



TROUBLESHOOTING LAYER 2 TRANSPORT AND TUNNELING (L2VPN) TECHNOLOGIES

SESSION ACC-3001

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

1

Agenda

Cisco.com

- **Motivations Behind L2VPNs**
- **AToM Troubleshooting**
 - Core Troubleshooting
 - Ethernet over MPLS
 - MPLS Ping, Traceroute and VCCV
 - Frame Relay over MPLS
 - ATM over MPLS
- **Layer 2 Tunneling Protocol Version 3**
 - L2TPv3 Protocol Overview
 - Troubleshooting L2TPv3
- **AToM and L2TPv3 Interworking**
- **Local Switching**
- **Q&A**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

2

Associated Sessions

Cisco.com

- **ACC-1000** Introduction to Layer 2 Transport and Tunneling Technologies (L2VPNs)
- **ACC-2000** Layer 2 Transport and Tunneling (L2VPN) Application and Deployment
- **ACC-2001** Sizing and Scaling Metro Layer 2 Services

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

3

Skill Level Assumptions

Cisco.com

- **Have protocol level knowledge of:**
 - MPLS, LDP, AToM, L2TPv3
- **Familiar with Cisco IOS® L2VPN configuration of:**
 - Core IP and core MPLS
 - L2TPv3 and AToM
 - Ethernet, VLAN, ATM, Frame Relay and other WAN technologies
 - Cisco Express Forwarding (CEF and dCEF)

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

4

L2VPN Troubleshooting Maxim

Cisco.com

**“KNOW YOUR PROTOCOLS. THAT WAY YOU
CAN COMPARE A GOOD KNOWN STATE TO A
CURRENTLY BROKEN ONE.”**

ANCIENT L2VPN TROUBLESHOOTING PROVERB

MOTIVATIONS BEHIND L2VPNS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

6

Why Is L2VPN Needed?

Cisco.com

- **It allows SP to have a single infrastructure for both IP and legacy services**
 - Move legacy ATM/FR traffic to MPLS/IP core without interrupting current services
- **ISP provide new P2P Layer 2 tunneling services**
 - Customer can have its own routing, QoS policy, etc.
- **A migration step towards IP/MPLS VPN**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

7

Benefits for L2VPNs

Cisco.com

- **New service opportunities:**
 - Virtual leased line service
 - Offer “PVC-like” Layer 2-based service
- **Reduced cost—consolidate multiple core technologies into a single packet-based network infrastructure**
- **Simplify services—Layer 2 transport provides options for Service Providers who need to provide L2 connectivity and maintain customer autonomy**
- **Protect existing investments—Greenfield networks to extend customer access to existing Layer 2 networks without deploying a new separate infrastructure**
- **Feature support—through the use of Cisco IOS features such as IPsec, QoS and Traffic Engineering, L2 transport can be tailored to meet customer requirements**

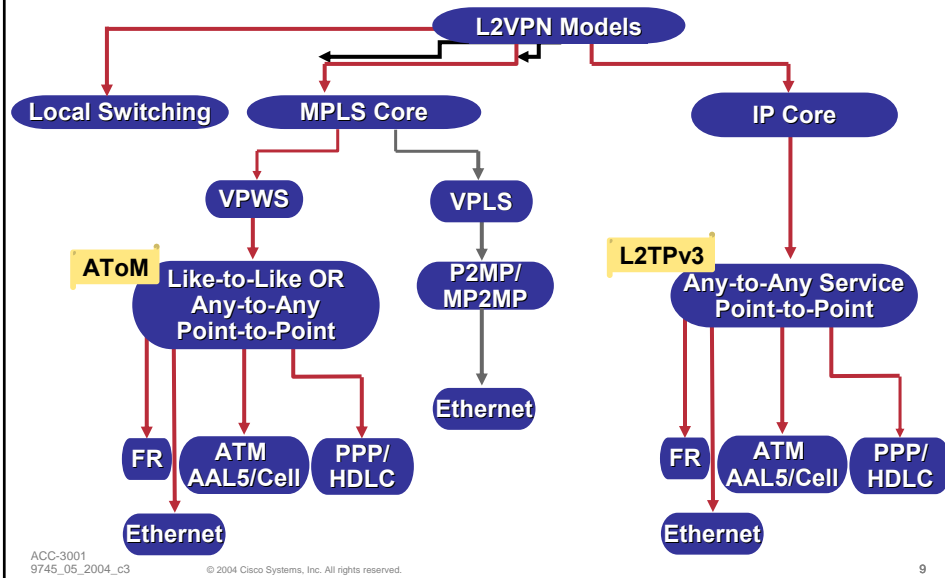
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

8

L2VPN Models

Cisco.com



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

9

Some Currently Defined VC-Types

Cisco.com

PW type	Description	
0x0001	Frame Relay DLCI	! Frame Relay
0x0002	ATM AAL5 SDU VCC transport	! ATM AAL5 SDU
0x0003	ATM transparent cell transport	! ATM Cell Port Mode
0x0004	Ethernet Tagged Mode	! Ethernet VLAN
0x0005	Ethernet	! Ethernet
0x0006	HDLC	! HDLC
0x0007	PPP	! PPP
0x0008	SONET/SDH Circuit Emulation Service Over MPLS (CEM) [Notel]	
0x0009	ATM n-to-one VCC cell transport	! ATM Cell VC Mode
0x000A	ATM n-to-one VPC cell transport	! ATM Cell VP Mode
0x000B	IP Layer2 Transport	! Interworking IP
0x000C	ATM one-to-one VCC Cell Mode	
0x000D	ATM one-to-one VPC Cell Mode	
0x000E	ATM AAL5 PDU VCC transport	
0x000F	Frame-Relay Port mode	
0x0010	SONET/SDH Circuit Emulation over Packet (CEP)	
0x0011	Structure-agnostic E1 over Packet (SATO1P)	
0x0012	Structure-agnostic T1 (DS1) over Packet (SATO1P)	
0x0013	Structure-agnostic E3 over Packet (SATO1P)	
0x0014	Structure-agnostic T3 (DS3) over Packet (SATO1P)	
0x0015	CESoPSN basic mode	
0x0016	TDMoIP basic mode	
0x0017	CESoPSN TDM with CAS	
0x0018	TDMoIP TDM with CAS	

Note 1: This PW Type Is Grandfathered for a Historical Protocol; the Recommended Standards-Track Protocol to Use Is CEP (PW Type 0x0010)

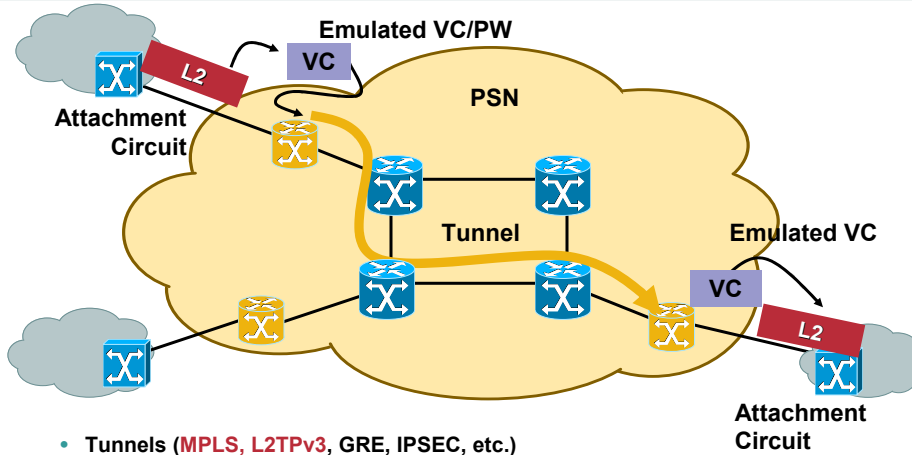
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

10

Generic L2 VPN Architecture

Cisco.com



- Tunnels (MPLS, L2TPv3, GRE, IPSEC, etc.)
- Emulated VCs (pseudowires) inside tunnels (many-to-one)
- Attachment VCs (e.g. FR DLCI, PPP) mapped to emulated VCs

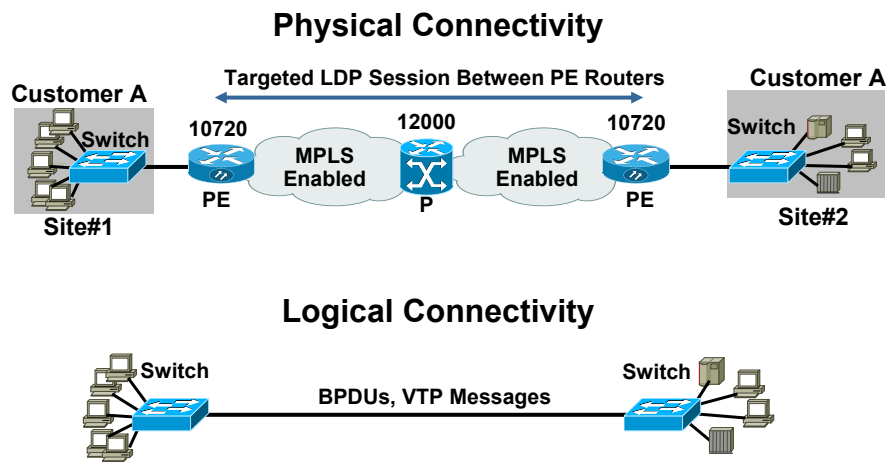
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

11

EoMPLS Reference Model

Cisco.com



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

12

ETHERNET OVER MPLS



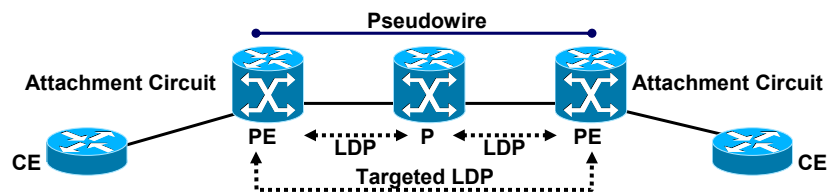
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

13

Control Plane

Cisco.com



- MPLS in the core
- Targeted (AKA directed) LDP session between PEs
- Targeted LDP session distributes pseudowire (Pw AKA VC) labels
- PE uses per-platform label space (label pool) for both link and targeted LDP sessions (i.e. router_id:0)
- Need LSPs among PEs => Use /32 loopback prefixes

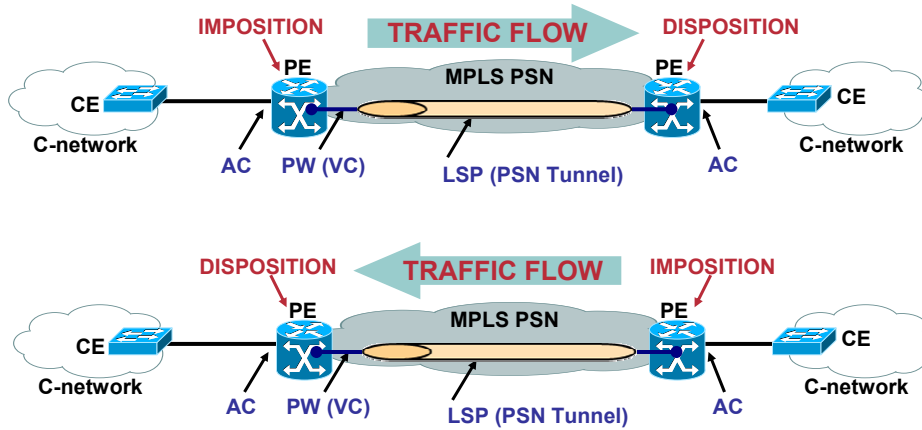
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

