VoIP QoS for Frame Relay to ATM Interworking with LLQ, PPP LFI and cRTP

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Contents

Introduction

This document provides a sample configuration for Voice over IP using Multilink PPP over ATM and Frame Relay Interworking (VoIP using MLPoATM / MLPoFR). The central focus of the configuration examples is the provision of Quality of Service (QoS) in order to properly support voice across an ATM / Frame Relay interworked WAN. The configuration examples also make use of compressed Real Time Protocol (cRTP), which has been supported on ATM since Cisco IOS® Software Release 12.2(2)T.

The document can be read stand−alone for configuration guidance, configuration examples, and verification commands in order to be used in building the network. Some background information is also provided for specific issues associated with the use of ATM / Frame Relay interworking. Refer to these documents for more information on QoS for VoIP over Frame Relay or PPP:

- VoIP over PPP Links with Quality of Service (LLQ / IP RTP Priority, LFI, cRTP)
- VoIP over Frame Relay with QoS (Fragmentation, Traffic Shaping, LLQ / IP RTP Priority)

Prerequisites

Requirements

Ensure that you meet these requirements before you attempt this configuration:

You should be familiar with these technology areas:

- Access control lists
- ATM permanent virtual circuits (PVCs)
- Frame Relay permanent virtual circuits (data−link connection identifier (DLCIs))
- Bandwidth management
- LLQ
- LFI

- Virtual templates and virtual access interfaces
- MLPPP
- cRTP

Components Used

The information in this document is based on these software and hardware versions:

- Cisco 3640 as the ATM router
- Cisco 2620 as the Frame Relay router
- Cisco IOS Software Release 12.2(8)T (IP Plus)

Note: As a general guideline, the latest Cisco IOS 12.2 mainline maintenance release is the recommended Cisco IOS software release to use for MLPoATM/FR. Cisco IOS Software Release 12.2T is required on the ATM router if cRTP is used.

Relevant features were introduced in these Cisco IOS software releases:

- LFI was introduced in Cisco IOS Software Release 11.3.
- LLQ was introduced in Cisco IOS Software Release 12.0(7)T.
- LLQ over Frame Relay and ATM per PVC was introduced in Cisco IOS Software Release 12.1(2)T.
- Multilink PPP LFI for Frame Relay and ATM Virtual Circuits was introduced in Cisco IOS Software Release 12.1(5)T.
- cRTP over ATM was introduced in Cisco IOS Software Release 12.2(2)T.

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Conventions

Refer to Cisco Technical Tips Conventions for more information on document conventions.

Background Information

The key issues in providing minimized end−to−end delay and jitter avoidance for VoIP across an ATM / Frame Relay interworked network are:

- Strict priority for Voice Traffic (low latency queueing (LLQ))
- Link Fragmentation and Interleaving (LFI)
- Frame Relay Traffic Shaping (FRTS) for Voice
- ATM Traffic Shaping

These documents provide useful sources of further background information:

- Quality of Service for Voice over IP
- Configuring Link Fragmentation and Interleaving for Frame Relay and ATM Virtual Circuits

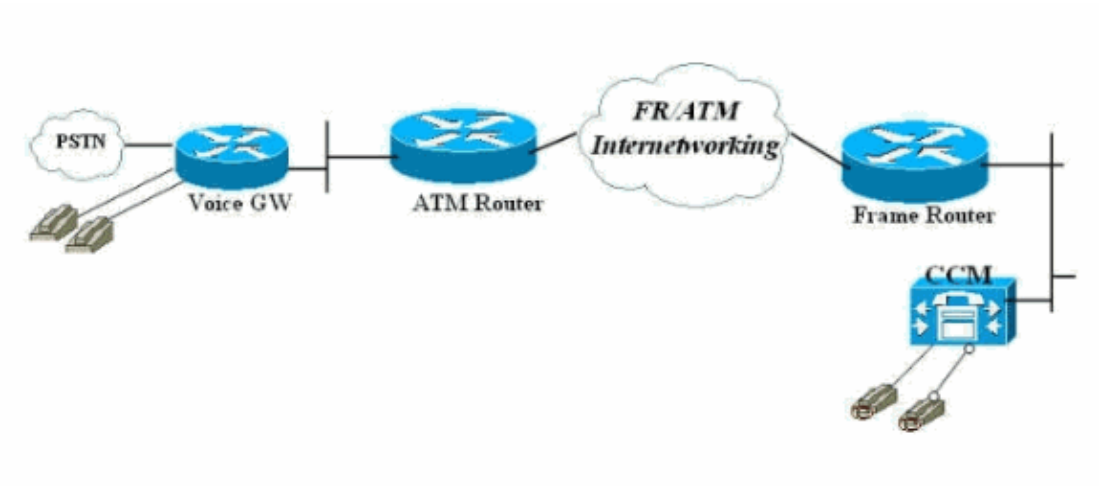
Configure

In this section, you are presented with the information to configure the features described in this document.

