



## **MPLS Basic Configuration Guide, Cisco IOS Release 15MT**

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# Multiprotocol Label Switching Overview

This chapter describes the Multiprotocol Label Switching (MPLS) distribution protocol. MPLS 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. It enables service providers to meet challenges brought about by explosive growth and provides the opportunity for differentiated services without necessitating the sacrifice of existing infrastructure.

The MPLS architecture is remarkable for its flexibility:

- Data can be transferred over any combination of Layer 2 technologies
- Support is offered for all Layer 3 protocols
- Scaling is possible well beyond anything offered in today's networks.

Specifically, MPLS can efficiently enable the delivery of IP services over an ATM switched network. It supports the creation of different routes between a source and a destination on a purely router-based Internet backbone. Service providers who use MPLS can save money and increase revenue and productivity.



## Note

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Label switching on a router requires that Cisco Express Forwarding be enabled on that router. Refer to the Cisco Express Forwarding feature documentation for configuration information.

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## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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.

## MPLS Tag Switching Terminology

Beginning with Cisco IOS Release 12.1, the Tag Switching distribution protocol has been replaced with the MPLS distribution protocol. The Tag Switching command-line interface (CLI) commands are supported but will be discontinued in a future release.

The table below lists tag switching terms (found in earlier releases of this document) and the equivalent MPLS terms used in this document.

**Table 1: Equivalency Table for Tag Switching and MPLS Terms**

Old Tag Switching Terminology	New MPLS Terminology
Tag Switching	Multiprotocol Label Switching (MPLS)
Tag (short for Tag Switching)	MPLS
Tag (item or packet)	Label
TDP (Tag Distribution Protocol)	LDP (Label Distribution Protocol)  Cisco TDP and LDP (MPLS Label Distribution Protocol) are nearly identical in function, but use incompatible message formats and some different procedures. Cisco is changing from TDP to a fully compliant LDP.
Tag Switched	Label Switched
TFIB (Tag Forwarding Information Base)	LFIB (Label Forwarding Information Base)
TSR (Tag Switching Router)	LSR (Label Switching Router)
TSC (Tag Switch Controller)	LSC (Label Switch Controller)



Old Tag Switching Terminology	New MPLS Terminology
ATM-TSR (ATM Tag Switch Router)	ATM-LSR (ATM Label Switch Router, such as the Cisco BPX 8650 switch)
TVC (Tag VC, Tag Virtual Circuit)	LVC (Label VC, Label Virtual Circuit)
TSP (Tag Switch Path)	LSP (Label Switch Path)
XTag ATM (extended Tag ATM port)	XmplsATM (extended MPLS ATM port)

## MPLS Commands and Saved Configurations

During the transition period from tag switching to MPLS, if a configuration command has both MPLS and tag switching forms, the tag switching version is written to saved configurations. For example, you can configure MPLS hop-by-hop forwarding for a router POS interface by issuing the following commands:

```
Router# configure terminal
Router(config)# interface POS3/0
Router(config-if)# mpls ip
```

In this example, the **mplsip** command has a tag switching form (**tag-switchingip**). After you enter these commands and save this configuration or display the running configuration by means of the **showrunningconfiguration** command, the configuration commands appear as follows:

```
interface POS3/0
tag-switching ip
```

Saving the tag switching form of commands (that have both tag switching and MPLS forms) allows for backward compatibility. You can use a new router software image to modify and write configurations, and then later use configurations created by the new image with earlier software versions that do not support the MPLS forms of commands.

Using the tag switching forms of the commands allows older software that supports tag switching commands, but not new MPLS commands, to successfully interpret interface configurations.

## MPLS Tag Switching CLI Command Summary

The table below summarizes general-purpose MPLS commands. Except where otherwise noted, these MPLS commands have been derived from existing tag-switching commands to preserve the familiar syntax of existing commands that formed the basis for implementing new MPLS functionality. The tag-switching versions of the command will be discontinued in a future release.

**Table 2: Summary of MPLS Commands Described in this Document**

Command	Corresponding Tag Switching Command	Description
<code>debug mpls adjacency</code>	<code>debug tag-switching adjacency</code>	Displays changes to label switching entries in the adjacency database.

Command	Corresponding Tag Switching Command	Description
<b>debug mpls events</b>	<b>debug tag-switching events</b>	Displays information about significant MPLS events.
<b>debug mpls lfib cef</b>	<b>debug tag-switching tfib cef</b>	Prints detailed information about label rewrites being created, resolved, and deactivated as CEF routes are added, changed, or removed.
<b>debug mpls lfib enc</b>	<b>debug tag-switching tfib enc</b>	Prints detailed information about label encapsulations while label rewrites are created or updated and placed into the label forwarding information base (LFIB).
<b>debug mpls lfib lsp</b>	<b>debug tag-switching tfib tsp</b>	Prints detailed information about label rewrites being created and deleted as TSP tunnels are added or removed.
<b>debug mpls lfib state</b>	<b>debug tag-switching tfib state</b>	Traces what happens when label switching is enabled or disabled.
<b>debug mpls lfib struct</b>	<b>debug tag-switching tfib struct</b>	Traces the allocation and freeing of LFIB-related data structures, such as the LFIB itself, label-rewrites, and label-info data.
<b>debug mpls packets</b>	<b>debug tag-switching packets</b>	Displays labeled packets switched by the host router.
<b>interface atm</b>	<b>interface atm</b>	Enters interface configuration mode, specifies ATM as the interface type, and enables the creation of a subinterface on the ATM interface.
<b>mpls atm control-vc</b>	<b>tag-switching atm control-vc</b>	Configures the VPI and VCI to be used for the initial link to the label switching peer device.
<b>mpls atm vpi</b>	<b>tag-switching atm vpi</b>	Configures the range of values to be used in the VPI field for label VCs.
<b>mpls ip (global configuration)</b>	<b>tag-switching ip (global configuration)</b>	Enables MPLS forwarding of IPv4 packets along normally routed paths for the platform.
<b>mpls ip (interface configuration)</b>	<b>tag-switching ip (interface configuration)</b>	Enables MPLS forwarding of IPv4 packets along normally routed paths for a particular interface.

Command	Corresponding Tag Switching Command	Description
<b>mpls ip default-route</b>	<b>tag-switching ip default-route</b>	Enables the distribution of labels associated with the IP default route.
<b>mpls ip propagate-ttl</b>	<b>tag-switching ip propagate-ttl</b>	Sets the time-to-live (TTL) value when an IP packet is encapsulated in MPLS.
<b>mpls ip ttl-expiration pop</b>	N/A	Forwards packets using the global IP routing table or the original label stack, depending on the number of labels in the packet.
<b>mpls label range</b>	<b>tag-switching tag-range downstream</b>	Configures the range of local labels available for use on packet interfaces.  <b>Note</b> The syntax of this command differs slightly from its tag-switching counterpart.
<b>mpls mtu</b>	<b>tag-switching mtu</b>	Sets the per-interface maximum transmission unit (MTU) for labeled packets.
<b>show mpls forwarding-table</b>	<b>show tag-switching forwarding-table</b>	Displays the contents of the label forwarding information base (LFIB).
<b>show mpls interfaces</b>	<b>show tag-switching interfaces</b>	Displays information about one or more interfaces that have been configured for label switching.
<b>show mpls label range</b>	N/A	Displays the range of local labels available for use on packet interfaces.

## Benefits

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 network of the service provider 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 needing to manage routing over a topologically complex virtual backbone composed of many PVCs, an MPLS VPN user can generally employ the backbone of the service provider 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 perform the following tasks:

- 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 perform the following tasks:

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

## 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:

- Label Distribution Protocol (LDP)--enables peer LSRs in an MPLS network to exchange label binding information for supporting hop-by-hop forwarding in an MPLS network
- 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.

## MPLS and Routing

A label represents a forwarding equivalence class, but it does not represent a particular path through the network. In general, the path through the network continues to be chosen by the existing Layer 3 routing algorithms such as OSPF, Enhanced IGRP, and BGP. That is, at each hop when a label is looked up, the next hop chosen is determined by the dynamic routing algorithm.

## MPLS Traffic Engineering

MPLS traffic engineering software enables an MPLS backbone to replicate and expand upon the traffic engineering capabilities of Layer 2 ATM and Frame Relay networks. MPLS is an integration of Layer 2 and Layer 3 technologies. By making traditional Layer 2 features available to Layer 3, MPLS enables traffic engineering. Thus, you can offer in a one-tier network what now can be achieved only by overlaying a Layer 3 network on a Layer 2 network.

Traffic engineering is essential for service provider and Internet service provider (ISP) backbones. Such backbones must support a high use of transmission capacity, and the networks must be very resilient so that they can withstand link or node failures.

MPLS traffic engineering provides an integrated approach to traffic engineering. With MPLS, traffic engineering capabilities are integrated into Layer 3, which optimizes the routing of IP traffic, given the constraints imposed by backbone capacity and topology.

## Why Use MPLS Traffic Engineering

WAN connections are an expensive item in an ISP budget. Traffic engineering enables ISPs to route network traffic to offer the best service to their users in terms of throughput and delay. By making the service provider more efficient, traffic engineering reduces the cost of the network.

Currently, some ISPs base their services on an overlay model. In the overlay model, transmission facilities are managed by Layer 2 switching. The routers see only a fully meshed virtual topology, making most destinations appear one hop away. If you use the explicit Layer 2 transit layer, you can precisely control how traffic uses available bandwidth. However, the overlay model has numerous disadvantages. MPLS traffic engineering achieves the traffic engineering benefits of the overlay model without running a separate network, and without needing a nonscalable, full mesh of router interconnects.

## How MPLS Traffic Engineering Works

MPLS traffic engineering automatically establishes and maintains LSPs across the backbone by using RSVP. The path that an LSP uses is determined by the LSP resource requirements and network resources, such as bandwidth.

Available resources are flooded by means of extensions to a link-state-based Interior Gateway Protocol (IGP).

Traffic engineering tunnels are calculated at the LSP head based on a fit between required and available resources (constraint-based routing). The IGP automatically routes the traffic onto these LSPs. Typically, a packet crossing the MPLS traffic engineering backbone travels on a single LSP that connects the ingress point to the egress point.

MPLS traffic engineering is built on the following Cisco IOS mechanisms:

- IP tunnel interfaces--From a Layer 2 standpoint, an MPLS tunnel interface represents the head of an LSP. It is configured with a set of resource requirements, such as bandwidth and media requirements, and priority.

From a Layer 3 standpoint, an LSP tunnel interface is the head-end of a unidirectional virtual link to the tunnel destination.

- MPLS traffic engineering path calculation module--This calculation module operates at the LSP head. The module determines a path to use for an LSP. The path calculation uses a link-state database containing flooded topology and resource information.
- RSVP with traffic engineering extensions--RSVP operates at each LSP hop and is used to signal and maintain LSPs based on the calculated path.
- MPLS traffic engineering link management module--This module operates at each LSP hop, does link call admission on the RSVP signalling messages, and does bookkeeping of topology and resource information to be flooded.
- Link-state IGP (Intermediate System-to-Intermediate System (IS-IS) or OSPF--each with traffic engineering extensions)--These IGPs are used to globally flood topology and resource information from the link management module.
- Enhancements to the SPF calculation used by the link-state IGP (IS-IS or OSPF)--The IGP automatically routes traffic onto the appropriate LSP tunnel based on tunnel destination. Static routes can also be used to direct traffic onto LSP tunnels.

- Label switching forwarding--This forwarding mechanism provides routers with a Layer 2-like ability to direct traffic across multiple hops of the LSP established by RSVP signalling.

One approach to engineering a backbone is to define a mesh of tunnels from every ingress device to every egress device. The MPLS traffic engineering path calculation and signalling modules determine the path taken by the LSPs for these tunnels, subject to resource availability and the dynamic state of the network. The IGP, operating at an ingress device, determines which traffic should go to which egress device, and steers that traffic into the tunnel from ingress to egress.

A flow from an ingress device to an egress device might be so large that it cannot fit over a single link, so it cannot be carried by a single tunnel. In this case, multiple tunnels between a given ingress and egress can be configured, and the flow is load-shared among them.

## MPLS Virtual Private Networks

Using MPLS VPNs in a Cisco IOS network provide the capability to deploy and administer scalable Layer 3 VPN backbone services including applications, data hosting network commerce, and telephony services to business customers. A VPN is a secure IP-based network that shares resources on one or more physical networks. A VPN contains geographically dispersed sites that can communicate securely over a shared backbone.

A one-to-one relationship does not necessarily exist between customer sites and VPNs; a given site can be a member of multiple VPNs. However, a site can associate with only one VPN routing and forwarding instance (VRF). Each VPN is associated with one or more VPN VRFs. A VRF includes routing and forwarding tables and rules that define the VPN membership of customer devices attached to CE routers. A VRF consists of the following:

- IP routing table
- CEF table
- Set of interfaces that use the CEF forwarding table
- Set of rules and routing protocol parameters to control the information in the routing tables

VPN routing information is stored in the IP routing table and the CEF table for each VRF. A separate set of routing and CEF tables is maintained for each VRF. These tables prevent information from being forwarded outside a VPN and also prevent packets that are outside a VPN from being forwarded to a router within the VPN.

## MPLS Quality of Service

The quality of service (QoS) feature for MPLS enables network administrators to provide differentiated types of service across an MPLS network. Differentiated service satisfies a range of requirements by supplying for each packet transmitted the particular kind of service specified for that packet by its QoS. Service can be specified in different ways, for example, using the IP precedence bit settings in IP packets.

In supplying differentiated service, MPLS QoS offers packet classification, congestion avoidance, and congestion management. The table below lists these functions and their descriptions.

**Table 3: QoS Services and Features**

Service	QoS Function	Description
Packet classification	Committed access rate (CAR). Packets are classified at the edge of the network before labels are assigned.	Classifies packets according to input or output transmission rates. Allows you to set the MPLS experimental bits or the IP Precedence or DSCP bits (whichever is appropriate).
Congestion avoidance	Weighted Random Early Detection (WRED). Packet classes are differentiated based on drop probability.	Monitors network traffic to prevent congestion by dropping packets based on the IP Precedence or DSCP bits or the MPLS experimental field.
Congestion management	Class-based weighted fair queueing (CBWFQ). Packet classes are differentiated based on bandwidth and bounded delay.	An automated scheduling system that uses a queueing algorithm to ensure bandwidth allocation to different classes of network traffic.

**Note**

MPLS QoS lets you duplicate Cisco IOS IP QoS (Layer 3) features as closely as possible in MPLS devices, including label edge routers (LERs), LSRs, and ATM-LSRs. MPLS QoS functions map nearly one-for-one to IP QoS functions on all interface types.

For more information on configuration of the QoS functions (CAR, WRED, and CBWFQ), refer to the *Cisco IOS Quality of Service Solutions Configuration Guide*.

For complete command syntax information for CAR, WRED, and WFQ, refer to the *Cisco IOS Quality of Service Solutions Command Reference*.