14

Imposition and Disposition

Cisco.com



- AToM needs MPLS LSP from PE to PE
- PEs need to use /32 loopback prefixes for LSPs

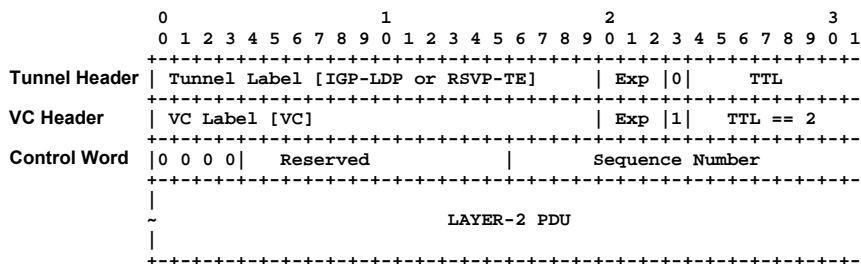
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

15

Data Plane: EoMPLS Packet Format

Cisco.com



- The control word (AToM Header) is optional for Ethernet, PPP, HDLC, and cell relay transport types; however, the control word is required for Frame Relay, and ATM AAL5 transport types
- First nibble is 0x0 to prevent aliasing with IP Packets over MPLS
- The AToM control word is supported; however, if a peer PE does not support the control word, it is disabled; this negotiation is done by LDP label mapping

ACC-3001
9745_05_2004_c3

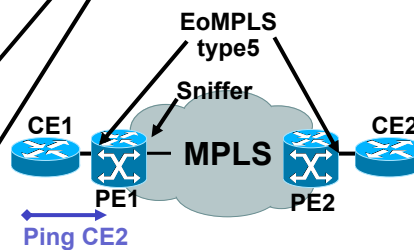
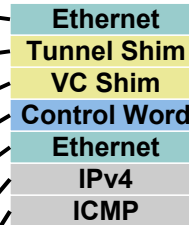
© 2004 Cisco Systems, Inc. All rights reserved.

16

Data Plane: A Real Packet

Cisco.com

Ethernet II Destination: xx:xx:xx:xx:xx:xx Source: yy:yy:yy:yy:yy:yy eType: MPLS Unicast (0x8847)
MultiProtocol Label Switching Header MPLS Label: 16 MPLS Experimental Bits: 0 MPLS Bottom Of Label Stack: 0 MPLS TTL: 255
MultiProtocol Label Switching Header MPLS Label: 16 MPLS Experimental Bits: 0 MPLS Bottom Of Label Stack: 1 MPLS TTL: 2
AToM EoMPLS Header AToM MPLS Control Word: 0x00000000
Ethernet II Destination: aa:aa:aa:aa:aa:aa Source: bb:bb:bb:bb:bb:bb eType: IPv4 (0x0800)
Internet Protocol Version: 4 Header length: 20 bytes [snip] Time to live: 255 Protocol: ICMP (0x01) Header checksum: 0xa3fd (correct) Source: 10.1.2.203 (10.1.2.203) Destination: 10.0.0.201 (10.0.0.201)
Internet Control Message Protocol Type: 8 (Echo (ping) request) Code: 0



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

17

AToM Prerequisite Configuration

Cisco.com

- **Enable [d]CEF globally**
Router(config)#ip cef
- **Enable MPLS globally**
Router(config)#mpls ip
- **Enable LDP globally as default label distribution protocol**
Router(config)#mpls label protocol ldp
- **Specify a loopback interface as LDP Router ID**
Router(config)#mpls ldp router-id loopback <#> [force]
- **Enable LDP in the P-PE and P-P interfaces**
Router(config-if)#mpls ip

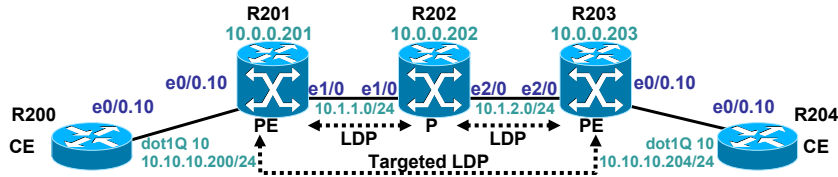
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

18

A Typical Configuration: EoMPLS VLAN

Cisco.com



```
hostname R201
!
ip cef
mpls ip
mpls label protocol ldp
mpls ldp router-id Loopback0 force
!
interface Loopback0
ip address 10.0.0.201 255.255.255.255
!
interface Ethernet0/0.10
description *** To R200 ***
encapsulation dot1Q 10
no ip directed-broadcast
no cdp enable
xconnect 10.0.0.203 10 encapsulation mpls
```

```
hostname R203
!
ip cef
mpls ip
mpls label protocol ldp
mpls ldp router-id Loopback0 force
!
interface Loopback0
ip address 10.0.0.203 255.255.255.255
!
pseudowire-class eompls
encapsulation mpls
!
interface Ethernet0/0.10
description *** To R204 ***
encapsulation dot1Q 10
no ip directed-broadcast
no cdp enable
xconnect 10.0.0.201 10 pw-class eompls
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

19

Verifying the Operation

Cisco.com

Remote Port Down or Not Configured

```
R201#show mpls l2transport vc 10 detail
Local interface: Et0/0.10 up, line protocol up, Eth VLAN 10 up
Destination address: 10.0.0.203, VC ID: 10, VC status: down
Tunnel label: not ready
Output interface: unknown, imposed label stack {}
Create time: 22:31:53, last status change time: 04:02:56
Signaling protocol: LDP, peer 10.0.0.203:0 up
MPLS VC labels: local 19, remote unassigned
Group ID: local 0, remote unknown
MTU: local 1500, remote unknown
Remote interface description:
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 1650, send 1743
byte totals: receive 552557, send 550044
packet drops: receive 0, send 7
```

R201#

MTU Mismatch

```
R201#show mpls l2transport vc 10 detail
Local interface: Et0/0.10 up, line protocol up, Eth VLAN 10 up
Destination address: 10.0.0.203, VC ID: 10, VC status: down
Tunnel label: not ready
Output interface: unknown, imposed label stack {}
Create time: 22:36:10, last status change time: 00:00:20
Signaling protocol: LDP, peer 10.0.0.203:0 up
MPLS VC labels: local 19, remote 21
Group ID: local 0, remote 0
MTU: local 1500, remote 1000
Remote interface description: *** To R204 ***
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 1880, send 1901
byte totals: receive 168476, send 155436
packet drops: receive 0, send 13
```

R201#

- **Tip: If using VLAN mode, remember to 'no cdp enable' on the main [Gig|Fast]Ethernet interface**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

20

Verifying the Operation

Cisco.com

Working Example

```
R201#show mpls l2transport vc 10 detail
Local interface: Et0/0.10 up, line protocol up, Eth VLAN 10 up
Destination address: 10.0.0.203, VC ID: 10, VC status: up
Preferred path: not configured
Default path: active
Tunnel label: 17, next hop 10.1.1.202
Output interface: Et1/0, imposed label stack {17 21}
Create time: 23:06:37, last status change time: 00:30:47
Signaling protocol: LDP, peer 10.0.0.203:0 up
MPLS VC labels: local 19, remote 21
Group ID: local 0, remote 0
MTU: local 1500, remote 1500
Remote interface description: *** To R204 ***
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 1683, send 1777
byte totals: receive 565455, send 563328
packet drops: receive 0, send 7
```

R201#

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

21

VC Status Meaning

Cisco.com

- **UP—VC can carry data between the 2 endpoints; this means both imposition and disposition are programmed**
 - The disposition interfaces is programmed if the VC has been configured and the CE interface is up
 - The imposition interface is programmed if the disposition interface is programmed and we have a remote VC label and an IGP label (Label Switch Path to the peer)
 - The IGP label can be implicit null in a back-to-back configuration
- **DOWN—VC is not ready to carry traffic between the two VC endpoints**
- **ADMINDOWN—VC disabled by a user**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

22

EoMPLS: Data Plane Overhead

Cisco.com

- At imposition, PE encapsulates CE's Ethernet or VLAN packet to route across MPLS cloud

- These are the associated overheads:

Transport Header is 6 Bytes DA + 6 Bytes SA + 2 Bytes etype + optional 4 Bytes of VLAN Tag

There's (at least) 2 levels of MPLS header (Tunnel + VC) each contributing with 4 Bytes

There is an optional 4-Byte control word



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

23

Calculating MTU Requirements for the Core

Cisco.com

- Core MTU \geq Edge MTU + Transport Header + AToM Header + (MPLS Label Stack * MPLS Header Size)
- Edge MTU is the MTU configured in the CE-facing PE's interface
- Examples (all in Bytes):

	Edge	Transport	AToM	MPLS Stack	MPLS Header	Total
EoMPLS Port Mode	1500	14	4 [0]	2	4	1526 [1522]
EoMPLS VLAN Mode	1500	18	4 [0]	2	4	1530 [1526]
EoMPLS Port w/ TE FRR	1500	14	4 [0]	3	4	1530 [1526]

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

24

Changing the MTU Size in the Core

Cisco.com

- Use the **mtu** command in PE and P routers to configured at least the calculated minimum MTU

```
Router(config-if)# mtu 1526
```

- Some interfaces (such as FastEthernet interfaces) require the **mpls mtu** command to change the MTU size

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

25

Transport Header Overhead

Cisco.com

Transport Type	Transport Header Size
Ethernet Port	14 Bytes
Ethernet VLAN	18 Bytes
Frame Relay DLCI, Cisco Encapsulation	2 Bytes
Frame Relay DLCI, IETF Encapsulation	8 Bytes
HDLC	4 Bytes
PPP	4 Bytes
AAL5	0–32 Bytes

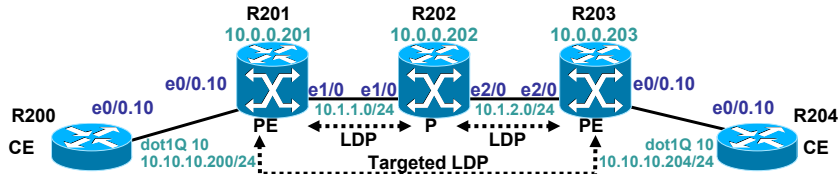
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

26

MTU Problem Example

Cisco.com



```
R200#ping ip 10.10.10.204 size 1470 timeout 1 df-bit
Type escape sequence to abort.
Sending 5, 1470-byte ICMP Echos to 10.10.10.204, timeout is 1 seconds:
Packet sent with the DF bit set
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 24/28/32 ms
R200#
```

```
R200#ping ip 10.10.10.204 size 1471 timeout 1 df-bit
Type escape sequence to abort.
Sending 5, 1470-byte ICMP Echos to 10.10.10.204, timeout is 1 seconds:
Packet sent with the DF bit set
.....
Success rate is 0 percent (0/5)
R200#
```

	Core Overhead
Transport	18 Bytes
AToM	4 Bytes
MPLS Stack	2 Headers
MPLS Header	4 Bytes
Total	30 Bytes

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

27

Control Plane: Displaying L2CKT Binding

Cisco.com

