

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.

- Prerequisites for MPLS Multilink PPP Support, on page 1
- Information About MPLS Multilink PPP Support, on page 1
- How to Configure MPLS Multilink PPP Support, on page 6
- Configuration Examples for MPLS Multilink PPP Support, on page 15
- Additional References for MPLS Multilink PPP Support, on page 18
- Feature Information for MPLS Multilink PPP Support, on page 18
- Glossary, on page 19

Prerequisites for MPLS Multilink PPP Support

- 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.

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 1: 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
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 (eiBGP) 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 2: 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

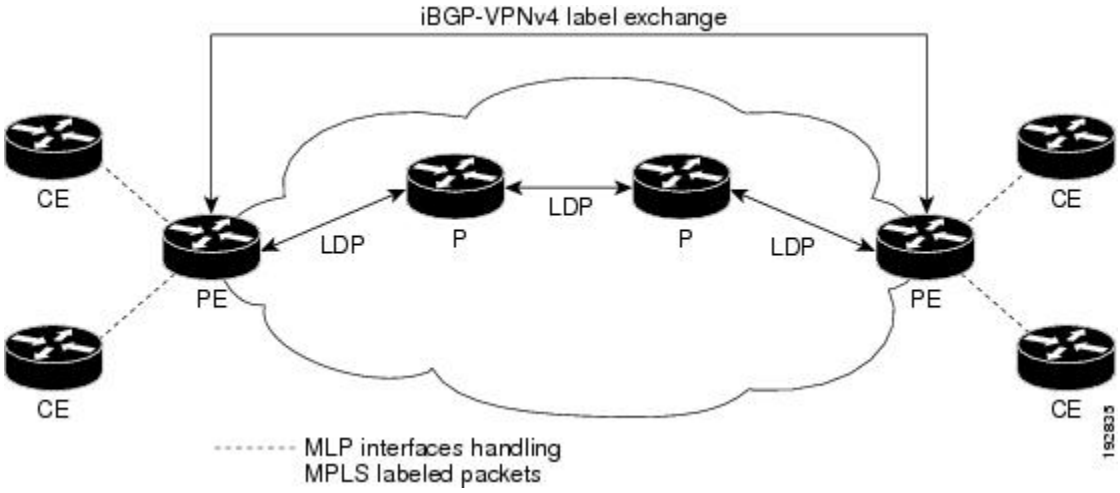
MPLS QoS Feature	CE-to-PE Links	PE-to-P Links	CSC CE-to-PE Links
Set MPLS EXP bits using the modular QoS Command-Line Interface (MQC)	Supported	Supported	Supported
Matching on MPLS EXP using MQC	Supported	Supported	Supported
Low Latency Queueing (LLQ)/Class-Based Weighted Fair Queueing (CBWFQ) support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

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.

Figure 1: MLP and Traditional PE-to-CE Links



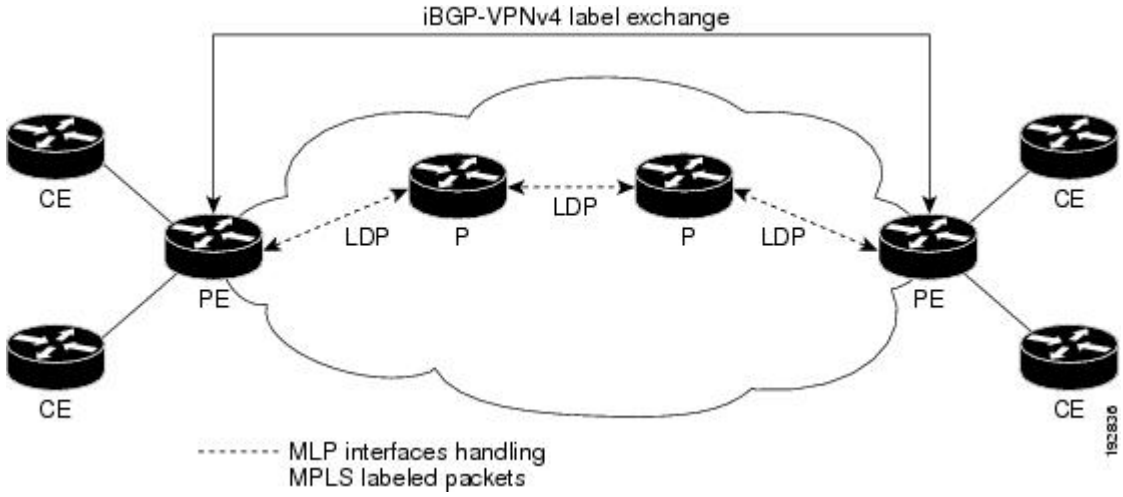
The PE-to-CE routing protocols that are supported for the MPLS Multilink PPP Support feature are external BGP (eBGP), Open Shortest Path First (OSPF), and Enhanced Interior Gateway Routing Protocol (EIGRP). Static routes are also supported between the CE and PE device.