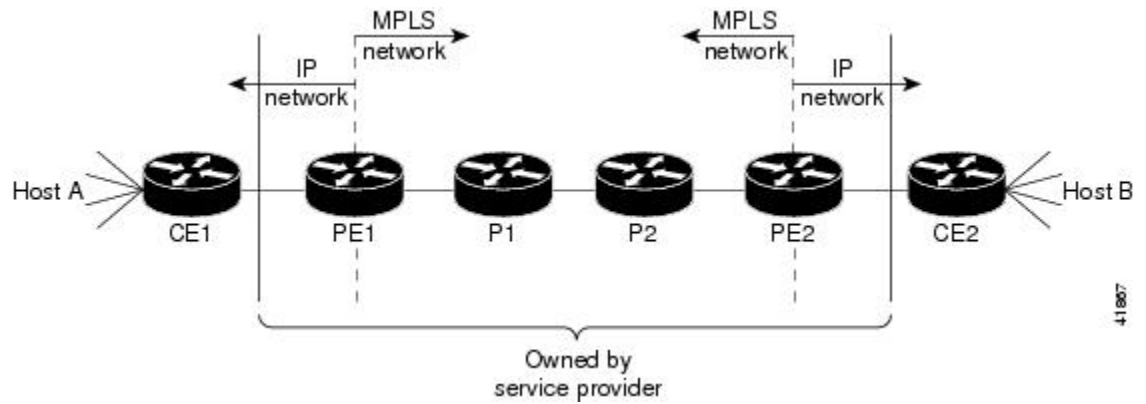
## Specifying the QoS in the IP Precedence Field

When you send IP packets from one site to another, the IP Precedence field (the first three bits of the DSCP field in the header of an IP packet) specifies the QoS. Based on the IP precedence marking, the packet is given the desired treatment such as the latency or the percent of bandwidth allowed for that quality of service. If the service provider network is an MPLS network, then the IP precedence bits are copied into the MPLS EXP field at the edge of the network. However, the service provider might want to set a QoS for a MPLS packet to a different value determined by the service offering.

This feature allows the service provider to set the MPLS experimental field instead of overwriting the value in the IP precedence field belonging to a customer. The IP header remains available for the customer's use; the QoS of an IP packet is not changed as the packet travels through the MPLS network.

The figure below shows an MPLS network that connects two sites of a IP network belonging to a customer.





**Note**

The network is bidirectional, but for the purpose of this document the packets move left to right.

In the figure above, the symbols have the following meanings displayed in the table below:

**Table 4: Device Symbols**

Symbol	Meaning
CE1	Customer equipment 1
PE1	Service provider edge router (ingress LSR)
P1	Service provider router within the core of the network of the service provider
P2	Service provider router within the core of the network of the service provider
PE2	Service provider edge router (egress LSR)
CE2	Customer equipment 2



**Note**

Notice that PE1 and PE2 are at the boundaries between the MPLS network and the IP network.

In the figure above, the following behavior occurs:

- Packets arrive as IP packets at PE1, the provider edge router (also known as the ingress label switching router).
- PE1 sends the packets as MPLS packets.
- Within the service provider network, there is *no IP Precedence field* for the queuing mechanism to look at because the packets are MPLS packets. The packets remain MPLS packets until they arrive at PE2, the provider edge router.

- PE2 removes the label from each packet and forwards the packets as IP packets.

This MPLS QoS enhancement allows service providers to classify packets according to their type, input interface, and other factors by setting (marking) each packet within the MPLS experimental field without changing the IP Precedence or DSCP field. For example, service providers can classify packets with or without considering the rate of the packets that PE1 receives. If the rate is a consideration, the service provider marks in-rate packets differently from out-of-rate packets.

**Note**

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The MPLS experimental bits allow you to specify the QoS for an MPLS packet. The IP Precedence/DSCP bits allow you to specify the QoS for an IP packet.

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## CHAPTER 2

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

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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 13
- [Information About MPLS Infrastructure Changes](#), page 13
- [Additional References](#), page 17
- [Feature Information for MPLS Infrastructure Changes](#), page 17

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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

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 5: Feature Information for MPLS Infrastructure Changes**

<b>Feature Name</b>	<b>Releases</b>	<b>Feature Information</b>
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.





## 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 [P] device).

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). The MPLS Multilink PPP Support feature can reduce the number of Interior Gateway Protocol (IGP) adjacencies and facilitate load sharing of traffic.

- [Finding Feature Information, page 19](#)
- [Prerequisites for MPLS Multilink PPP Support, page 20](#)
- [Restrictions for MPLS Multilink PPP Support, page 20](#)
- [Information About MPLS Multilink PPP Support, page 20](#)
- [How to Configure MPLS Multilink PPP Support, page 25](#)
- [Configuration Examples for MPLS Multilink PPP Support, page 37](#)
- [Additional References for MPLS Multilink PPP Support, page 40](#)
- [Feature Information for MPLS Multilink PPP Support, page 41](#)
- [Glossary, page 42](#)

### Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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## Prerequisites for MPLS Multilink PPP Support

- Cisco Express Forwarding or distributed Cisco Express Forwarding must be enabled.
- Multiprotocol Label Switching (MPLS) must be enabled on provider edge (PE) and provider (P) devices
- Cisco Express Forwarding switching must be enabled on the interface by using the **ip route-cache cef** command

## Restrictions for MPLS Multilink PPP Support

The MPLS Multilink PPP Support feature is limited by platform-specific restrictions that apply to the use of Multilink PPP (MLP) and distributed MLP (dMLP).

## Information About MPLS Multilink PPP Support

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

The table below lists Multiprotocol Label Switching (MPLS) Layer 3 Virtual Private Network (VPN) features supported for Multilink PPP (MLP) and indicates if the feature is supported on customer edge-to-provider edge (CE-to-PE) links, PE-to-provider (P) links, and Carrier Supporting Carrier (CSC) CE-to-PE links.

**Table 6: 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	Not supported	Not supported
External Border Gateway Protocol (eBGP)	Supported	Not applicable to this configuration	Supported
Intermediate System-to-Intermediate System (IS-IS)	Not supported	Supported	Not supported
Open Shortest Path First (OSPF)	Supported	Supported	Not supported
Enhanced Interior Gateway Routing Protocol (EIGRP)	Supported	Supported	Not supported

MPLS L3 VPN Feature	CE-to-PE Links	PE-to-P Links	CSC CE-to-PE Links
Interprovider interautonomous (Inter-AS) VPNs (with Label Distribution Protocol [LDP])	Not applicable to this configuration	Supported (MLP between Autonomous System Boundary 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 supported	Not applicable to this configuration	Supported
CSC VPNs with IPv4 label distribution	Supported	Not applicable to this configuration	Supported
External and internal BGP (eBGP) Multipath	Not supported	Not supported	Not applicable to this configuration
Internal BGP (iBGP) Multipath	Not applicable to this configuration	Not supported	Not applicable to this configuration
eBGP Multipath	Not supported	Not supported	Not supported

## MPLS Quality of Service Features Supported for Multilink PPP

The table below lists the Multiprotocol Label Switching (MPLS) quality of service (QoS) features supported for Multilink PPP (MLP) and indicates if the feature is supported on customer edge-to-provider edge (CE-to-PE) links, PE-to-provider (P) links, and Carrier Supporting Carrier (CSC) CE-to-PE links.

**Table 7: 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	Not supported	Not supported
Set MPLS EXP bits using the modular QoS Command-Line Interface (MQC)	Supported	Supported	Supported
Matching on MPLS EXP using MQC	Supported	Supported	Supported

MPLS QoS Feature	CE-to-PE Links	PE-to-P Links	CSC CE-to-PE Links
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

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

The figure below shows a typical Multiprotocol Label Switching (MPLS) network in which the provider edge (PE) device is responsible for label imposition (at ingress) and disposition (at egress) of the MPLS traffic.

In this topology, Multilink PPP (MLP) is deployed on the PE-to-customer edge (CE) links. The Virtual Private Network (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.

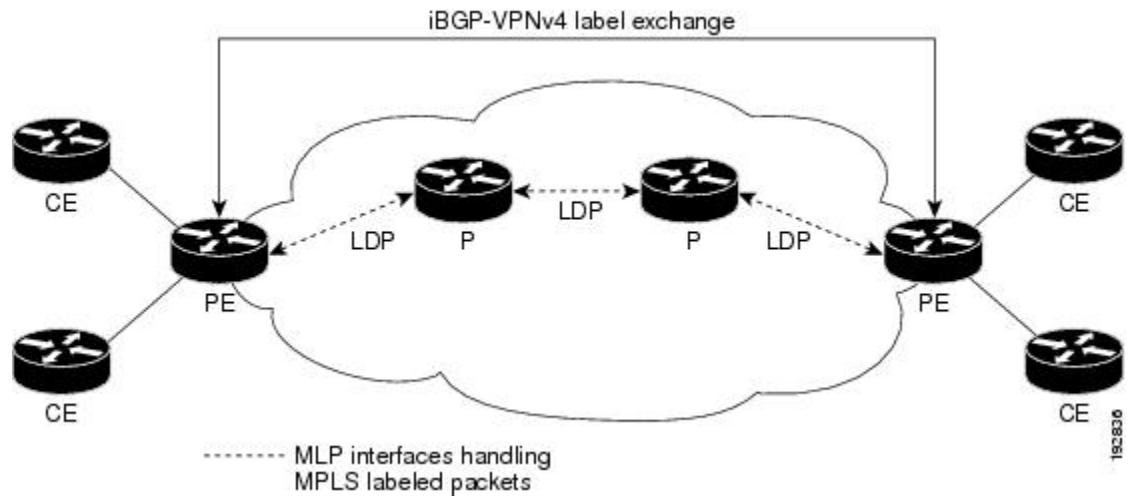
The PE-to-CE routing protocols that are supported for the MPLS Multilink PPP Support feature are external Border Gateway Protocol (eBGP), Open Shortest Path First (OSPF), and Enhanced Interior Gateway Routing Protocol (EIGRP). Static routes are also supported between the CE and PE devices.

Quality of service (QoS) features that are supported for the MPLS Multilink PPP Support feature on CE-to-PE links are link fragmentation and interleaving (LFI), compressed Real-Time Transport Protocol (cRTP), policing, marking, and classification.

## MPLS Multilink PPP Support and Core Links

The figure below shows a sample topology in which Multiprotocol Label Switching (MPLS) is deployed over Multilink PPP (MLP) on provider edge-to-provider (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 1: MLP on PE-to-P and P-to-P Links**



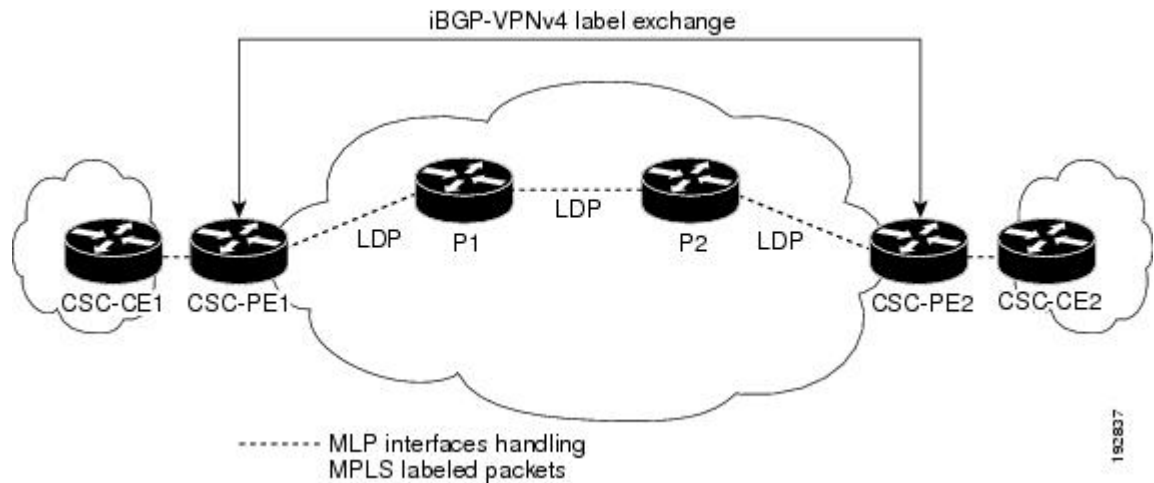
You employ MLP in the PE-to-P or P-to-P links primarily so that you can reduce the number of Interior Gateway Protocol (IGP) adjacencies and facilitate the load sharing of traffic.

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 the Label Distribution Protocol (LDP).

## MPLS Multilink PPP Support in a CSC Network

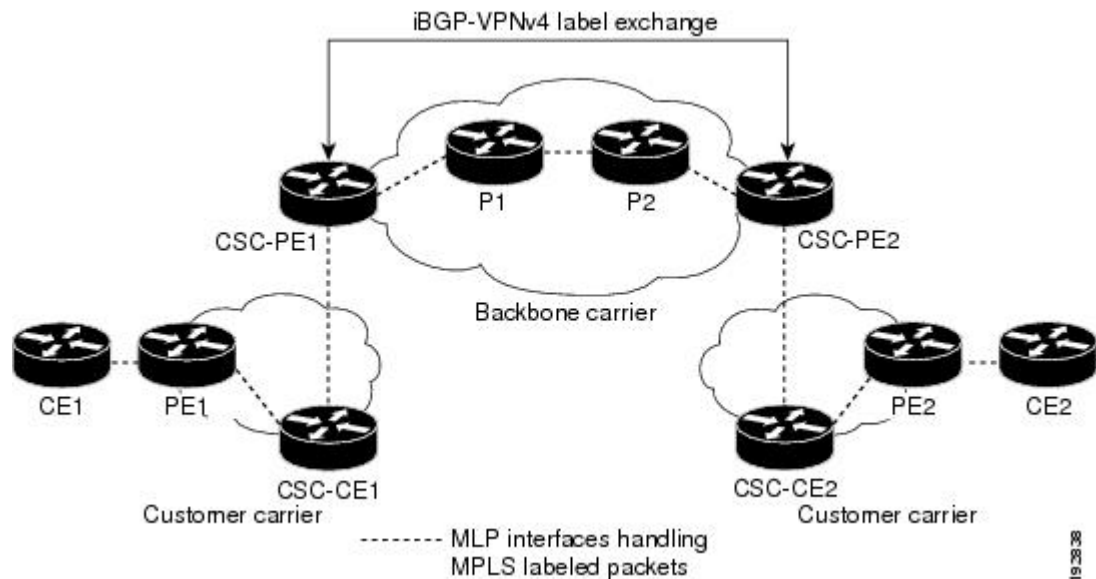
The figure below shows a typical Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) Carrier Supporting Carrier (CSC) network where Multilink PPP (MLP) is configured on the CSC customer edge (CE)-to-provider edge (PE) links.

**Figure 2: MLP on CSC CE-to-PE Links with MPLS VPN Carrier Supporting Carrier**



The MPLS Multilink PPP Support feature supports MLP between CSC-CE and CSC-PE links with the Label Distribution Protocol (LDP) or with external Border Gateway Protocol (eBGP) IPv4 label distribution. This feature also supports link fragmentation and interleaving (LFI) for an MPLS VPN CSC configuration. The figure below shows all MLP links that this feature supports for CSC configurations.

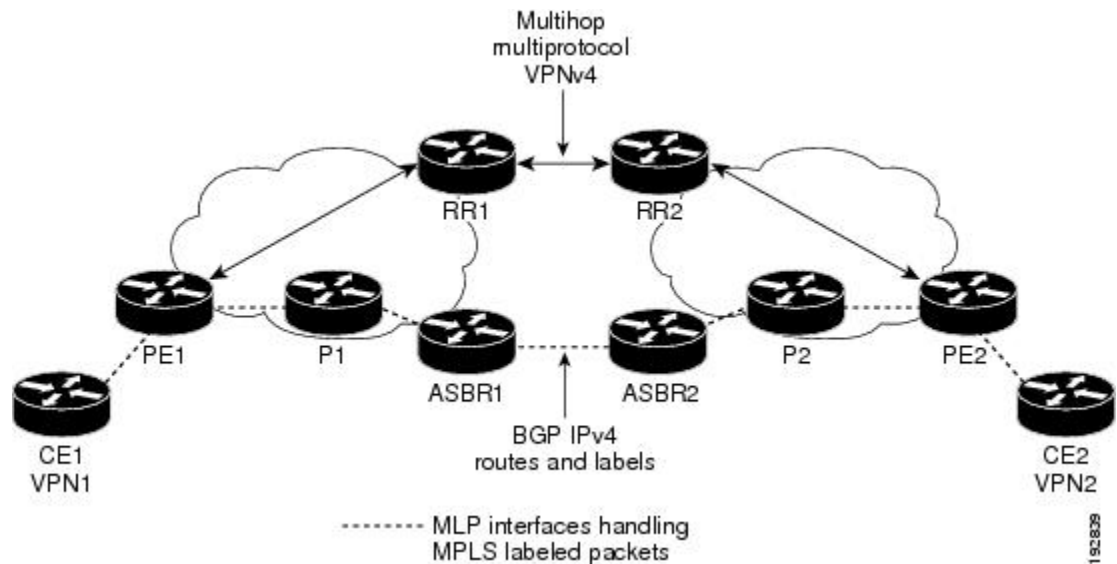
**Figure 3: MLP Supported Links with MPLS VPN Carrier Supporting Carrier**



## MPLS Multilink PPP Support in an Interautonomous System

The figure below shows a typical Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) interautonomous system (Inter-AS) network where Multilink PPP (MLP) is configured on the provider edge-to-customer edge (PE-to-CE) links.