```
R201#show mpls l2transport binding 10
Destination Address: 10.0.0.203, VC ID: 10
Local Label: 19
  Cbit: 1, VC Type: Eth VLAN, GroupID: 0
  MTU: 1500, Interface Desc: *** To R200 ***
  VCCV Capabilities: Type 1, Type 2
Remote Label: 21
  Cbit: 1, VC Type: Eth VLAN, GroupID: 0
  MTU: 1500, Interface Desc: *** To R204 ***
  VCCV Capabilities: Type 1, Type 2
R201#
```

Advertised by LDP

Signaled as Interface Parameters

- **Cbit: Flags the presence of a control word**
- **VC Type: (PW type) A 15 bit quantity containing a value which represents the type of PW**
- **VCCV Capabilities: Virtual Circuit Connection Verification**
 - Type 1: PWE3 control word (0x0001 as first nibble of CW)
 - Type 2: MPLS Router Alert Label
- **Interface parameters: used to provide interface specific parameters, such as CE-facing interface MTU**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

28

Decoded Label Mapping (Binding) for PW

Cisco.com

```
Label Mapping Message
0... .. = U bit: Unknown bit not set
Message Type: Label Mapping Message (0x400)
Message Length: 53
Message ID: 0x00000a37
Forwarding Equivalence Classes TLV
00... .. = TLV Unknown bits: Known TLV, do not Forward (0x00)
TLV Type: Forwarding Equivalence Classes TLV (0x100)
TLV Length: 37
FEC Elements
  FEC Element 1 VCID: 10
    FEC Element Type: Virtual Circuit FEC (128)
    1... .. = C-bit: Control Word Present
    .000 0000 0000 0100 = VC Type: Ethernet VLAN (0x0004)
    VC Info Length: 29
    Group ID: 0
    VC ID: 10
    Interface Parameter: MTU 1500
      ID: MTU (0x01)
      Length: 4
      MTU: 1500
    Interface Parameter: Description
      ID: Interface Description (0x03)
      Length: 17
      Description: *** To R200 ***
    Interface Parameter: VCCV
      ID: VCCV (0x0a)
      Length: 4
      VCCV Capabilities: Type 1 and 2
Generic Label TLV
00... .. = TLV Unknown bits: Known TLV, do not Forward (0x00)
TLV Type: Generic Label TLV (0x200)
TLV Length: 4
Generic Label: 19
```

ID for VCCV Was
Changed from
0x0A to 0x0C

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

29

Control Plane (LDP) Issues

Cisco.com

- If there are local or peer problems, core MPLS (IGP) would normally exhibit symptoms first

```
R201#
*Apr 21 16:54:28.861: %LDP-5-GR: GR session 10.0.0.202:0 (inst. 1): interrupted--recovery pending
*Apr 21 16:54:28.861: %LDP-5-NBRCHG: LDP Neighbor 10.0.0.202:0 is DOWN ! Link LDP Session
*Apr 21 16:55:36.908: %LDP-5-GR: GR session 10.0.0.203:0 (inst. 3): interrupted--recovery pending
*Apr 21 16:55:36.908: %LDP-5-NBRCHG: LDP Neighbor 10.0.0.203:0 is DOWN ! Targeted LDP Session
R201#
R201#show mpls ldp parameters
Protocol version: 1
Downstream label generic region: min label: 16; max label: 100000
Session hold time: 180 sec; keep alive interval: 60 sec
Discovery hello: holdtime: 15 sec; interval: 5 sec
Discovery targeted hello: holdtime: 90 sec; interval: 10 sec
Downstream on Demand max hop count: 255
LDP for targeted sessions
LDP initial/maximum backoff: 15/120 sec
LDP loop detection: off
R201#
```

- TIP: Enable LDP GR [Graceful Restart]

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

30

Checking LDP State

Cisco.com

```
R201#show mpls ldp discovery
Local LDP Identifier:
 10.0.0.201:0
Discovery Sources:
Interfaces:
  Ethernet1/0 (ldp): xmit/rcv
    LDP Id: 10.0.0.202:0
Targeted Hellos:
 10.0.0.201 -> 10.0.0.203 (ldp): active/passive, xmit/rcv
    LDP Id: 10.0.0.203:0
R201#show mpls ldp neighbor
Peer LDP Ident: 10.0.0.202:0; Local LDP Ident 10.0.0.201:0
TCP connection: 10.0.0.202.11039 - 10.0.0.201.646
State: Oper; Msgs sent/rcvd: 54/54; Downstream
Up time: 00:41:07
LDP discovery sources:
  Ethernet1/0, Src IP addr: 10.1.1.202
Addresses bound to peer LDP Ident:
 10.0.0.202 10.1.1.202 10.1.2.202
Peer LDP Ident: 10.0.0.203:0; Local LDP Ident 10.0.0.201:0
TCP connection: 10.0.0.203.11010 - 10.0.0.201.646
State: Oper; Msgs sent/rcvd: 53/53; Downstream
Up time: 00:38:36
LDP discovery sources:
  Targeted Hello 10.0.0.201 -> 10.0.0.203, active, passive
Addresses bound to peer LDP Ident:
 10.0.0.203 10.1.2.203
R201#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

31

Verifying Core Forwarding State

Cisco.com

- IGP Labels untagged!

```
R201#show mpls forwarding-table
Local  Outgoing  Prefix          Bytes tag  Outgoing     Next Hop
tag    tag or VC   or Tunnel Id   switched  interface
16     Untagged   10.1.2.0/24    0         Et1/0        10.1.1.202
17     Untagged   10.0.0.202/32  0         Et1/0        10.1.1.202
18     Untagged   10.0.0.203/32  0         Et1/0        10.1.1.202
19     Untagged   12ckt(10)      1984544   Et0/0.10    point2point
20     Untagged   12ckt(20)      45183     Et3/0       point2point
21     Untagged   12ckt(50)      1435873   Se5/0       point2point
R201#
```

IGP Outgoing Labels Untagged;
These Are Label Mappings We Should
Have Received from the LDP Neighbor

- The Link LDP session may be down

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

32

Core LDP Problems

Cisco.com

- Indeed, IGP LDP session is down

```
R201#show mpls ldp neighbor
Peer LDP Ident: 10.0.0.203:0; Local LDP Ident 10.0.0.201:0
TCP connection: 10.0.0.203.11027 - 10.0.0.201.646
State: Oper; Msgs sent/rcvd: 12/12; Downstream
Up time: 00:01:30
LDP discovery sources:
  Targeted Hello 10.0.0.201 -> 10.0.0.203, active, passive
Addresses bound to peer LDP Ident:
  10.0.0.203      10.1.2.203
R201#
R201#show mpls ldp discovery
Local LDP Identifier:
  10.0.0.201:0
Discovery Sources:
Interfaces:
  Ethernet1/0 (ldp): xmit
Targeted Hellos:
  10.0.0.201 -> 10.0.0.203 (ldp): active/passive, xmit/recv
  LDP Id: 10.0.0.203:0
R201#
```

Only Targeted Session Is UP

Transmitting LDP Hellos but Not Receiving Any; Good State Is xmit/recv

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

33

Note of Caution

Cisco.com

- The operational status in `show mpls interfaces` is not an indicator of neighbor UP

```
R201#show mpls interfaces
Interface      IP          Tunnel  Operational
Ethernet1/0    Yes (ldp)   No      Yes
R201#
```

- The operational status merely shows that some application has enabled processing of MPLS packets
- In fact, in Inter-AS scenarios the interface to which the MP-eBGP VPNv4 neighbor is connected will show operational Yes even without `mpls ip` configured on the interface

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

34

Use IP/ICMP-Based Traceroute from PE

Cisco.com

- Traceroute with core LDP down (but targeted LDP UP)

```
R201#traceroute 10.0.0.203
Type escape sequence to abort.
Tracing the route to 10.0.0.203
 1 10.1.1.202 28 msec 24 msec 40 msec
 2 10.1.2.203 32 msec 44 msec 36 msec
R201#
```

- Traceroute with core LDP UP

```
R201#traceroute 10.0.0.203
Type escape sequence to abort.
Tracing the route to 10.0.0.203
 1 10.1.1.202 [MPLS: Label 17 Exp 0] 36 msec 20 msec 40 msec
 2 10.1.2.203 28 msec 40 msec 28 msec
R201#
```

ICMP Extensions for MultiProtocol Label Switching

No MPLS Shim Due to PHP, Would Be 0 if 'mpls ldp explicit-null'

- Remember that PE receives Layer 2 (not IP) packet from CE; here there's no concept of 'mpls ip propagate-ttl'

ACC-3001
9745_05_2004_c3

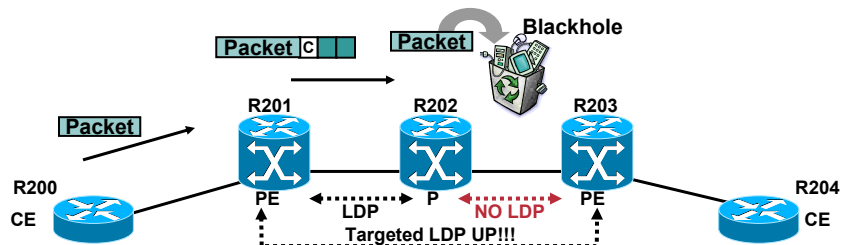
© 2004 Cisco Systems, Inc. All rights reserved.

35

Core LDP Important Note

Cisco.com

- The targeted LDP session can be UP even if the Link LDP session (core LDP) is down; all VCs would be UP
- Hey, it just needs a TCP connection that can run over TCPoIP as opposed to TCPoIPoMPLS
- However, the data path is broken (need end-to-end LSP; no IP PID [Protocol ID] for MPLS)



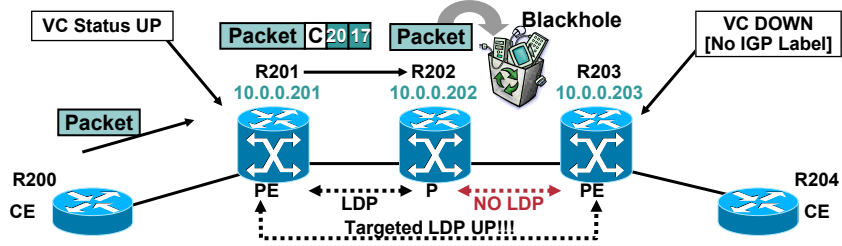
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

36

Core Network Dataplane Blackhole

Cisco.com



```
R201#show mpls l2transport vc 10 detail | i status:|Out
Destination address: 10.0.0.203, VC ID: 10, VC status: up
Output interface: Et1/0, imposed label stack {17 20}
R201#show mpls forwarding-table 10.0.0.203
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
22 17 10.0.0.203/32 0 Et1/0 10.1.1.202
R201#
```

```
R202#show mpls forwarding-table
Local Outgoing Prefix Bytes tag Outgoing Next Hop
tag tag or VC or Tunnel Id switched interface
16 0 10.0.0.201/32 0 Et1/0 10.1.1.201
17 Untagged 10.0.0.203/32 44773 Et2/0 10.1.2.203
R202#
```

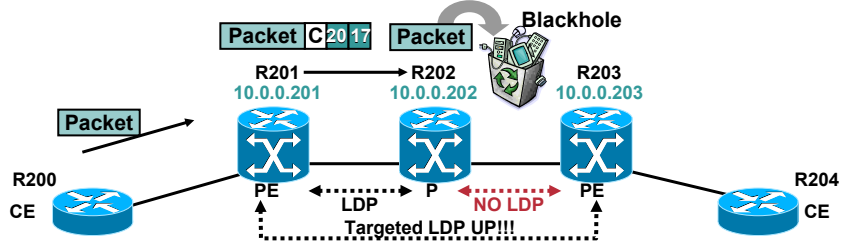
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

37

Core Network Dataplane Blackhole

Cisco.com



```
R201#traceroute 10.0.0.203
Type escape sequence to abort.
Tracing the route to 10.0.0.203
 1 10.1.1.202 [MPLS: Label 17 Exp 0] 16 msec 44 msec 20 msec
 2 10.1.2.203 28 msec 28 msec 48 msec
R201#
```

With ICMP/IP Based Traceroute, We Cannot Tell If the Absence of MPLS Header Is Because:
1. PHP :-)
2. UNTAGGED !!! :-)

- But data path is broken...
- How do we troubleshoot this one?

