QoS: Latency and Jitter Configuration Guide, Cisco IOS Release 12.4

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

CONTENTS

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

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

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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.

Frame Relay Fragmentation

Cisco has developed the following three methods of performing Frame Relay fragmentation:

- End-to-end FRF.12 (and higher) fragmentation

- Frame Relay fragmentation using FRF.11 Annex C (and higher)
- Cisco proprietary encapsulation

For more information about Frame Relay fragmentation, see the " Frame Relay Queueing and Fragmentation at the Interface" 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 feature information and caveats, see the release notes for your platform and software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the Feature Information Table at the end of this document.

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Information About Multilink

Restrictions for Multilink

Multilink uses first-in first-out (FIFO) queuing to queue and interleave packets. Alternative mechanisms such as low latency queuing (LLQ), weighted fair queuing (WFQ), or class-based weighted fair queuing (CBWFQ) may be used. If you want to use one of these alternative mechanisms, enable it before configuring Multilink. For more information about queuing mechanisms, see the "Configuring Weighted Fair Queueing" module.

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

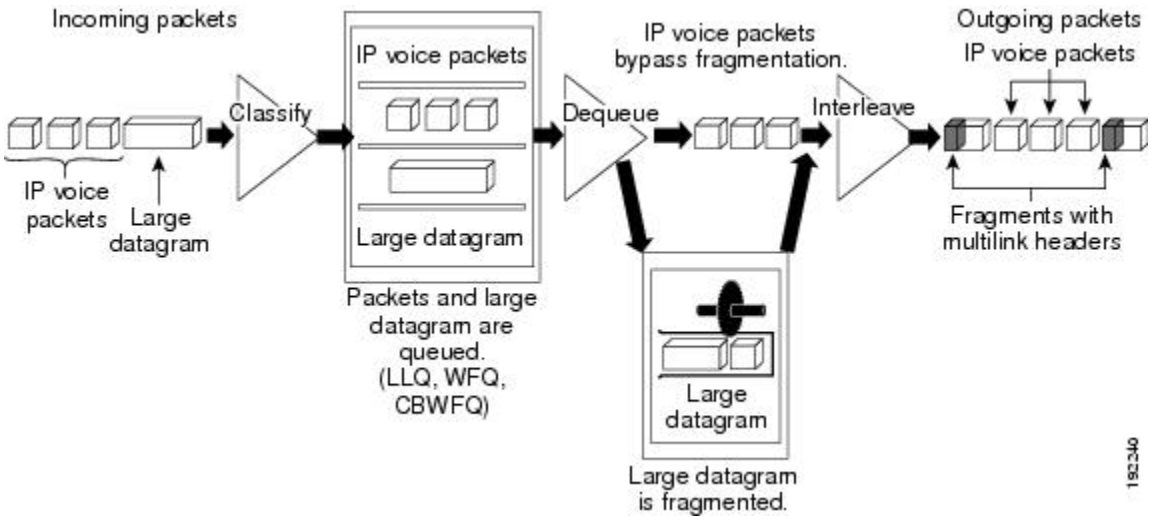
finished before the priority packet can be sent. By segmenting long datagrams into small fragments, and checking for newly arrived priority frames between fragments, the priority frame is delayed only by the time it takes to transmit a previously queued fragment rather than a complete large datagram.

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.

Multiclass Multilink PPP

Multiclass Multilink PPP (MCMP) is based on RFC 2686: *Multi-Class Extension to Multi-Link PPP* . Multiclass Multilink PPP is an extension to the multilink functionality that adds the ability to divide network traffic over the multilink bundle into several independently sequenced streams of fragments. Multilink, as defined by RFC 1990: *The PPP Multilink Protocol (MP)* , provides for one sequenced stream only. RFC 1990 also implicitly allows one additional unsequenced stream, as large datagrams may be transmitted without multilink headers as long as the large datagrams do not need to be fragmented.

In Multiclass Multilink PPP, outgoing packets may be divided into as many as 16 different streams, for which RFC 2686 uses the term classes. Each stream or class has its own governing sequence number, and the receiving network peer (bundle) sorts and processes each stream independently.

Packets can still be sent without multilink headers. However, part of the purpose behind Multiclass Multilink PPP is to reduce or eliminate the need to send unsequenced data.

Multiclass Multilink PPP was created explicitly to allow the packets to be divided into several preemptable classes, so that any lower priority class could be interrupted in favor of sending a packet from a higher priority class. Each class of data can be fragmented, and all classes are expected to be fragmented (with the possible exception of the highest priority class). Also, frames from the different streams may be mixed if necessary.

Multiclass Multilink PPP was created as a mechanism to allow implementations to do interleaving, yet without giving up the sequencing of the interleaved packets such as occurs with standard interleaving.

In the Cisco IOS software, when Multilink Multiclass PPP is used instead of standard interleaving, the regular non-priority data is fragmented and transmitted in one class, and interleaved frames are sent in a separate class. Specifically, the regular traffic is sent in class 0 and the interleaved frames are sent in class 1. Thus, interleaving works just as it does with standard interleaving, except that the interleaved frames are sent in class 1 rather than as unsequenced frames. Multilink does not transmit data using additional classes, although Multilink is capable of receiving data from peers that do.

Multiclass Multilink PPP must be successfully negotiated with the peer system. If interleaving and Multiclass Multilink PPP are both configured, but the use of Multiclass Multilink PPP cannot be negotiated with the peer system, standard interleaving will be used.

Distributed Multilink PPP

Distributed Multilink PPP (dMLP) is an implementation of Multilink on systems that support distributed processing. With distributed processing, packet processing can be handled by "dedicated hardware"--that is,

either by the CPU or by another internal device such as a Versatile Interface Processor (VIP) inside the router or a FlexWAN inside the switch. This dedicated hardware can also be referred to as the "dMLP engine."

One system that supports distributed processing is the Cisco 7500 series router with a Versatile Interface Processor (VIP2-40 or higher). Distributed processing is supported on a number of additional routers and switches as well. Refer to the documentation for your specific router or switch to see if it supports distributed processing.

Note On a Cisco 7500 series router, a VIP2-50 or higher is recommended when the aggregate line rate of the port adapters on the VIP is greater than DS3. A VIP2-50 card is required for OC-3 rates.

With dMLP, packet fragmentation, interleaving, and fragment reassembly are done by the dMLP engine instead of by the Cisco IOS software. However, the Cisco IOS software manages the member links, creates and disassembles the bundles, and handles the control plane processing (including the handling of all PPP control packets).

