QoS: Latency and Jitter Configuration Guide, Cisco IOS XE Gibraltar 16.12.x

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Read Me First

Important Information about Cisco IOS XE 16

Effective Cisco IOS XE Release 3.7.0E for Catalyst Switching and Cisco IOS XE Release 3.17S (for Access and Edge Routing) the two releases evolve (merge) into a single version of converged release—the Cisco IOS XE 16—providing one release covering the extensive range of access and edge products in the Switching and Routing portfolio.

Feature Information

Use Cisco Feature Navigator to find information about feature support, platform support, and Cisco software image support. An account on Cisco.com is not required.

Related References

- Cisco IOS Command References, All Releases

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CHAPTER 2

Link Efficiency Mechanisms Overview

Cisco IOS software offers a number of link-layer efficiency mechanisms or features (listed below) designed to reduce latency and jitter for network traffic. These mechanisms work with queuing and fragmentation to improve the efficiency and predictability of the application service levels.

This chapter gives a brief introduction to these link-layer efficiency mechanisms described in the following sections:

- Finding Feature Information, on page 3
- Multilink PPP, on page 3
- Header Compression, on page 4

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.

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.

Multilink PPP

At the top level, Multilink PPP (also known as MLP or simply Multilink) provides packet interleaving, packet fragmentation, and packet resequencing across multiple logical data links. The packet interleaving, packet fragmentation, and packet resequencing are used to accommodate the fast transmission times required for sending real-time packets (for example, voice packets) across the network links. Multilink is especially useful over slow network links (that is, a network link with a link speed less than or equal to 768 kbps).

For more information about the functionality of Multilink when providing quality of service (QoS) on your network, see the "Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP" module.

Header Compression

Header compression is a mechanism that compresses the IP header in a packet before the packet is transmitted. Header compression reduces network overhead and speeds up the transmission of Real-Time Transport Protocol (RTP) and Transmission Control Protocol (TCP) packets. Header compression also reduces the amount of bandwidth consumed when the RTP or TCP packets are transmitted.

Cisco provides two basic types of header compression: RTP header compression (used for RTP packets) and TCP header compression (used for TCP packets).

For more information about header compression, see the "Header Compression" module.

Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP

This module contains information about reducing latency and jitter for real-time traffic on your network. One Cisco mechanism for reducing latency and jitter for real-time traffic is Multilink PPP (MLP), also known as Multilink. This module contains conceptual information about Multilink and describes how Multilink PPP can be used with network peers to reduce latency and jitter for real-time traffic on your network.

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.

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Information About Multilink

Queueing Mechanisms for Multilink

You can use the following queueing mechanisms with Multilink:

- Low latency queueing (LLQ)

- Weighted fair queueing (WFQ)

- Class-based weighted fair queueing (CBWFQ)

Multilink Functionality

At the top level, Multilink provides packet interleaving, packet fragmentation, and packet resequencing across multiple logical data links. The packet interleaving, packet fragmentation, and packet resequencing is used to accommodate the fast transmission times required for sending real-time packets (for example, voice packets) across the network links. Multilink is especially useful over slow network links (that is, a network link with a link speed less than or equal to 768 kbps).

Multilink Interleaving

Multilink interleaving is based upon two other integral Multilink activities:

- The ability to fragment packets (or datagrams)

- The ability to multiplex at least two independent data streams

The term interleaving comes from the latter activity, that is, the interleaving of two (or more) independent data streams which are processed independently by the network peer.

Multilink interleaving is a mechanism that allows short, real-time (that is, time-sensitive) packets to be transmitted to a network peer within a certain amount of time (the "delay budget"). To accomplish this task, Multilink interleaving interrupts the transmission of large non-time-sensitive (sometimes referred to as "bulk") datagrams or packets in favor of transmitting the time-sensitive packet. Once the real-time packet is sent, the system resumes sending the bulk packet.

An example may help to illustrate the concept of delay budget. The network starts transmitting a large datagram to a network peer. This large datagram takes 500 milliseconds (ms) to transmit. Three milliseconds later (while the large datagram is still being transmitted), a voice packet arrives in the transmit queue. By the time the large datagram is completely transmitted (497 ms later) the voice packet (which is highly time-sensitive) is subject to unacceptable delay (that is, its delay budget is exceeded).