Note: Use the Command Lookup Tool (registered customers only) in order to find more information on the commands used in this document.

Network Diagram

This document uses this network setup:



Configurations

This document uses these configurations:

- Frame Relay Connected Router
- ATM Connected Router

Note: It is important to note that in this configuration, the two routers are connected back−to−back over a Frame Relay to ATM interworking switch. In most topologies however, the voice enabled routers can exist anywhere. Usually, the voice routers use LAN connectivity to other routers, which are connected to the ATM/Frame WAN. In those cases, the routers connected to the WAN, Frame Relay, and ATM have to be configured for LLQ, LFI, and MLPPP so they can provide QoS, and not the voice gateways as shown in these configurations.

Frame Relay Connected Router

```
!--- Note: This configuration is commented and numbered
!--- in the order that commands should be entered.


version 12.2
service timestamps debug datetime msec
service timestamps log uptime
no service password-encryption
!
hostname FR
!
enable password cisco
!
username ATM password 0 cisco
voice-card 0
dspfarm
!
ip subnet-zero
!
```

```
!
!
!


!--- access-list 105 permit ip any any dscp ef specifies
!--- that all traffic with Differentiated Services Code Point (DSCP)
!--- are set to 40 falls into this access-list.
!--- This class-map command defines a class of traffic called "voice".


access-list 105 permit ip any any dscp ef
access-list 105 permit udp any any  range 16384 32767
access-list 105 permit ip any any precedence critical
!
class-map match-all voice
match access-group 105
!

!
!

!--- This policy-map command defines a policy for LLQ called "VoIP" and
!--- maps the "voice" class to the "VOIP" policy.
!--- "priority" defines the amount of bandwidth reserved for the priority queue.
!--- "class-default" specifies that the default class is also mapped to this policy.
!--- "fair-queue" specifies that all other traffic is served in the WFQ.


policy-map VOIP
  class voice
    priority 48
  class class-default
   fair-queue


!--- Note: Although it is possible to queue various types of
!--- real-time traffic to the priority queue,
!--- Cisco recommends that you direct only voice traffic
!--- to it. Real-time traffic such as video or voice
!--- could introduce variations in delay. Please note voice and
!--- video should not be combined in the same PVC.
!--- (the priority queue is a First In First Out (FIFO)
!--- queue). Voice traffic requires that delay be
!--- nonvariable in order to avoid jitter.

!--- Note: The sum of the values for priority and
!--- bandwidth statements needs to be less
!--- than or equal to 75% of the link bandwidth.
!--- Otherwise service-policy cannot be
!--- assigned to the link. When configuring VoIP over a
!--- 64 Kbps link to support two
!--- voice calls, it is common to allocate more than 75%
!--- (48 Kbps) of the link bandwidth to
!--- the priority queue. In such cases, you can use the
!--- max-reserved-bandwidth <#%> command in order to raise
!--- available bandwidth to a value more than 75%.


!
!
!
fax interface-type fax-mail
mta receive maximum-recipients 0
!
interface Loopback0
```

```
 ip address 10.1.1.2 255.255.255.0
!
!
interface FastEthernet0/0
 ip address 172.17.111.16 255.255.255.224
 duplex auto
 speed auto
!
interface Serial0/0
 no ip address
 encapsulation frame-relay IETF
 no ip route-cache
 no ip mroute-cache
 frame-relay traffic-shaping
!