However, once a bundle is established, the handling of Multilink packets is turned over to the dMLP engine. The dMLP engine handles all the multilink data-path functionality, including fragmentation, interleaving, multilink encapsulation, load balancing among the multiple links, and sorting and reassembly of inbound fragments.

The capabilities of the dMLP engines vary widely, and they may not always behave like the Cisco IOS Multilink feature. The dMLP engine may fragment and load balance using entirely different schemes than those used by the Cisco IOS software, and they may not support the same multilink features. For more information, refer to the documentation for the dMLP engine you are using.

Where to Go Next

The next step is to go to the module containing the instructions for the type of Multilink PPP you want to use, as listed below.

To use Multilink PPP over Frame Relay, see the "Using Multilink PPP over Frame Relay" module.

To use Multilink PPP over ATM links, see the "Using Multilink PPP over ATM Links" module.

To use Multilink PPP over dialer interface links, see the "Using Multilink PPP over Dialer Interface Links" module.

To use Multilink PPP over serial interface links, see the "Using Multilink PPP over Serial Interface Links" module.

Note If you are using an ASR 1000 Series Router, follow the instructions for using Multilink PPP over serial interface links.

Additional References

The following sections provide additional references about Multilink.

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
Frame Relay configurations	Configuring Frame Relay" module
ATM configurations	"Configuring ATM" module
Multiclass Multilink PPP	"Multiclass Multilink PPP" module
Multilink PPP configuration information	"Configuring Media-Independent PPP and Multilink PPP" module
Multilink PPP over ATM links (including ATM interfaces and ATM PVCs)	"Using Multilink PPP over ATM Links" 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	Title
RFC 2686	Multi-Class Extension to Multi-Link PPP

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 ATM Links

This module contains conceptual information and configuration tasks for using Multilink PPP over ATM links. Multilink PPP is a method that is used to reduce latency and jitter for real-time traffic.

Finding Feature Information

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

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Prerequisites for Using Multilink PPP over ATM Links

- Be familiar with the concepts in the "Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP" module.
- Multilink PPP uses first-in first-out (FIFO) queueing for queueing and interleaving packets. Other queueing mechanisms such as low latency queueing (LLQ), weighted fair queueing (WFQ), and class-based weighted fair queueing (CBWFQ) can be used. If you want to use one of these alternative mechanisms, enable it before configuring Multilink.

Restrictions for Using Multilink PPP over ATM Links

- Only Voice over IP (VoIP) is supported; Voice over ATM is not supported.

- Multilink PPP over ATM must use the following ATM network modules:
  - Multiport T1/E1 ATM Network Module with Inverse Multiplexing over ATM
  - ATM OC-3 Network Module
  - Enhanced ATM Port Adapter

Information About Using Multilink PPP over ATM Links

MQC and Multilink PPP over ATM Links

Before using Multilink PPP over ATM links, a policy map must be created. (See the MQC and Multilink PPP over ATM Links, page 12.) Policy maps are created using the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC).

VirtualTemplateInterfaces

A virtual template interface is a logical interface that is configured with generic configuration information for a specific purpose or a configuration common to specific users, plus router-dependent information. The template takes the form of a list of Cisco IOS interface commands that are applied to virtual access interfaces, as needed.

Multilink Group Interfaces

A multilink group interface is a collection of interfaces that are bundled together in the multilink PPP configuration. With a multilink group interface, you can bundle interfaces into logical multilink groups.

How to Configure Multilink PPP over ATM Links

While the first two procedures are listed as optional, you must choose one or the other according to the Cisco router that you are using in your network.

Configuring Multilink PPP over ATM Links on a Virtual Template Interface

These steps apply if you are using the Cisco 7500 series router or the Cisco 7600 series router only. If you are using another series of Cisco router, do not complete these steps. Instead, advance to the Configuring Multilink PPP over ATM Links on a Multilink Group Interface, page 15.

Before proceeding with this task, you must create a policy map. The policy map contains the configuration parameters used to apply a specific QoS feature, such as distributed LLQ (dLLQ), to the network traffic.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface virtual-template** *number*
4. **bandwidth** *kbps*
5. **ip address** *ip-address mask* [**secondary**]
6. **service-policy output** *policy-map-name*
7. **service-policy input** *policy-map-name*
8. **ppp multilink**
9. **ppp multilink fragment delay** *milliseconds* [*microseconds*]
10. **ppp multilink interleave**
11. **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 virtual-template** *number* **Example:** `Router(config)# interface virtual-template 4`	Creates a virtual template and enters interface configuration mode. • Enter the virtual template number.
Step 4	**bandwidth** *kbps* **Example:** `Router(config-if)# bandwidth 32`	Sets the bandwidth value for an interface. • Enter the bandwidth value in kilobits per second.

	Command or Action	Purpose
Step 5	**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 6	**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 7	**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 8	**ppp multilink** **Example:** `Router(config-if)# ppp multilink`	Enables Multilink PPP (MLP) on the interface.
Step 9	**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 an MLP bundle. • Enter the maximum amount of time, in milliseconds. **Note** The fragment delay can be calculated using the following formula: fragment delay = (fragment size * 8)/bandwidth
Step 10	**ppp multilink interleave** **Example:** `Router(config-if)# ppp multilink interleave`	Enables interleaving of packets among the fragments of larger packets on a multilink bundle.
Step 11	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode and returns to privileged EXEC mode.

Configuring Multilink PPP over ATM Links on a Multilink Group Interface

If you are using the Cisco 7500 series router or the Cisco 7600 series router, do not complete these steps. Instead, complete the steps in Configuring Multilink PPP over ATM Links on a Virtual Template Interface, page 12.

Before proceeding with this task, you must create a policy map. The policy map contains the configuration parameters used to apply a specific QoS feature, such as distributed LLQ (dLLQ), to the network traffic.

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.

	Command or Action	Purpose
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). See the Configuring Multilink PPP over ATM Links on a Multilink Group Interface, page 15. 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). See the Configuring Multilink PPP over ATM Links on a Multilink Group Interface, page 15. 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.
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.

	Command or Action	Purpose
Step 10	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode and returns to privileged EXEC mode.

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- Associating the Virtual Template Interface with the Multilink Group, page 17

What to Do Next

After configuring Multilink PPP over ATM links on a multilink group interface, the next step is to associate the virtual template interface with the multilink group by completing the steps in the following section.

If you are using a Cisco 7500 series router or a Cisco 7600 series router, advance to the Associating the Virtual Template Interface with an ATM PVC, page 18 to continue.

Associating the Virtual Template Interface with the Multilink Group

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface virtual-template** *number*
4. **no ip address** [*ip-address mask* [**secondary**]]
5. **ppp multilink group** *group-number*
6. **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.