Multilink interleaving is particularly useful for applications where too much latency (that is, delay) is detrimental to the function of the application, such as Voice over IP (VoIP). However, it is also beneficial for other forms of "interactive" data, such as Telnet packets where the Telnet packets echo the keystrokes entered by the user at a keyboard.

Multilink Fragmentation

With Multilink fragmentation, the large datagram is fragmented ("chopped") into a number of small packet fragments, Multilink headers are added to the packet fragments, and the packet fragments are transmitted individually to a network peer.

When interleaving is enabled, the packet fragments are small enough so that the time it takes to transmit them does not exceed the time budgeted for transmitting the real-time (time-sensitive) data packet. The real-time data packets are interleaved between the fragments of the large datagram.

Each time Multilink prepares to send another data packet fragment or frame to the receiving network peer, Multilink first checks to see if a real-time (time-sensitive) packet has arrived in the transmit queue. If so, the high-priority packet is sent first before sending the next fragment from the large datagram.

The time delay before the priority packets arrive at the receiving network link is subject to the usual serialization delays at the network link level. That is, any other data already being transmitted has to be finished before the priority packet can be sent. By segmenting long datagrams into small fragments, and checking for newly arrived priority frames between fragments, the priority frame is delayed only by the time it takes to transmit a previously queued fragment rather than a complete large datagram.

Thus, the maximum size of the fragments dictates the responsiveness for insertion of priority packets into the stream. The fragment size can be tuned by adjusting the fragment delay with the **ppp multilink fragment delay** command.

To ensure correct order of transmission and reassembly (which occurs later), multilink headers are added to the large datagram fragments after the packets are dequeued and ready to be sent.

The figure below is a simplified illustration of how Multilink fragments and interleaves packets.

Figure 1: Multilink Fragmentation and Interleaving
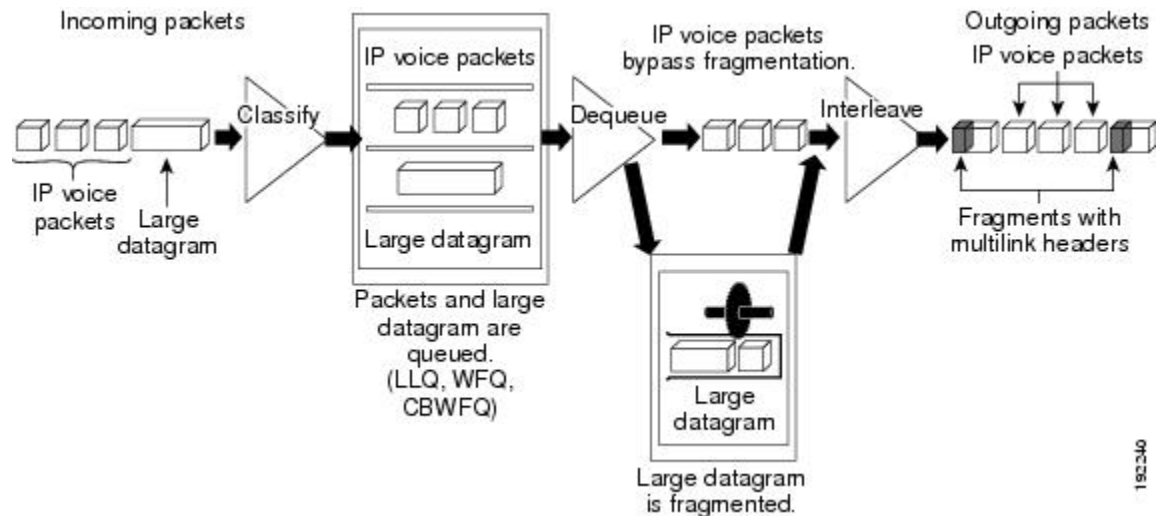
In the figure above, both IP voice packets and a large datagram arrive at the interface from a single network link. Your network may have multiple links. The IP voice packet and large datagram are queued according to their classification. The large datagram is fragmented (the IP voice packets are not). The IP voice packets are interleaved between the fragments of the large datagram, to which multilink headers are added.