**Figure 4: MLP on ASBR-to-PE Links in an MPLS VPN Inter-AS Network**



The MPLS Multilink PPP Support feature supports MLP between Autonomous System Boundary Router (ASBR) links for Inter-AS VPNs with Label Distribution Protocol (LDP) and with external Border Gateway Protocol (eBGP) IPv4 label distribution.

## How to Configure MPLS Multilink PPP Support

The tasks in this section can be performed on customer edge-to-provider edge (CE-to-PE) links, PE-to-provider (P) links, P-to-P links, and Carrier Supporting Carrier (CSC) CE-to-PE links.

### Enabling Cisco Express Forwarding or Distributed Cisco Express Forwarding

Perform the following task to enable Cisco Express Forwarding or distributed Cisco Express Forwarding.

#### Before You Begin

Multilink PPP (MLP) requires the configuration of Cisco Express Forwarding. Distributed MLP (dMLP) requires the configuration of distributed Cisco Express Forwarding.

Cisco Express Forwarding is enabled by default on most Cisco platforms running Cisco software. To find out if Cisco Express Forwarding is enabled on your platform, enter the **show ip cef** command. If Cisco Express Forwarding is enabled, you receive output that looks like this:

```
Device# 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
```

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

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

Distributed Cisco Express Forwarding is enabled by default on devices such as the Catalyst 6500 series switch, the Cisco 7500 series router, and the Cisco 12000 series Internet router.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. Enter one of the following commands:
  - **ip cef**
  - **ip cef distributed**
4. **exit**

## DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	Enter one of the following commands: <ul style="list-style-type: none"> <li>• <b>ip cef</b></li> <li>• <b>ip cef distributed</b></li> </ul> <b>Example:</b> Device(config)# ip cef	Enables Cisco Express Forwarding switching. or Enables distributed Cisco Express Forwarding switching.



	Command or Action	Purpose
	<b>Example:</b> Device(config)# ip cef distributed	
<b>Step 4</b>	<b>exit</b>  <b>Example:</b> Device(config)# exit	Returns to privileged EXEC mode.

## Creating a Multilink Bundle

Perform this task to create a multilink bundle for the MPLS Multilink PPP Support feature. This multilink bundle can reduce the number of Interior Gateway Protocol (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
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 3</b>	<b>interface multilink</b> <i>group-number</i>  <b>Example:</b> Device(config)# interface multilink 1	Creates a multilink bundle and enters multilink interface configuration mode. <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 4</b>	<b>ip address</b> <i>address mask</i> [ <b>secondary</b> ]  <b>Example:</b> Device(config-if)# ip address 10.0.0.0 255.255.0.0	Sets a primary or secondary IP address for an interface. <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> This command is used to assign an IP address to the multilink interface.
<b>Step 5</b>	<b>encapsulation</b> <i>encapsulation-type</i>  <b>Example:</b> Device(config-if)# encapsulation ppp	Sets the encapsulation method as PPP to be used by the interface. <ul style="list-style-type: none"> <li>The <i>encapsulation-type</i> argument specifies the encapsulation type.</li> </ul>
<b>Step 6</b>	<b>ppp multilink</b>  <b>Example:</b> Device(config-if)# ppp multilink	Enables MLP on an interface.
<b>Step 7</b>	<b>end</b>  <b>Example:</b> Device(config-if)# end	Returns to privileged EXEC mode.

## Assigning an Interface to a Multilink Bundle

### 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 / port : channel-group*
7. **ip route-cache** [**cef** | **distributed**]
8. **no ip address**
9. **keepalive** [*period* [*retries*]]
10. **encapsulation** *encapsulation-type*
11. **ppp multilink group** *group-number*
12. **ppp multilink**
13. **ppp authentication chap**
14. **end**

### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> enable	Enables privileged EXEC mode.  • Enter your password if prompted.
<b>Step 2</b>	<b>configure terminal</b>  <b>Example:</b> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>controller</b> <i>{t1   e1} slot/port</i>  <b>Example:</b> Device# controller t1 1/3	Configures a T1 or E1 controller and enters controller configuration mode.  • The <b>t1</b> keyword indicates a T1 line card. • The <b>e1</b> keyword indicates an E1 line card. • 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.
<b>Step 4</b>	<b>channel-group</b> <i>channel-number timeslots range</i>	Defines the time slots that belong to each T1 or E1 circuit.

	Command or Action	Purpose
	<p><b>Example:</b></p> <pre>Device(config-controller)# channel-group 1 timeslots 1</pre>	<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</b> <i>range</i> keyword and argument 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>
<b>Step 5</b>	<p><b>exit</b></p> <p><b>Example:</b></p> <pre>Device(config-controller)# exit</pre>	Returns to global configuration mode.
<b>Step 6</b>	<p><b>interface serial</b> <i>slot / port</i> : <i>channel-group</i></p> <p><b>Example:</b></p> <pre>Device(config)# interface serial 1/0:1</pre>	<p>Configures a serial interface for a Cisco 7500 series router with channelized T1 or E1 and enters interface configuration mode.</p> <ul style="list-style-type: none"> <li>The <i>slot</i> argument indicates the slot number. Refer to the appropriate hardware manual for slot and port information.</li> <li>The <i>/port</i> argument indicates the port number. Refer to the appropriate hardware manual for slot and port information.</li> <li>The <i>:channel-group</i> argument indicates the channel group number. Cisco 7500 series routers specify the channel group number in the range of 0 to 4 defined with the <b>channel-group</b> controller configuration command.</li> </ul>
<b>Step 7</b>	<p><b>ip route-cache</b> [<b>cef</b>   <b>distributed</b>]</p> <p><b>Example:</b></p> <pre>Device(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> <li>The <b>distributed</b> keyword enables distributed switching on the interface.</li> </ul>
<b>Step 8</b>	<p><b>no ip address</b></p> <p><b>Example:</b></p> <pre>Device(config-if)# no ip address</pre>	Removes any specified IP address.
<b>Step 9</b>	<p><b>keepalive</b> [<i>period</i> [<i>retries</i>]]</p> <p><b>Example:</b></p> <pre>Device(config-if)# keepalive</pre>	<p>Enables keepalive packets and specifies the number of times that the Cisco 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> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>The <i>retries</i> argument specifies the number of times that the device continues to send keepalive packets without a 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 continues to send keepalive packets without a response before bringing the tunnel interface protocol down.</p>
<b>Step 10</b>	<b>encapsulation</b> <i>encapsulation-type</i>  <b>Example:</b> <pre>Device(config-if)# encapsulation ppp</pre>	Sets the encapsulation method used by the interface. <ul style="list-style-type: none"> <li>The <i>encapsulation-type</i> argument specifies the encapsulation type. The example specifies PPP encapsulation.</li> </ul>
<b>Step 11</b>	<b>ppp multilink group</b> <i>group-number</i>  <b>Example:</b> <pre>Device(config-if)# ppp multilink group 1</pre>	Restricts a physical link to join only one designated multilink group interface. <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>Device(config-if)# ppp multilink</pre>	Enables MLP on the interface.
<b>Step 13</b>	<b>ppp authentication chap</b>  <b>Example:</b> <pre>Device(config-if)# ppp authentication chap</pre>	(Optional) Enables Challenge Handshake Authentication Protocol (CHAP) authentication on the serial interface.
<b>Step 14</b>	<b>end</b>  <b>Example:</b> <pre>Device(config-if)# end</pre>	Returns 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
Step 1	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.
Step 3	<b>interface <i>type number</i></b>  <b>Example:</b> Device(config)# interface serial 1/0/0	Configures an interface type and enters interface configuration mode. <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 they can be displayed with the <b>show interfaces</b> command.</li> </ul>
Step 4	<b>ppp multilink fragmentation disable</b>  <b>Example:</b> Device(config-if)# ppp multilink fragmentation disable	Disables packet fragmentation.

	Command or Action	Purpose
Step 5	<b>end</b>  <b>Example:</b> Device(config-if)# end	Returns to privileged EXEC mode.

## 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 *type number*
6. show mpls forwarding-table
7. exit

### DETAILED STEPS

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

**Example:**

```
Device> enable
Device#
```

**Step 2**     **show ip interface brief**  
Verifies logical and physical Multilink PPP (MLP) interfaces.

**Example:**

```
Device# 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	up	down
Serial1/1/3:1	unassigned	YES	NVRAM	up	up	up
Serial1/1/3:2	unassigned	YES	NVRAM	up	up	up
Multilink6	10.30.0.2	YES	NVRAM	up	up	up
Multilink8	unassigned	YES	NVRAM	administratively	down	down
Multilink10	10.34.0.2	YES	NVRAM	up	up	up
Loopback0	10.0.0.1	YES	NVRAM	up	up	up

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

Verifies that you have created a multilink bundle.

**Example:**

```
Device# 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**

Displays information about a specific MLP interface.

**Example:**

```
Device# 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)
Se1/1/3:1, since 00:42:46, 240 weight, 232 frag size
Se1/1/3:2, since 00:42:46, 240 weight, 232 frag size
```

**Step 5** **show interface type number**

Displays information about serial interfaces in your configuration.

**Example:**

```
Device# 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

```

Device# **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:

Device# **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**

Displays contents of the Multiprotocol Label Switching (MPLS) Label Forwarding Information Base (LFIB). Look for information on multilink interfaces associated with a point2point next hop.

**Example:**

```
Device# show mpls forwarding-table
```

Local tag	Outgoing tag or VC	Prefix or Tunnel Id	Bytes tag switched	Outgoing interface	Next Hop
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		
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:**

```
Device# 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**

Returns to user EXEC mode.

**Example:**

```
Device# exit
Device>
```

---

# Configuration Examples for MPLS Multilink PPP Support

## Sample MPLS Multilink PPP Support Configurations

The following examples show sample configurations for Multilink PPP (MLP) on a Cisco 7200 router, on a Cisco 7500 router, and on a Carrier Supporting Carrier (CSC) network. The configuration of MLP on an interface is the same for provider edge-to-customer edge (PE-to-CE) links, PE-to-provider (P) links, and P-to-P links.

### Example: Sample Multilink PPP Configuration on Cisco 7200 Series Router

The following sample configuration is for a Cisco 7200 router, which is connected with a T1 line card and configured with an MPLS Multilink PPP interface:

```
controller T1 1/3
  framing esf
  clock source internal
  linecode b8zs
  channel-group 1 timeslots 1
  channel-group 2 timeslots 2
  no yellow generation
  no yellow detection
!
interface Multilink6
  ip address 10.37.0.1 255.0.0.0
  ppp multilink interleave
  tag-switching ip
  load-interval 30
  multilink-group 6
!
interface Serial1/3:1
  encapsulation ppp
  no ip address
  ppp multilink
  tx-queue-limit 26
  multilink-group 6
  peer neighbor-route
!
interface Serial1/3:2
  encapsulation ppp
  no ip address
  ppp multilink
  tx-queue-limit 26
  multilink-group 6
  peer neighbor-route
```

### Example: Sample Multilink PPP Configuration for Cisco 7500 Series Router

The following sample configuration is for a Cisco 7500 router, which is connected with a T1 line card and configured with an MPLS Multilink PPP interface:

```
controller T1 1/1/3
  framing esf
  clock source internal
  linecode b8zs
  channel-group 1 timeslots 1
  channel-group 2 timeslots 2
  no yellow generation
```

```

    no yellow detection
    !
interface Multilink6
ip address 10.37.0.2 255.0.0.0
ppp multilink interleave
tag-switching ip
load-interval 30
multilink-group 6
!
interface Serial1/1/3:1
encapsulation ppp
no ip address
ppp multilink
tx-queue-limit 26
multilink-group 6
peer neighbor-route
!
interface Serial1/1/3:2
encapsulation ppp
no ip address
ppp multilink
tx-queue-limit 26
multilink-group 6
peer neighbor-route

```

## Example: Configuring Multilink PPP on an MPLS CSC PE Device

The following example shows how to configure for Multiprotocol Label Switching (MPLS) Carrier Supporting Carrier (CSC) provider edge (PE) device.

```

!
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 or Distributed Cisco Express Forwarding

The following example shows how to enable Cisco Express Forwarding for Multilink PPP (MLP) configurations:

```

enable
configure terminal
ip cef

```

The following example shows how to enable distributed Cisco Express Forwarding for distributed MLP (dMLP) configurations:

```

enable
configure terminal
ip cef distribute

```

## Example: Creating a Multilink Bundle

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

```

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

```

## Example: Assigning an Interface to a Multilink Bundle

The following example shows how to create four multilink interfaces with Cisco Express Forwarding switching and Multilink PPP (MLP) enabled. Each of the newly created interfaces is added to a multilink bundle.

```
interface multilink1
 ip address 10.0.0.0 10.255.255.255
 ppp chap hostname group 1
 ppp multilink
 ppp multilink group 1

interface serial 1/0/0/:1
 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp multilink
 ppp multilink group 1
interface serial 1/0/0/:2
 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp chap hostname group 1
 ppp multilink
 ppp multilink group 1
interface serial 1/0/0/:3
 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp chap hostname group 1
 ppp multilink
 ppp multilink group 1
interface serial 1/0/0/:4
 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp chap hostname group 1
 ppp multilink
 ppp multilink group 1
```

## Additional References for MPLS Multilink PPP Support

### Related Documents

Related Topic	Document Title
Cisco IOS commands	<a href="#">Cisco IOS Master Commands List, All Releases</a>
MPLS commands	<a href="#">Cisco IOS Multiprotocol Label Switching Command Reference</a>
Basic MPLS VPNs	“MPLS Virtual Private Networks” chapter in the <i>MPLS Layer 3 VPNs Configuration Guide</i>

**RFCs**

<b>RFCs</b>	<b>Title</b>
RFC 1990	<i>The PPP Multilink Protocol (MP)</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 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 8: Feature Information for MPLS Multilink PPP Support**

Feature Name	Releases	Feature Information
MPLS Multilink PPP Support	12.2(8)T 12.2(15)T10 12.2(28)SB 12.3(5a) 12.3(7)T 12.4(20)T 15.4(1)S	<p>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 [P]device).</p> <p>In 12.2(8)T, MLP support on CE-to-PE links was introduced.</p> <p>In 12.2(15)T10 and 12.3(5a), MLP support for MPLS networks was extended to PE-to-P links, PE-to-PE links, Carrier Supporting Carrier (CSC) CE-to-PE links, and interautonomous system (Inter-AS) PE-to-PE links.</p> <p>In 12.3(7)T, this feature was integrated.</p> <p>In 12.2(28)SB, this feature was integrated.</p> <p>In 12.4(20)T, this feature was integrated.</p> <p>In Cisco IOS Release 15.4(1)S, support was added for the Cisco ASR 901S 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 devices 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 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 device-to-device 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.