	Command or Action	Purpose
Step 3	**interface virtual-template** *number* **Example:** `Router(config)# interface virtual-template 2`	Creates a virtual template interface that can be configured and applied dynamically in creating virtual access interfaces, and enters interface configuration mode. • Enter the number used to identify the virtual template interface.
Step 4	**no ip address** [*ip-address mask* [**secondary**]] **Example:** `Router(config-if)# no ip address`	Removes an IP address or disables IP processing.
Step 5	**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 6	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode and returns to privileged EXEC mode.

Associating the Virtual Template Interface with an ATM PVC

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number* [**name-tag**]
4. **pvc** [*name*] *vpi* / *vci* [**ces** | **ilmi** | **qsaal** | **smds** | **l2transport**]
5. **abr** *output-pcr output-mcr*
6. **vbr-nrt** *output-pcr output-scr output-mbs* [*input-pcr*] [*input-scr*] [*input-mbs*]
7. **protocol ppp virtual-template** *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** *type number* [**name-tag**] **Example:** `Router(config)# interface atm2/0/0`	Configures an interface type and enters interface configuration mode. • Enter the interface type and number.
Step 4	**pvc** [*name*] *vpi* / *vci* [**ces** | **ilmi** | **qsaal** | **smds** | **l2transport**] **Example:** `Router(config-if)# pvc cisco 0/16`	Creates or assigns a name to an ATM permanent virtual circuit (PVC) and enters ATM virtual circuit configuration mode. • Enter the ATM PVC name, the network virtual path identifier, and the network virtual channel identifier.
Step 5	**abr** *output-pcr output-mcr* **Example:** `Router(config-if-atm-vc)# abr 100 80`	(Optional) Selects available bit rate (ABR) QoS and configures the output peak cell rate (PCR) and output minimum guaranteed cell rate (MCR) for an ATM PVC. • Enter the output PCR and the output MCR.
Step 6	**vbr-nrt** *output-pcr output-scr output-mbs* [*input-pcr*] [*input-scr*] [*input-mbs*] **Example:** `Router(config-if-atm-vc)# vbr-nrt 1100 1100 100`	(Optional) Configures the variable bit rate-nonreal time (VBR-NRT) quality of service (QoS) and specifies the output peak cell rate (PCR), the output sustainable cell rate (SCR), and the output maximum burst cell size (MBS) for an ATM PVC, PVC range, switched virtual circuit (SVC), VC class, or VC bundle member. • Enter the output PCR, SCR, and MBS.
Step 7	**protocol ppp virtual-template** *number* **Example:** `Router(config-if-atm-vc)# protocol ppp virtual-template 2`	Specifies that PPP is established over the ATM PVC using the configuration from the specified virtual template. • Enter the virtual-template number.

	Command or Action	Purpose
Step 8	**end** **Example:** `Router(config-if-atm-vc)# end`	(Optional) Exits ATM virtual circuit configuration mode and returns to privileged EXEC mode.

Verifying the Multilink PPP over ATM Links Configuration

SUMMARY STEPS

1. **enable**
2. **show atm pvc** [*vpi* / *vci* | *name* | **interface atm** *interface-number*[**.** *subinterface-number* **multipoint**]] [**ppp**]
3. **show interfaces** [*type number*] [*first*] [*last*] [**accounting**]
4. **show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]]
5. **show policy-map interface** *interface-name* [**vc** [*vpi* /] *vci*] [**dlci** *dlci*] [**input** | **output**]
6. **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 atm pvc** [*vpi* / *vci*	*name*	**interface atm** *interface-number*[**.** *subinterface-number* **multipoint**]] [**ppp**] **Example:** `Router# show atm pvc`	(Optional) Displays all ATM PVCs and traffic information.
Step 3	**show interfaces** [*type number*] [*first*] [*last*] [**accounting**] **Example:** `Router# show interfaces`	(Optional) Displays statistics for all interfaces that are configured on the router or access server.

	Command or Action	Purpose
Step 4	**show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]] **Example:** `Router# show ppp multilink`	(Optional) Displays bundle information for multilink bundles.
Step 5	**show policy-map interface** *interface-name* [**vc** [*vpi* /] *vci*] [**dlci** *dlci*] [**input** | **output**] **Example:** `Router# show policy-map interface serial0/0`	(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 PVC on the interface.
Step 6	**exit** **Example:** `Router# exit`	(Optional) Exits privileged EXEC mode.

Configuration Examples for Using Multilink PPP over ATM Links

Example Configuring Multilink PPP over ATM Links on a Virtual Template Interface

The following is an example of configuring Multilink PPP over ATM links on a virtual template interface:

```
Router> enable
Router# configure terminal
Router(config)# interface virtual-template 4
Router(config-if)# bandwidth 32
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
Router(config-if)# ppp multilink fragment delay 20
Router(config-if)# ppp multilink interleave
Router(config-if)# end
```

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

The following is an example of configuring Multilink PPP over ATM 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
```

Example Associating the Virtual Template Interface with the Multilink Group

The following is an example of associating the virtual template interface with the multilink group:

```
Router> enable
Router# configure terminal
Router(config)# interface virtual-template 2
Router(config-if)# no ip address
Router(config-if)# ppp multilink group 1
Router(config-if)# end
```

Example Associating the Virtual Template Interface with an ATM PVC

The following is an example of associating the virtual template interface with an ATM PVC:

```
Router> enable

Router# configure terminal

Router(config)# interface atm2/0/0

Router(config-if)# pvc cisco 0/16

Router(config-if-atm-vc)# abr 100 80

Router(config-if-atm-vc)# protocol ppp virtual-template 2

Router(config-if-atm-vc)# end
```

Example Verifying the Multilink PPP over ATM Links Configuration

The following is an example of the **show ppp multilink** command output. In this example, one multilink bundle called 7206-2 is on the system. This bundle has two member links: one active link and one inactive link.