Packets Dequeued and Transmitted

When the large datagram is dequeued, and space becomes available on a member link, Multilink takes a fragment from the original large datagram and transmits the fragments over that link. If an IP voice packet (or other real-time packet) arrives at the transmit queue before Multilink has completely sent the datagram fragment, the next time a link is available to send more packets, Multilink will dequeue and send the high-priority packet. The high-priority packet will be sent instead of another fragment from the large datagram.

Multilink Resequencing

A multilink bundle is a virtual Point-to-Point Protocol (PPP) connection or session over a network link. A multilink bundle at the transmitting end of the network sends the fragments to a multilink bundle on the receiving end of the network link.

The multilink bundle at the receiving end of the network accepts the fragments from the transmitting multilink bundle.

As fragments are received, the multilink bundle reassembles (resequences) the original large datagram from the fragments using the sequence number in the multilink header attached to the fragment by the sender. The reassembled large datagrams are then forwarded in normal fashion.

Multilink Bundles and Their Network Links

As mentioned earlier, a multilink bundle is a virtual PPP connection over a network link. The transmitting multilink bundle transmits the packet over a network link to a receiving multilink bundle, where the multilink bundle reassembles the fragments using the sequence number in the multilink header of the fragment.

The individual member links in a multilink bundle are standard serial PPP connections. Most forms of PPP connections may be used as member links in a bundle, including PPP over ATM, PPP over Frame Relay, and PPP over dial interfaces. However, there may be certain limitations and issues associated with using PPP sessions over certain media types, particularly those for "tunneling" protocols such as PPP over ATM, PPP over Frame Relay, and PPP over Ethernet.

Additional References

Related Documents

Related Topic	Document Title
QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	Cisco IOS Quality of Service Solutions Command Reference
LLQ, WFQ, CBWFQ, and other queueing mechanisms	"Applying QoS Features Using the MQC" module
Multilink PPP over serial interface links	"Using Multilink PPP over Serial Interface Links" module

Standards

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

MIBs

MIB	MIBs Link
No new or modified MIBs are supported, and support for existing MIBs has not been modified.	To locate and download MIBs for selected platforms, Cisco IOS XE Software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs

RFCs

RFC	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

Using Multilink PPP over Serial Interface Links

This module tells you how to use Multilink PPP over serial interface links.

Note As of Cisco IOS XE Software Release 2.1, Multilink PPP over serial interface links is the only Multilink PPP type supported. Multiclass MLPPP is not supported.

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.

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.

Prerequisites for Using Multilink PPP over Serial Interface Links

Be familiar with the concepts in the "Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP" module.

Enable a queueing mechanism such as low latency queueing (LLQ), weighted fair queueing (WFQ), class-based WFQ (CBWFQ) and Weighted Random Early Detection (WRED), as applicable, before configuring multilink.

Restrictions for Using Multilink PPP over Serial Interface Links

If a multilink bundle has one link or packet order is not important for interleaved packets, use Link Fragmentation and Interleaving (LFI) without multiclass. Use LFI with multiclass if a multilink bundle has multiple links.

Only Voice over IP (VoIP) is supported.

As of Cisco IOS XE Release 2.1, Multilink PPP over serial interface links is the only Multilink PPP type supported. Multiclass MLPPP is not supported.

Information About Using Multilink PPP over Serial Interface Links

MQC and Multilink PPP over Serial Interface Links

Before using Multilink PPP over serial interface links, a traffic policy (policy map) must be created. Policy maps are created using the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC).

How to Configure Multilink PPP over Serial Interface Links

Configuring Multilink PPP over Serial Interface Links on a Multilink Group Interface