## CHAPTER

# 4

## MPLS MTU Command Changes

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This document explains the change in the behavior of the **mplsmtu** command for the following Cisco IOS releases:

- 12.2(27)SBC and later
- 12.2(33)SRA and later
- 12.2(33)SXH and later
- 12.4(11)T and later
- 15.0(1)M1
- 15.1(2)S

You cannot set the Multiprotocol Label Switching (MPLS) maximum transmission unit (MTU) to a value larger than the interface MTU value. This eliminates problems such as dropped packets, data corruption, and high CPU rates from occurring when the MPLS MTU value settings are larger than the interface MTU values. Cisco IOS software allows the MPLS MTU value to be higher than the interface MTU value only for interfaces that have a default interface MTU value of 1580 or less.



### Note

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In Cisco IOS Release 15.0(1)M1, you can configure the interface MTU on PA-1FE and PA-2FE port adapters (PAs). The range of values is from 1500 to 1530. Before this enhancement, the MTU of those interfaces was not configurable, and any attempt to configure the interface MTU displayed the following message: *%Interface{InterfaceName}doesnotsupportusersettablemtu.*

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- [Finding Feature Information, page 46](#)
- [Information About MPLS MTU Command Changes, page 46](#)
- [How to Configure MPLS MTU Values, page 48](#)
- [Configuration Examples for Setting the MPLS MTU Values, page 51](#)
- [Additional References, page 53](#)
- [Feature Information for MPLS MTU Command Changes, page 54](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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 MTU Command Changes

### MPLS MTU Values During Upgrade

If you have configuration files with MPLS MTU values that are larger than the interface MTU values and you upgrade to Cisco IOS Release 12.2(27)SBC, 12.2(33)SRA, 12.4(11)T, 12.2(33)SXH, or later releases, the software does not change the MPLS MTU value. When you reboot the router, the software accepts the values that are set for the MPLS MTU and the interface MTU. The following error message is displayed during system initialization:

```
Setting the mpls mtu to xxxx on interface x/x, which is higher than the interface MTU xxxx.  
This could lead to packet forwarding problems including packet drops.  
You must set the MPLS MTU values equal to or lower than the interface MTU values.
```

**Caution**

If you do not set the MPLS MTU less than or equal to the interface MTU, data corruption, dropped packets, and high CPU conditions can occur.

### Guidelines for Setting MPLS MTU and Interface MTU Values

When configuring the network to use MPLS, set the core-facing interface MTU values greater than the edge-facing interface MTU values using one of the following methods:

- Set the interface MTU values on the core-facing interfaces to a higher value than the interface MTU values on the customer-facing interfaces to accommodate any packet labels, such as MPLS labels, that an interface might encounter. Make sure that the interface MTUs on the remote end interfaces have the same interface MTU values. The interface MTU values on both ends of the link must match.
- Set the interface MTU values on the customer-facing interfaces to a lower value than the interface MTU on the core-facing interfaces to accommodate any packet labels, such as MPLS labels, that an interface might encounter. When you set the interface MTU on the edge interfaces, ensure that the interface MTUs on the remote end interfaces have the same values. The interface MTU values on both ends of the link must match.

Changing the interface MTU can also modify the IP MTU, Connectionless Network Service (CLNS) MTU, and other MTU values because they depend on the value of the interface MTU. The Open Shortest Path First (OSPF) routing protocol requires that the IP MTU values match on both ends of the link. Similarly, the

Intermediate System-to-Intermediate System (IS-IS) routing protocol requires that the CLNS MTU values match on both ends of the link. If the values on both ends of the link do not match, IS-IS or OSPF cannot complete initialization.

If the configuration of the adjacent router does not include the **mplsmtu** and **mtu** commands, add these commands to the router.

**Note**

The MPLS MTU setting is displayed only in the show running-config output if the MPLS MTU value is different from the interface MTU value. If the values match, only the interface MTU value is displayed.

If you attempt to set the MPLS MTU value higher than the interface MTU value, the software displays the following error message, which prompts you to set the interface MTU to a higher value before you set the MPLS MTU value:

```
% Please increase interface mtu to xxxx and then set mpls mtu
```

**Note**

In Cisco IOS Release 15.1(2)S, the **mplsmtu** command was modified. This command was made available in L3VPN encapsulation configuration mode. The **maximum** keyword was replaced with the **max** keyword. The **override** keyword and the *bytes* argument were removed from the GRE tunnel interface. To set MPLS MTU to the maximum MTU on L3VPN profiles, use the **mplsmtu** command in L3VPN encapsulation configuration mode.

## MPLS MTU Values for Ethernet Interfaces

If you have an interface with a default interface MTU value of 1500 or less (such as an Ethernet interface), the **mplsmtu** command provides an **override** keyword, which allows you to set the MPLS MTU to a value higher than the interface MTU value. The **override** keyword is not available for interface types that do not have a default interface MTU value of 1500 or less. For configuration details, see the [Setting the MPLS MTU Value on an Ethernet Interface, on page 49](#).

Setting the MPLS MTU value higher than the Ethernet interface MTU value can lead to dropped packets, data corruption, or high CPU rates. When you set the MPLS MTU value higher than the Ethernet interface MTU value, the software displays the following message:

```
%MFI-30-MPLS_MTU_SET: Setting the mpls mtu to xxxx on Ethernet x/x, which is higher than
the interface MTU xxxx. This could lead to packet forwarding problems including packet
drops.
Most drivers will be able to support baby giants and will gracefully drop packets that are
too large. Certain drivers will have packet forwarding problems including data corruption.
```

Setting the mpls mtu higher than the interface mtu can lead to packet forwarding problems and may be blocked in a future release.

**Note**

The **override** keyword is supported in Cisco IOS Release 12.2(27)SBC, 12.2(33)SRA, 12.4(11)T, 12.2(33)SXH, and later releases, but may not be supported in a future release.

# How to Configure MPLS MTU Values

The following sections explain how to configure MPLS MTU and interface MTU values:

## Setting the Interface MTU and MPLS MTU Values

Use the following steps to set the interface MTU and the MPLS MTU.



### Note

In Cisco IOS Release 15.0(1)M1, you can configure the interface MTU on PA-1FE and PA-2FE port adapters. The range of values is from 1500 to 1530. Before this enhancement, the MTU of those interfaces was not configurable.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot / port*
4. **mtu** *bytes*
5. **mpls mtu** *bytes*
6. **end**

### 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 slot / port</i>  <b>Example:</b> Router(config)# interface Serial 1/0	Enters interface configuration mode to configure the interface.

	Command or Action	Purpose
<b>Step 4</b>	<b>mtu</b> <i>bytes</i>  <b>Example:</b> Router(config-if)# mtu 1520	Sets the interface MTU size.
<b>Step 5</b>	<b>mpls mtu</b> <i>bytes</i>  <b>Example:</b> Router(config-if)# mpls mtu 1520	Sets the MPLS MTU to match the interface MTU.
<b>Step 6</b>	<b>end</b>  <b>Example:</b> Router(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.

## Setting the MPLS MTU Value on an Ethernet Interface

Use the following steps to set the MPLS MTU value on an Ethernet interface.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type slot / port*
4. **mpls mtu** *override bytes*
5. **end**

### DETAILED STEPS

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

	Command or Action	Purpose
<b>Step 3</b>	<b>interface</b> <i>type slot / port</i>  <b>Example:</b> Router(config)# interface ethernet 1/0	Enters interface configuration mode to configure the Ethernet interface.
<b>Step 4</b>	<b>mpls mtu</b> <b>override</b> <i>bytes</i>  <b>Example:</b> Router(config-if)# mpls mtu override 1510	Sets the MPLS MTU to a value higher than the interface MTU value.  <b>Caution</b> Setting the MPLS MTU to a value higher than the Ethernet interface MTU value can lead to dropped packets, data corruption, or high CPU rates.
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Router(config-if)# end	Exits interface configuration mode and returns to privileged EXEC mode.

## Setting the MPLS MTU Value to the Maximum on L3VPN Profiles

Use the following steps to set the MPLS MTU value to the maximum on L3VPN profiles.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **l3vpn encapsulation ip** *profile*
4. **mpls mtu** **max**
5. **end**

### DETAILED STEPS

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



	Command or Action	Purpose
<b>Step 3</b>	<b>l3vpn encapsulation ip</b> <i>profile</i>  <b>Example:</b> Router(config)# l3vpn encapsulation ip profile1	Configures an L3VPN encapsulation profile and enters the L3VPN encapsulation configuration mode.
<b>Step 4</b>	<b>mpls mtu</b> <b>max</b>  <b>Example:</b> Router(config-l3vpn-encap-ip)# mpls mtu max	Sets the MPLS MTU value to the maximum MTU on the L3VPN profile.
<b>Step 5</b>	<b>end</b>  <b>Example:</b> Router(config-l3vpn-encap-ip)# end	Exits L3VPN encapsulation configuration mode and returns to privileged EXEC mode.

## Configuration Examples for Setting the MPLS MTU Values

### Example Setting the Interface MTU and MPLS MTU

The following example shows how to set the interface and MPLS MTU values. The serial interface in the following configuration examples is at the default interface MTU value. The MPLS MTU value is not set. The interface settings are as follows:

```
interface Serial 4/0
 ip unnumbered Loopback0
 mpls traffic-eng tunnels
 mpls ip
 serial restart-delay 0
 ip rsvp bandwidth 2000 2000
end
```

The following example attempts to set the MPLS MTU value to 1520. This returns an error because MPLS MTU cannot be set to a value greater than the value of the interface MTU.

```
Router# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)# interface serial 4/0
Router(config-if)# mpls mtu 1520
% Please increase interface mtu to 1520 and then set mpls mtu
```

The following example first sets the interface MTU to 1520 and then sets the MPLS MTU to 1520:

```
Router(config-if)# mtu 1520
Router(config-if)# mpls mtu 1520
```

The following example shows the new interface MTU value. The MPLS MTU value is not displayed because it is equal to the interface value.

```
Router#
show running-config interface serial 4/0
Building configuration...
interface Serial4/0
  mtu 1520
  ip unnumbered Loopback0
  mpls traffic-eng tunnels
  mpls ip
  serial restart-delay 0
  ip rsvp bandwidth 2000 2000
end
```

The following example sets the MPLS MTU value to 1510:

```
Router(config-if)# mpls mtu 1510
```

The following example shows the new interface MTU value. The MPLS MTU value is displayed because it is different than the interface MTU value.

```
Router#
show running-config interface serial 4/0
Building configuration...
interface Serial4/0
  mtu 1520
  ip unnumbered Loopback0
  mpls mtu 1510
  mpls traffic-eng tunnels
  mpls ip
  serial restart-delay 0
  ip rsvp bandwidth 2000 2000
end
```

## Example Setting the MPLS MTU Value on an Ethernet Interface



### Caution

Setting the MPLS MTU to a value higher than the Ethernet interface MTU value can lead to dropped packets, data corruption, or high CPU rates.

The following example shows how to set the MPLS MTU values on an Ethernet interface. The Ethernet interface in the following configuration examples is at the default interface MTU value. The MPLS MTU value is not set. The interface settings are as follows:

```
interface Ethernet 2/0
  ip unnumbered Loopback0
  mpls traffic-eng tunnels
  mpls ip
  serial restart-delay 0
  ip rsvp bandwidth 2000 2000
end
```

The following example uses the **override** keyword to set the MPLS MTU to 1520, which is higher than the Ethernet interface's MTU value:

```
Router(config-if)# mpls mtu override 1520
%MFI-30-MPLS_MTU_SET: Setting the mpls mtu to 1520 on Ethernet2/0, which is higher than the
interface MTU 1500. This could lead to packet forwarding problems including packet drops.
```

The following example shows the new MPLS MTU value:

```
Router#
show running-config interface ethernet 2/0
Building configuration...
interface Ethernet 2/0
  mtu 1500
  ip unnumbered Loopback0
  mpls mtu 1520
  mpls traffic-eng tunnels
  mpls ip
  serial restart-delay 0
  ip rsvp bandwidth 2000 2000
end
```

## Example Setting the MPLS MTU Value to the Maximum MTU on L3VPN profiles

The following example shows how to set the MPLS MTU value to the maximum MTU on L3VPN profiles:

```
Router# configure terminal
Router(config)# l3vpn encapsulation ip profile1
Router(config-l3vpn-encap-ip)# mpls mtu max
```

## Additional References

### Related Documents

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

### MIBs

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

**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 MTU Command 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 9: Feature Information for MPLS MTU Command Changes

Feature Name	Releases	Feature Information
MPLS MTU Command Changes	12.2(27)SBC 12.2(28)SB 12.2(33)SRA 12.2(33)SXH 12.4(11)T 15.0(1)M1 15.1(2)S	<p>This document explains the changes to the <b>mplsmtu</b> command. You cannot set the MPLS MTU value larger than the interface MTU value, except for Ethernet interfaces.</p> <p>In 12.2(28)SB, support was added for the Cisco 10000 router.</p> <p>In 12.2(33)SRA, support was added for the Cisco 7600 series router.</p> <p>This feature was integrated into Cisco IOS Release 12.4(11)T.</p> <p>This feature was integrated into Cisco IOS Release 12.2(33)SXH.</p> <p>In 15.0(1)M1, you can configure the interface MTU on PA-1FE and PA-2FE port adapters.</p> <p>In 15.1(2)S, the <b>mplsmtu</b> command was made available in L3VPN encapsulation configuration mode. The <b>maximum</b> keyword was replaced with the <b>max</b> keyword. The <b>override</b> keyword and the <i>bytes</i> argument were removed from the GRE tunnel interface.</p>





## NetFlow MPLS Label Export

The NetFlow MPLS Label Export feature allows a label switch router (LSR) to collect and export Multiprotocol Label Switching (MPLS) labels allocated by the LSR when an adjacent router pushes that label on the top of the label stack of a transit packet. At the same time, the LSR collects the prefix associated with the MPLS label and the application that allocated the label. The router collects the information in a table called the MPLS Prefix/Application/Label (PAL) table and exports this data to a NetFlow collector as the label is allocated or, if so configured, periodically exports the full MPLS PAL table.

You can use this information to create a provider edge (PE)-to-PE matrix, which is useful for network traffic planning and billing. To realize this benefit, you must export the MPLS label information to a NetFlow collector for analysis. This feature also provides information that a NetFlow collector can use to create a Virtual Private Network (VPN) routing and forwarding instance (VRF)-to-PE and PE-to-VRF matrix.

- [Finding Feature Information, page 57](#)
- [Prerequisites for NetFlow MPLS Label Export, page 58](#)
- [Restrictions for NetFlow MPLS Label Export, page 58](#)
- [Information About NetFlow MPLS Label Export, page 59](#)
- [How to Configure NetFlow MPLS Label Export, page 63](#)
- [Configuration Examples for NetFlow MPLS Label Export, page 69](#)
- [Additional References, page 69](#)
- [Command Reference, page 71](#)
- [Feature Information for NetFlow MPLS Label Export, page 71](#)
- [Glossary, page 72](#)

## Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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## Prerequisites for NetFlow MPLS Label Export

The NetFlow MPLS Label Export feature requires the following:

- NetFlow configured on the LSR
- MPLS enabled on the LSR

If you are exporting data to a Cisco NetFlow collector, the following requirements apply:

- NetFlow Version 9 export format configured on the LSR
- NetFlow collector and analyzer that can use MPLS PAL records exported in NetFlow Version 9 format

## Restrictions for NetFlow MPLS Label Export

The following restrictions apply to the NetFlow MPLS Label Export feature for Cisco IOS 12.2S releases and Cisco IOS Release 12.5(1):

- The MPLS PAL table does not support the export of information for the following:
  - IP Version 6 (IPv6) labels
  - IP Multicast labels
  - Quality of service (QoS) labels
  - Traffic engineering (TE) tunnel headend labels
- The ability to create a VRF-to-VRF traffic matrix is not supported.
- If one application deallocates a label and a second application soon reallocates the same label, the NetFlow collector might not be able to determine how many packets flowed while the label was owned by each application.
- In MPLS PAL table records, for labels allocated by VPNs, Border Gateway Protocol (BGP) IPv4, or BGP VPN Version 4 (VPNv4), the stored prefix can be either 0.0.0.0 or a route distinguisher (RD)-specific address:
  - If you do not configure the **mplsexportvpnv4prefixes** command, VPN prefixes are not tracked in the MPLS PAL table. These prefixes are displayed by the **showmplsflowmappings** command as 0.0.0.0.
  - If you configure the **mplsexportvpnv4prefixes** command, VPN prefixes are tracked and RD-specific addresses are displayed by the **showmplsflowmappings** command.