```
Router# show ppp multilink
Multilink1, bundle name is 7206-2
  Endpoint discriminator is 7206-2
  Bundle up for 00:00:24, 1/255 load
  Receive buffer limit 12000 bytes, frag timeout 1000 ms
    0/0 fragments/bytes in reassembly list
    0 lost fragments, 0 reordered
    0/0 discarded fragments/bytes, 0 lost received
    0x0 received sequence, 0x0 sent sequence
  Member links: 1 active, 1 inactive (max not set, min not set)
    Vi3, since 00:00:24
    PPPoATM link, ATM PVC 2/101 on ATM2/0/0
    Packets in ATM PVC Holdq: 0 , Particles in ATM PVC Tx Ring: 1
    Vt1 (inactive)
```

Where to Go Next

To use Multilink PPP over Frame Relay, see the "Using Multilink PPP over Frame Relay" module.

To use Multilink PPP over dialer interface links, see the "Using Multilink PPP over Dialer Interface Links" module.

To use Multilink PPP over serial interface links, see the "Using Multilink PPP over Serial Interface Links" module.

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 ATM 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 ATM Links

Feature Name	Releases	Feature Information
Distributed Link Fragmentation and Interleaving for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers	12.2(4)T	The Distributed Link Fragmentation and Interleaving (dLFI) for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers feature extends link fragmentation and interleaving functionality to VIP-enabled Cisco 7500 series routers. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over ATM interface links.

Feature Name	Releases	Feature Information
Distributed Link Fragmentation and Interleaving over Leased Lines	12.2(8)T	The Distributed Link Fragmentation and Interleaving over Leased Lines feature extends distributed link fragmentation and interleaving functionality to leased lines. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over ATM interface links.
MLP LFI over ATM Configuration Scaling	12.2(25)S 12.2(27)SBA 15.0(1)M	The MLP LFI over ATM Configuration Scaling feature supports the transport of real-time (voice) and non-real-time (data) traffic on lower-speed Frame Relay and ATM permanent virtual circuits (PVCs) without causing excessive delay of real-time traffic. The following commands were introduced or modified: **ppp multilink group**

Using Multilink PPP over Dialer Interface Links

This module contains conceptual information and configuration tasks for using Multilink PPP over dialer interface links. Multilink PPP is a method used to reduce latency and jitter for real-time traffic.

Finding Feature Information

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

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

Prerequisites for Using Multilink PPP over Dialer Interface Links

- Be familiar with the concepts in the "Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP" module.
- Multilink uses first-in first out (FIFO) queuing for queuing and interleaving packets. Other queuing mechanisms such as low latency queuing (LLQ), weighted fair queuing (WFQ), and class-based weighted fair queuing (CBWFQ) can be used. If you want to use one of these alternative mechanisms, enable it before configuring Multilink.

Restrictions for Using Multilink PPP over Dialer Interface Links

- Route/switch processing (RSP) is not recommended when using Multilink PPP over dialer interface links.

Information About Using Multilink PPP over Dialer Interface Links

Dialer Profiles

The dialer profiles implementation of dial-on-demand routing (DDR) is based on a separation between logical and physical interface configuration. Dialer profiles also allow the logical and physical configurations to be bound together dynamically on a per-call basis.

Dialer profiles are advantageous in the following situations:

- When you want to share an interface (ISDN, asynchronous, or synchronous serial) to place or receive calls.
- When you want to change any configuration on a per-user basis.
- When you want to maximize ISDN channel usage using the Dynamic Multiple Encapsulations feature to configure various encapsulation types and per-user configurations on the same ISDN B channel at different times according to the type of call.
- When you want to bridge to many destinations, and for avoiding split horizon problems.

Most routed protocols are supported; however, International Organization for Standardization Connectionless Network Service (ISO CLNS) is not supported.

If you decide to configure dialer profiles, you must disable validation of source addresses for the routed protocols you support.

MQC and Multilink PPP over Dialer Interface Links

Before using Multilink PPP over dialer interface links, a traffic policy (also known as a policy map) must be created. (See the MQC and Multilink PPP over Dialer Interface Links, page 30.) Policy maps are created using the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC).

The MQC is a CLI structure that allows users to create traffic policies (policy maps) and attach these policy maps to interfaces. A policy map contains a traffic class and one or more QoS features. A traffic class is used to classify traffic. The QoS features in the traffic policy determine how to treat the classified traffic.

How to Configure Multilink PPP over Dialer Interface Links

Configuring Multilink PPP over Dialer Interface Links

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. See the MQC and Multilink PPP over Dialer Interface Links, page 30.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface dialer** *dialer-rotary-group-number*
4. **ip address** *ip-address mask* [**secondary**]
5. **ip unnumbered** *type number*
6. **encapsulation** *encapsulation-type*
7. **dialer pool** *number*
8. **dialer in-band** [**no-parity** | **odd-parity**]
9. **service-policy output** *policy-map-name*
10. **service-policy input** *policy-map-name*
11. **ppp authentication** {*protocol1* [*protocol2...*]} [**if-needed**] [*list-name* | **default**] [**callin**] [**one-time**] [**optional**]
12. **ppp chap hostname** *hostname*
13. **ppp chap password** *secret*
14. **ppp multilink** [**bap**]
15. **ppp multilink fragment delay** *milliseconds* [*microseconds*]
16. **ppp multilink interleave**
17. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface dialer** *dialer-rotary-group-number* **Example:** `Router(config)# interface dialer 1`	Defines a dialer rotary group and enters interface configuration mode. • Enter the dialer rotary group 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	**ip unnumbered** *type number* **Example:** `Router(config-if)# ip unnumbered ethernet 0`	(Optional) Enables IP processing on a serial interface without assigning an explicit IP address to the interface. • Enter the type and number of another interface on which the router has an assigned IP address. It cannot be another unnumbered interface.
Step 6	**encapsulation** *encapsulation-type* **Example:** `Router(config-if)# encapsulation ppp`	Sets the encapsulation method used by the interface. • Enter the encapsulation method. For this feature, enter **ppp**.
Step 7	**dialer pool** *number* **Example:** `Router(config-if)# dialer pool 3`	(Optional) Specifies which dialing pool to use to connect to a specific destination subnetwork. • Enter the dialing pool number.
Step 8	**dialer in-band** [**no-parity** | **odd-parity**] **Example:** `Router(config-if)# dialer in-band`	(Optional) Specifies that dial-on-demand routing (DDR) is to be supported.

	Command or Action	Purpose
Step 9	**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 10	**service-policy input** *policy-map-name* **Example:** `Router(config-if)# service-policy input policy1`	Attaches the previously created QoS traffic policy (policy map). See the Configuring Multilink PPP over Dialer Interface Links, page 31. The policy map evaluates and applies QoS features for traffic *entering*the interface. • Enter the policy map name.
Step 11	**ppp authentication** {*protocol1* [*protocol2*...]} [**if-needed**] [*list-name* | **default**] [**callin**] [**one-time**] [**optional**] **Example:** `Router(config-if)# ppp authentication chap`	Enables at least one Point-to-Point Protocol (PPP) authentication protocol and specifies the order in which the protocols are selected on the interface. • Enter the PPP authentication protocol to be used.
Step 12	**ppp chap hostname** *hostname* **Example:** `Router(config-if)# ppp chap hostname ISPCorp`	Creates a pool of dialup routers that all appear to be the same host when authenticating with Challenge Handshake Authentication Protocol (CHAP). • Enter the name sent in the CHAP challenge.
Step 13	**ppp chap password** *secret* **Example:** `Router(config-if)# ppp chap password 7`	Enables a router calling a collection of routers that do not support this command (such as routers running older Cisco IOS software images) to configure a CHAP secret password to use in response to challenges from an unknown peer. • Enter the secret password used to compute the response value for any CHAP challenge from an unknown peer.
Step 14	**ppp multilink** [**bap**] **Example:** `Router(config-if)# ppp multilink`	Enables multilink on an interface.

	Command or Action	Purpose
Step 15	**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 16	**ppp multilink interleave** **Example:** `Router(config-if)# ppp multilink interleave`	Enables interleaving of packets among the fragments of larger packets on a multilink bundle.
Step 17	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode.

Associating the Dialer Interface with a BRI

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface bri** *number*
4. **dialer pool-member** *number* [**priority** *priority*] [**min-link** *minimum*] [**max-link** *maximum*]
5. **dialer rotary-group** *interface-number*
6. **ppp multilink** [**bap**]
7. **end**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**enable** **Example:** `Router> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Router# configure terminal`	Enters global configuration mode.
Step 3	**interface bri** *number* **Example:** `Router(config)# interface bri 1`	Configures a BRI interface and enters interface configuration mode. • Enter port, connector, or interface card number.
Step 4	**dialer pool-member** *number* [**priority** *priority*] [**min-link** *minimum*] [**max-link** *maximum*] **Example:** `Router(config-if)# dialer pool-member 3`	(Optional) Configures a physical interface to be a member of a dialer profile dialing pool. • Enter the dialer profile dialing pool number.
Step 5	**dialer rotary-group** *interface-number* **Example:** `Router(config-if)# dialer rotary-group 1`	(Optional) Includes a specified interface in a dialer rotary group. • Enter the number of the dialer interface (defined in Associating the Dialer Interface with a BRI, page 34) in whose rotary group this interface is to be included.
Step 6	**ppp multilink** [**bap**] **Example:** `Router(config-if)# ppp multilink`	Enables Multilink on an interface.
Step 7	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode.

Verifying the Multilink PPP over Dialer 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. **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:** `Router# show interfaces`	(Optional) Displays statistics for all interfaces configured on the router or access server.
Step 3	**show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]] **Example:** `Router# show ppp multilink`	(Optional) Displays bundle information for the multilink bundles.
Step 4	**exit** **Example:** `Router# exit`	(Optional) Exits privileged EXEC mode.

Configuration Examples for Using Multilink PPP over Dialer Interface Links

Example Configuring Multilink PPP over Dialer Interface Links

The following is an example of configuring Multilink PPP over a dialer interface link:

```
Router> enable
Router# configure terminal
Router(config)# interface dialer 1
Router(config-if)# ip address 10.10.100.1 255.255.255.0

Router(config-if)# encapsulation ppp
Router(config-if)# dialer pool 3
Router(config-if)# service-policy output policy1
Router(config-if)# service-policy input policy1
Router(config-if)# ppp authentication chap
Router(config-if)# ppp chap hostname ISPCorp
Router(config-if)# ppp chap password 7
Router(config-if)# ppp multilink
Router(config-if)# ppp multilink fragment delay 20
Router(config-if)# ppp multilink interleave
Router(config-if)# end
```

Example Associating the Dialer Interface with a BRI

The following is an example of associating the dialer interface with a BRI:

```
Router> enable
Router# configure terminal
Router(config)# interface bri 1
Router(config-if)# dialer pool-member 3
Router(config-if)# ppp multilink
Router(config-if)# end
```

Example Verifying the Multilink PPP over Dialer Interface Link Configuration

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

- **show interfaces**
- **show ppp multilink**

The following section provides sample output of the **show ppp multilink** command only. For sample output of the other commands, see the appropriate Cisco IOS Release 12.3 T command reference publication.

show ppp multilink Command Output Example

The following is an example of the **show ppp multilink** command output. In this example, one multilink bundle called 7206-2 is on the system. This bundle has one member link.