!--- Choose the frame relay interface to be
!--- associated with the virtual interface. The
!--- virtual template could equally have been associated
!--- with the physical interface.
!--- The "class mlp" associates the virtual template interface
!--- defined in "interface Virtual-Template1" with a Frame Relay DLCI.
!--- Associates a Frame Relay map class with a DLCI.


interface Serial0/0.1 point-to-point
 no ip route-cache
 no ip mroute-cache
 frame-relay interface-dlci 16 ppp Virtual-Template1
  class mlp


!--- The interface command creates a virtual
!--- template called Virtual-Template1.
!--- A bandwidth of 64 Kbps is assigned to this
!--- template interface. This bandwidth is used
!--- by Cisco IOS to calculate the data fragment size as noted regarding
!--- interleaving of PPP segments.

!--- "ip rtp header-compression" cRTP is supported in an ATM/Frame Relay Interworking
!--- environment. It requires Cisco IOS Software Release 12.2(2)T on the
!--- ATM router.

!--- "service-policy output VOIP" The VoIP policy created earlier is assigned
!--- to this interface in the outbound direction.

!--- PPP multilink is enabled and the
!--- maximum delay per segment is specified. This bandwidth is
!--- used by Cisco IOS to calculate the data fragement size as noted.

!--- Interleaving of PPP segments is enabled, which allows
!--- voice packets to be expedited. Voice
!--- packets need only wait behind a single segment of
!--- a previously queued data packet (for example, 10 ms
!--- delay) rather than wait until the end of the
!--- entire data packet. Cisco IOS calculates the
!--- data fragment size using the following formula:
!--- fragment size = delay x bandwidth/8

!
interface Virtual-Template1
 bandwidth 64
 ip unnumbered loopback0
 ip rtp header-compression
 no ip route-cache
 load-interval 30
```

```
 max-reserved-bandwidth 99
 service-policy output VOIP
 ppp multilink
 ppp multilink fragment-delay 10
 ppp multilink interleave
!


!
ip classless
ip route 0.0.0.0 0.0.0.0 172.17.111.1
no ip http server
ip pim bidir-enable
!
!
!

!--- A map class called mlp is created.
!--- With "no frame-relay adaptive-shaping", adaptive
!--- shaping is disabled. You do not
!--- want to exceed CIR and have voice packets
!--- possibly queued within the Frame Relay network.
!--- Waiting for a BECN to resolve this
!--- situation could result in poor voice quality.
!--- The frame-relay cir 64000 command forces the router to transmit
!--- at the desired CIR rate rather than line
!--- rate for the port.
!--- "frame-relay bc 640" configures the Bc value to force the desired
!--- Tc (shaping interval) value is 10 ms.
!--- This formula should be used to determine
!--- the Bc value to use: Tc = Bc/CIR. A
!--- smaller Tc value reduces the interval a voice
!--- packet has to wait to be sent.
!--- As in "frame-relay be 0", the Be value should be set to zero
!--- in order to avoid voice being sent as part of a burst
!--- that is not guaranteed by the Frame Relay network.


map-class frame-relay mlp

 no frame-relay adaptive-shaping
 frame-relay cir 64000
 frame-relay bc 640
 frame-relay be 0


!
call rsvp-sync
!
voice-port 1/0/0
!
voice-port 1/0/1
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
dial-peer voice 123 voip
 destination-pattern 123
 session target ipv4:10.1.1.1
 ip qos dscp cs5 media
 ip qos dscp cs5 signaling
 no vad
```

```
!
dial-peer voice 456 pots
 destination-pattern 456
 port 1/0/0
!
!
line con 0
line aux 0
line vty 0 4
 exec-timeout 0 0
 password cisco
 login
!
!
end
```