# Information About NetFlow MPLS Label Export

The following sections contain useful information for understanding how to configure and use the NetFlow MPLS Label Export feature:

## MPLS Label Information Gathering and Exporting

In a Cisco IOS 12.0S, 12.3T, or 12.4T release that supports the MPLS-Aware NetFlow feature, the mapping of the MPLS label to a prefix and an MPLS application is achieved through the use of the Label Forwarding Information Base (LFIB). You can display this information with the **show ip cache verbose flow** command. These releases do not support the NetFlow MPLS Label Export feature.

In a Cisco IOS 12.2(28)SB release or later release that supports the NetFlow MPLS Label Export feature, the mapping of the MPLS label to a destination prefix or Forwarding Equivalence Class (FEC) and to the MPLS application currently using the label is achieved through the use of an MPLS PAL table. Each supported MPLS application on the router where the NetFlow MPLS Label Export feature is configured registers its label values, prefixes, and owning applications as the labels are allocated. This label-tracking functionality operates on the Route Processor (RP) software.

The MPLS label information (label to prefix and application) mapping is exported to a NetFlow collector at the time when the label is allocated. You can configure periodic export of the full MPLS PAL table to a collector for further processing and analysis through the use of the **mplsexportinterval** command.

An *interval* argument to the **mplsexportinterval** command controls the time in minutes between full MPLS PAL table exports to the NetFlow collector. You can configure an interval in the range of 0 to 10080 (1 week) minutes:

- If you want to export MPLS PAL table information only when the label is allocated, then configure this command with a 0 time interval with the **mplsexportinterval0** command.
- If you want to trigger an immediate export of the full MPLS PAL table, reconfigure the command with an *interval* argument that is different from the interval that is configured. For example, if you have configured the **mplsexportinterval1440** command, reconfigure the command with any nonzero number except 1440.
- If you have a complex network that generates a large amount of traffic, configure a large interval between MPLS PAL table exports. You might want to configure an interval from 6 to 12 hours (360 and 720 minutes).

The *interval* argument that you specify is the least amount of time that passes before another export of the MPLS PAL table occurs. The system could delay the MPLS PAL table export for 10 minutes if the PAL export queue already contains a large number of entries. This could happen if the export occurred at a time when thousands of routes just came up, or if NetFlow did not have the time to clear the export queue from either a previous export of the full table or a previous time when thousands of routes came up in a brief period of time.

After you have entered the **mplsexportinterval** command, you can use the **show mpls flow mappings** command to display MPLS PAL table entries. To display information about the number of MPLS PAL records exported to the collector, use the **show ip flow export verbose** command.

## Labels Allocated by VPNs BGP IPv4 or BGP VPNv4 in the MPLS PAL Table

If you want to see VPN prefix information, that is, labels allocated by VPN, BGP IPv4, or BGP VPNv4, you need to configure the **mplsexportvpn4prefixes** command. If you do not configure the **mplsexportvpn4prefixes** command, MPLS PAL stores labels allocated by these application as prefix 0.0.0.0.

After you configure the **mplsexportvpn4prefixes** command, the VPN prefix and the associated RD are stored in the MPLS PAL table. VPN addresses are made unique by adding an RD to the front of the address. The RD removes any ambiguity when the same VPN prefix is used for more than one VRF.



### Note

To export VPN prefixes and associated RDs from the MPLS PAL table, the first time you configure the **mplsexportvpn4prefixes** command you need to save the configuration and reboot the router or clear all routes from the table.

To display the VPN prefix entries in the MPLS PAL table, use the **showmplsflowmappings** command.

With the **mplsexportvpn4prefixes** command configured, a line of the output might look like this:

```
Router# show mpls flow mappings
Label      Owner      Route-Distinguisher Prefix      Allocated
.
.
.
27         BGP        100:1       10.34.0.0   00:57:48
```

The format of the Route-Distinguisher field in the output depends on how the RD was configured. The RD can be configured in the as-number:network number (ASN:nn) format, as shown in the example, or it can be configured in the IP address:network number format (IP-address:nn).

If you did not configure the **mplsexportvpn4prefixes** command, a line of the output looks like this:

```
Router# show mpls flow mappings
.
.
.
Label      Owner      Route-Distinguisher Prefix      Allocated
21         BGP        .           0.0.0.0     00:52:18
```

The Route-Distinguisher field is not populated and the Prefix is displayed as 0.0.0.0.

If the MPLS PAL table tracks a per-VRF aggregate label and you configured the **mplsexportvpn4prefixes** command, the **showmplsflowmappings** command displays the RD associated with the per-VRF aggregate label, but the prefix for the per-VRF aggregate label is reported as 0.0.0.0. If the **mplsexportvpn4prefixes** command is not configured, the per-VRF aggregate label is reported with no RD and prefix 0.0.0.0, and you cannot distinguish the per-VRF aggregate label from a normal BGP label.

## MPLS PAL Table Record Export

In Cisco IOS Release 12.0S and later releases, the export of MPLS-Aware NetFlow cache records makes use of the NetFlow Version 9 export format data and template. The export of MPLS PAL table entries also uses the NetFlow Version 9 export format. MPLS PAL packets are exported as NetFlow options packets rather than NetFlow data packets. NetFlow options packets are defined in *Cisco Systems NetFlow Services Export Version 9*, Request for Comments (RFC) 3954.

The RP on the PE router learns and queues the MPLS PAL table records for export. The RP can combine large numbers of PAL table entries in a single Version 9 record and send the record to the NetFlow collector. The information exported by the RP contains instances of the following for each tracked label:

Label, allocating-application (Owner), Route-Distinguisher, Prefix, time stamp (Allocated)

Because the mapping may change as labels expire and are reused, each PAL record contains a time stamp indicating the system uptime at which the label was allocated.

### **NetFlow Export Template Format Used for MPLS PAL Entries**

This is the NetFlow Version 9 export template format used for MPLS PAL entries:

MPLS label: 3 bytes

MPLS label application type: 1 byte

MPLS label IP prefix: 4 bytes

MPLS VPN prefix RD: 8 bytes

MPLS label allocation time: 4 bytes

### **MPLS Application Types Exported**

The following MPLS application types are exported in the MPLS label application type field:

TE = 1

ATOM = 2

VPN = 3

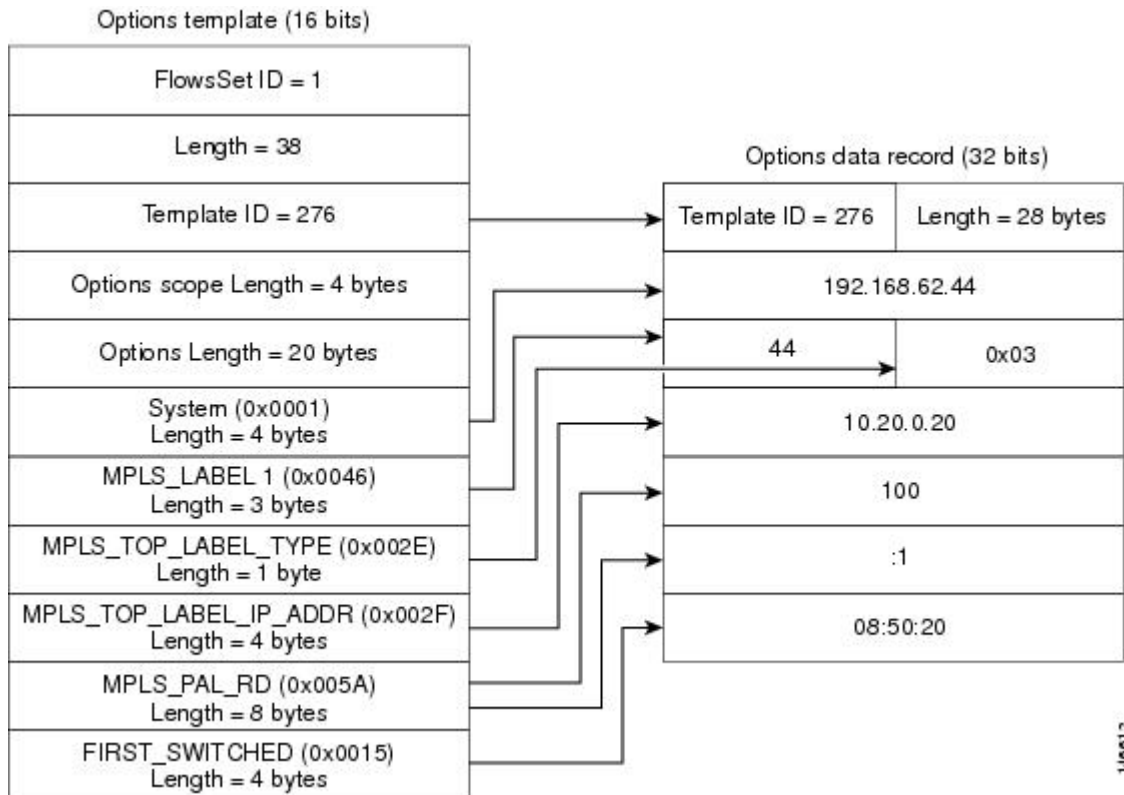
BGP = 4

LDP = 5

### Options Template and Options Data Record for MPLS PAL Record Export

The figure below shows an example of the options template and options data record for MPLS PAL record export. This example shows that MPLS label 44 was allocated by a VPN 0x03 at 08:50:20 and is associated with the IP address 10.20.0.20 and with RD 100:1.

**Figure 5: MPLS PAL Export Format Record**



## MPLS PAL and NetFlow Statistics Correlation on a NetFlow Collector

A NetFlow collector can gather the PAL NetFlow packets from a PE router and correlate the label mappings with the recent NetFlow records from adjacent provider core (P) routers.

For example, the MPLS PAL export packet contains MPLS label mappings over a period of time, as each label is allocated and reallocated on the PE router. The packet might contain the following information:

```
label 5, prefix 10.0.0.0, type LDP, 12:00:00
label 4, prefix 10.10.0.0, type LDP, 13:00:00
label 5, prefix 10.9.0.0, type VPN, 14:00:00
```

The NetFlow collector then receives a NetFlow packet from the adjacent P router indicating the following:

```
label 5, 123 packets, 9876 bytes, time 12:22:15.
```

The collector would match the time range known from the PAL packets with the line card (LC) packet time stamp. This would result in the correct mapping for label 5 at time 12:22:15, as follows:

```
label 5, application LDP, prefix 10.0.0.0.
```

The NetFlow collector needs to be able to handle relative differences in the time stamps caused by different reboot times of the P and PE routers.

To implement the offline label mapping checks in the NetFlow collector, the collector needs to maintain a history of label mappings obtained from the MPLS PAL NetFlow packets sent by the RP. If a label is deallocated and reallocated, the collector should track both the old and the new MPLS PAL information for the label.

**Note**

---

On a rare occasion, the collector might not be able to accurately track how many packets flowed for a label that has been deallocated by one application and soon reallocated by another application.

---

## MPLS Label Mapping on a Line Card

Label to prefix and application mapping is registered and exported from the router RP. This functionality does not occur on the line card. If you want to see the mapping for a particular label on a line card and the label of interest is tracked by the MPLS PAL table, then you can do the following:

- Enter the **showmplsforwarding** command on the line card.
- Enter the **showmplsflowmappings** on the RP.
- Compare the output of the two commands.

You might find the **include** keyword to the commands useful in this case. For example, You could enter the **showmplsflowmappings include 777** command to see the information for any label with substring 777.

## How to Configure NetFlow MPLS Label Export

Perform the following tasks to configure the NetFlow MPLS Label Export feature on an LSR. This feature provides the label, prefix, and application mapping through the MPLS PAL table that collects and exports the data to a NetFlow collector.

### Configuring NetFlow MPLS Label Export and MPLS PAL Table Export

Perform this task to configure the NetFlow MPLS Label Export feature and MPLS PAL table export to a NetFlow collector. You can use the information generated for network traffic planning and billing.

The following task must be completed before MPLS labels are allocated by the router for the MPLS PAL table to be exported to a NetFlow collector.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls export interval** *interval*
4. **end**
5. **copy running-config startup-config**
6. **exit**
7. Reboot the router.

## 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>mpls export interval</b> <i>interval</i>  <b>Example:</b> Router(config)# mpls export interval 360  <b>Example:</b>	Configures a periodic time interval for the export of the entire MPLS PAL table to a NetFlow collector. <ul style="list-style-type: none"> <li>• The <i>interval</i> argument specifies the time in minutes between full PAL table exports. The range of valid time intervals is 0 to 10,080 minutes.</li> <li>• We recommend that you select a time interval from 360 minutes (6 hours) to 1440 minutes (24 hours) depending on the size of your network and how often the NetFlow collector might be restarted.</li> <li>• If you enter an interval of 0, full PAL table exports are disabled. PAL information is exported only as labels are allocated.</li> <li>• If you need to restart your NetFlow collector and want to learn PAL information immediately, you can change the <i>interval</i> argument. When you change the time interval, the application exports the full PAL table.</li> </ul> <p><b>Note</b> Allocated labels are tracked only after you enter the <b>mplsexportinterval</b> command. Any labels allocated before you enter this command are not tracked.</p>
Step 4	<b>end</b>  <b>Example:</b> Router(config)# <b>end</b>	Exits to privileged EXEC mode.

	Command or Action	Purpose
<b>Step 5</b>	<b>copy running-config startup-config</b>  <b>Example:</b> <pre>Router# copy running-config startup-config</pre>	Copies the modified configuration into router NVRAM, permanently saving the settings.  The next time the router is reloaded or rebooted the NetFlow MPLS Label Export feature is already part of the configuration.
<b>Step 6</b>	<b>exit</b>  <b>Example:</b> <pre>Router# exit</pre>	Exits to user EXEC mode.
<b>Step 7</b>	Reboot the router.	(Optional) Saves the configuration and reboots the router to ensure that the information collected by this feature is complete.

## Displaying Information About the MPLS PAL Table

Perform this task to display information about the MPLS PAL table. The information displayed includes the label, the application that allocated the label, an RD and destination prefix associated with the label, and the time the label was allocated by the application.

### SUMMARY STEPS

1. **enable**
2. **show mpls flow mappings**
3. **show ip flow export verbose | include PAL**
4. **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 mpls flow mappings**  
Use this command to display entries in the MPLS PAL table. For example:

**Example:**

```
Router# show mpls flow mappings
Label   Owner      Route-Distinguisher Prefix      Allocated
18      LDP        10.0.0.5      10.0.0.5   00:52:10
21      BGP        0.0.0.0      0.0.0.0    00:52:18
22      BGP        0.0.0.0      0.0.0.0    00:52:18
25      BGP        0.0.0.0      0.0.0.0    00:51:44
26      LDP        10.32.0.0    10.32.0.0  00:52:10
27      TE-MIDPT  10.30.0.2    10.30.0.2  00:52:06
28      LDP        10.33.0.0    10.33.0.0  00:52:10
29      LDP        10.0.0.1     10.0.0.1   00:52:10
30      LDP        10.0.0.3     10.0.0.3   00:52:10
```

In this example, the `mplsexportvpnv4prefixes` command was not configured. Therefore, the MPLS PAL functionality did not export an RD for the BGP application, and the associated prefix is exported as 0.0.0.0.