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), header compression, 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 2: MLP on PE-to-P and P-to-P Links



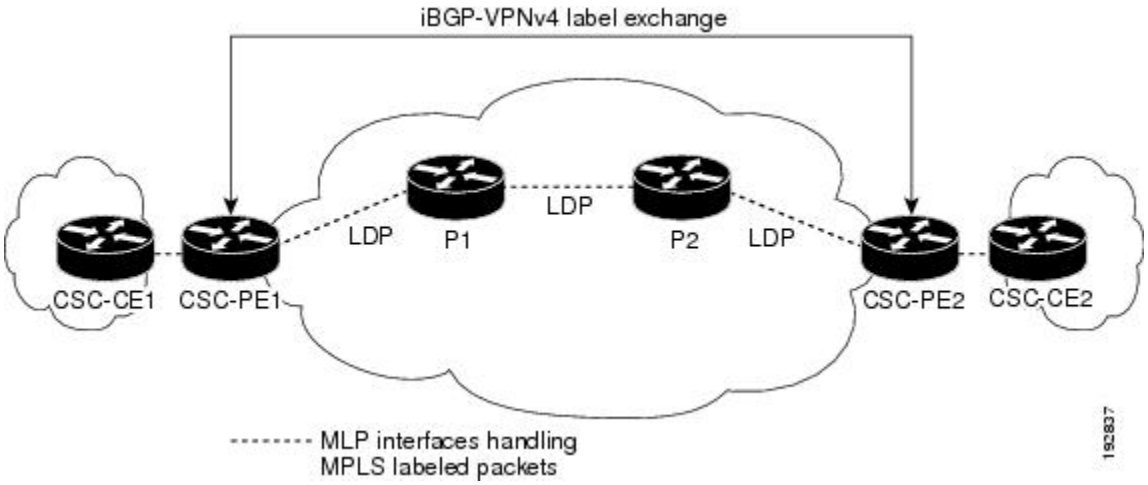
You employ MLP in the PE-to-P or P-to-P links primarily so that you can reduce the number of Interior Gateway Protocol (IGP) adjacencies and facilitate the load sharing of traffic.

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

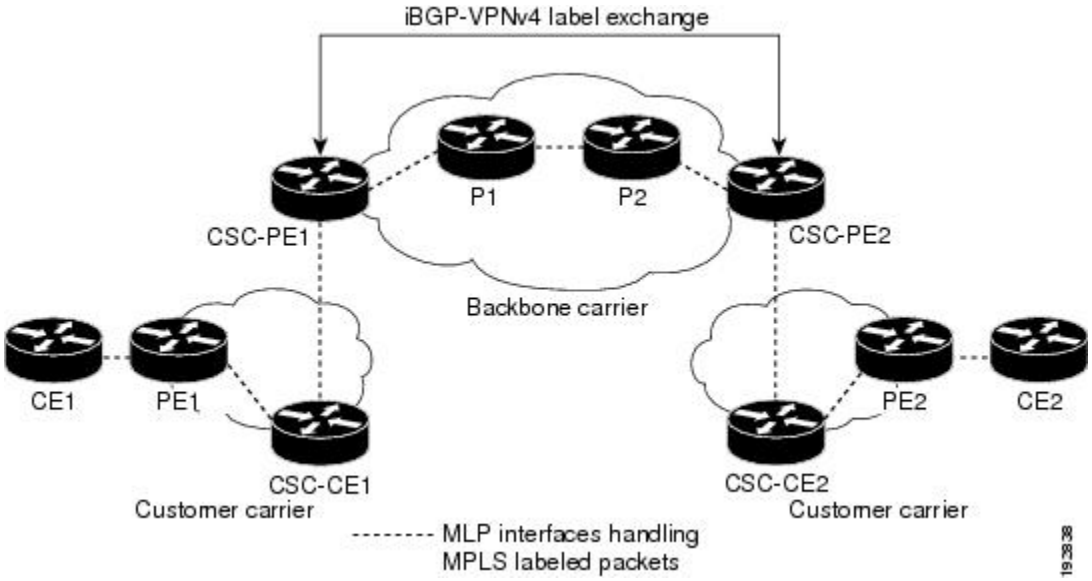
The figure below shows a typical Multiprotocol Label Switching (MPLS) Virtual Private Network (VPN) Carrier Supporting Carrier (CSC) network where Multilink PPP (MLP) is configured on the CSC customer edge (CE)-to-provider edge (PE) links.

