

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

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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) 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 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. For background information relating to QoS for VoIP over Frame Relay or PPP refer to the following documents:

- 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)

Conventions

For more information on document conventions, see the Cisco Technical Tips Conventions.

Background Theory

The key issues in providing minimised 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

The following 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: To find additional information on the commands used in this document, use the IOS Command Lookup tool.

Prerequisites

To work with the configuration in this document you should be familiar with the following 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

These configurations were tested with the following equipment:

- 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 version 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 the following Cisco IOS releases:

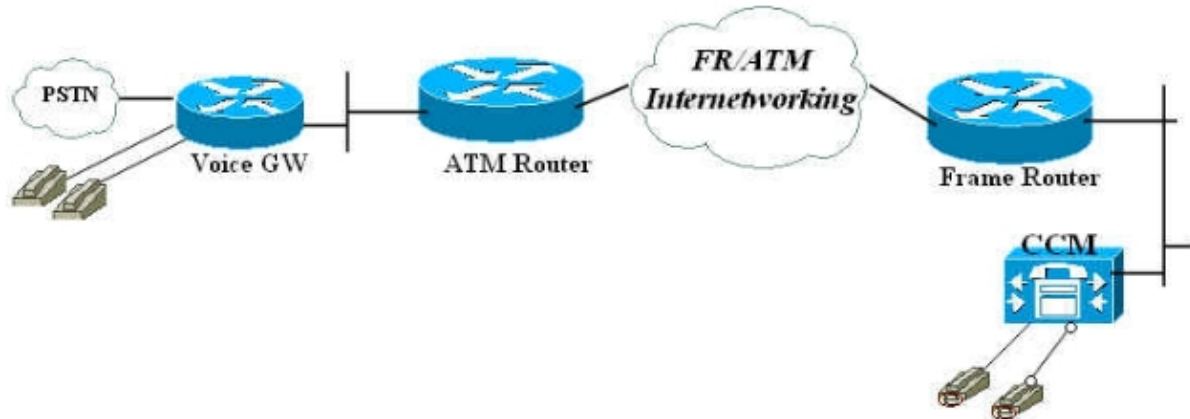
- LFI was introduced in Cisco IOS Software Release 11.3.
- LLQ was introduced in Cisco IOS Software Release 12.0(7)T.
- LLQ over Frame Relay and ATM per PVC was introduced in Cisco IOS Software Release 12.1(2)T.
- Multilink PPP LFI for Frame Relay and ATM Virtual Circuits was introduced in Cisco IOS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

The information presented in this document was created from devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If you are working in a live

network, ensure that you understand the potential impact of any command before using it.

Network Diagram

This document uses the network setup shown in the diagram below.



Configurations

This document uses the configurations shown below.

- Frame Relay Connected Router
- ATM Connected Router

Note: It is important to note that in the configuration below, 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 will have to be configured for LLQ, LFI, and MLPPP so they can provide QoS, and not the voice gateways as shown in the configurations below.

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 1
access-list 105 permit udp any any range 16384 32767
access-list 105 permit ip any any precedence critical
!
class-map match-all voice 2
match access-group 105
!

/--- 1 Specifies that all traffic with Differentiated
/--- Services Code Point (DSCP) set to 40 falls into this access-list.
/--- 2 This class-map command defines a class of traffic called "voice".
!
!
policy-map VOIP 3
  class voice 4
    priority 48 5
  class class-default 6
    fair-queue 7

/--- 3 This policy-map command defines a policy for LLQ called "VoIP" and
/--- 4 maps the "voice" class to the "VoIP" policy.
/--- 5 Defines the amount of bandwidth reserved for the priority queue.
/--- 6 The default class is also mapped to this policy.
/--- 7 Specifies that all other traffic is served in the WFQ.

/--- 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 command
/--- max-reserved-bandwidth <#%> 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
!
interface Serial0/0.1 point-to-point 18
  no ip route-cache
  no ip mroute-cache
  frame-relay interface-dlci 16 ppp Virtual-Template1 19
  class mlp 20

!---- 19 Select the frame relay interface to be
!---- associated with the virtual interface. The
!---- virtual template could equally have been associated
!---- with the physical interface.
!---- 20 Associates the virtual template interface
!---- defined in 8 below with a Frame Relay DLCI.
!---- 21 Associates a Frame Relay map class with a DLCI.
!
interface Virtual-Template1 8
  bandwidth 64 9
  ip unnumbered loopback0
  ip rtp header-compression 9b
  no ip route-cache
  load-interval 30
  max-reserved-bandwidth 99
  service-policy output VOIP 10
  ppp multilink 11
  ppp multilink fragment-delay 10 12
  ppp multilink interleave 13
!