ATM Connected Router

```
!--- Note: This configuration is commented only
!--- where additional consideration is required from the
!--- above configuration of the Frame Relay router.


version 12.2
service timestamps debug datetime msec
service timestamps log uptime
no service password-encryption
!
hostname ATM
!
enable password cisco
!
username FR password 0 cisco
memory-size iomem 25
ip subnet-zero
!
!
!
access-list 105 permit ip any any dscp ef
access-list 105 permit udp any any  range 16384 32767
access-list 105 permit ip any any precedence critical
!
class-map match-all voice
 match access-group 105
!
!

!--- Note: Matching commands to the Frame Relay
!--- router side of the network.


!
!
policy-map VOIP
  class voice
    priority 48
  class class-default
   fair-queue


!--- Note: Matching commands to the Frame Relay
!--- router side of the network.
```

```
!
!
fax interface-type fax-mail
mta receive maximum-recipients 0
!
controller T1 2/0
 framing sf
 linecode ami
!
!
!
!
interface ATM0/0
 no ip address
 ip route-cache
 no atm ilmi-keepalive
!

!--- "interface ATM0/0.1 point-to-point" chooses the ATM subinterface.
!---  The physical interface could equally have been used.
!--- "pvc 10/100" creates an ATM PVC.
!--- "cbr 64" A VBR PVC has been defined on this example.
!--- This exapmle uses VBR non-realtime and the sustained
!--- cell rate (SCR) should be equal to the peak
!--- cell rate (PCR)  in order to avoid bursting.
!--- ATM cell tax and the possibility
!--- of ATM bandwidth expansion due to poor
!--- fragment/cell alignment, means that it
!--- cannot be assumed that the PCR/SCR on the ATM
!--- side should equal the CIR of the Frame Relay side.
!--- Maintain the value of CIR on the Frame-Relay side to define
!--- our SCR, in this case, 64 kbps. This value may in some networks
!--- require some fine-tuning as the CIR on the Frame side does not
!--- exactly match the SCR on the ATM but makes for a good-enough estimation
!--- for most purposes.
!--- Refer to Designing and Deploying
!--- Multilink PPP over Frame Relay and ATM
!--- for more information.
!--- "encapsulation aal5snap" is required.
!--- "protocol ppp Virtual-Template1" associates the virtual
!--- template with the ATM PVC.


interface ATM0/0.1 point-to-point
 ip route-cache
 pvc 10/100
  cbr 64
  encapsulation aal5snap
  protocol ppp Virtual-Template1


!
!
interface loopback0
 ip address 10.1.1.1 255.255.255.0
!
interface Ethernet3/0
 ip address 172.17.111.15 255.255.255.224
 half-duplex
!
interface Ethernet3/1
 no ip address
 shutdown
 half-duplex
!
interface Virtual-Template1
```

```
 bandwidth 64
 ip unnumbered loopback0
 ip rtp header-compression
 no ip route-cache
 load-interval 30
 max-reserved-bandwidth 99
 service-policy output VOIP
 ppp multilink
 ppp multilink fragment-delay 10
 ppp multilink interleave


!--- Note: The virtual template is created in
!--- exactly the same way as for the
!--- Frame Relay router side of the network.
!--- An additional consideration for
!--- the ATM router is that the fragment size
!--- should be optimized to fit into
!--- an integral number of ATM cells.
!--- Refer to Designing and Deploying
!--- Multilink PPP over Frame Relay and ATM
!--- for more information on this issue.


!
ip classless
ip route 0.0.0.0 0.0.0.0 172.17.111.1
ip http server
ip pim bidir-enable
!
!
call rsvp-sync
!
voice-port 1/0/0
 description FXS
!
voice-port 1/0/1
!
voice-port 1/1/0
 description FXO
!
voice-port 1/1/1
!
!
mgcp profile default
!
dial-peer cor custom
!
!
!
dial-peer voice 456 voip
 destination-pattern 456
 session target ipv4:10.1.1.2
 ip qos dscp cs5 media
 ip qos dscp cs5 signaling
 no vad
!
dial-peer voice 123 pots
 destination-pattern 123
 port 1/1/0
!
!
line con 0
line aux 0
line vty 0 4
 exec-timeout 0 0
```

```
 password cisco
 login
!
!
end
```

Verify

Use this section to confirm that your configuration works properly.

The Output Interpreter Tool (registered customers only) (OIT) supports certain **show** commands. Use the OIT to view an analysis of **show** command output.

These **show** commands are useful in the verification of the operational status of the ATM/Frame Relay interworking environment, which includes DLCI and PVC statistics, physical and virtual interface status, policy (QoS) application, and cRTP information:

- **show ppp multilink interface** *interface−name* Verifies if the bundle is up/down, which virtual−access interface is the bundle (MLPPP bundle), and which are members (PPP link). This command also verifies if the carrier drops cells/frames (lost fragments <> 0). The only acceptable fragment loss is one caused by cyclic redundancy check (CRC) errors.
- **show user** Displays the number associated with the virtual access interface. You can use information from this command or the **show ppp multilink** command so you can display statistics about the interface or clear the interface.
- **show frame−relay pvc** *dlci* Displays information such as traffic shaping parameters, fragmentation values, and dropped packets. This command also shows if the physical interface has been bound to the virtual interface.
- **show atm pvc** *pvc* Displays all active ATM PVCs and traffic information.
- **show policy−map interface** *interface−name* Displays all the LLQ operation and any drops in the PQ. Refer to Understanding Packet Counters in the **show policy−map interface** command output for more information on the various fields of this command.