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

38

With MPLS Embedded Management

Cisco.com

- **Virtual Circuit Connection Verification (VCCV) is smart enough to differentiate POP vs. untagged**
 - POP—the next hop advertised an implicit NULL label for the destination and that this router pops the top label
 - Untagged—there is no label for the destination from the next hop; remove all labels in the stack
- **“Detecting MPLS dataplane failures” has PING and traceroute modes**
- **MPLS echo request and echo reply are UDP packets to port 3503 using label stack to be switched **inband** the LSP**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

39

Virtual Circuit Connection Verification

Cisco.com

- **MPLS ping has `IPv4', `pseudowire' and `traffic-eng' modes**
- **MPLS traceroute has `IPv4' and `traffic-eng' modes**
- **VCCV consists of:**
 - Signaling component in LDP label mapping for VC FEC with VCCV interface parameter
 - Switching component so that VCCV “control” packet is treated as ATOM payload from switching standpoint
 - Disposition capabilities are:
 - Type 1—Uses PID in ATOM control word (0x1) [default]
 - Type 2—Uses MPLS router alert label

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

40

MPLS Pseudowire PING

Cisco.com

```
R201#ping 10.0.0.203
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.203, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/27/36 ms
R201#
```

```
R201#ping mpls pseudowire 10.0.0.203 10
Sending 5, 100-byte MPLS Echos to 10.0.0.203/0,
timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not transmitted,
        '.' - timeout, 'U' - unreachable,
        'R' - downstream router but not target

Type escape sequence to abort.
.....
Success rate is 0 percent (0/5)
R201#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

41

Virtual Circuit Connection Verification

Cisco.com

- **Two reply modes:**
 - IPv4**—replies with UDP/IPv4 packet; do not have control over whether the reply is forwarded as IP or IPoMPLS; if no reply, use the next option
 - Router alert**—adds the router alert option to the IP header (RFC2113); this means that Cisco routers will process switched (by the RP) at each intermediate hop
- **The 'router-alert' option bypasses hardware and linecard forwarding table inconsistencies by being punted to the process switching path, but it's more expensive**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

42

VCCV Reply Mode: IPv4

Cisco.com

```
R201#ping mpls pseudowire 10.0.0.203 20 reply mode ipv4
Sending 5, 100-byte MPLS Echos to 10.0.0.203/0,
timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not transmitted,
       '.' - timeout, 'U' - unreachable,
       'R' - downstream router but not target

Type escape sequence to abort.
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 92/102/120 ms
R201#
*Apr 26 14:02:44.633: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:44.733: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=0
*Apr 26 14:02:44.825: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:44.893: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=0
*Apr 26 14:02:44.985: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:45.065: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=0
*Apr 26 14:02:45.153: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:45.213: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=0
*Apr 26 14:02:45.293: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:45.353: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=0
R201#
```

- R201 is advertising `Explicit-null` label
- Using `debug mpls packets`

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

43

VCCV Reply Mode: Router Alert

Cisco.com

```
R201#ping mpls pseudowire 10.0.0.203 20 reply mode router-alert
Sending 5, 100-byte MPLS Echos to 10.0.0.203/0,
timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not transmitted,
       '.' - timeout, 'U' - unreachable,
       'R' - downstream router but not target

Type escape sequence to abort.
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 72/99/144 ms
R201#
*Apr 26 14:02:52.477: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:52.537: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=1/0
*Apr 26 14:02:52.641: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:52.753: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=1/0
*Apr 26 14:02:52.849: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:52.913: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=1/0
*Apr 26 14:02:53.005: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:53.085: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=1/0
*Apr 26 14:02:53.169: MPLS: Et1/0: xmit: CoS=0, TTL=255, Label(s)=17/16
*Apr 26 14:02:53.233: MPLS: Et1/0: recvd: CoS=6, TTL=254, Label(s)=1/0
R201#
```

- Label == 1 reserved to router alert
- RFC3032: "When a received packet contains this label value at the top of the label stack, it is delivered to a local software module for processing, [snip] however, if the packet is forwarded further, the router alert label should be pushed back onto the label stack before forwarding"

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

44

MPLS Traceroute for IPv4

Cisco.com

```
R201#traceroute mpls ipv4 10.0.0.203/32
Tracing MPLS Label Switched Path to 10.0.0.203/32, timeout is 2 seconds

Codes: '!' - success, 'Q' - request not transmitted,
        '.' - timeout, 'U' - unreachable,
        'R' - downstream router but not target

Type escape sequence to abort.
 0 10.1.1.201 MRU 1500 [Labels: 17 Exp: 0] ! MRU in show mpls forw det
R 1 10.1.2.202 MRU 1504 [No Label] 60 ms      ! Untagged
! 2 10.1.2.203 80 ms
R201#
```

```
R201#traceroute mpls ipv4 10.0.0.203/32
Tracing MPLS Label Switched Path to 10.0.0.203/32, timeout is 2 seconds

Codes: '!' - success, 'Q' - request not transmitted,
        '.' - timeout, 'U' - unreachable,
        'R' - downstream router but not target

Type escape sequence to abort.
 0 10.1.1.201 MRU 1500 [Labels: 17 Exp: 0]
R 1 10.1.2.202 MRU 1500 [Labels: 0 Exp: 0] 40 ms ! Explicit NULL
! 2 10.1.2.203 80 ms
R201#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

45

MPLS Traceroute for IPv4

Cisco.com

```
R201#traceroute mpls ipv4 10.0.0.203/32
Tracing MPLS Label Switched Path to 10.0.0.203/32, timeout is 2 seconds

Codes: '!' - success, 'Q' - request not transmitted,
        '.' - timeout, 'U' - unreachable,
        'R' - downstream router but not target

Type escape sequence to abort.
 0 10.1.1.201 MRU 1500 [Labels: 17 Exp: 0]
R 1 10.1.2.202 MRU 1504 [implicit-null] 64 ms ! Implicit NULL
! 2 10.1.2.203 92 ms
R201#
```

```
R201#traceroute mpls ipv4 10.0.0.203/32
Tracing MPLS Label Switched Path to 10.0.0.203/32, timeout is 2 seconds

Codes: '!' - success, 'Q' - request not transmitted,
        '.' - timeout, 'U' - unreachable,
        'R' - downstream router but not target

Type escape sequence to abort.
 0 10.1.1.201 MRU 1500 [Labels: 17 Exp: 0]
R 1 10.1.2.202 MRU 1504 [No Label] 76 ms
. 2 *
[snip]
. 6 *
R201#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

46

Verifying Forwarding State for L2CKTs

Cisco.com

- No local labels for PW; targeted LDP down?

```
R201#show mpls forwarding-table | include Prefix|l2ckt
Local  Outgoing  Prefix          Bytes tag  Outgoing  Next Hop
R201#
```

- Local labels assigned to PW (VC)

```
R201#show mpls forwarding-table | include Prefix|l2ckt
Local  Outgoing  Prefix          Bytes tag  Outgoing  Next Hop
 19    Untagged  l2ckt(10)      1952531   Et0/0.10  point2point
 20    Untagged  l2ckt(20)      3024      Et3/0     point2point
 21    Untagged  l2ckt(50)      1404829   Se5/0     point2point
R201#
```

Labels Advertised VC ID (Pw ID) P2p Adjacency

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

47

EoMPLS VC Status DOWN...

Cisco.com

- ...but everything seems fine on the PEs
- VC Type (PW Type) mismatch

PW Type—A 15 bit quantity containing a value which represents the type of PW

VC type—0x0004 is used for IEEE 802.1Q VLAN over MPLS application; ISL **is not supported**

VC type—0x0005 is used for Ethernet port tunneling application (**port transparency**)

- MTU mismatch

MTU is carried as interface parameter in label mapping message for VC (PW) FEC

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

48

VC Type Mismatch

- Show AToM bindings

```
R201#show mpls l2transport binding 10
Destination Address: 10.0.0.203, VC ID: 10
Local Label: 19
  Cbit: 1, VC Type: Ethernet, GroupID: 0
  MTU: 1500, Interface Desc: n/a
  VCCV Capabilities: Type 1, Type 2
Remote Label: 21
  Cbit: 1, VC Type: Eth VLAN, GroupID: 0
  MTU: 1500, Interface Desc: *** To R204 ***
  VCCV Capabilities: Type 1, Type 2
```

VC Type Mismatch !!!

- AToM VC is not enough to find the problem

```
R201#show mpls l2transport vc 10 detail
Local interface: Et3/0 up, line protocol up, Ethernet up
Destination address: 10.0.0.203, VC ID: 10, VC status: down
Tunnel label: not ready
Output interface: unknown, imposed label stack {}
Create time: 00:47:45, last status change time: never
Signaling protocol: LDP, peer 10.0.0.203:0 up
MPLS VC labels: local 19, remote 21
Group ID: local 0, remote 0
MTU: local 1500, remote 1500
Remote interface description: *** To R204 ***
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 0, send 0
byte totals: receive 0, send 0
packet drops: receive 0, send 0
```

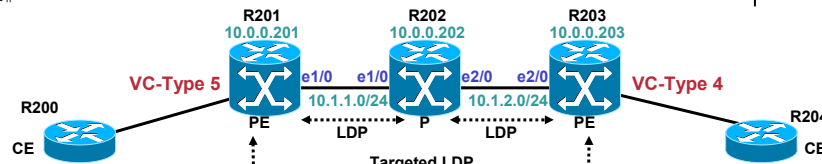
VC Down But All Seems Fine

VC Type Mismatch

- Enable 'debug mpls l2transport signaling message'
- Need to shut/no shut to trigger sending new LDP msgs

```
R201#
*Apr 21 19:17:44.308: ATOM LDP [10.0.0.203]: Received label withdraw msg, id 3964
vc type 4, cbit 1, vc id 10, group id 0, vc label 22, status 0, mtu 0
*Apr 21 19:17:44.400: ATOM LDP [10.0.0.203]: Sending label release msg
vc type 4, cbit 1, vc id 10, group id 0, vc label 22, status 0, mtu 0
*Apr 21 19:17:58.188: ATOM LDP [10.0.0.203]: Received label mapping msg, id 3965
vc type 4, cbit 1, vc id 10, group id 0, vc label 21, status 0, mtu 1500
*Apr 21 19:18:42.100: ATOM LDP [10.0.0.203]: Sending label withdraw msg
vc type 5, cbit 1, vc id 10, group id 0, vc label 19, status 0, mtu 1500
*Apr 21 19:18:42.512: ATOM LDP [10.0.0.203]: Received label release msg, id 3968
vc type 5, cbit 1, vc id 10, group id 0, vc label 19, status 0, mtu 0
*Apr 21 19:18:43.500: ATOM LDP [10.0.0.203]: Sending label mapping msg
vc type 5, cbit 1, vc id 10, group id 0, vc label 20, status 0, mtu 1500
R201#
```

R201 R203
~~Withdraw~~
~~Release~~
~~Mapping~~
~~Withdraw~~
~~Release~~
~~Mapping~~



VC Type Mismatch

Cisco.com

- debug mpls I2transport vc event