```
Router# show ppp multilink
Dialer2, bundle name is 7206-2
  Username is 7206-2
  Endpoint discriminator is 7206-2
  Bundle up for 00:00:10, 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, 0x0 sent sequence
  Member links:1 (max not set, min not set)
    BR2/0:1, since 00:00:09
```

Where to Go Next

To use Multilink PPP over Frame Relay, see the "Using Multilink PPP over Frame Relay" module.

To use Multilink PPP over ATM links, see the "Using Multilink PPP over ATM Links" module.

To use Multilink PPP over serial interface links, see the "Using Multilink PPP over Serial Interface Links" module.

Additional References

The following sections provide references related to Multilink PPP over dialer interface 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*

Related Topic	Document Title
LLQ, WFQ, CBWFQ, PQ, CQ, FIFO and other queueing mechanisms	"Configuring Weighted Fair Queueing" module
MQC	"Applying QoS Features Using the MQC" module
Dialer profiles and DDR	"Preparing to Configure DDR" module
Multilink PPP configuration information	"Configuring Media-Independent PPP and Multilink PPP" 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 ATM links (including ATM interfaces and ATM PVCs)	"Using Multilink PPP over ATM 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 Dialer 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 2 Feature Information for Using Multilink PPP over Dialer Interface Links

Feature Name	Software Releases	Feature Configuration Information
Distributed Link Fragmentation and Interleaving Over Leased Lines	12.2(8)T	The Distributed Link Fragmentation and Interleaving over Leased Lines feature extends distributed link fragmentation and interleaving functionality to leased lines. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over dialer interface links.

Feature Name	Software Releases	Feature Configuration Information
Distributed Link Fragmentation and Interleaving for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers	12.2(4)T	The Distributed Link Fragmentation and Interleaving (dLFI) for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers feature extends link fragmentation and interleaving functionality to VIP-enabled Cisco 7500 series routers. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over dialer interface links.

Using Multilink PPP over Frame Relay

Multilink PPP is a method used to reduce latency and jitter for real-time traffic. This module contains conceptual information and configuration tasks for using Multilink PPP over Frame Relay.

Finding Feature Information

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

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

Prerequisites for Using Multilink PPP over Frame Relay

Knowledge

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

Enable Queuing Mechanism

- Multilink uses first-in first out (FIFO) queuing for queuing and interleaving packets. Other queuing mechanisms such as low latency queuing (LLQ), weighted fair queuing (WFQ), and class-based weighted fair queuing (CBWFQ) can be used. If you want to use one of these alternative mechanisms, enable it before configuring Multilink.

Enable FRTS

- Frame Relay Traffic Shaping (FRTS) must be enabled on the Frame Relay interface.

Restrictions for Using Multilink PPP over Frame Relay

Number of Links per Multilink Bundle

Only one link per multilink bundle is supported.

VoIP Support

Only Voice over IP (VoIP) is supported; Voice over Frame Relay (VoFR) is not supported.

QoS Configuration

Only one PVC is supported per virtual template.

To handle congestion, a shape policy in an MLP over Frame Relay should be configured via a map class and attached to the PVC.

Information About Using Multilink PPP over Frame Relay

Frame Relay Traffic Shaping and Multilink PPP over Frame Relay

Before using Multilink PPP over Frame Relay, FRTS must be enabled.

Note On the Cisco 7200 and lower series of routers, the **frame-relay traffic-shaping** command is used to enable FRTS. On the Cisco 7500 and higher series of routers, the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC) is used to enable FRTS. For more information about MQC, see the "MQC and Multilink PPP over Frame Relay" section.

FRTS is a Cisco traffic shaping mechanism. A traffic shaping mechanism allows you to regulate (that is, "shape") the packet flow on a network. When you shape traffic, you control the speed of traffic leaving an interface. This way, you can match the flow of the traffic to the speed of the interface and avoid bottlenecks on the network.

Cisco has long provided support for forward explicit congestion notification (FECN) for DECnet and OSI, and backward explicit congestion notification (BECN) for Systems Network Architecture (SNA) traffic using Logical Link Control, type 2 (LLC2) encapsulation via RFC 1490 and discard eligible (DE) bit support. FRTS builds upon this existing Frame Relay support with additional capabilities that improve the scalability and performance of a Frame Relay network, increasing the density of virtual circuits (VCs) and improving response time.

FRTS can eliminate bottlenecks in Frame Relay networks that have high-speed connections at the central site and low-speed connections at branch sites. You can configure rate enforcement--a peak rate configured to limit outbound traffic--to limit the rate at which data is sent on the VC at the central site.

MQC and Multilink PPP over Frame Relay

Before using Multilink PPP over Frame Relay, a policy map must be created. (See the "Prerequisites" section.) Policy maps are created using the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC).

Virtual Template Interfaces

A virtual template interface is logical interface configured with generic configuration information for a specific purpose or configuration common to specific users, plus router-dependent information. The template takes the form of a list of Cisco IOS interface commands that are applied to virtual access interfaces, as needed.

Multilink Group Interfaces

A multilink group interface is a collection of interfaces bundled together in the multilink PPP configuration. With a multilink group interface, you can bundle interfaces into logical multilink groups.

How to Configure Multilink PPP over Frame Relay

While the first two procedures are listed as optional, you must choose one or the other according to the Cisco router that you are using in your network.

- Configuring Multilink PPP over Frame Relay on a Virtual Template Interface, page 45
- Configuring Multilink PPP over Frame Relay on a Multilink Group Interface, page 48
- Associating the Virtual Template Interface with a Frame Relay PVC, page 51
- Verifying the Multilink PPP over Frame Relay Configuration, page 53

Configuring Multilink PPP over Frame Relay on a Virtual Template Interface

These steps apply if you are using the Cisco 7500 series router or the Cisco 7600 series router only. If you are using another series of Cisco router, do not complete these steps. Instead, advance to Configuring Multilink PPP over Frame Relay on a Multilink Group Interface, page 48.

Before proceeding with this task, you must create a policy map. The policy map contains the configuration parameters used to apply a specific QoS features such as distributed LLQ (dLLQ) to the network traffic. To create a policy map and configure the appropriate QoS feature, use the MQC. See the MQC and Multilink PPP over Frame Relay, page 45.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface virtual-template** *number*
4. **bandwidth** *kbps*
5. **ip address** *ip-address mask* [**secondary**]
6. **service-policy output** *policy-map-name*
7. **service-policy input** *policy-map-name*
8. **ppp multilink**
9. **ppp multilink fragment delay** *milliseconds* [*microseconds*]
10. **ppp multilink interleave**
11. **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 virtual-template** *number* **Example:** `Router(config)# interface virtual-template 1`	Creates a virtual template and enters interface configuration mode. • Enter the virtual template number.