  Note: The fancy queuing is always applied to the virtual−access2 interface. The other interfaces use FIFO queuing.
- **show ip rtp header−compression** Displays the RTP header compression statistics if configured. Notice that the statistics are attached to the virtual−access2 interface, which is the bundle interface.

Examples of these commands are shown here:

```
FR#show ppp multilink interface virtual−access 2
Virtual−Access2, bundle name is ATM
Bundle up for 00:22:42
0 lost fragments, 0 reordered, 0 unassigned
0 discarded, 0 lost received, 231/255 load
0x2E5 received sequence, 0x10C31 sent sequence
Member links: 1 (max not set, min not set)
Virtual−Access1, since 00:22:42, last rcvd seq 0002E4 160 weight
```

This output shows the **show users** on the Frame Relay router.

```
FR#show users
Line User Host(s) Idle Location
67 vty 1 idle 00:00:00 10.1.1.1
Interface User Mode Idle Peer Address
Vi1 Virtual PPP (FR ) −
Vi2 Virtual PPP (Bundle) 00:00:00 10.1.1.1
FR#
```

This output shows the **show users** on the ATM router.

```
ATM#show users
Line User Host(s) Idle Location
131 vty 1 idle 00:00:00 64.104.207.95
Interface User Mode Idle Peer Address
Vi1 Virtual PPP (ATM ) –
Vi2 Virtual PPP (Bundle) 00:00:02 10.1.1.2
ATM#
```

This output shows the **show frame−relay pvc** command.

```
FR#show frame−relay pvc 16
 PVC Statistics for interface Serial0/0 (Frame Relay DTE)
 DLCI = 16, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial0/0.1

     input pkts 2301 output pkts 2295 in bytes 152266
     out bytes 151891 dropped pkts 0 in FECN pkts 0
     in BECN pkts 0 out FECN pkts 0 out BECN pkts 0
     in DE pkts 0 out DE pkts 0
     out bcast pkts 0 out bcast bytes 0
     5 minute input rate 9000 bits/sec, 9 packets/sec
     5 minute output rate 9000 bits/sec, 9 packets/sec
     pvc create time 23:46:56, last time pvc status changed 00:22:56
     Bound to Virtual−Access1 (up, cloned from Virtual−Template1)

!−−− PPP link interface.

     cir 64000 bc 640 be 0 byte limit 80 interval 10
     mincir 64000 byte increment 80 Adaptive Shaping none
     pkts 2296 bytes 152053 pkts delayed 9 bytes delayed 375
     shaping active
     traffic shaping drops 0
     Queueing strategy: fifo
     Output queue 0/40, 0 drop, 0 dequeued
FR#
```

This output shows the **show atm pvc 10/100** command on the ATM router.

```
ATM#show atm pvc 10/100
     ATM0/0.1: VCD: 1, VPI: 10, VCI: 100
     CBR, SusRate: 128
     AAL5−LLC/SNAP, etype:0x0, Flags: 0x820, VCmode: 0x0
     OAM frequency: 0 second(s), OAM retry frequency: 1 second(s)
     OAM up retry count: 3, OAM down retry count: 5
     OAM Loopback status: OAM Disabled
     OAM VC state: Not Managed
     ILMI VC state: Not Managed
     InARP frequency: 15 minutes(s)
     Transmit priority 1
     InPkts: 729, OutPkts: 729, InBytes: 49700, OutBytes: 51158
     InPRoc: 0, OutPRoc: 729
     InFast: 729, OutFast: 0, InAS: 0, OutAS: 0
     InPktDrops: 0, OutPktDrops: 0/0/0 (holdq/outputq/total)
     CrcErrors: 0, SarTimeOuts: 0, OverSizedSDUs: 0, LengthViolation: 0,
     CPIErrors: 0
     OAM cells received: 0
     F5 InEndloop: 0, F5 InSegloop: 0, F5 InAIS: 0, F5 InRDI: 0
     F4 InEndloop: 0, F4 InSegloop: 0, F4 InAIS: 0, F4 InRDI: 0
     OAM cells sent: 0
     F5 OutEndloop: 0, F5 OutSegloop: 0, F5 OutRDI: 0
     F4 OutEndloop: 0, F4 OutSegloop: 0, F4 OutRDI: 0
     OAM cell drops: 0
     Status: UP
   PPP: Virtual−Access2 from Virtual−Template1
```

```
!--- MLPPP bundle interface.

ATM#
```