Before you begin

Before proceeding with this task, you must create a policy map. The policy map contains the configuration parameters used to apply the specific quality of service feature to the network traffic. To create a policy map, use the MQC.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface multilink** *multilink-bundle-number*
4. **ip address** *ip-address mask* [**secondary**]
5. **service-policy output** *policy-map-name*
6. **service-policy input** *policy-map-name*
7. **ppp multilink fragment delay** *milliseconds* [*microseconds*]
8. **ppp multilink interleave**
9. **ppp multilink multiclass**
10. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface multilink** *multilink-bundle-number* **Example:** `Router(config)# interface multilink 1`	Creates a multilink bundle and enters interface configuration mode. • Enter the multilink bundle number.
Step 4	**ip address** *ip-address* *mask* [**secondary**] **Example:** `Router(config-if)# ip address 10.10.100.1 255.255.255.0`	Sets a primary IP address for an interface. This command can also set the optional secondary IP address for an interface. • Enter the primary IP address (and, optionally, the secondary IP address).
Step 5	**service-policy output** *policy-map-name* **Example:** `Router(config-if)# service-policy output policy1`	Attaches the previously created QoS traffic policy (policy map). The policy map evaluates and applies QoS features for traffic *leaving* the interface. • Enter the policy map name.
Step 6	**service-policy input** *policy-map-name* **Example:** `Router(config-if)# service-policy input policy1`	Attaches the previously created QoS traffic policy (policy map). The policy map evaluates and applies QoS features for traffic *entering*the interface. • Enter the policy map name.
Step 7	**ppp multilink fragment delay** *milliseconds* [*microseconds*] **Example:** `Router(config-if)# ppp multilink fragment delay 20`	Specifies a maximum size in units of time for packet fragments on a Multilink PPP (MLP) bundle. • Enter the maximum amount of time, in milliseconds.
Step 8	**ppp multilink interleave** **Example:** `Router(config-if)# ppp multilink interleave`	Enables interleaving of packets among the fragments of larger packets on a multilink bundle.

	Command or Action	**Purpose**
Step 9	**ppp multilink multiclass** **Example:** `Router(config-if)# ppp multilink multiclass`	(Optional) Enables Multiclass Multilink PPP (MCMP) on an interface. **Note** Use this command only if there are multiple links in the multilink bundle.
Step 10	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode.

Associating the Serial Interface with the Multilink Group

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface serial** *slot* / *port* **:** *timeslot*
4. **no fair-queue**
5. **encapsulation ppp**
6. **ppp multilink**
7. **ppp multilink group** *group-number*
8. **end**

DETAILED STEPS

	Command or Action	**Purpose**
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface serial** *slot* / *port* **:** *timeslot* **Example:** `Router# interface serial 4/1:23` **Example:**	Specifies a serial interface created on a channelized E1 or channelized T1 controller (for ISDN PRI, channel-associated signaling, or robbed-bit signaling), and enters interface configuration mode. • Enter the slot number and port number where the channelized E1 or T1 controller is located.

	Command or Action	Purpose
Step 4	**no fair-queue** **Example:** Router(config-if)# no fair-queue	Disables WFQ (or DWFQ for VIP-enabled routers).
Step 5	**encapsulation ppp** **Example:** Router(config-if)# encapsulation ppp	Sets the serial interface encapsulation method used by the interface.
Step 6	**ppp multilink** **Example:** Router(config-if)# ppp multilink	Enables Multilink on an interface.
Step 7	**ppp multilink group** *group-number* **Example:** Router(config-if)# ppp multilink group 1	Restricts a physical link to joining only a designated multilink group interface. • Enter the multilink group number.
Step 8	**end** **Example:** Router(config-if)# end	(Optional) Exits interface configuration mode.

Verifying the Multilink PPP over Serial Interface Link Configuration

SUMMARY STEPS

    1. **enable**
    2. **show interfaces** [*type number*] [*first*] [*last*] [**accounting**]
    3. **show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]]
    4. **show policy-map interface**   *interface-name* [**vc** [*vpi/*] *vci*] [**dlci** *dlci*] [**input** | **output**]
    5. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** Router> enable	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**show interfaces** [*type number*] [*first*] [*last*] [**accounting**] **Example:**	(Optional) Displays statistics for all interfaces configured on the router or access server.

	Command or Action	Purpose
	`Router# show interfaces`	
Step 3	**show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]] **Example:** `Router# show ppp multilink`	(Optional) Displays bundle information for mutlilink bundles.
Step 4	**show policy-map interface** *interface-name* [**vc** [*vpi/*] *vci*] [**dlci** *dlci*] [**input** | **output**] **Example:** `Router# show policy-map interface serial0/0/0`	(Optional) Displays the packet statistics of all classes that are configured for all service policies either on the specified interface or subinterface or on a specific permanent virtual circuit (PVC) on the interface.
Step 5	**exit** **Example:** `Router# exit`	(Optional) Exits privileged EXEC mode.