The following shows sample output from the `showmplsflowmappings` command if you previously entered the `mplsexportvpnv4prefixes` command:

**Example:**

```
Router# show mpls flow mappings
Label   Owner      Route-Distinguisher Prefix      Allocated
16      LDP        10.0.0.3     10.0.0.3   00:58:03
17      LDP        10.33.0.0    10.33.0.0  00:58:03
19      TE-MIDPT  10.30.0.2    10.30.0.2  00:58:06
20      LDP        10.0.0.5     10.0.0.5   00:58:03
23      LDP        10.0.0.1     10.0.0.1   00:58:03
24      LDP        10.32.0.0    10.32.0.0  00:58:03
27      BGP        100:1        10.34.0.0  00:57:48
31      BGP        100:1        10.0.0.9   00:58:21
32      BGP        100:1        10.3.3.0   00:58:21
```

**Step 3** `show ip flow export verbose | include PAL`

Use this command to display the number of MPLS PAL records that were exported to the NetFlow collector. For example:

**Example:**

```
Router# show ip flow verbose | include PAL
6 MPLS PAL records exported
```

When you specify the `verbose` keyword and MPLS PAL records have been exported using NetFlow Version 9 data format, the command output contains an additional line that precedes the “x records exported in y UDP datagrams” line.

**Step 4** `exit`

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

**Example:**

```
Router# exit
Router>
```

---



## Configuring the Export of MPLS VPN Version 4 Label Information from the MPLS PAL Table to a NetFlow Collector

Perform the following task to configure the export of VPNv4 label information from the MPLS PAL table to a NetFlow collector.

This allows you to track VPN prefix information for MPLS labels allocated by VPNs, BGP IPv4, and BGP VPNv4. You can use the data analyzed by the collector to assist in network traffic planning and billing.

### Before You Begin

A VRF must be configured on the router.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mpls export interval *interval***
4. **mpls export vpnv4 prefixes**
5. **end**
6. **copy running-config startup-config**
7. **exit**
8. Reboot the router.
9. **enable**
10. **show mpls flow mappings**

### 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 export interval <i>interval</i></b>  <b>Example:</b> Router(config)# mpls export interval 1440	Configures the collection and export of MPLS PAL information to a NetFlow collector. <ul style="list-style-type: none"> <li>• The <i>interval</i> argument specifies the time in minutes between full PAL table exports. The range of valid time intervals is 0 to 10,080 minutes.</li> </ul>

	Command or Action	Purpose
		<ul style="list-style-type: none"> <li>• We recommend that you select a time interval of 6 hours (360 minutes) to 24 hours (1440 minutes) depending on the size of your network.</li> <li>• If you enter an interval of 0, full PAL table exports are disabled. PAL information is exported only as labels are allocated.</li> <li>• If you need to restart your NetFlow collector and want to learn PAL information immediately, you can change the <i>interval</i> argument. When you change the time interval, the application exports the full PAL table.</li> </ul>
<b>Step 4</b>	<b>mpls export vpnv4 prefixes</b>  <b>Example:</b> <pre>Router(config)# mpls export vpnv4 prefixes</pre>	Configures the tracking and export of VPNv4 label information from the MPLS PAL table to a NetFlow collector.
<b>Step 5</b>	<b>end</b>  <b>Example:</b> <pre>Router(config)# end</pre>	Exits to privileged EXEC mode.
<b>Step 6</b>	<b>copy running-config startup-config</b>  <b>Example:</b> <pre>Router# copy running-config startup-config</pre>	<p>Copies the modified configuration into router NVRAM, permanently saving the settings.</p> <p>The next time the router is rebooted the tracking and export of VPNv4 label information from the MPLS PAL table to a NetFlow collector is already part of the configuration.</p>
<b>Step 7</b>	<b>exit</b>  <b>Example:</b> <pre>Router# exit</pre>	Exits to user EXEC mode.
<b>Step 8</b>	Reboot the router.	(Optional) Saves the configuration and reboots the router to ensure that the information collected by this feature is complete.
<b>Step 9</b>	<b>enable</b>  <b>Example:</b> <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>
<b>Step 10</b>	<b>show mpls flow mappings</b>  <b>Example:</b> <pre>Router# show mpls flow mappings</pre>	Displays MPLS PAL table entries that include VPNv4 prefixes and VPN RDs.

# Configuration Examples for NetFlow MPLS Label Export

## Configuring NetFlow MPLS Prefix Application Label Table Export Examples

The following examples show how to configure NetFlow MPLS PAL table export on a PE router.

This example shows how to configure the export of the full MPLS PAL table every 480 minutes (8 hours):

```
configure terminal
!
mpls export interval 480
end
copy running-config startup-config
exit
```

This example shows how to configure MPLS PAL information export only as the labels are allocated:

```
configure terminal
!
mpls export interval 0
end
copy running-config startup-config
exit
```

In this example, the full MPLS PAL table is not exported repeatedly.

## Configuring the Export of MPLS VPNv4 Label Information from the MPLS PAL Table Example

The following example shows how to configure the export of MPLS VPNv4 label information from the MPLS PAL table:

```
configure terminal
!
mpls export interval 720
mpls export vpnv4 prefixes
end
copy running-config startup-config
exit
```

The full MPLS PAL table with MPLS VPNv4 label information is configured to export to the NetFlow collector every 720 minutes (12 hours).

## Additional References

The following sections provide references related to the NetFlow MPLS Label Export feature.

**Related Documents**

Related Topic	Document Title
Tasks for configuring MPLS-aware NetFlow	Configuring MPLS-aware NetFlow
Overview of the NetFlow application and advanced NetFlow features and services	Cisco IOS NetFlow Overview
Tasks for configuring NetFlow to capture and export network traffic data	Configuring NetFlow and NetFlow Data Export
Tasks for configuring MPLS egress NetFlow accounting	Configuring MPLS Egress NetFlow Accounting
Detailed information about the fields available in Version 9 export format and about export format architecture	<a href="#">Cisco IOS NetFlow Version 9 Flow-Record Format</a>

**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 IOS releases, and feature sets, use Cisco MIB Locator found at the following URL:  <a href="http://www.cisco.com/go/mibs">http://www.cisco.com/go/mibs</a>

**RFCs**

RFC	Title
RFC 3954	<a href="#">Cisco Systems NetFlow Services Export Version 9</a>
RFC 2547	<a href="#">BGP/MPLS VPNs</a>

**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>	<p><a href="http://www.cisco.com/techsupport">http://www.cisco.com/techsupport</a></p>

## Command Reference

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

- **mpls export interval**
- **mpls export vpnv4 prefixes**
- **show ip flow export**
- **show mpls flow mappings**

## Feature Information for NetFlow MPLS Label Export

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 10: Feature Information for NetFlow MPLS Label Export**

Feature Name	Releases	Feature Information
NetFlow MPLS Label Export	12.2(28)SB 12.2(33)SRA	<p>The NetFlow MPLS Label Export feature provides the label switch router (LSR) with the capability of collecting and exporting the top label in the MPLS label stack along with its prefix or Forwarding Equivalence Class (FEC) and the application allocating the label to a NetFlow collector for supported MPLS applications.</p> <p>In 12.2(28)SB, this feature was introduced.</p> <p>In 12.2(33)SRA, this feature was integrated into a 12.2SRA release.</p>

## Glossary

**BGP** --Border Gateway Protocol. An interdomain routing protocol that replaces Exterior Gateway Protocol (EGP). A BGP system exchanges reachability information with other BGP systems. It is defined by RFC 1163.

**export packet** --A type of packet built by a device (for example, a router) with NetFlow services enabled. The packet is addressed to another device (for example, the NetFlow Collection Engine). The packet contains NetFlow statistics. The other device processes the packet (parses, aggregates, and stores information on IP flows).

**FEC** --Forward Equivalency Class. A set of packets that can be handled equivalently for the purpose of forwarding and thus is suitable for binding to a single label. The set of packets destined for an address prefix is one example of an FEC. A flow is another example

**flow** --A unidirectional stream of packets between a given source and destination--each of which is defined by a network-layer IP address and transport-layer source and destination port numbers. A unique flow is defined as the combination of the following key fields: source IP address, destination IP address, source port number, destination port number, Layer 3 protocol type, type of service (ToS), and input logical interface.

**flowset** --A collection of flow records that follow the packet header in an export packet. A flowset contains information that must be parsed and interpreted by the NetFlow Collection Engine. There are two different types of flowsets: template flowsets and data flowsets. An export packet contains one or more flowsets, and both template and data flowsets can be mixed in the same export packet.

**IPv6** --IP Version 6. Replacement for IP Version 4 (IPv4). IPv6 includes support for flow ID in the packet header, which can be used to identify flows. Formerly called IPng (next generation).

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

**LDP** --Label Distribution Protocol. A standard protocol that operates between Multiprotocol Label Switching (MPLS)-enabled routers to negotiate the labels (addresses) used to forward packets. The Cisco proprietary version of this protocol is the Tag Distribution Protocol (TDP).

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

**LSR** --label switch router. A router that forwards packets in a Multiprotocol Label Switching (MPLS) network by looking only at the fixed-length label.

**MPLS** --Multiprotocol Label Switching. A switching method in which IP traffic is forwarded through use of a label. This label instructs the routers and the switches in the network where to forward the packets. The forwarding of MPLS packets is based on preestablished IP routing information.

**NetFlow** --A Cisco IOS application that provides statistics on packets flowing through the router. It is emerging as a primary network accounting and security technology.

**NetFlow Collection Engine** (formerly NetFlow FlowCollector)--A Cisco application that is used with NetFlow on Cisco routers and Catalyst series switches. The NetFlow Collection Engine collects packets from the router that is running NetFlow and decodes, aggregates, and stores them. You can generate reports on various aggregations that can be set up on the NetFlow Collection Engine.

**NetFlow v9** --NetFlow export format Version 9. A flexible and extensible means of carrying NetFlow records from a network node to a collector. NetFlow Version 9 has definable record types and is self-describing for easier NetFlow Collection Engine configuration.

**network byte order** --Internet-standard ordering of the bytes corresponding to numeric values.

**options data record** --Special type of data record that is used in the NetFlow process. It is based on an options template and has a reserved template ID that provides information about the NetFlow process itself.

**options template** --A type of template record that the router uses to communicate the format of NetFlow-related data to the NetFlow collector.

**P router** --provider core or backbone router. A router that is part of a service provider's core or backbone network and is connected to the provider edge (PE) routers.

**packet header** --First part of an export packet. It provides basic information about the packet (such as the NetFlow version, number of records contained in the packet, and sequence numbering) so that lost packets can be detected.

**PAL table** --Prefix/Application/Label table. A data structure that collects and exports the prefix, application, and time stamp for a specific label.

**PE router** --provider edge router. A router that is part of a service provider's network connected to a customer edge (CE) router. All Virtual Private Network (VPN) processing occurs in the PE router.

**RD** --route distinguisher. An 8-byte value that is concatenated with an IPv4 prefix to create a unique VPN IPv4 prefix.

There are two formats for configuring the route distinguisher argument. It can be configured in the as-number:network number (ASN:nn) format or it can be configured in the IP address:network number format (IP-address:nn).

**RP** --Route Processor. A processor module in the Cisco 7000 series routers that contains the CPU, system software, and most of the memory components that are used in the router. Sometimes called a Supervisory Processor.

**TE** --traffic engineering. Techniques and processes that 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.

**TE tunnel** --traffic engineering tunnel. 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.

**template flowset** --A collection of template records that are grouped in an export packet.

**template ID** --A unique number that distinguishes a template record produced by an export device from other template records produced by the same export device. A NetFlow Collection Engine application can receive export packets from several devices. You should be aware that uniqueness is not guaranteed across export devices. Thus, you should configure the NetFlow Collection Engine to cache the address of the export device that produced the template ID in order to enforce uniqueness.

**VPN** --Virtual Private Network. A secure IP-based network that shares resources on one or more physical networks. A VPN contains geographically dispersed sites that can communicate securely over a shared backbone.

**VPNv4 prefix** --IPv4 prefix preceded by an 8-byte route distinguisher. The VPN addresses are made unique by adding a route distinguisher to the front of the address.





## 6PE Multipath

---

The 6PE multipath feature uses multiprotocol internal BGP (MP-iBGP) to distribute IPv6 routes over the MPLS IPv4 core network and to attach an MPLS label to each route

- [Finding Feature Information, page 75](#)
- [Information About 6PE Multipath, page 75](#)
- [How to Configure 6PE Multipath, page 76](#)
- [Configuration Examples for 6PE Multipath, page 77](#)
- [Additional References, page 77](#)
- [Feature Information for 6PE Multipath, page 78](#)

### Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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 6PE Multipath

#### 6PE Multipath

Internal and external BGP multipath for IPv6 allows the IPv6 device to load balance between several paths (for example, the same neighboring autonomous system or subautonomous system, or the same metric) to reach its destination. The 6PE multipath feature uses MP-iBGP to distribute IPv6 routes over the MPLS IPv4 core network and to attach an MPLS label to each route.

When MP-iBGP multipath is enabled on the 6PE device, all labeled paths are installed in the forwarding table with MPLS information (label stack) when MPLS information is available. This functionality enables 6PE to perform load balancing.

## How to Configure 6PE Multipath

### Configuring IBGP Multipath Load Sharing

Perform this task to configure IBGP multipath load sharing and control the maximum number of parallel IBGP routes that can be installed in a routing table.

#### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp** *as-number*
4. **maximum-paths ibgp** *number-of-paths*

#### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>router bgp</b> <i>as-number</i>  <b>Example:</b> Device(config)# router bgp 65000	Enters router configuration mode for the specified routing process.
<b>Step 4</b>	<b>maximum-paths ibgp</b> <i>number-of-paths</i>  <b>Example:</b> Device(config-router)# maximum-paths ibgp 3	Controls the maximum number of parallel IBGP routes that can be installed in a routing table.

# Configuration Examples for 6PE Multipath

## Example: Configuring 6PE Multipath

```
Device# show ipv6 cef internals
IPv6 CEF is enabled and running
Slow processing intvl = 1 seconds backoff level current/max 0/0
0 unresolved prefixes, 0 requiring adjacency update
IPv6 CEF default table
14 prefixes tableid 0
table version 17
root 6283F5D0
```

## Additional References

### Related Documents

Related Topic	Document Title
IPv6 addressing and connectivity	<i>IPv6 Configuration Guide</i>
Cisco IOS commands	<a href="#">Master Commands List, All Releases</a>
IPv6 commands	<a href="#">IPv6 Command Reference</a>
Cisco IOS IPv6 features	<a href="#">IPv6 Feature Mapping</a>

### Standards and RFCs

Standard/RFC	Title
RFCs for IPv6	<i>IPv6 RFCs</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 6PE Multipath

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 11: Feature Information for 6PE Multipath**

Feature Name	Releases	Feature Information
6PE Multipath	12.2(25)S 12.2(28)SB 12.2(33)SRA 12.4(6)T	The 6PE multipath feature uses MP-iBGP to distribute IPv6 routes over the MPLS IPv4 core network and to attach an MPLS label to each route.  The following commands were introduced or modified: <b>maximum-paths ibgp, router bgp, show ipv6 cef internals.</b>



## IPv6 Switching: Provider Edge Router over MPLS

Multiprotocol Label Switching (MPLS) is deployed by many service providers in their IPv4 networks. Service providers want to introduce IPv6 services to their customers, but changes to their existing IPv4 infrastructure can be expensive and the cost benefit for a small amount of IPv6 traffic does not make economic sense. Several integration scenarios have been developed to leverage an existing IPv4 MPLS infrastructure and add IPv6 services without requiring any changes to the network backbone. This document describes how to implement IPv6 over MPLS.