This is the **show policy-map** on the Frame Relay router.

```
FR#show policy-map interface Virtual-Access2
Service-policy output: VoIP
Class-map: voice (match-all)
15483 packets, 959502 bytes
30 second offered rate 24000 bps, drop rate 0 bps
Match: ip dscp 40
Weighted Fair Queueing
Strict Priority

!--- LLQ Strict Priority Queue for voice.

Output Queue: Conversation 24
Bandwidth 48(kbps) Burst 1500 (Bytes)
(pkts matched/bytes matched) 15536/962784
(total drops/bytes drops) 0/0

!--- No drops in the voice queue.

Class-map: class-default (match-any)
139 packets, 19481 bytes
30 second offered rate 1000 bps, drop rate 0 bps
Match: any
Weighted Fair Queueing
Flow Based Fair Queueing
Maximum Number of Hashed Queues 16
(total queued/total drops/no-buffer drops) 0/0/0
```

This output shows the **show policy map** command on the ATM router.

```
ATM#show policy-map interface Virtual-Access2
Service-policy output: VOIP
Class-map: voice (match-all)
11293 packets, 699718 bytes
30 second offered rate 24000 bps, drop rate 0 bps
Match: ip dscp 40
Weighted Fair Queueing
Strict Priority

!--- LLQ Strict Priority Queue for voice.

Output Queue: Conversation 24
Bandwidth 48 (kbps) Burst 1500 (Bytes)
(pkts matched/bytes matched) 11352/703376
(total drops/bytes drops) 0/0

!--- No drops in the voice queue.

Class-map: class-default (match-any)
63 packets, 9772 bytes
30 second offered rate 0 bps, drop rate 0 bps
Match: any
Weighted Fair Queueing
Flow Based Fair Queueing
Maximum Number of Hashed Queues 16
(total queued/total drops/no-buffer drops) 0/0/0
ATM#
```

This output shows the **show ip rtp header−compression** command on the Frame Relay router.

```
FR#show ip rtp header−compression
RTP/UDP/IP header compression statistics:
Interface Virtual−Access1:
Rcvd: 0 total, 0 compressed, 0 errors
0 dropped, 0 buffer copies, 0 buffer failures
Sent: 0 total, 0 compressed,
0 bytes saved, 0 bytes sent
Connect: 16 rx slots, 16 tx slots,
0 long searches, 0 misses 0 collisions

Interface Virtual−Template1:
Rcvd: 0 total, 0 compressed, 0 errors
0 dropped, 0 buffer copies, 0 buffer failures
Sent: 0 total, 0 compressed,
0 bytes saved, 0 bytes sent
Connect: 16 rx slots, 16 tx slots,
0 long searches, 0 misses 0 collisions

Interface Virtual−Access2:
Rcvd: 23682 total, 23681 compressed, 0 errors
0 dropped, 0 buffer copies, 0 buffer failures
Sent: 327 total, 233 compressed,
8821 bytes saved, 5159 bytes sent
2.70 efficiency improvement factor
Connect: 16 rx slots, 16 tx slots,
0 long searches, 94 misses 0 collisions
71% hit ratio, five minute miss rate 0 misses/sec, 0 max
```

