
  exit-address-family
  !
  address-family ipv4 vrf vpn2
  redistribute connected
  neighbor 10.35.0.1 remote-as 300
  neighbor 10.35.0.1 activate
  neighbor 10.35.0.1 as-override
  neighbor 10.35.0.1 advertisement-interval 5
  no auto-summary
  no synchronization
  exit-address-family

```

## Example Enabling Cisco Express Forwarding

The following example shows how to enable Cisco Express Forwarding for MLP configurations:

```

Router> enable
Router# configure terminal
Router(config)# ip cef

```

## Example Creating a Multilink Bundle for MPLS--Multilink PPP Support

The following example shows how to create a multilink bundle for the MPLS--Multilink PPP Support feature:

```

Router(config)# interface multilink 1
Router(config-if)# ip address 10.0.0.0 10.255.255.255
Router(config-if)# encapsulation ppp
Router(config-if)# ppp chap hostname group 1

```

```
Router(config-if)# ppp multilink
Router(config-if)# multilink-group 1
```

## Additional References

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
Description of commands associated with MPLS and MPLS applications	<i>Cisco IOS Multiprotocol Label Switching Command Reference</i>
Basic MPLS VPNs	Configuring MPLS Layer 3 VPNs

### Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	--

### MIBs

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

### RFCs

RFCs	Title
RFC 1990	<i>The PPP Multilink Protocol (MP)</i>

**Technical Assistance**

Description	Link
The Cisco Support and Documentation website provides online resources to download documentation, software, and tools. Use these resources to install and configure the software and to troubleshoot and resolve technical issues with Cisco products and technologies. Access to most tools on the Cisco Support and Documentation website requires a Cisco.com user ID and password.	<a href="http://www.cisco.com/cisco/web/support/index.html">http://www.cisco.com/cisco/web/support/index.html</a>

## Feature Information for MPLS--Multilink PPP Support

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

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

**Table 7** *Feature Information for MPLS--Multilink PPP Support*

Feature Name	Releases	Feature Information
MPLS--Multilink PPP Support	Cisco IOS XE Release 2.1	The MPLS--Multilink PPP Support feature ensures that MPLS Layer 3 Virtual Private Networks (VPNs) with quality of service (QoS) can be enabled for bundled links. This feature supports Multiprotocol Label Switching (MPLS) over Multilink PPP (MLP) links in the edge (provider edge [PE]-to-customer edge [CE]) or in the MPLS core (PE-to-PE and PE-to-provider router [P]).

## Glossary

**bundle** --A group of interfaces connected by parallel links between two systems that have agreed to use Multilink PPP (MLP) over those links.

**CBWFQ** --class-based weighted fair queueing. A queueing option that extends the standard Weighted Fair Queueing (WFQ) functionality to provide support for user-defined traffic classes.

**Cisco Express Forwarding** --A proprietary form of switching that optimizes network performance and scalability for networks with large and dynamic traffic patterns, such as the Internet, and for networks



characterized by intensive web-based applications or interactive sessions. Although you can use Cisco Express Forwarding in any part of a network, it is designed for high-performance, highly resilient Layer 3 IP backbone switching.

**EIGRP** --Enhanced Interior Gateway Routing Protocol. An advanced version of the Interior Gateway Routing Protocol (IGRP) developed by Cisco. It provides superior convergence properties and operating efficiency, and combines the advantages of link-state protocols with those of distance vector protocols.

**IGP** --Interior Gateway Protocol. An Internet protocol used to exchange routing information within an autonomous system. Examples of common Internet IGPs include Interior Gateway Routing Protocol (IGRP), Open Shortest Path First (OSPF), and Routing Information Protocol (RIP).

**IGRP** --Interior Gateway Routing Protocol. An Interior Gateway Protocol (IGP) developed by Cisco to address the issues associated with routing in large, heterogeneous networks. Compare with Enhanced Interior Gateway Routing Protocol (EIGRP).

**IS-IS** --Intermediate System-to-Intermediate System. An Open Systems Interconnection (OSI) link-state hierarchical routing protocol, based on DECnet Phase V routing, in which IS-IS routers exchange routing information based on a single metric to determine network topology.

**LCP** --Link Control Protocol. A protocol that establishes, configures, and tests data link connections for use by PPP.

**LFI** --link fragmentation and interleaving. The Cisco IOS XE LFI feature reduces delay on slower-speed links by breaking up large datagrams and interleaving low-delay traffic packets with the smaller packets resulting from the fragmented datagram. LFI allows reserve queues to be set up so that Real-Time Protocol (RTP) streams can be mapped into a higher priority queue in the configured weighted fair queue set.

**link** --One of the interfaces in a bundle.

**LLQ** --low latency queueing. A quality of service QoS queueing feature that provides a strict priority queue (PQ) for voice traffic and weighted fair queues for other classes of traffic. It is also called priority queueing/class-based weighted fair queueing (PQ/CBWFQ).

**MLP** --Multilink PPP. A method of splitting, recombining, and sequencing datagrams across multiple logical links. The use of MLP increases throughput between two sites by grouping interfaces and then load balancing packets over the grouped interfaces (called a bundle). Splitting packets at one end, sending them over the bundled interfaces, and recombining them at the other end achieves load balancing.

**MQC** --Modular QoS CLI. MQC is a CLI structure that allows users to create traffic polices and attach these polices to interfaces. MQC allows users to specify a traffic class independently of QoS policies.

**NCP** --Network Control Protocol. A series of protocols for establishing and configuring different network layer protocols (such as for AppleTalk) over PPP.

**OSPF** --Open Shortest Path First. A link-state, hierarchical Interior Gateway Protocol (IGP) routing algorithm proposed as a successor to Routing Information Protocol (RIP) in the Internet community. OSPF features include least-cost routing, multipath routing, and load balancing. OSPF was derived from an early version of the IS-IS protocol.

**PPP** --Point-to-Point Protocol. A successor to the Serial Line Interface Protocol (SLIP) that provides router-to-router and host-to-network connections over synchronous and asynchronous circuits. PPP works with several network layer protocols (such as IP, Internetwork Packet Exchange [IPX], and AppleTalk Remote Access [ARA]). PPP also has built-in security mechanisms (such as Challenge Handshake Authentication Protocol [CHAP] and Password Authentication Protocol [PAP]). PPP relies on two protocols: Link Control Protocol (LCP) and Network Control Protocol (NCP).

**RIP** --Routing Information Protocol. A version of Interior Gateway Protocol (IGP) that is supplied with UNIX Berkeley Standard Distribution (BSD) systems. Routing Information Protocol (RIP) is the most common IGP in the Internet. It uses hop count as a routing metric.

**Virtual Bundle Interface** --An interface that represents the master link of a bundle. It is not tied to any physical interface. Data going over the bundle is transmitted and received through the master link.

**WFQ** --weighted fair queueing. A congestion management algorithm that identifies conversations (in the form of traffic streams), separates packets that belong to each conversation, and ensures that capacity is shared fairly among the individual conversations. WFQ is an automatic way of stabilizing network behavior during congestion and results in improved performance and reduced retransmission.

**WRED** --weighted random early detection. A queueing method that ensures that high-precedence traffic has lower loss rates than other traffic during times of congestion.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: [www.cisco.com/go/trademarks](http://www.cisco.com/go/trademarks). Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1110R)

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.