- [Finding Feature Information, page 79](#)
- [Prerequisites for IPv6 Switching: Provider Edge Router over MPLS, page 80](#)
- [Information About IPv6 Switching: Provider Edge Router over MPLS, page 80](#)
- [How to Deploy IPv6 Switching: Provider Edge Router over MPLS, page 83](#)
- [Configuration Examples for IPv6 Switching: Provider Edge Router over MPLS, page 88](#)
- [Additional References for IPv6 Switching: Provider Edge Router over MPLS, page 92](#)
- [Feature Information for IPv6 Switching: Provider Edge Router over MPLS, page 92](#)

### Finding Feature Information

Your software release may not support all the features documented in this module. For the latest caveats and feature information, see [Bug Search Tool](#) and 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 module.

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 IPv6 Switching: Provider Edge Router over MPLS

Before the IPv6 Provider Edge Router over MPLS (6PE) feature can be implemented, MPLS must be running over the core IPv4 network. If Cisco devices are used, Cisco Express Forwarding or distributed Cisco Express Forwarding must be enabled for both IPv4 and IPv6 protocols. This module assumes that you are familiar with MPLS.

## Information About IPv6 Switching: Provider Edge Router over MPLS

### Benefits of Deploying IPv6 over MPLS Backbones

IPv6 over MPLS backbones enables isolated IPv6 domains to communicate with each other over an MPLS IPv4 core network. This implementation requires only a few backbone infrastructure upgrades and no reconfiguration of core devices because forwarding is based on labels rather than the IP header itself, providing a very cost-effective strategy for the deployment of IPv6.

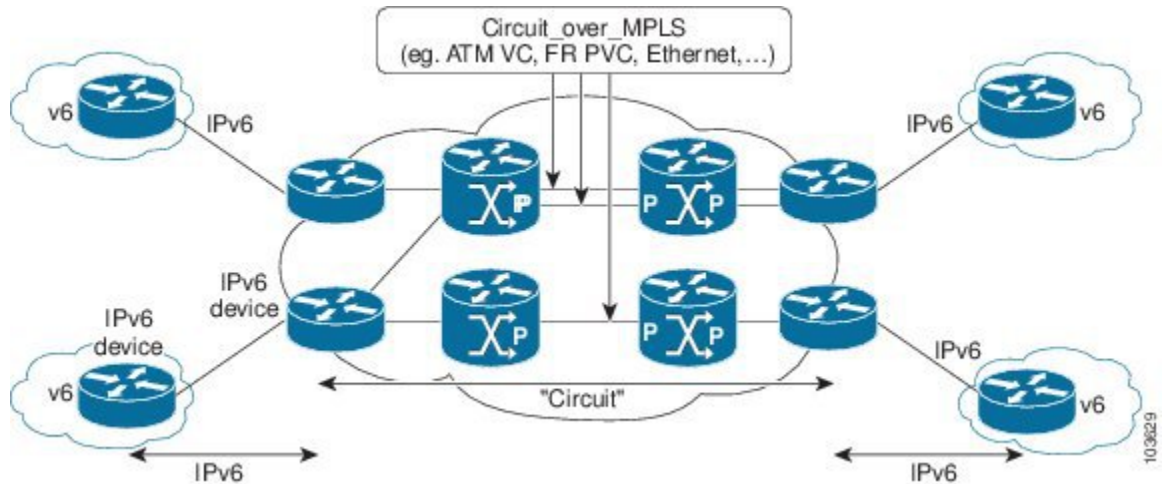
Additionally, the inherent Virtual Private Network (VPN) and MPLS traffic engineering (MPLS-TE) services available within an MPLS environment allow IPv6 networks to be combined into IPv4 VPNs or extranets over an infrastructure supporting IPv4 VPNs and MPLS-TE.

### IPv6 over a Circuit Transport over MPLS

Using any circuit transport for deploying IPv6 over MPLS networks has no impact on the operation or infrastructure of MPLS, and requires no configuration changes to the core or provider edge devices. Communication between the remote IPv6 domains runs native IPv6 protocols over a dedicated link, where the underlying mechanisms are fully transparent to IPv6. The IPv6 traffic is tunneled using the Any Transport over MPLS (MPLS/AToM) or Ethernet over MPLS (EoMPLS) feature with the devices connected through an ATM OC-3 or Ethernet interface, respectively.

The figure below shows the configuration for IPv6 over any circuit transport over MPLS.

**Figure 6: IPv6 over a Circuit Transport over MPLS**

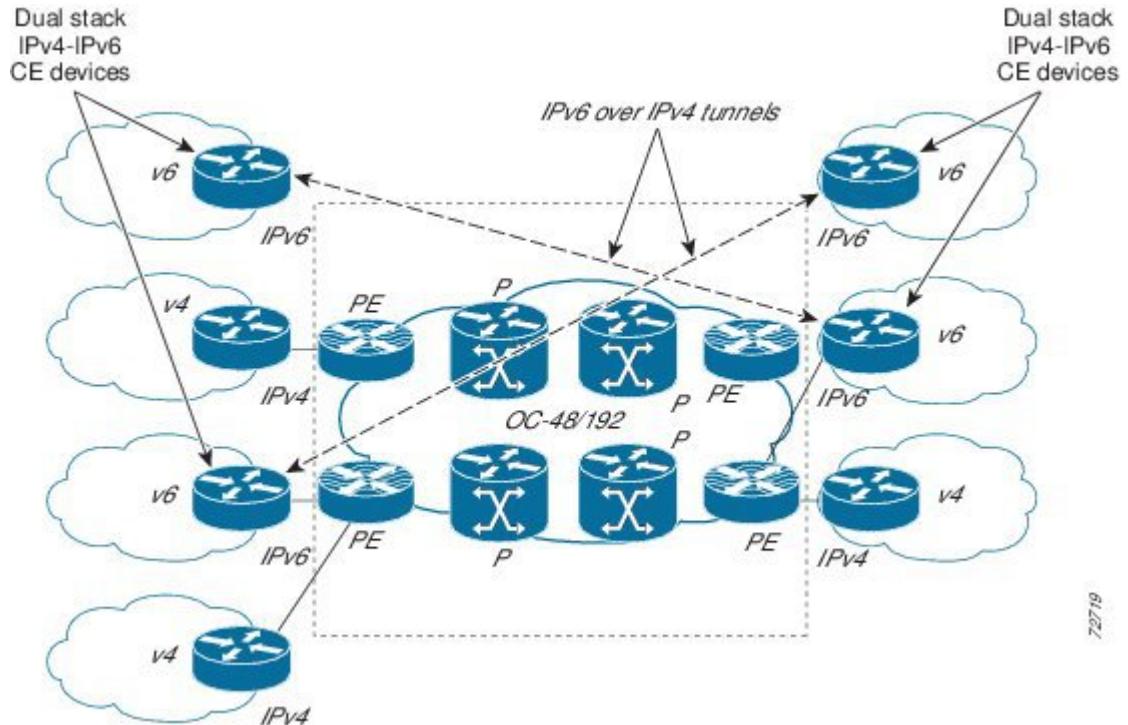


## IPv6 Using Tunnels on the Customer Edge Devices

Using tunnels on the customer edge (CE) devices is the simplest way of deploying IPv6 over MPLS networks with no impact on the operation or infrastructure of MPLS, and no configuration changes to the core or provider edge devices. Communication between the remote IPv6 domains uses standard tunneling mechanisms and

requires the CE devices to be configured to run dual IPv4 and IPv6 protocol stacks. The figure below shows the configuration using tunnels on the CE devices.

**Figure 7: IPv6 Using Tunnels on the CE Devices**



Refer to Implementing Tunneling for IPv6 for configuration information on manually configured tunnels, automatic tunnels, and 6to4 tunnels.

Limitations on using tunnels involve the manual configuring of a mesh of tunnels on the CE devices, creating scaling issues for large networks.

## IPv6 on the Provider Edge Devices

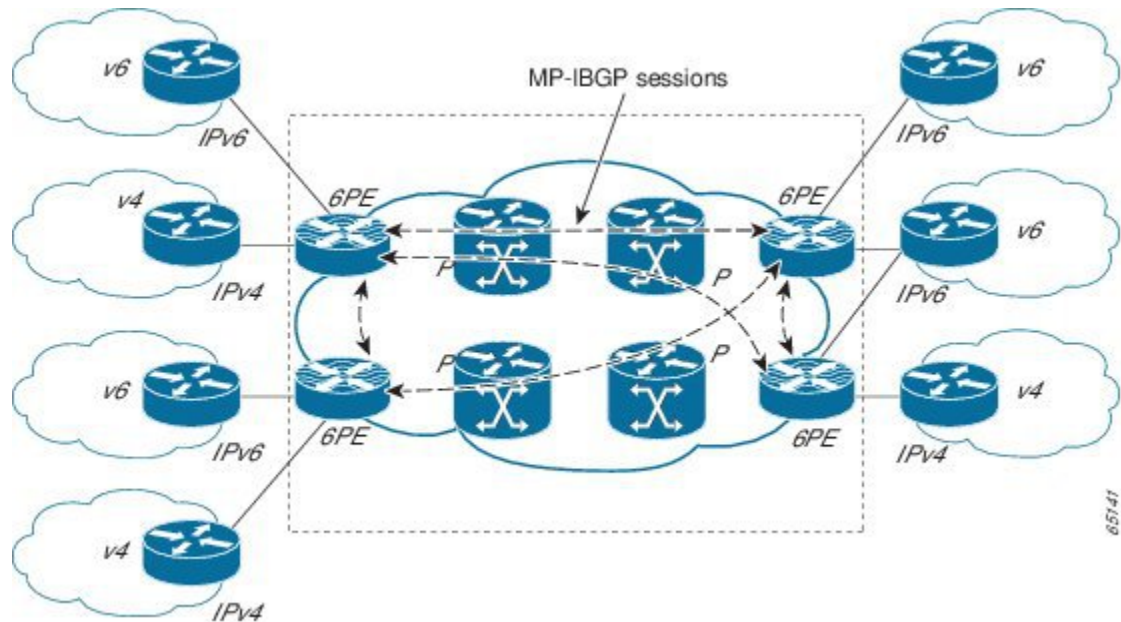
The Cisco implementation of IPv6 Provider Edge Router over MPLS is called 6PE, and it enables IPv6 sites to communicate with each other over an MPLS IPv4 core network using MPLS label switched paths (LSPs). This feature relies on multiprotocol Border Gateway Protocol (BGP) extensions in the IPv4 network configuration on the provider edge (PE) device to exchange IPv6 reachability information in addition to an MPLS label for each IPv6 address prefix to be advertised. Edge devices are configured to be dual stack running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange.

A hierarchy of labels is imposed on the 6PE ingress device to keep the IPv6 traffic transparent to all the core devices. The top label provides connectivity inside the IPv4 MPLS core network and the label is distributed by Label Distribution Protocol (LDP), Tag Distribution Protocol (TDP), or Resource Reservation Protocol (RSVP). TDP and LDP can both be used for label distribution, but RSVP is used only in the context of MPLS-TE label exchange. The bottom label, automatically assigned to the IPv6 prefix of the destination, is distributed by multiprotocol BGP and used at each 6PE egress device for IPv6 forwarding.



In the figure below the 6PE devices are configured as dual stack devices able to route both IPv4 and IPv6 traffic. Each 6PE device is configured to run LDP, TDP, or RSVP (if traffic engineering is configured) to bind the IPv4 labels. The 6PE devices use multiprotocol BGP to exchange reachability information with the other 6PE devices within the MPLS domain, and to distribute IPv6 labels between them. All 6PE and core devices--P devices in Figure 3--within the MPLS domain share a common IPv4 Interior Gateway Protocol (IGP) such as Open Shortest Path First (OSPF) or Integrated Intermediate System-to-Intermediate System (IS-IS).

**Figure 8: 6PE Device Topology**



The interfaces on the 6PE devices connecting to the CE device can be configured to forward IPv6 traffic, IPv4 traffic, or both types of traffic depending on the customer requirements. 6PE devices advertise IPv6 reachability information learned from their 6PE peers over the MPLS cloud. Service providers can delegate an IPv6 prefix from their registered IPv6 prefixes over the 6PE infrastructure; otherwise, there is no impact on the CE device.

The P devices in the core of the network are not aware that they are switching IPv6 packets. Core devices are configured to support MPLS and the same IPv4 IGP as the PE devices to establish internal reachability inside the MPLS cloud. Core devices also use LDP, TDP, or RSVP for binding IPv4 labels. Implementing the Cisco 6PE feature does not have any impact on the MPLS core devices.

Within the MPLS network, IPv6 traffic is forwarded using label switching, making the IPv6 traffic transparent to the core of the MPLS network. No IPv6 over IPv4 tunnels or Layer 2 encapsulation methods are required.

## How to Deploy IPv6 Switching: Provider Edge Router over MPLS

### Deploying IPv6 over a Circuit Transport over MPLS

To deploy IPv6 over a circuit transport over MPLS, the IPv6 devices must be configured for IPv6 connectivity. The MPLS device configuration requires AToM configuration or EoMPLS configuration.

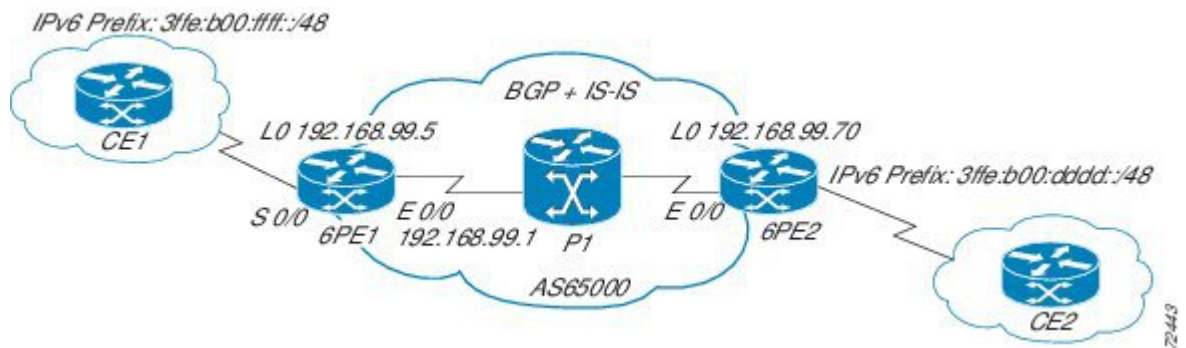
## Deploying IPv6 on the Provider Edge Devices (6PE)

### Specifying the Source Address Interface on a 6PE Device

Two configuration tasks using the network shown in the figure below are required at the 6PE1 device to enable the 6PE feature.

The customer edge device--CE1 in the figure below--is configured to forward its IPv6 traffic to the 6PE1 device. The P1 device in the core of the network is assumed to be running MPLS, a label distribution protocol, an IPv4 IGP, and Cisco Express Forwarding or distributed Cisco Express Forwarding, and does not require any new configuration to enable the 6PE feature.

**Figure 9: 6PE Configuration Example**



### Before You Begin

- The 6PE devices--the 6PE1 and 6PE2 devices in the figure below--must be members of the core IPv4 network. The 6PE device interfaces attached to the core network must be running MPLS, the same label distribution protocol, and the same IPv4 IGP, as in the core network.
- The 6PE devices must also be configured to be dual stack to run both IPv4 and IPv6.

### SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 unicast-routing**
4. **ipv6 cef**
5. **interface** *type number*
6. **ipv6 address** *ipv6-address / prefix-length | prefix-name sub-bits / prefix-length*

## DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>ipv6 unicast-routing</b>  <b>Example:</b> Device(config)# ipv6 unicast-routing	Enables the forwarding of IPv6 unicast datagrams.
<b>Step 4</b>	<b>ipv6 cef</b>  <b>Example:</b> Device(config)# ipv6 cef	Enables IPv6 Cisco Express Forwarding.
<b>Step 5</b>	<b>interface</b> <i>type number</i>  <b>Example:</b> Device(config)# interface Serial 0/0	Specifies an interface type and number and enters interface configuration mode. <ul style="list-style-type: none"> <li>• In the context of this feature, the interface to be configured is the interface communicating with the CE device.</li> </ul>
<b>Step 6</b>	<b>ipv6 address</b> <i>ipv6-address / prefix-length   prefix-name sub-bits / prefix-length</i>  <b>Example:</b> Device(config-if)# ipv6 address 2001:DB8:FFFF::2/64	Configures an IPv6 address based on an IPv6 general prefix and enable IPv6 processing on an interface.

## Binding and Advertising the 6PE Label to Advertise Prefixes

Perform this task to enable the binding and advertising of labels when advertising IPv6 prefixes to a specified BGP neighbor.

## SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **router bgp** *as-number*
4. **no bgp default ipv4-unicast**
5. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **remote-as** *as-number*
6. **neighbor** {*ip-address* | *ipv6-address* | *peer-group-name*} **update-source** *interface-type interface-number*
7. **address-family ipv6** [**unicast**]
8. **neighbor** {*ip-address* | *peer-group-name* | *ipv6-address*} **activate**
9. **neighbor** {*ip-address* | *ipv6-address*} **send-label**

## DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.
<b>Step 3</b>	<b>router bgp</b> <i>as-number</i>  <b>Example:</b> Device(config)# router bgp 65000	Enters router configuration mode for the specified routing process.
<b>Step 4</b>	<b>no bgp default ipv4-unicast</b>  <b>Example:</b> Device(config-router)# no bgp default ipv4-unicast	Disables the IPv4 unicast address family for the BGP routing process specified in the previous step. <p><b>Note</b> Routing information for the IPv4 unicast address family is advertised by default for each BGP routing session configured with the <b>neighbor remote-as</b> command unless you configure the <b>no bgp default ipv4-unicast</b> command before configuring the <b>neighbor remote-as</b> command.</p>
<b>Step 5</b>	<b>neighbor</b> { <i>ip-address</i>   <i>ipv6-address</i>   <i>peer-group-name</i> } <b>remote-as</b> <i>as-number</i>  <b>Example:</b> Device(config-router)# neighbor 192.168.99.70 remote-as 65000	Adds the IP address of the neighbor in the specified autonomous system to the BGP neighbor table of the local device.

	Command or Action	Purpose
<b>Step 6</b>	<p><b>neighbor</b> { <i>ip-address</i>   <i>ipv6-address</i>   <i>peer-group-name</i> } <b>update-source</b> <i>interface-type</i> <i>interface-number</i></p> <p><b>Example:</b></p> <pre>Device(config-router)# neighbor 192.168.99.70 update-source Loopback 0</pre>	<p>Specifies the interface whose IPv4 address is to be used as the source address for the peering.</p> <ul style="list-style-type: none"> <li>In the context of this task, the interface must have an IPv4 address with a 32-bit mask configured. Use of a loopback interface is recommended. This address is used to determine the IPv6 next hop by the peer 6PE.</li> </ul>
<b>Step 7</b>	<p><b>address-family ipv6</b> [<b>unicast</b>]</p> <p><b>Example:</b></p> <pre>Device(config-router)# address-family ipv6</pre>	<p>Specifies the IPv6 address family and enters address family configuration mode.</p> <ul style="list-style-type: none"> <li>The <b>unicast</b> keyword specifies the IPv6 unicast address family. By default, the device is placed in configuration mode for the IPv6 unicast address family if the <b>unicast</b> keyword is not specified with the <b>address-family ipv6</b> command.</li> </ul>
<b>Step 8</b>	<p><b>neighbor</b> { <i>ip-address</i>   <i>peer-group-name</i>   <i>ipv6-address</i> } <b>activate</b></p> <p><b>Example:</b></p> <pre>Device(config-router-af)# neighbor 192.168.99.70 activate</pre>	<p>Enables the neighbor to exchange prefixes for the IPv6 address family with the local device.</p>
<b>Step 9</b>	<p><b>neighbor</b> { <i>ip-address</i>   <i>ipv6-address</i> } <b>send-label</b></p> <p><b>Example:</b></p> <pre>Device(config-router-af)# neighbor 192.168.99.70 send-label</pre>	<p>Advertises the capability of the device to send MPLS labels with BGP routes.</p> <ul style="list-style-type: none"> <li>In IPv6 address family configuration mode this command enables binding and advertisement of labels when advertising IPv6 prefixes in BGP.</li> </ul>

## Configuring IBGP Multipath Load Sharing

Perform this task to configure IBGP multipath load sharing and control the maximum number of parallel IBGP routes that can be installed in a routing table.

### SUMMARY STEPS

- enable**
- configure terminal**
- router bgp** *as-number*
- maximum-paths ibgp** *number-of-paths*

## DETAILED STEPS

	Command or Action	Purpose
Step 1	<b>enable</b>  <b>Example:</b> Device> 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> Device# configure terminal	Enters global configuration mode.
Step 3	<b>router bgp <i>as-number</i></b>  <b>Example:</b> Device(config)# router bgp 65000	Enters router configuration mode for the specified routing process.
Step 4	<b>maximum-paths ibgp <i>number-of-paths</i></b>  <b>Example:</b> Device(config-router)# maximum-paths ibgp 3	Controls the maximum number of parallel IBGP routes that can be installed in a routing table.

## Configuration Examples for IPv6 Switching: Provider Edge Router over MPLS

### Example: Customer Edge Device

This example shows that the serial interface 0/0 of the customer edge device--CE1 in the figure above--is connected to the service provider and is assigned an IPv6 address. IPv6 is enabled and a default static route is installed using the IPv6 address of serial interface 0/0 of the 6PE1 device.

```
ip cef
!
ipv6 unicast-routing
!
interface Serial 0/0
  description to_6PE1_router
  no ip address
  ipv6 address 2001:DB8:FFFF::2/64
!
ipv6 route ::/0 Serial 0/0 FE80::210:XXXX:FEE1:1001
```

## Example: Provider Edge Device

The 6PE device--Device 6PE1 in the figure above--is configured for both IPv4 and IPv6 traffic. Ethernet interface 0/0 is configured with an IPv4 address and is connected to a device in the core of the network--device P1 in the figure above. Integrated IS-IS and TDP configurations on this device are similar to the P1 device.

Device 6PE1 exchanges IPv6 routing information with another 6PE device--Device 6PE2 in the figure above--using internal BGP (iBGP) established over an IPv4 connection so that all the **neighbor** commands use the IPv4 address of the 6PE2 device. All the BGP peers are within autonomous system 65000, so synchronization with IGP is turned off for IPv4. In IPv6 address family configuration mode, synchronization is disabled by default.

IPv6 and Cisco Express Forwarding for IPv6 are enabled, the 6PE2 neighbor is activated, and label binding and advertisement is enabled for IPv6 prefixes using the **neighbor send-label** command. Connected and static IPV6 routes are redistributed using BGP. If IPv6 packets are generated in the local device, the IPv6 address for MPLS processing will be the address of loopback interface 0.

This example shows that the serial interface 0/0 connects to the customer and the IPv6 prefix delegated to the customer is 2001:DB8:ffff::/48, which is determined from the service provider IPv6 prefix. A static route is configured to route IPv6 packets between the 6PE route and the CE device.

```
ip cef
ipv6 cef
ipv6 unicast-routing
!
mpls ipv6 source-interface Loopback0
tag-switching tdp router-id Loopback0
!
interface Loopback0
 ip address 192.168.99.5 255.255.255.255
 ipv6 address 2001:DB8:1000:1::1/64
!
interface Ethernet0/0
 description to_P_router
 ip address 192.168.99.1 255.255.255.252
 ip router isis
 tag-switching ip
!
interface Serial0/0
 description to_CE_router
 no ip address
 ipv6 address 2001:DB8:FFFF::1/64
!
router isis
 passive-interface Loopback0
 net 49.0001.1921.6809.9005.00
!
router bgp 65000
 no bgp default ipv4-unicast
 bgp log-neighbor-changes
 neighbor 192.168.99.70 remote-as 65000
 neighbor 192.168.99.70 description to_6PE2
 neighbor 192.168.99.70 update-source Loopback0
!
 address-family ipv6
  neighbor 192.168.99.70 activate
  neighbor 192.168.99.70 send-label
  network 2001:DB8:FFFF::/48
 exit-address-family
!
ipv6 route 2001:DB8:FFFF::/48 Ethernet0/0 2001:DB8:FFFF::2
```

## Example: Core Device

This example shows that the device in the core of the network--Device P in the figure above--is running MPLS, IS-IS, and IPv4 only. The Ethernet interfaces are configured with IPv4 address and are connected to the 6PE devices. IS-IS is the IGP for this network and the P1 and 6PE devices are in the same IS-IS area 49.0001. TDP and tag switching are enabled on both the Ethernet interfaces. Cisco Express Forwarding is enabled in global configuration mode.

```
ip cef
!
tag-switching tdp router-id Loopback0
!
interface Loopback0
 ip address 192.168.99.200 255.255.255.255
!
interface Ethernet0/0
 description to_6PE1
 ip address 192.168.99.2 255.255.255.252
 ip router isis
 tag-switching ip
!
interface Ethernet0/1
 description to_6PE2
 ip address 192.168.99.66 255.255.255.252
 ip router isis
 tag-switching ip
router isis
 passive-interface Loopback0
 net 49.0001.1921.6809.9200.00
```

## Example: Monitoring 6PE

This example shows output information about an IPv6 route using the **show bgp ipv6** command with an IPv6 prefix:

```
Device# show bgp ipv6 2001:DB8:DDDD::/48

BGP routing table entry for 2001:DB8:DDDD::/48, version 15
Paths: (1 available, best #1, table Global-IPv6-Table)
  Not advertised to any peer
  Local
    ::FFFF:192.168.99.70 (metric 20) from 192.168.99.70 (192.168.99.70)
      Origin IGP, localpref 100, valid, internal, best
```

This example shows output information about a BGP peer, including the IPv6 label capability, using the **show bgp ipv6 neighbors** command with an IP address:

```
Device# show bgp ipv6 neighbors 192.168.99.70

BGP neighbor is 192.168.99.70, remote AS 65000, internal link
  BGP version 4, remote router ID 192.168.99.70
  BGP state = Established, up for 00:05:17
  Last read 00:00:09, hold time is 0, keepalive interval is 60 seconds
  Neighbor capabilities:
    Route refresh: advertised and received
    Address family IPv6 Unicast: advertised and received
    ipv6 MPLS Label capability: advertised and received
  Received 54 messages, 0 notifications, 0 in queue
  Sent 55 messages, 1 notifications, 0 in queue
  Default minimum time between advertisement runs is 5 seconds

For address family: IPv6 Unicast
  BGP table version 21880, neighbor version 21880
  Index 1, Offset 0, Mask 0x2
  Route refresh request: received 0, sent 0
```



```

77 accepted prefixes consume 4928 bytes
Prefix advertised 4303, suppressed 0, withdrawn 1328
Number of NLRIs in the update sent: max 1, min 0

```

This example shows output information linking the MPLS label with prefixes using the **show mpls forwarding-table** command. If the 6PE feature is configured, the labels are aggregated because there are several prefixes for one local label, and the prefix column contains IPv6 instead of a target prefix.

```
Device# show mpls forwarding-table
```

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
16	Pop Label	1.1.1.1/32	0		Et0/0	10.0.0.1
18	No Label	nh-id(1)	0		Et2/0	10.0.2.2
19	No Label	nh-id(2)	0		Et1/0	10.0.1.2
20	No Label	nh-id(3)	0		Et1/0	10.0.1.2
22	No Label	nh-id(5)	0		Et1/0	10.0.1.2
24	No Label	nh-id(5)	0		Et2/0	10.0.2.2

This example shows output information about the top of the stack label with label switching information using the **show bgp ipv6 labels** command with the **labels** keyword:

```
Device# show bgp ipv6 labels
```

```

Network                Next Hop                In tag/Out tag
2001:DB8:DDDD::/64    ::FFFF:192.168.99.70    notag/20

```

This example shows output information about labels from the Cisco Express Forwarding table using the **show ipv6 cef** command with an IPv6 prefix:

```
Device# show ipv6 cef 2001:DB8:DDDD::/64
```

```

2001:DB8:DDDD::/64
  nexthop ::FFFF:192.168.99.70
  fast tag rewrite with Se0/0, point2point, tags imposed {19 20}

```

This example shows output information from the IPv6 routing table using the **show ipv6 route** command. The output shows the IPv6 MPLS virtual interface as the output interface of IPv6 routes forwarded across the MPLS cloud.

The 6PE2 device has advertised the IPv6 prefix of 2001:DB8:dddd::/48 configured for the CE2 device and the next-hop address is the IPv4-compatible IPv6 address ::ffff:192.168.99.70, where 192.168.99.70 is the IPv4 address of the 6PE2 device.

```
Device# show ipv6 route
```

```

IPv6 Routing Table - 10 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea
B 2001:DB8:DDDD::/64 [200/0]
  via ::FFFF:192.168.99.70, IPv6-mpls
B 2001:DB8:DDDD::/64 [200/0]
  via ::FFFF:192.168.99.70, IPv6-mpls
L 2001:DB8:FFFF::1/128 [0/0]
  via ::, Ethernet0/0
C 2001:DB8:FFFF::/64 [0/0]
  via ::, Ethernet0/0
S 2001:DB8:FFFF::/48 [1/0]
  via 2001:DB8:B00:FFFF::2, Ethernet0/0

```

## Additional References for IPv6 Switching: Provider Edge Router over MPLS

### Related Documents

Related Topic	Document Title
IPv6 addressing and connectivity	<i>IPv6 Configuration Guide</i>
Cisco IOS commands	<a href="#">Master Commands List, All Releases</a>
IPv6 commands	<a href="#">IPv6 Command Reference</a>
Cisco IOS IPv6 features	<a href="#">IPv6 Feature Mapping</a>

### Standards and RFCs

Standard/RFC	Title
RFCs for IPv6	<i>IPv6 RFCs</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 IPv6 Switching: Provider Edge Router over MPLS

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

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

**Table 12: Feature Information for IPv6 Switching: Provider Edge Router over MPLS**

Feature Name	Releases	Feature Information
IPv6 Switching: Provider Edge Router over MPLS	12.0(22)S 12.2(14)S 12.2(28)SB 12.2(33)SRA 12.2(15)T	<p>The Cisco implementation of IPv6 Provider Edge Router over MPLS enables IPv6 sites to communicate with each other over an MPLS IPv4 core network using MPLS LSPs.</p> <p>The following commands were introduced or modified:  <b>address-family ipv6, ipv6 address, ipv6 cef, ipv6 unicast-routing, maximum-paths ibgp, neighbor activate, neighbor remote-as, neighbor send-label, neighbor update-source, no bgp default ipv4-unicast, router bgp, show bgp ipv6, show bgp ipv6 labels, show bgp ipv6 neighbors, show ipv6 cef, show ipv6 route, show mpls forwarding-table.</b></p>