This output shows the **show ip rtp header−compression** command on the ATM router.

```
ATM#show ip rtp header−compression
RTP/UDP/IP header compression statistics:
Interface Virtual−Access1:
Rcvd: 0 total, 0 compressed, 0 errors
0 dropped, 0 buffer copies, 0 buffer failures
Sent: 0 total, 0 compressed,
0 bytes saved, 0 bytes sent
Connect: 16 rx slots, 16 tx slots,
0 long searches, 0 misses 0 collisions, 0 negative cache hits

Interface Virtual−Template1:
Rcvd: 0 total, 0 compressed, 0 errors
0 dropped, 0 buffer copies, 0 buffer failures
Sent: 0 total, 0 compressed,
0 bytes saved, 0 bytes sent
Connect: 16 rx slots, 16 tx slots,
0 long searches, 0 misses 0 collisions, 0 negative cache hits

Interface Virtual−Access2:
Rcvd: 283 total, 233 compressed, 0 errors
0 dropped, 0 buffer copies, 0 buffer failures
Sent: 25341 total, 25340 compressed,
955537 bytes saved, 564463 bytes sent
2.69 efficiency improvement factor
Connect: 16 rx slots, 16 tx slots,
0 long searches, 1 misses 0 collisions, 100 negative cache hits
99% hit ratio, five minute miss rate 0 misses/sec, 0 max
```

Troubleshoot

Use this section in order to troubleshoot your configuration.

This section provides some example debugs intended to clarify MLP LFI and serve as working examples to troubleshoot your configuration.

Troubleshooting Commands

The Output Interpreter Tool (registered customers only) (OIT) supports certain **show** commands. Use the OIT to view an analysis of **show** command output.

Note: Refer to Important Information on Debug Commands before you use **debug** commands.

- **debug ppp negotiation** Illustrates the process of cloning the two virtual−access interfaces to represent the PPP and PPP bundle links. Virtual−access interface 1 (Vi1) is the PPP link to which the (ATM or frame) PVC is bound. Virtual interface 2 (Vi2) is the PPP bundle link to which queuing policies are attached.
- **debug ppp multilink fragment** Illustrates the concept of larger data packets being interleaved with smaller voice packets. The interleaving occurs on the Vi2 interface (the MLP level) since the bundle interface has the fancy queuing assigned.