```
R203# ! Remote shut
1d04h: AToM MGR [10.0.0.201, 10]: Delete remote vc label binding
R203# ! Remote no shut
1d04h: AToM MGR [10.0.0.201, 10]: Remote end up
1d04h: AToM MGR [10.0.0.201, 10]: Mismatch vc type in remote label binding, local 4, remote 5
R203#
```

Remote PE

VC Id

- debug mpls I2transport vc fsm

```
R203# ! Remote shut
1d04h: AToM MGR [10.0.0.201, 10]: Event remote down, state changed from establishing to local ready
R203# ! Remote no shut
1d04h: AToM MGR [10.0.0.201, 10]: Event remote up, state changed from local ready to establishing
1d04h: AToM MGR [10.0.0.201, 10]: Event remote invalidated, state changed from establishing to establishing
1d04h: AToM MGR [10.0.0.201, 10]: Take no action
R203#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

51

MTU Mismatch

Cisco.com

- debug mpls I2transport vc event

```
R203#
1d05h: AToM MGR [10.0.0.201, 50]: Remote end up
1d05h: AToM MGR [10.0.0.201, 50]: Mismatch MTU in remote label binding, local 1500, remote 4400
R203#
```

- debug mpls I2transport vc fsm

```
R203#
1d05h: AToM MGR [10.0.0.201, 50]: Event remote up, state changed from local ready to establishing
1d05h: AToM MGR [10.0.0.201, 50]: Event remote invalidated, state changed from establishing to establishing
1d05h: AToM MGR [10.0.0.201, 50]: Take no action
R203#
```

- **Note: Changing `MTU` will cause a new LDP Mapping message to be sent for the VC (PW) FEC**
- **Changing the `description` will not, and shut/no shut is needed to generate the signaling message**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

52

A Successful Pseudowire Establishment

Cisco.com

- debug mpls l2transport vc event

```
R203#
1d05h: ATom MGR [10.0.0.201, 50]: Remote end up
1d05h: ATom MGR [10.0.0.201, 50]: Validate vc, activating data plane
1d05h: ATom SMGR: Submit Imposition Update
1d05h: ATom SMGR: Submit Disposition Update
1d05h: ATom SMGR: Submit SSM event
1d05h: ATom SMGR [10.0.0.201, 50]: Event Imposition Enable, imp-ctrlflag 83, remote vc label 20
1d05h: ATom SMGR [10.0.0.201, 50]: Imposition Programmed, Output Interface: Et1/0
1d05h: ATom SMGR [10.0.0.201, 50]: State [Provisioned->Imposition Rdy]
1d05h: ATom SMGR [10.0.0.201, 50]: Event Disposition Enable, disp-ctrlflag 3, local vc label 16
1d05h: ATom SMGR [10.0.0.201, 50]: State [Imposition Rdy->Imposition/Disposition Rdy]
1d05h: ATom SMGR: Event SSM event
1d05h: ATom SMGR [10.0.0.201, 50]: successfully processed ssm provision request pwid 300001F
1d05h: ATom SMGR [10.0.0.201, 50]: Send COMPLETE signal to SSM
1d05h: ATom SMGR [10.0.0.201, 50]: successfully setup sss switch for pwid 300001F
1d05h: ATom SMGR: Submit SSM event
1d05h: ATom SMGR: Event SSM event
1d05h: ATom SMGR [10.0.0.201, 50]: successfully processed ssm bind for pwid 300001F
1d05h: ATom MGR [10.0.0.201, 50]: Receive SSM dataplane up notification
1d05h: ATom MGR [10.0.0.201, 50]: Dataplane activated
R203#
```

Pseudowire Dataplane Is Up
Only if Imposition/Disposition
Are Successfully Programmed

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

53

What If the Core Uses Traffic Engineering?

Cisco.com

- Need to use the command 'preferred-path {interface | peer}' under the 'pseudowire-class'; have in mind that:

The selected path must be a label switched path (LSP) destined to the peer PE router

If you specify a tunnel (selecting interface):

The tunnel must be an MPLS traffic engineering tunnel

The tunnel tailend must be on the remote PE router

If you specify an IP address (selecting peer):

The address must be the IP address of a *loopback* interface on the *remote PE router*, not necessarily the LDP router-id address; peer means *targeted LDP peer*

The address must have a /32 mask

There must be an LSP destined to that selected address

The LSP does not have to be a TE tunnel

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

54

Tunnel Selection Details

Cisco.com

- Tunnel selection configuration

```
pseudowire-class AToM_FRoMPLS
encapsulation mpls
preferred-path interface Tunnell
!
interface Tunnell
description AToM_Tunnel
ip unnumbered Loopback1
mpls ip
tunnel destination 192.168.200.2
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng autoroute announce
tunnel mpls traffic-eng path-option 1 dynamic
connect VPN200 POS3/0 200 l2transport
xconnect 192.168.200.2 200 encapsulation mpls pw-class AToM_FRoMPLS
```

- Tunnel selection verification

```
PE1#show mpls l2transport vc 200 de
Local interface: PO3/0 up, line protocol up, FR DLCI 200 up
Destination address: 192.168.200.2, VC ID: 200, VC status: up
Data plane status: imposition OK, disposition OK
Output interface: Tu1, imposed label stack {24 35}
Preferred path: Tunnell, active
Default path: not supported
Create time: 00:28:33, last status change time: 00:27:09
Signaling protocol: LDP, peer 192.168.200.2:0 up
MPLS VC labels: local 39, remote 24
Group ID: local 0, remote 0
MTU: local 4470, remote 4470
Remote interface description: to CE2
Sequencing: receive disabled, send disabled
VC statistics:
packet totals: receive 30, send 30
byte totals: receive 11295, send 11745
packet drops: receive 0, send 0
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

55

AToM and Label Stack

Cisco.com

- If only LDP is used in the MPLS network, the label stack size is 2 {LDP label; VC label}
- If only RSVP-TE is used in the MPLS network (a TE tunnel between PE routers), the imposition PE uses a label stack size of 2 {TE label; VC label}
- If RSVP-TE and LDP are both used in the MPLS network (a P-P or PE-P TE tunnel, with LDP on the tunnel), the label stack is 3 {TE label; LDP label; VC label}
- If using MPLS Fast Reroute (FRR) anywhere in the MPLS network add one more label to the stack for the above cases, max label stack in this case is 4 {FRR label; TE label; LDP label; VC label}

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

56

AToM and Label Stack

Cisco.com

- If AToM is used in a MPLS-VPN CSC environment, the maximum MPLS label stack size in the provider carrier network is 5 {FRR label; TE label; LDP label; VPN label; VC label}
- If AToM tunnel spans different service providers and the providers exchange MPLS labels using IPv4 BGP (RFC3107), then the max label stack size is 5 {FRR label; TE label; BGP label; LDP label; VC label}
- Add a Router Alert label here or there, and label stack size is now 6
- ...and there is no mechanism to discover the MTU of an LSP dynamically...

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

57

Troubleshooting Attachment Circuits

Cisco.com

- Using `debug acircuit {error | event}'

```
R203#debug acircuit ?
  error Attachment Circuit errors
  event Attachment Circuit events

R203#
R203(config-if)#no shut
R203(config-if)#
3d20h: ACLIB [10.0.0.201, 20]: SW AC interface UP for Ethernet interface Et3/0
3d20h: ACLIB [10.0.0.201, 20]: pthru_intf_handle_circuit_up() calling acmgr_circuit_up
3d20h: ACLIB [10.0.0.201, 20]: Setting new AC state to Ac-Connecting
3d20h: ACLIB: Update switching plane with circuit UP status
3d20h: ACLIB [10.0.0.201, 20]: SW AC interface UP for Ethernet interface Et3/0
3d20h: ACLIB [10.0.0.201, 20]: pthru_intf_handle_circuit_up() ignoring up event. Already connected or connecting.
3d20h: Et3/0 ACMGR: Receive <Circuit Up> msg
3d20h: Et3/0 ACMGR: circuit up event, FSP state chg sip up to connected, action is send connected msg
3d20h: ACLIB: pthru_intf_response hdl is D6000019, response is 2
3d20h: ACLIB [10.0.0.201, 20]: Setting new AC state to Ac-Connected
3d20h: Et3/0 ACMGR: Receive <Remote Up Notification> msg
3d20h: Et3/0 ACMGR: remote up event, FSP connected state no chg, action is ignore
3d20h: %LINK-3-UPDOWN: Interface Ethernet3/0, changed state to up
3d20h: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet3/0, changed state to up
```

- Also `debug xconnect {error | event}'

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

58

FRAME RELAY OVER MPLS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

59

FRoMPLS

Cisco.com

- **Q: Do we know of a way of transporting Frame Relay frames port more?**
- **A: Yes! Using HDLC transport**

- **Q: What about LMI?**
- **A: In that case, LMI runs between CE devices; therefore, use NNI if Switches, or FR DCE-DTE if routers**

- **Q: Can we also use HDLCoMPLS to transport PPP?**
- **A: Yes, any protocol that uses HDLC-like frames**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

60

Configuring FRoMPLS PVC Mode

Cisco.com

- Typical PE configuration

```
R201#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R201(config)#frame-relay switching ! To enable FR DCE/NNI LMI
R201(config)#interface serial7/0
R201(config-if)#encapsulation frame-relay ietf
R201(config-if)#frame-relay intf-type dce
R201(config-if)#no shut
R201(config-if)#exit
R201(config)#
*Apr 26 16:12:35.344: %LINK-3-UPDOWN: Interface Serial7/0, changed state to up
*Apr 26 16:12:51.416: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial7/0,
changed state to up
R201(config)#connect frompls serial7/0 100 l2transport
R201(config-fr-pw-switching)#xconnect 10.0.0.203 70 encapsulation mpls
R201(config-fr-pw-switching)#end
R201#
```

- debug mpls l2transport signaling

```
Oct 31 22:21:26.924 PST: ATOM LDP [192.168.0.7]: Sending label mapping msg
vc type 1, cbit 1, vc id 70, group id 0, vc label 69, status 0, mtu 1500
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

61

Configuring FRoMPLS

Cisco.com

Typical CE Configuration (Same as If Connected to FR Switch)

```
!
interface Serial7/0
no ip address
no ip directed-broadcast
encapsulation frame-relay IETF
!
interface Serial7/0.1 point-to-point
ip address 10.10.7.204 255.255.255.0
no ip directed-broadcast
frame-relay interface-dlci 100 IETF
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

62

Decoding an FRoMPLS Packet

Cisco.com

- Captured using 'debug mpls l2transport packet data'