Step 4	**bandwidth** *kbps* **Example:** `Router(config-if)# bandwidth 32`	Sets the bandwidth value for an interface. • Enter the bandwidth value in kilobits per second. **Note** The bandwidth value for the interface should match the traffic speed of the PVC; for instance, if the VBR peak cell rate is 128 kbps, the *kbps* option in the **bandwidth** command should be entered as 128. Similarly, if the PVC is being shaped to 64 kbps, the *kbps* option should be entered as 64.

	Command or Action	Purpose
Step 5	**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 6	**service-policy output** *policy-map-name* **Example:** `Router(config-if)# service-policy output policy1`	Attaches the previously created QoS traffic policy (policy map). See the Configuring Multilink PPP over Frame Relay on a Virtual Template Interface, page 45. The policy map evaluates and applies QoS features for traffic *leaving* the interface. • Enter the policy map name.
Step 7	**service-policy input** *policy-map-name* **Example:** `Router(config-if)# service-policy input policy1`	Attaches the previously created QoS traffic policy (policy map). See the Configuring Multilink PPP over Frame Relay on a Virtual Template Interface, page 45. The policy map evaluates and applies QoS features for traffic *entering* the interface. • Enter the policy map name.
Step 8	**ppp multilink** **Example:** `Router(config-if)# ppp multilink`	Enables MLP on the interface.
Step 9	**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. **Note** The fragment size can be configured using the following formula: fragment size = bandwidth x fragment-delay / 8
Step 10	**ppp multilink interleave** **Example:** `Router(config-if)# ppp multilink interleave`	Enables interleaving of packets among the fragments of larger packets on a multilink bundle.
Step 11	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode.

Configuring Multilink PPP over Frame Relay on a Multilink Group Interface

If you are using the Cisco 7500 series router or the Cisco 7600 series router, do not complete these steps. Instead, complete the steps in Configuring Multilink PPP over Frame Relay on a Virtual Template Interface, page 45.

Before proceeding with this task, you must create a policy map. The policy map contains the configuration parameters used to apply a specific QoS features such as distributed LLQ (dLLQ) to the network traffic. To create a policy map and configure the appropriate QoS feature, use the MQC. See the MQC and Multilink PPP over Frame Relay, page 45.

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. **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.

	Command or Action	Purpose
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). See the Configuring Multilink PPP over Frame Relay on a Multilink Group Interface, page 48. 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). See the Configuring Multilink PPP over Frame Relay on a Multilink Group Interface, page 48. 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 bundle. • Enter the maximum amount of time, in milliseconds, required to transmit a fragment.
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.
Step 9	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode.

- What to Do Next, page 49
- Associating the Virtual Template Interface with the Multilink Group, page 50

What to Do Next

After configuring Multilink PPP over Frame Relay on a multilink group interface, the next step is to associate the virtual template interface with the multilink group by completing the steps in the following section.

If you are using a Cisco 7500 series router or a Cisco 7600 series router, advance to Associating the Virtual Template Interface with a Frame Relay PVC, page 51 to continue.

Associating the Virtual Template Interface with the Multilink Group

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface virtual-template** *number*
4. **no ip address**
5. **ppp multilink group** *group-number*
6. **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 virtual-template** *number* **Example:** `Router# interface virtual-template 1`	Creates a virtual template interface that can be configured and applied dynamically in creating virtual access interfaces, and enters interface configuration mode. • Enter the number used to identify the virtual template interface.
Step 4	**no ip address** **Example:** `Router(config-if)# no ip address`	Removes an IP address or disables IP processing.

	Command or Action	Purpose
Step 5	**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 6	**end** **Example:** `Router(config-if)# end`	(Optional) Exits interface configuration mode.

Associating the Virtual Template Interface with a Frame Relay PVC

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *type number* [**name-tag**]
4. **frame-relay traffic-shaping**
5. **frame-relay interface-dlci** *dlci* [**ietf** | **cisco**] [**voice-cir** *cir*] [**ppp** *virtual-template-name*]
6. **class** *name*
7. **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.

	Command or Action	Purpose
Step 3	**interface** *type number* [**name-tag**] **Example:** `Router(config)# interface serial1/0/0/1:0`	Configures an interface type and enters interface configuration mode. • Enter the interface type and number.
Step 4	**frame-relay traffic-shaping** **Example:** `Router(config-if)# frame-relay traffic-shaping`	Enables both traffic shaping and per-virtual-circuit queueing for all permanent virtual circuits (PVCs) and switched virtual circuits (SVCs) on a Frame Relay interface. **Note** Use this command on Cisco 7200 and lower series routers *only* . Do not use this command on Cisco 7500 or higher series routers. For Cisco 7500 and higher series routers, use the MQC instead of this command.
Step 5	**frame-relay interface-dlci** *dlci* [**ietf** | **cisco**] [**voice-cir** *cir*] [**ppp** *virtual-template-name*] **Example:** `Router(config-if)# frame-relay interface-dlci 100 ppp virtual-template1`	Assigns a data-link connection identifier (DLCI) to a specified Frame Relay subinterface on the router or access server, assigns a specific PVC to a DLCI, or applies a virtual template configuration for a PPP session. Enters Frame Relay DLCI configuration mode. • Enter the DLCI number and any optional keywords and arguments, as appropriate.
Step 6	**class** *name* **Example:** `Router(config-fr-dlci)# class frdlci`	Associates a map class with a specified DLCI. • Enter the name of the map class to associate with the specified DLCI. **Note** Use this command on Cisco 7200 and lower series routers *only* . For Cisco 7500 and higher series routers, this command is not needed.
Step 7	**end** **Example:** `Router(config-fr-dlci)# end`	(Optional) Exits Frame Relay DLCI configuration mode.

Verifying the Multilink PPP over Frame Relay Configuration

SUMMARY STEPS

1. **enable**
2. **show frame-relay pvc** [**interface** *interface*] [**dlci**] [**64-bit**]
3. **show interfaces** [*type number*] [*first*] [*last*] [**accounting**]
4. **show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]]
5. **show policy-map interface** *interface-name* [**vc** [*vpi/*] *vci*] [**dlci** *dlci*] [**input** | **output**]
6. **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 frame-relay pvc** [**interface** *interface*] [**dlci**] [**64-bit**] **Example:** `Router# show frame-relay pvc`	(Optional) Displays statistics about permanent virtual circuits (PVCs) for Frame Relay interfaces.
Step 3	**show interfaces** [*type number*] [*first*] [*last*] [**accounting**] **Example:** `Router# show interfaces`	(Optional) Displays statistics for all interfaces configured on the router or access server.
Step 4	**show ppp multilink** [**active** | **inactive** | **interface** *bundle-interface* | [**username** *name*] [**endpoint** *endpoint*]] **Example:** `Router# show ppp multilink`	(Optional) Displays bundle information for multilink bundles.
Step 5	**show policy-map interface** *interface-name* [**vc** [*vpi/*] *vci*] [**dlci** *dlci*] [**input** | **output**] **Example:** `Router# show policy-map interface serial0/0`	(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 PVC on the interface.

	Command or Action	Purpose
Step 6	**exit** **Example:** `Router# exit`	(Optional) Exits privileged EXEC mode.

Configuration Examples for Multilink PPP over Frame Relay

Example Configuring Multilink PPP over Frame Relay on a Virtual Template Interface

The following is an example of configuring Multilink PPP over Frame Relay on a virtual template interface:

```
Router> enable
Router# configure terminal
Router(config)# interface virtual-template 1
Router(config-if)# bandwidth 32
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
Router(config-if)# ppp multilink fragment delay 20
Router(config-if)# ppp multilink interleave
Router(config-if)# end
```

Example Configuring Multilink PPP over Frame Relay on a Multilink Group Interface

The following is an example of configuring Multilink PPP over Frame Relay 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)# end
```

Example Associating the Virtual Template Interface with the Multilink Group

The following is an example of associating the virtual template interface with the multilink group:

```
Router> enable

Router# configure terminal

Router(config)# interface virtual-template 1

Router(config-if)# no ip address

Router(config-if)# ppp multilink group 1

Router(config-if)# end
```

Example Associating the Virtual Template Interface with a Frame Relay PVC

The following is an example of associating the virtual template interface with a Frame Relay PVC:

```
Router> enable

Router# configure terminal

Router(config)# interface serial1/0/0/1:0

Router(config-if)# frame-relay interface-dlci 100 ppp virtual-template1

Router(config-fr-dlci)# class frdlci

Router(config-fr-dlci)# end
```

Example Verifying the Multilink PPP over Frame Relay Configuration

You can verify the Multilink with PPP over Frame Relay configuration by using one or more of the following **show** commands:

- **show frame relay pvc**
- **show interfaces**
- **show ppp multilink**
- **show policy-map interface**

The following section provides sample output of the **show ppp multilink** command only. For sample output of the other commands, see the appropriate Cisco IOS Release 12.3T command reference publication.

show ppp multilink Command Output Example

The following is an example of the **show ppp multilink** command output. In this example, one Multilink bundle called 7206-2 is on the system. This bundle has two member links: one active link and one inactive link.

```
Router# show ppp multilink

Multilink1, bundle name is 7206-2
  Endpoint discriminator is 7206-2
  Bundle up for 00:00:15, 1/255 load
  Receive buffer limit 12000 bytes, frag timeout 3428 ms
    0/0 fragments/bytes in reassembly list
    1 lost fragments, 1 reordered
    0/0 discarded fragments/bytes, 0 lost received
    0x3 received sequence, 0x3 sent sequence
  Member links:1 active, 1 inactive (max not set, min not set)
    Vi2, since 00:00:15, 105 weight, 93 frag size
    Vt1 (inactive)
```

Where to Go Next

To use Multilink PPP over ATM links, see the "Using Multilink PPP over ATM Links" module.

To use Multilink PPP over dialer interface links, see the "Using Multilink PPP over Dialer Interface Links" module.

To use Multilink PPP over serial interface links, see the "Using Multilink PPP over Serial Interface Links" module.

Additional References

The following sections provide references related to using Multilink PPP over Frame Relay.

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
FRTS	"MQC-Based Frame Relay Traffic Shaping" 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 ATM links (including ATM interfaces and ATM PVCs)	"Using Multilink PPP over ATM Links" 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 Frame Relay

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 Using Multilink PPP over Frame Relay

Feature Name	Software Releases	Feature Configuration Information
Distributed Link Fragmentation and Interleaving for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers	12.2(4)T	The Distributed Link Fragmentation and Interleaving (dLFI) for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers feature extends link fragmentation and interleaving functionality to VIP-enabled Cisco 7500 series routers. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over Frame Relay.
Distributed Link Fragmentation and Interleaving Over Leased Lines	12.2(8)T	The Distributed Link Fragmentation and Interleaving over Leased Lines feature extends distributed link fragmentation and interleaving functionality to leased lines. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over Frame Relay.

Using Multilink PPP over Serial Interface Links

This module contains conceptual information and configuration tasks for using Multilink PPP over serial interface links. Multilink PPP is a method used to reduce latency and jitter for real-time traffic.

Finding Feature Information

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

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

Prerequisites for Using Multilink PPP over Serial Interface Links

Knowledge

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

Enable Queueing Mechanism

- Multilink uses first-in first out (FIFO) queuing for queueing and interleaving packets. Other queueing mechanisms such as low latency queueing (LLQ), weighted fair queueing (WFQ), and class-based

weighted fair queueing (CBWFQ) can be used. If you want to use one of these alternative mechanisms, enable it before configuring multilink.

Restrictions for Using Multilink PPP over Serial Interface Links

Number of Links per Multilink Bundle

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.

VoIP Support

Only Voice over IP (VoIP) is supported.

Queueing Mechanisms Not Supported

Many of the legacy queueing mechanisms are not supported by multilink. These mechanisms include:

- Fair queueing on a virtual template interface
- Weighted random early detection (WRED) on a virtual template interface
- Custom queueing
- Priority queueing

Note Fair queueing, WRED, and priority queueing can be configured in a traffic policy using the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC).

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 (also known as a policy map) must be created. (See the MQC and Multilink PPP over Serial Interface Links, page 62.) Policy maps are created using the Modular Quality of Service (QoS) Command-Line Interface (CLI) (MQC).

The MQC is a CLI structure that allows users to create traffic polices (policy maps) and attach these policy maps to interfaces. A policy map contains a traffic class and one or more QoS features. A traffic class is used to classify traffic. The QoS features in the traffic policy determine how to treat the classified traffic.

Multilink Group Interfaces

A multilink group interface is a collection of interfaces bundled together in the multilink PPP configuration. With a multilink group interface, you can bundle interfaces into logical multilink groups.

How to Configure Multilink PPP over Serial Interface Links

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

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. See the MQC and Multilink PPP over Serial Interface Links, page 62.

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.

	Command or Action	Purpose
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). See the Configuring Multilink PPP over Serial Interface Links on a Multilink Group Interface, page 63. 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). See the Configuring Multilink PPP over Serial Interface Links on a Multilink Group Interface, page 63. 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.

	Command or Action	Purpose
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.
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:** `Router# show interfaces`	(Optional) Displays statistics for all interfaces configured on the router or access server.
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`	(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
```

Verifying the Multilink PPP over Serial Interface Link Configuration Example

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 **show ppp multilink** command only. For sample output of the other commands, see the appropriate Cisco IOS Release 12.3 T command reference publication.

show ppp multilink Command Output Example

The following is an example of the **show ppp multilink** command output. In this example, one multilink bundle called 7206-2 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 7206-2
  Endpoint discriminator is 7206-2
  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)
```

Where to Go Next

To use Multilink PPP over ATM links, see the "Using Multilink PPP over ATM Links" module.

To use Multilink PPP over Frame Relay, see the "Using Multilink PPP over Frame Relay" module.

To use Multilink PPP over dialer interface links, see the "Using Multilink PPP over Dialer Interface Links" module.

Additional References

The following sections provide references related to Multilink PPP over serial interface 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
Multilink PPP overview module	"Reducing Latency and Jitter for Real-Time Traffic Using Multilink PPP" module
Multilink PPP over ATM links (including ATM interfaces and ATM PVCs)	"Using Multilink PPP over ATM Links" 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

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 4 Feature Information for Using Multilink PPP over Serial Interface Links

Feature Name	Software Releases	Feature Configuration Information
Distributed Link Fragmentation and Interleaving Over Leased Lines	12.2(8)T	The Distributed Link Fragmentation and Interleaving over Leased Lines feature extends distributed link fragmentation and interleaving functionality to leased lines. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over serial interface links.
Distributed Link Fragmentation and Interleaving for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers	12.2(4)T	The Distributed Link Fragmentation and Interleaving (dLFI) for Frame Relay and ATM Interfaces on Cisco 7500 Series Routers feature extends link fragmentation and interleaving functionality to VIP-enabled Cisco 7500 series routers. This feature was extensively rewritten from the perspective of using Multilink PPP for link fragmentation and interleaving over serial interface links.