Figure 3: 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.

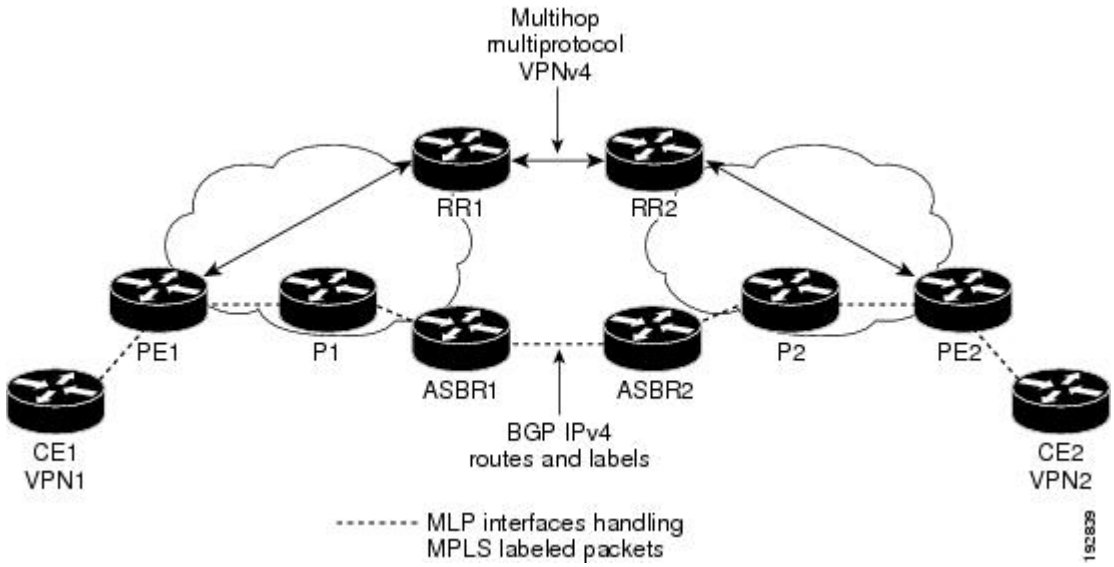
Figure 4: MLP Supported Links with MPLS VPN Carrier Supporting Carrier



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 5: 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

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

Before you begin

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

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

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

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

SUMMARY STEPS

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

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip cef** **Example:** `Device(config)# ip cef`	Enables Cisco Express Forwarding.
Step 4	**exit** **Example:** `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

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface multilink** *group-number* **Example:** `Device(config)# interface multilink 1`	Creates a multilink bundle and enters multilink interface configuration mode. • The *group-number* argument is the number of the multilink bundle (a nonzero number).
Step 4	**ip address** *address mask* [**secondary**] **Example:** `Device(config-if)# ip address 10.0.0.0 255.255.0.0`	Sets a primary or secondary IP address for an interface. • The *address* argument is the IP address. • The *mask* argument is the mask for the associated IP subnet. • The **secondary** keyword specifies that the configured address is a secondary IP address. If this keyword is omitted, the configured address is the primary IP address. This command is used to assign an IP address to the multilink interface.
Step 5	**encapsulation** *encapsulation-type* **Example:** `Device(config-if)# encapsulation ppp`	Sets the encapsulation method as PPP to be used by the interface. • The *encapsulation-type* argument specifies the encapsulation type.
Step 6	**ppp multilink** **Example:** `Device(config-if)# ppp multilink`	Enables MLP on an interface.
Step 7	**end** **Example:** `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/subslot/port*[**.***subinterface*]
7. **ip route-cache** [**cef**]
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

Procedure

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

	Command or Action	Purpose
	Example: `Device(config-controller)# channel-group 1 timeslots 1`	• The *channel-number* 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. • The **timeslots** *range* 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).
Step 5	**exit** **Example:** `Device(config-controller)# exit`	Returns to global configuration mode.
Step 6	**interface serial** *slot/subslot/port*[**.***subinterface*] **Example:** `Device(config)# interface serial 1/0/0:1`	Configures a serial interface and enters interface configuration mode.
Step 7	**ip route-cache** [**cef**] **Example:** `Device(config-if)# ip route-cache cef`	Controls the use of switching methods for forwarding IP packets. • The **cef** keyword enables Cisco Express Forwarding operation on an interface after Cisco Express Forwarding operation was disabled.
Step 8	**no ip address** **Example:** `Device(config-if)# no ip address`	Removes any specified IP address.
Step 9	**keepalive** [*period* [*retries*]] **Example:** `Device(config-if)# keepalive`	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. • The *period* argument is an integer value, in seconds, greater than 0. The default is 10. • The *retries* argument specifies the number of times that the device continues to send keepalive packets without a response before bringing the interface down.