```
*Apr 26 16:39:09.108: ATOM disposition: in Et1/0, size 102, seq 0, control word 0x0
*Apr 26 16:39:09.108: 03 CC 45 00 00 64 04 7A 00 00 FF 01 93 77 0A 0A
  ^^ ^^ ^^^^^^...
  | | Begins IP Packet
  | | IP NLPID
  | | Control
*Apr 26 16:39:09.108: 07 C8 0A 0A 07 CC 00 00 88 46 00 09 00 04 00 00
*Apr 26 16:39:09.108: 00 00 14 4E E9 A8 AB CD AB CD AB CD AB CD AB CD
*Apr 26 16:39:09.108: AB CD AB CD AB CD AB CD AB CD AB CD AB CD AB CD
*Apr 26 16:39:09.108: AB CD AB CD AB CD AB CD AB CD AB CD AB CD
*Apr 26 16:39:09.108: AB CD AB CD AB CD AB CD AB CD AB CD AB CD
*Apr 26 16:39:09.108: AB CD AB CD AB CD
```

- At disposition, only AToM PDU is displayed

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

65

Verifying the FRoMPLS VC

Cisco.com

```
R203#show connection all
ID   Name                Segment 1                Segment 2                State
=====
1    frompls             Se7/0 100                10.0.0.201 70           UP

R203#show connection id 1
FR/Pseudo-Wire Connection: 1 - frompls
Status - UP
Segment 1 - Serial7/0 DLCI 100
Segment status: UP
Line status: UP
PVC status: ACTIVE
NNI PVC status: ACTIVE
Segment 2 - 10.0.0.201 70
Segment status: UP
Requested AC state: UP
PVC status: ACTIVE
NNI PVC status: ACTIVE
R203#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

66

Verifying the FRoMPLS VC

Cisco.com

```
R203#show mpls l2transport vc | i Local|---|70
Local intf    Local circuit  Dest address  VC ID    Status
-----
Se7/0        FR DLCI 100    10.0.0.201   70       UP
R203#
R203#show mpls l2transport vc 70 detail
Local interface: Se7/0 up, line protocol up, FR DLCI 100 up
Destination address: 10.0.0.201, VC ID: 70, VC status: up
  Preferred path: not configured
  Default path: active
  Tunnel label: 16, next hop 10.1.2.202
  Output interface: Et1/0, imposed label stack {16 16}
  Create time: 00:17:17, last status change time: 00:06:54
  Signaling protocol: LDP, peer 10.0.0.201:0 up
  MPLS VC labels: local 16, remote 16
  Group ID: local 0, remote 0
  MTU: local 2000, remote 2000
  Remote interface description:
  Sequencing: receive disabled, send disabled
  VC statistics:
    packet totals: receive 106, send 103
    byte totals:   receive 11862, send 12420
    packet drops:  receive 0, send 0

R203#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

67

Frame Relay: Show Frame Relay PVC on CE

Cisco.com

```
R204#show frame-relay pvc interface serial 7/0 100
PVC Statistics for interface Serial7/0 (Frame Relay DTE)

DLCI = 100, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial7/0.1

input pkts 783      output pkts 788      in bytes 84510
out bytes 86254     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 604  out bcast bytes 73636
pvc create time 01:30:14, last time pvc status changed 01:22:27

R204#
```

USAGE	LOCAL	If DLCI Is Configured on the Router
	UNUSED	If DLCI Is Not Configured on the Router But Switch Is Reporting the DLCI
STATUS	STATIC	If keepalives Are Disabled
	DELETED	If DLCI Is Defined on the Router But Not Switch
	INACTIVE	If DLCI Is Defined on Switch But the PVC Is Not up (I.E. Network, Atom, VC Failure)
	ACTIVE	If DLCI Is Defined on the Switch and Is Enabled

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

68

Frame Relay: Show Frame Relay PVC on PE

Cisco.com

```
R203#show frame-relay pvc interface serial 7/0 100
PVC Statistics for interface Serial7/0 (Frame Relay DCE)
DLCI = 100, DLCI USAGE = SWITCHED, PVC STATUS = ACTIVE, INTERFACE = Serial7/0

input pkts 769          output pkts 770          in bytes 84244
out bytes 83280        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
switched pkts 769
Detailed packet drop counters:
no out intf 0         out intf down 0         no out PVC 0
in PVC down 0        out PVC down 0         pkt too big 0
pvc create time 01:32:01, last time pvc status changed 01:21:13
R203#
```

- **Note: A PE router may provide circuit status signalling:**
 - FR MUST**—through the use of LMI procedures
 - ATM SHOULD**—through the use of ILMI procedures

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

69

Frame Relay: Debugging LMI

Cisco.com

```
R204# debug frame-relay lmi
*Mar 6 17:46:50.797: Serial0/0(in): Status, myseq 137
*Mar 6 17:46:50.797: RT IE 1, length 1, type 1
*Mar 6 17:46:50.797: KA IE 3, length 2, yourseq 137, myseq 137
*Mar 6 17:47:00.789: Serial0/0(out): StEnq, myseq 138, yourseen 137, DTE up
*Mar 6 17:47:00.789: datagramstart = 0x1BE69F4, datagramsize = 13
*Mar 6 17:47:00.789: FR encap = 0xFCF10309
*Mar 6 17:47:00.789: 00 75 01 01 00 03 02 8A 89
*Mar 6 17:47:00.789:
*Mar 6 17:47:00.801: Serial0/0(in): Status, myseq 138
*Mar 6 17:47:00.801: RT IE 1, length 1, type 0
*Mar 6 17:47:00.801: KA IE 3, length 2, yourseq 138, myseq 138
*Mar 6 17:47:00.801: PVC IE 0x7 , length 0x6 , dlc1 100, status 0x2 , bw 0
*Mar 6 17:47:00.801: PVC IE 0x7 , length 0x6 , dlc1 101, status 0x2 , bw 0
*Mar 6 17:47:00.801: PVC IE 0x7 , length 0x6 , dlc1 102, status 0x8 , bw 0
```

0x0 is added/inactive 0x4 is deleted 0xa is new/active
0x2 is added/active 0x8 is new/inactive

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

70

FRoPW Debugging on the PE

Cisco.com

- Captured using `debug frame-relay pseudowire`

```
R203(config-if)#no shut
R203(config-if)#
*Apr 27 14:16:51.247: %LINK-3-UPDOWN: Interface Serial7/0, changed state to up
*Apr 27 14:16:51.247: FRoPW [10.0.0.201, 70]: Local up, sending acmgr_circuit_up
*Apr 27 14:16:51.247: FRoPW [10.0.0.201, 70]: Setting pw segment UP
*Apr 27 14:16:51.263: Se7/0 ACMGR: Receive <Circuit Up> msg
*Apr 27 14:16:51.263: Se7/0 ACMGR: circuit up event, SIP state chg fsp up to
connected, action is p2p up forwarded
*Apr 27 14:16:51.263: FRoPW [10.0.0.201, 70]: PW nni_pvc_status set ACTIVE
*Apr 27 14:16:51.607: Se7/0 ACMGR: Rcv SIP msg: resp peer-to-peer msg,
hdl 78000004, sss_hdl B000006
*Apr 27 14:16:51.607: Se7/0 ACMGR: remote up event, SIP connected state no chg,
action is ignore
*Apr 27 14:16:52.267: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial7/0,
changed state to up
*Apr 27 14:17:01.271: FRoPW [10.0.0.201, 70]: SW AC update circuit state to up
*Apr 27 14:17:01.271: ACLIB: Update switching plane with circuit UP status
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

71

ATM OVER MPLS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

72

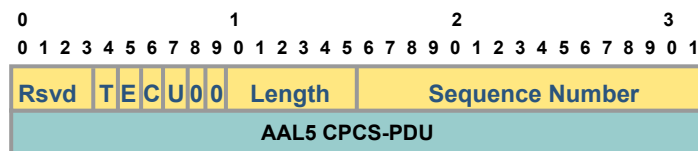
ATMoMPLS

Two Different Modes of Operation of ATMoMPLS:

- ATM AAL5 (RFC2684/1483) over MPLS:
Configured using ``encapsulation aal5'`
- ATM Cell Relay over MPLS:
Configured using ``encapsulation aal0'`
 - VC Mode
 - VP Mode
 - Port Mode
 - Single Cell Relay (Default)
 - Packed Cell Relay

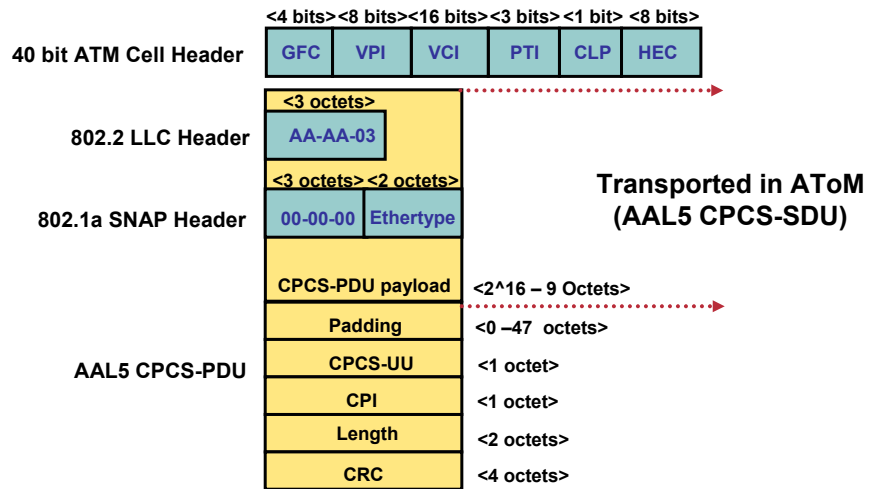
AAL5oMPLS and AAL5 Encapsulation Details

- ATM AAL5 PDUs are re-assembled at ingress PE router
 - Each CPCS-PDU is transported as a single packet
- The control word is **REQUIRED**
 - But its use is optional
- EFCI and CLP bits are carried within the control word



ATM AAL5 Frame Format (Routed)

Cisco.com



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

75

ATMoMPLS Configuration

Cisco.com

```

!
interface ATM3/0.1 point-to-point
  pvc 1/100 l2transport
  encapsulation aal5
  xconnect 192.168.0.6 10 encapsulation mpls
!
interface ATM3/0.3 point-to-point
  pvc 1/300 l2transport
  encapsulation aal0
  xconnect 192.168.0.6 20 encapsulation mpls
!
Local-PE#show mpls l2transport vc
-----
Local intf   Local circuit   Dest address   VC ID   Status
-----
AT3/0.1     ATM AAL5 1/100 192.168.0.6   10      UP
AT3/0.3     ATM VCC CELL 1/300 192.168.0.6 20      UP
-----

Local-PE#show mpls l2transport vc
-----
Local intf   Local circuit   Dest address   VC ID   Status
-----
AT1/0       ATM CELL ATM1/0 192.168.0.6   100     UP
-----

```

The diagram shows the configuration of ATMoMPLS. The configuration includes two interfaces (ATM3/0.1 and ATM3/0.3) and two VC configurations (VC 10 and VC 20). The VC 10 configuration is labeled as AAL5oMPLS and the VC 20 configuration is labeled as ATM_CelloMPLS. The output of the show mpls l2transport vc command shows the status of the VC configurations.