!---- 8 The interface command creates a virtual
!---- template called Virtual-Template1.
!---- 9 A bandwidth of 64 Kbps is assigned to this
!---- template interface. This bandwidth is used
!---- by Cisco IOS to calculate the data fragmentation size as noted in 13 below.

!---- 9b CRTP is supported in an ATM/Frame Relay Interworking
!---- environment. It requires Cisco IOS Software Release 12.2(2)T on the
!---- ATM router.

!---- 10 The VoIP policy created earlier is assigned
!---- to this interface in the outbound direction.

!---- 11 PPP multilink is enabled and the
!---- 12 maximum delay per segment is specified. This bandwidth is
!---- used by IOS to calculate the data fragmentation size as noted in
!---- 13 below.

!---- 13 Interleaving of PPP segments is enabled allowing
!---- 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. IOS calculates the
!---- data fragment size using the following formula:
!---- fragment size = delay x bandwidth/8
!
ip classless
ip route 0.0.0.0 0.0.0.0 172.17.111.1
no ip http server
ip pim bidir-enable
!

```

```

!
!
map-class frame-relay mlp

14
no frame-relay adaptive-shaping 15
frame-relay cir 64000 16
frame-relay bc 640 17
frame-relay be 0 18

!--- 14 A map class called mlp is created.
!--- 15 Adaptive shaping is disabled. We 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.
!--- 16 This command forces the router to transmit
!--- at the desired CIR rate rather than line
!--- rate for the port.
!--- 17 Configure the Bc value to force the desired
!--- Tc (shaping interval) value is 10 ms.
!--- The following formula should be used to determine
!--- the Bc value to use:  $Tc = Bc/CIR$ . A
!--- smaller Tc value will reduce the interval a voice
!--- packet will have to wait to be sent.
!--- 18 The Be value should be set to zero to avoid
!--- voice being sent as part of a burst
!--- that is not guaranteed by the Frame Relay network.
!
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 2
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 22
  ip route-cache
  pvc 10/100 23
    cbr 64 24
    encapsulation aal5snap 25
    protocol ppp Virtual-Templatel 26

!--- 22 Selects the ATM subinterface. The physical
```

```

!--- interface could equally have been used.
!--- 23 Creates an ATM PVC.
!--- 24 A VBR PVC has been defined on our example.
!--- We have used VBR non-realtime and the sustained
!--- cell rate (SCR) should be equal
!--- to the peak cell rate (PCR) 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.
!--- We 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.
!--- For a detailed discussion on this
!--- topic refer to the document
!--- Designing and Deploying Multilink PPP over Frame Relay and ATM
!--- 25 AAL5SNAP encapsulation is required.
!--- 26 Associates the virtual template with the ATM PVC.
!
!
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 optimised to fit into
!--- an integral number of ATM cells. Refer to Designing and
!--- Deploying Multilink PPP over Frame Relay and ATM
!--- for a detailed discussion of 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

This section provides information you can use to confirm your configuration is working properly.

Certain **show** commands are supported by the Output Interpreter tool, which allows you to view an analysis of **show** command output.

The following **show** commands are useful in verifying the operational status of the ATM/Frame Relay interworking environment including 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 is dropping 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 *dci*** – 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. For more information on the various fields of this command, refer to Understanding Packet Counters in the *show policy-map interface* command output.
- 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 below:

```
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
```

The following is 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#
```

The following is 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#
```

The following 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#

The following 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#

The following 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
The following 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#
```

The following 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-Templat1:
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
```

The following 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-Templat1:  
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

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

Troubleshooting Commands

Certain **show** commands are supported by the Output Interpreter tool, which allows you to view an analysis of **show** command output.

Note: Before issuing **debug** commands, please see Important Information on 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.

Below 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

```

The following 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 – Cisco Systems**

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