	Command or Action	Purpose
		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. 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.
Step 10	**encapsulation** *encapsulation-type* **Example:** `Device(config-if)# encapsulation ppp`	Sets the encapsulation method used by the interface. • The *encapsulation-type* argument specifies the encapsulation type. The example specifies PPP encapsulation.
Step 11	**ppp multilink group** *group-number* **Example:** `Device(config-if)# ppp multilink group 1`	Restricts a physical link to join only one designated multilink group interface. • The *group-number* argument is the number of the multilink bundle (a nonzero number).
Step 12	**ppp multilink** **Example:** `Device(config-if)# ppp multilink`	Enables MLP on the interface.
Step 13	**ppp authentication chap** **Example:** `Device(config-if)# ppp authentication chap`	(Optional) Enables Challenge Handshake Authentication Protocol (CHAP) authentication on the serial interface.
Step 14	**end** **Example:** `Device(config-if)# end`	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

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface serial 1/0/0`	Configures an interface type and enters interface configuration mode. • The *type* argument indicates the type of interface to be configured. • The *number* 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 **show interfaces** command.
Step 4	**ppp multilink fragmentation disable** **Example:** `Device(config-if)# ppp multilink fragmentation disable`	Disables packet fragmentation.
Step 5	**end** **Example:** `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

Procedure

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:

Step 3 **show ppp multilink**

Verifies that you have created a multilink bundle.

Example:

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

Displays information about a specific MLP interface.

Example:

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

Displays information about serial interfaces in your configuration.

Example:

```
Device#


  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#


  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  Outgoing    Prefix           Bytes tag  Outgoing   Next Hop
tag    tag or VC   or Tunnel Id     switched   interface
16     Untagged    10.30.0.1/32     0          Mu6        point2point
17     Pop tag     10.0.0.3/32      0          Mu6        point2point
18     Untagged    10.0.0.9/32[V]   0          Mu10       point2point
19     Untagged    10.0.0.11/32[V]  6890       Mu10       point2point
20     Untagged    10.32.0.0/8[V]   530        Mu10       point2point
21     Aggregate   10.34.0.0/8[V]   0
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

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
!


!

 no ip address
 encapsulation ppp

 ppp multilink
 ppp multilink group 1

interface Multilink1
 ip vrf forwarding vpn2
 ip address 10.35.0.2 255.0.0.0
 no peer neighbor-route
 load-interval 30
 ppp multilink
 ppp multilink interleave
 ppp multilink group 1

!
!
router ospf 200
 log-adjacency-changes
 auto-cost reference-bandwidth 1000
 redistribute connected subnets
 passive-interface Multilink1
 network 10.0.0.7 0.0.0.0 area 200
 network 10.31.0.0 0.255.255.255 area 200
!
!
 router bgp 200
 no bgp default ipv4-unicast
 bgp log-neighbor-changes
 neighbor 10.0.0.11 remote-as 200
 neighbor 10.0.0.11 update-source Loopback0
 !
 address-family vpnv4
 neighbor 10.0.0.11 activate
 neighbor 10.0.0.11 send-community extended
 bgp scan-time import 5
 exit-address-family
 !
 address-family ipv4 vrf vpn2
 redistribute connected
 neighbor 10.35.0.1 remote-as 300
 neighbor 10.35.0.1 activate
 neighbor 10.35.0.1 as-override
 neighbor 10.35.0.1 advertisement-interval 5
 no auto-summary
 no synchronization
 exit-address-family
```

Example: Enabling Cisco Express Forwarding

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

```
Device> enable
Device# configure terminal
Device(config)# ip cef
```

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



 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp multilink
 ppp multilink group 1

 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp chap hostname group 1
 ppp multilink
 ppp multilink group 1

 no ip address
 encapsulation ppp
 ip route-cache cef
 no keepalive
 ppp chap hostname group 1
 ppp multilink
 ppp multilink group 1

 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	Cisco IOS Master Commands List, All Releases
MPLS commands	Cisco IOS Multiprotocol Label Switching Command Reference
Basic MPLS VPNs	"MPLS Virtual Private Networks" chapter in the *MPLS Layer 3 VPNs Configuration Guide*

RFCs

RFCs	Title
RFC 1990	*The PPP Multilink Protocol (MP)*

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.	http://www.cisco.com/cisco/web/support/index.html

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. An account on Cisco.com is not required.

Table 3: Feature Information for MPLS Multilink PPP Support

Feature Name	Releases	Feature Information
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).

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—ink 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.