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

76

Debug ATMoMPLS AAL5 and AAL0

Cisco.com

Debug signaling [AAL5]:

Nov 1 07:02:50.113 UTC: ATOM LDP [192.168.0.23]: Sending label withdraw msg
vc type 2, cbit 1, vc id 10, group id 10, vc label 72, status 0, mtu 4470

Debug signaling [AAL0]:

Nov 1 07:04:16.321 UTC: ATOM LDP [192.168.0.23]: Sending label withdraw msg
vc type 9, cbit 1, vc id 300, group id 10, vc label 74, status 0, mtu 4470

```
Remote-PE#show mpls l2transport vc 10 detail
Local interface: AT3/0.1 up, line protocol up, ATM AAL5 1/100 up
Destination address: 192.168.0.23, VC ID: 10, VC status: up
Preferred path: not configured
Default path: active
Tunnel label: imp-null, next hop point2point
Output interface: Tu0, imposed label stack {64 16}
Create time: 1d21h, last status change time: 00:00:17
Signaling protocol: LDP, peer 192.168.0.23:0 up
MPLS VC labels: local 16, remote 16
Group ID: local 10, remote 7
MTU: local 4470, remote 4470
Remote interface description:
Sequencing: receive disabled, send disabled
VC statistics:
  packet totals: receive 6, send 7
  byte totals:   receive 672, send 772
  packet drops:  receive 0, send 0
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

77

OAM Cell Emulation for AAL5oMPLS

Cisco.com

- Locally terminates or loops OAM Cells
- Need to configure in both PEs

```
Router#interface ATM 1/0/0
Router(config-if)#pvc 1/100 l2transport
Router(config-atm-vc)#oam-ac emulation-enable 30
Router(config-atm-vc)#oam-pvc manage

Router#show atm pvc 1/100
ATM4/1/0.200: VCD: 6, VPI: 5, VCI: 500
UBR, PeakRate: 1
AAL5-LLC/SNAP, etype:0x0, Flags: 0x34000C20, VCmode: 0x0
OAM Cell Emulation: enabled, F5 End2end AIS Xmit frequency: 1 second(s)
OAM frequency: 0 second(s), OAM retry frequency: 1 second(s)
OAM up retry count: 3, OAM down retry count: 5
[snip]
Router#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

78

ATM Cell over MPLS Modes

Cisco.com

- **Q: How do we select VC vs. VP vs. port mode?**
- **A: Depending on the configuration mode the `xconnect` command is applied**

VC MODE:

```
interface ATM4/0.300 point-to-point
pvc 0/300 l2transport
encapsulation aal0
xconnect 10.0.0.200 300 encapsulation mpls
```

VP MODE:

```
interface atm 5/0
atm pvp 1 l2transport
xconnect 10.0.0.200 100 encapsulation mpls
```

PORT MODE:

```
interface atm 5/0
xconnect 10.0.0.200 100 encapsulation mpls
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

79

Packed Cell Relay

Cisco.com

- Use the command **`cell-packing`**
- The **`atm mcpt-timers`** indicates the time the PE should wait for cells to be packet into an MPLS packet; three timers are configured
- The command **`cell-packing`** indicates how many cells should be packet per MPLS packet, and which timer to use

```
int atm 1/0
atm mcpt-timer 500 800 1000
pvc 1/100 l2transport
encapsulation aal0
xconnect 10.0.0.1 123 encapsulation mpls
cell-packing 5 mcpt-timer 1
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

80

AToM RECAP ANY QUESTIONS?



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

81

L2TPv3 PROTOCOL OVERVIEW



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

82

L2TPv3 Protocol Overview

Cisco.com

- **Control plane**
- **Data plane**
- **Packet flow**
- **Layer 2 payload supported**
- **Configuration examples**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

83

L2TPv3

Cisco.com

- **Transparent Layer 2 traffic transport**
- **Extension to L2TP version 2 (RFC 2661)**
- **Operates over native IP backbone network**
- **Supports multiple Layer 2 Data Link emulation types**

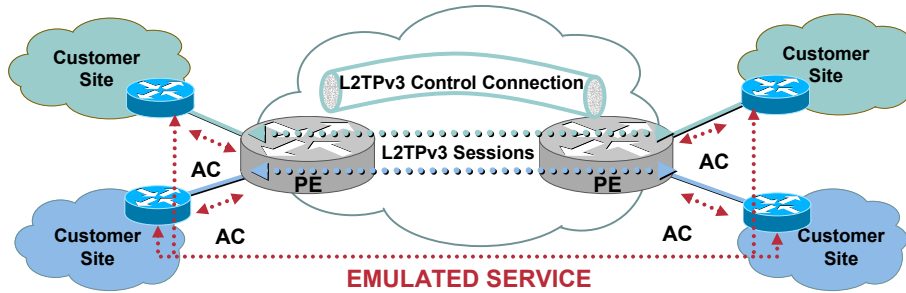
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

84

L2TPv3 Architecture and Protocol Model

Cisco.com



- The optional L2TPv3 Control Connection (tunnel) exists between two peers and is used for advertising and negotiating capabilities
- For each emulated pseudowire, L2TPv3 negotiates individual sessions

ACC-3001
9745_05_2004_c3

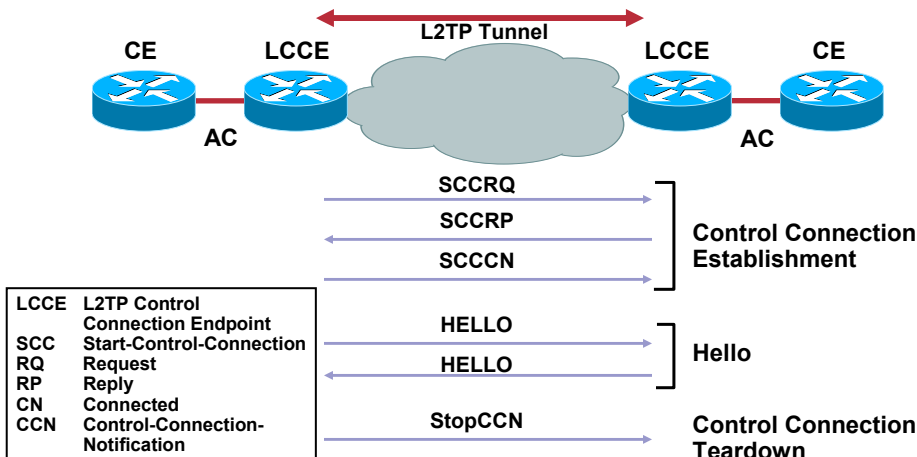
© 2004 Cisco Systems, Inc. All rights reserved.

85

L2TPv3 Control Plane

Cisco.com

Control Connection



ACC-3001
9745_05_2004_c3

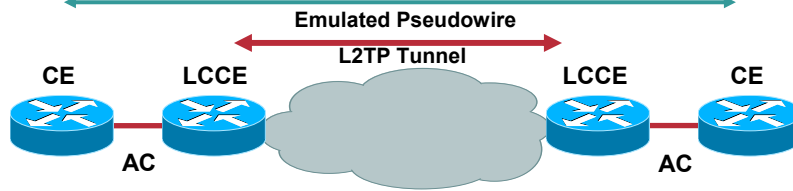
© 2004 Cisco Systems, Inc. All rights reserved.

86

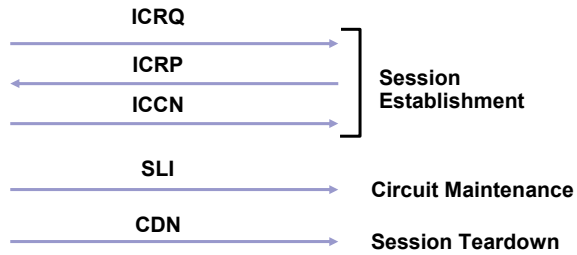
L2TPv3 Control Plane

Cisco.com

Session Establishment



LCCE	L2TP Control Connection Endpoint
IC	Incoming-Call
RQ	Request
RP	Reply
CN	Connected
SLI	Set-Link-Info
CDN	Call-Disconnect-Notify



ACC-3001
9745_05_2004_c3

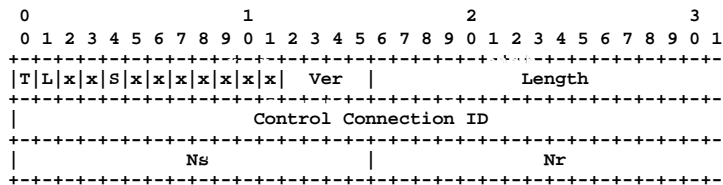
© 2004 Cisco Systems, Inc. All rights reserved.

87

L2TPv3 Control Plane

Cisco.com

Control Message Header Format



- T** SET TO 1, INDICATES THIS IS A CONTROL MESSAGE
- L, S** For a control message, this must be set to 1 indicating the presence of Length and Sequence fields
- x** Reserved for future extensions
- Ver** Indicates which version of L2TP is in use; this field must be set to 3
- Length** Indicates the total size of the control message in octets, starting with the T bit

ACC-3001
9745_05_2004_c3

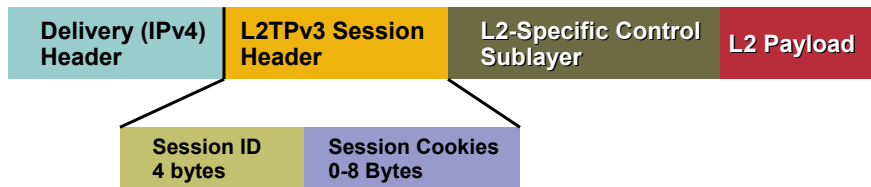
© 2004 Cisco Systems, Inc. All rights reserved.

88

L2TPv3 Data Plane

Cisco.com

Data Message Format



Delivery header—the IPv4 header needed to transport the L2TPv3 frames across an IP backbone network

L2TPv3 Session header—the PSN specific header used to uniquely identify tunneled traffic among multiple L2TP data sessions

L2-Specific Sublayer—control fields that are used to facilitate the tunneling of each frame (e.g. sequence numbers or flags)

L2 Payload—link layer payload to be transported by L2TPv3

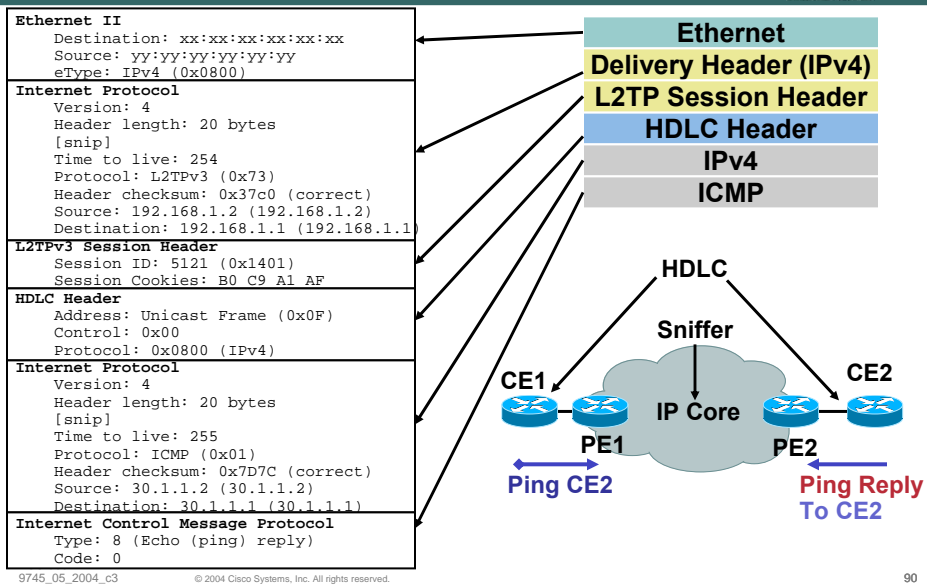
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