Configuration Examples for Using Multilink PPP over Serial Interface Links

Configuring Multilink PPP over Serial Interface Links on a Multilink Group Interface Example

The following is an example of configuring Multilink PPP over serial interface links on a multilink group interface:

```
Router> enable

Router# configure terminal

Router(config)# interface multilink 1

Router(config-if)# ip address 10.10.100.1 255.255.255.0

Router(config-if)# service-policy output policy1

Router(config-if)# service-policy input policy1

Router(config-if)# ppp multilink fragment delay 20
```

```
Router(config-if)# ppp multilink interleave

Router(config-if)# ppp multilink multiclass

Router(config-if)# end
```

Associating the Serial Interface with the Multilink Group Example

The following is an example of associating the serial interface serial4/1 with the multilink group:

```
Router> enable

Router# configure terminal

Router(config)# interface serial 4/1:23

Router(config-if)# no fair-queue

Router(config-if)# encapsulation ppp

Router(config-if)# ppp multilink

Router(config-if)# ppp multilink group 1

Router(config-if)# end
```

Example Verifying the Multilink PPP over Serial Interface Link Configuration

You can verify the Multilink PPP over serial interface links configuration by using one or more of the following **show** commands:

- **show interfaces**
- **show ppp multilink**
- **show policy-map interface**

The following section provides sample output of the **showpppmultilink** command only. For sample output of the other commands, see the *Cisco IOS Quality of Service Solutions Command Reference*.

show ppp multilink Command Output Example

The following is an example of the **showpppmultilink** command output. In this example, one multilink bundle called bundle-1 is on the system. This bundle has two member links: one active link and one inactive link.

```
Router# show ppp multilink
Multilink2, bundle name is bundle-1
  Endpoint discriminator is bundle-1
  Bundle up for 00:00:09, 1/255 load
  Receive buffer limit 12000 bytes, frag timeout 1500 ms
    0/0 fragments/bytes in reassembly list
    0 lost fragments, 0 reordered
    0/0 discarded fragments/bytes, 0 lost received
    0x0 received sequence, 0x3 sent sequence
  Member links:1 active, 1 inactive (max not set, min not set)
    Se3/2, since 00:00:10, 240 weight, 232 frag size
    Se3/3 (inactive)
```

Additional References

The following sections provide references related to using Multilink PPP over ATM links.

Related Documents

Related Topic	Document Title
QoS commands: complete command syntax, command modes, command history, defaults, usage guidelines, and examples	*Cisco IOS Quality of Service Solutions Command Reference*
LLQ, WFQ, CBWFQ, PQ, CQ, FIFO, and other queueing mechanisms	"Configuring Weighted Fair Queueing" module
MQC	"Applying QoS Features Using the MQC" module
Multilink PPP configurations	"Configuring Media-Independent PPP and Multilink PPP" module
Virtual template interfaces	"Configuring Virtual Template Interfaces" module
Multilink PPP overview module	"Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP" module
Multilink PPP over Frame Relay	"Using Multilink PPP over Frame Relay" module
Multilink PPP over dialer interface links	"Using Multilink PPP over Dialer Interface Links" module
Multilink PPP over serial interface links	"Using Multilink PPP over Serial Interface Links" module

Standards

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

MIBs

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

RFCs

RFC	Title
RFC 1990	*The PPP Multilink Protocol (MP)*
RFC 2686	*Multiclass Extension to Multilink PPP (MCML)*

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 Using Multilink PPP over Serial Interface Links

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 1: Feature Information for Using Multilink PPP over Serial Interface Links

Feature Name	Software Releases	Feature Configuration Information
MLPPP QoS (CBWFQ, LLQ, WRED)	Cisco IOS XE Release 2.1	The MLPPP QoS feature implements Multilink PPP (MLPPP) using a distributed hierarchical queueing framework (HQF). The MLPPP QoS feature incorporates class-based weighted fair queueing (CBWFQ), low latency queueing (LLQ), and weighted random early detection (WRED) functionality.