This is the command output for the **debug ppp negotiation** command.

```
FR(config−if)#no shut
FR(config−if)#^Z
FR#
FR#
6d23h: %LINK−3−UPDOWN: Interface Virtual−Access1, changed state to up
*Mar 7 23:20:42.842: Vi1 PPP: Treating connection as
a dedicated line

!−−− Vi1 is the PPP link to which the PVC is bound.

*Mar 7 23:20:42.842: Vi1 PPP: Phase is ESTABLISHING, Active Open
*Mar 7 23:20:42.842: Vi1 LCP: O CONFREQ [Closed] id 197 len 19
*Mar 7 23:20:42.842: Vi1 LCP: MagicNumber 0xF44128D2 (0x0506F44128D2)
*Mar 7 23:20:42.842: Vi1 LCP: MRRU 1524 (0x110405F4)
*Mar 7 23:20:42.842: Vi1 LCP: EndpointDisc 1 FR (0x1305014652)

!−−− Router FR at one end of PPP discovery.

*Mar 7 23:20:42.858: Vi1 LCP: I CONFREQ [REQsent] id 14 len 20
*Mar 7 23:20:42.858: Vi1 LCP: MagicNumber 0x294819D4 (0x0506294819D4)
*Mar 7 23:20:42.858: Vi1 LCP: MRRU 1524 (0x110405F4)
*Mar 7 23:20:42.858: Vi1 LCP: EndpointDisc 1 ATM (0x13060141544D)

!−−− Router ATM at the other end of PPP discovery.

*Mar 7 23:20:42.858: Vi1 LCP: O CONFACK [REQsent] id 14 len 20

*Mar 7 23:20:42.862: Vi1 LCP: MagicNumber 0x294819D4 (0x0506294819D4)
*Mar 7 23:20:42.862: Vi1 LCP: MRRU 1524 (0x110405F4)
*Mar 7 23:20:42.862: Vi1 LCP: EndpointDisc 1 ATM (0x13060141544D)
*Mar 7 23:20:42.870: Vi1 LCP: I CONFACK [ACKsent] id 197 len 19
*Mar 7 23:20:42.870: Vi1 LCP: MagicNumber 0xF44128D2 (0x0506F44128D2)
*Mar 7 23:20:42.870: Vi1 LCP: MRRU 1524 (0x110405F4)
*Mar 7 23:20:42.870: Vi1 LCP: EndpointDisc 1 FR (0x1305014652)
*Mar 7 23:20:42.870: Vi1 LCP: State is Open
*Mar 7 23:20:42.870: Vi1 PPP: Phase is FORWARDING, Attempting Forward
*Mar 7 23:20:42.874: Vi1 PPP: Phase is ESTABLISHING, Finish LCP
*Mar 7 23:20:42.874: Vi1 PPP: Phase is VIRTUALIZED
*Mar 7 23:20:42.942: Vi2 PPP: Phase is DOWN, Setup
*Mar 7 23:20:43.222: Vi1 IPCP: Packet buffered while building MLP bundle interface
6d23h: %LINK−3−UPDOWN: Interface Virtual−Access2, changed state to up
```

```
!--- MLP level queuing.

*Mar 7 23:20:43.226: Vi2 PPP: Treating connection as a dedicated line
*Mar 7 23:20:43.226: Vi2 PPP: Phase is ESTABLISHING, Active Open
*Mar 7 23:20:43.226: Vi2 LCP: O CONFREQ [Closed] id 1 len 19
*Mar 7 23:20:43.226: Vi2 LCP: MagicNumber 0xF4412A53 (0x0506F4412A53)
*Mar 7 23:20:43.226: Vi2 LCP: MRRU 1524 (0x110405F4)
*Mar 7 23:20:43.230: Vi2 LCP: EndpointDisc 1 FR (0x1305014652)
*Mar 7 23:20:43.230: Vi2 MLP:
Added first link Vi1 to bundle ATM

!--- PVCs make up the bundle.

*Mar 7 23:20:43.230: Vi2 PPP: Phase is UP
*Mar 7 23:20:43.230: Vi2 IPCP: O CONFREQ [Closed] id 1 len 10
*Mar 7 23:20:43.234: Vi2 IPCP: Address 10.1.1.2 (0x03060A010102)
*Mar 7 23:20:43.234: Vi2 PPP: Pending ncpQ size is 1
*Mar 7 23:20:43.234: Vi1 IPCP: Redirect packet to Vi1
*Mar 7 23:20:43.234: Vi2 IPCP: I CONFREQ [REQsent] id 1 len 10
*Mar 7 23:20:43.234: Vi2 IPCP: Address 10.1.1.1 (0x03060A010101)
*Mar 7 23:20:43.234: Vi2 IPCP: O CONFACK [REQsent] id 1 len 10
*Mar 7 23:20:43.234: Vi2 IPCP: Address 10.1.1.1 (0x03060A010101)
*Mar 7 23:20:43.266: Vi2 IPCP: I CONFACK [ACKsent] id 1 len 10
*Mar 7 23:20:43.266: Vi2 IPCP: Address 10.1.1.2 (0x03060A010102)
*Mar 7 23:20:43.266: Vi2 IPCP: State is Open
*Mar 7 23:20:43.266: Vi2 IPCP: Install route to 10.1.1.1
*Mar 7 23:20:43.270: Vi2 IPCP: Add link info for cef entry 10.1.1.1
```

This command output is from the **debug ppp multilink fragment** command.

```
*Mar 7 23:16:08.034: Vi2 MLP:
Packet interleaved from queue 24
*Mar 7 23:16:08.038: Vi1 MLP: O ppp UNKNOWN(0x0000) (0000) size 64
*Mar 7 23:16:08.038: Vi2 MLP: Packet interleaved from queue 24
*Mar 7 23:16:08.038: Vi1 MLP: O ppp UNKNOWN(0x0000) (0000) size 64
*Mar 7 23:16:08.038: Vi2 MLP: Packet interleaved from queue 24
*Mar 7 23:16:08.038: Vi1 MLP: O ppp UNKNOWN(0x0000) (0000) size 64
*Mar 7 23:16:08.038: Vi1 MLP: O frag 0000829B size 160
*Mar 7 23:16:08.042: Vi1 MLP: I ppp IP (0021) size 64 direct
*Mar 7 23:16:08.046: Vi1 MLP: I ppp IP (0021) size 64 direct
```

Related Information

- **Designing and Deploying Multilink PPP over Frame Relay and ATM**
- **VoIP over PPP Links with Quality of Service (LLQ / IP RTP Priority, LFI, cRTP)**
- **VoIP over Frame Relay with QoS (Fragmentation, Traffic Shaping, LLQ / IP RTP Priority)**
- **Voice Technology Support**
- **Voice and Unified Communications Product Support**
- **Recommended Reading: Troubleshooting Cisco IP Telephony**
- **Technical Support & Documentation − Cisco Systems**

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