89

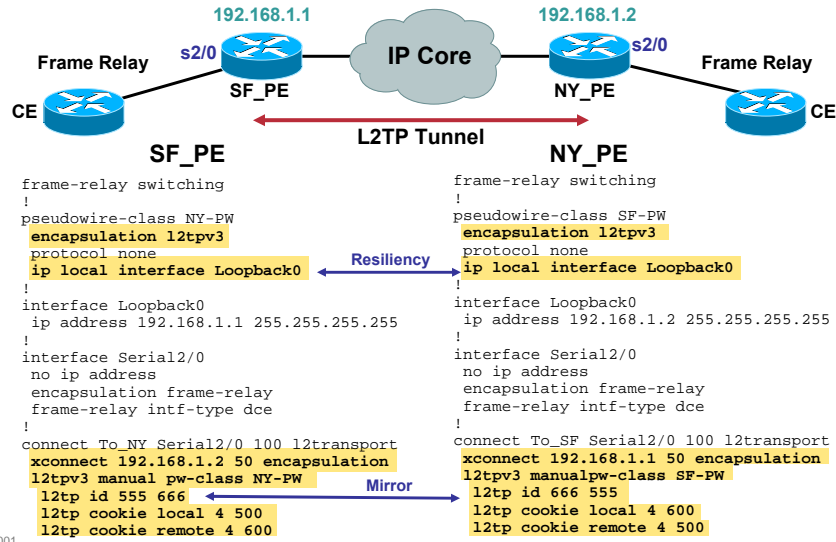
L2TPv3 Data Plane: A Real Packet

Cisco.com



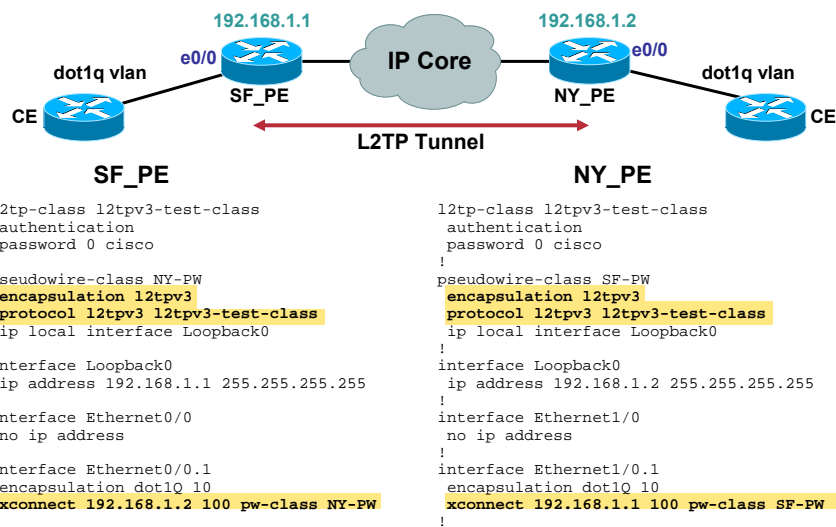
Configuration Example #1 Static Session with FR DLCI-DLCI

Cisco.com



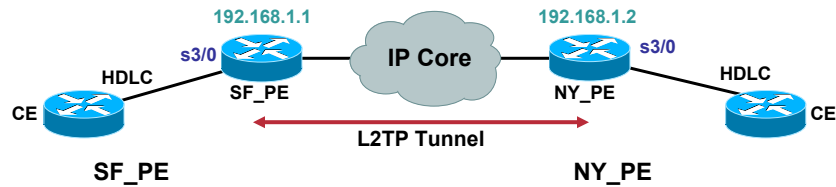
Configuration Example #2 Dynamic Session with Ethernet VLAN

Cisco.com



Configuration Example #3 Dynamic Session with HDLC

Cisco.com



```

l2tp-class l2tpv3-test-class
authentication
password 0 cisco
cookie size 8
!
pseudowire-class NY-PW-HDLC
encapsulation l2tpv3
protocol l2tpv3 l2tpv3-test-class
ip local interface Loopback0
!
interface Loopback0
ip address 192.168.1.1 255.255.255.255
!
interface Serial3/0
no ip address
no ip directed-broadcast
no cdp enable
xconnect 192.168.1.2 30 pw-class NY-PW-HDLC

```

```

l2tp-class l2tpv3-test-class
authentication
password 0 cisco
!
pseudowire-class SF-PW-HDLC
encapsulation l2tpv3
protocol l2tpv3 l2tpv3-test-class
ip local interface Loopback0
!
interface Loopback0
ip address 192.168.1.2 255.255.255.255
!
interface Serial3/0
no ip address
no ip directed-broadcast
no cdp enable
xconnect 192.168.1.1 30 pw-class SF-PW-HDLC

```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

93

Configuration Example #3 Note Different Cookie Size

Cisco.com

```

SF_PE R201#show l2tun session all
Session Information Total tunnels 1 sessions 1

Session id 56877 is up, tunnel id 14721
[snip]
Circuit state is UP
Remote session id is 54243, remote tunnel id 41867
DF bit off, ToS reflect disabled, ToS value 0, TTL value 255
Session cookie information:
local cookie, size 8 bytes, value 40 04 BC 5D FA 21 01 33
FS cached header information:
encap size = 24 bytes
00000000 00000000 00000000 00000000
00000000 00000000
Sequencing is off
R201#

```

```

NY_PE R203#show l2tun session all
Session Information Total tunnels 1 sessions 1
Tunnel control packets dropped due to failed digest 0

Session id 54243 is up, tunnel id 41867
[snip]
Circuit state is UP
Remote session id is 56877, remote tunnel id 14721
DF bit off, ToS reflect disabled, ToS value 0, TTL value 255
Session cookie information:
remote cookie, size 8 bytes, value 40 04 BC 5D FA 21 01 33
FS cached header information:
encap size = 32 bytes
00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000
Sequencing is off
R203#

```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

94

L2TPv3 TROUBLESHOOTING



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

95

L2TP Troubleshooting

Cisco.com

- **Understand the show commands**
- **Useful debugs**
- **PMTUD issues**
- **Debug dynamic L2TP sessions**
- **Debug static L2TP sessions**
- **Debug link layer specific issues**
- **Summary**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

96

Understanding the Show Commands

Cisco.com

- Verify the control connection operation

```
SF_PE#show l2tun tunnel
Tunnel Information Total tunnels 1 sessions 3

LocID RemID Remote Name      State Remote Address  Port Sessions L2TPclass
59273 22017 NY_PE      est  192.168.1.2     0    2      v3-test-class
```

- Verify the session information

```
SF_PE#show l2tun session brief
Session Information Total tunnels 1 sessions 3

LocID      TunID      Peer-address  State      Username, Intf/
5120      59273     192.168.1.2  est,UP     30, Et0/0.1:100
5121      59273     192.168.1.2  est,UP     40, Se3/0
555      0         192.168.1.2  est,UP     50, Se2/0:100
```

Static Session

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

97

Detailed Tunnel Information

Cisco.com

```
SF_PE#show l2tun tunnel all
Tunnel Information Total tunnels 1 sessions 3

Tunnel id 59273 is up, remote id is 22017, 2 active sessions
Tunnel state is established, time since change 3d10h
Tunnel transport is IP (115)
Remote tunnel name is R201 ! Can be modified
Internet Address 192.168.1.2, port 0
Local tunnel name is R203
Internet Address 192.168.1.1, port 0
Tunnel domain is
VPDN group for tunnel is -
L2TP class for tunnel is v3-test-class
9904 packets sent, 9904 received
3495196 bytes sent, 3495206 received
Control Ns 4944, Nr 4941
Local RWS 1024 (default), Remote RWS 1024 (max)
Tunnel PMTU checking disabled
Retransmission time 1, max 1 seconds
Unsent queuesize 0, max 0
Resend queuesize 0, max 4
Total resends 1, ZLB ACKs sent 4936
Current nosession queue check 0 of 5
Retransmit time distribution: 0 0 1 0 0 0 0 0
Sessions disconnected due to lack of resources 0
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

98

Detailed Session Information

Cisco.com

```
SF_PE#show l2tun session l2tp all vcid 40 / Avoid VCID Overlap with AToM
Session Information Total tunnels 1 sessions 3

Session id 5121 is up, tunnel id 59273
Call serial number is 1734400020
Remote tunnel name is R203
Internet address is 192.168.1.2
Session is L2TP signalled
Session state is established, time since change 00:34:56
 40 Packets sent, 40 received
12455 Bytes sent, 12455 received
Receive packets dropped:
  out-of-order:      0
  total:             0
Send packets dropped:
  exceeded session MTU: 0
  total:             0
Session vcid is 40
Session Layer 2 circuit, type is HDLC, name is Serial3/0
Circuit state is UP
  Remote session id is 50249, remote tunnel id 22017
DF bit off, ToS reflect disabled, ToS value 0, TTL value 255
Session cookie information:
  local cookie, size 4 bytes, value B0 C9 A1 AF
  remote cookie, size 4 bytes, value 7C 64 B4 0B
FS cached header information:
encap size = 32 bytes
00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000

Sequencing is on
Ns 40, Nr 40, 0 out of order packets received
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

99

PMTUD Issues

Cisco.com

- Just like any other encapsulation protocols, L2TPv3 may have PMTUD and fragmentation issues with large packets
- Typical problems are
 - Poor performance due to reassembly on the receive
 - Applications with DF bit set (PMTUD) don't work
- Ideally, we want to avoid fragmentation and reassembly through MTU tuning
- Sweep ping is a very useful tool to identify fragmentation issues and the boundary conditions

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

100

Transport Header Overhead

Cisco.com

Transport Type	Transport Header Size
Ethernet Port	14 Bytes
Ethernet VLAN	18 Bytes
Frame Relay DLCI, Cisco Encapsulation	2 Bytes
Frame Relay DLCI, IETF Encapsulation	8 Bytes
HDLC	4 Bytes
PPP	4 Bytes
AAL5	0–32 Bytes

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

101

Fragmentation Issues with L2TPv3

Cisco.com

- Large packets will need to be fragmented after tunnel encapsulation
- The receiving tunnel endpoint needs to perform packet reassembly which occurs in the process path, causing high cpu

```
NY_PE#show proc cpu | in util|PID|IP Input
CPU utilization for five seconds: 96%/0%; one minute: 9%; five minutes: 11%
PID Runtime(ms)   Invoked    uSecs   5Sec   1Min   5Min  TTY Process
 18      388756     40279    9651  90.31%  8.08%  8.09%   0 IP Input
```

```
NY_PE#show ip traffic | in fragment|reassembl
Fragments: 1378 reassembled, 0 timeouts, 0 couldn't reassemble
           2754 fragmented, 0 couldn't fragment
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

102

Fragmentation Issues: Solutions

Cisco.com

- Use the “ip pmtu [max]” command to have the PE dynamically adjust the session MTU based on encapsulation size
- Use the “ip dfbit set” command to have the PE participate set the DF bit in the encapsulation header and participate in PMTUD themselves
- End station will learn about the adjusted PMTU when they perform PMTUD by setting the DF bit

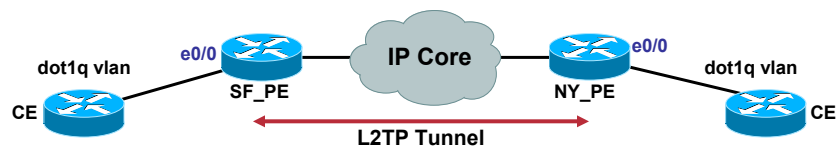
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

103

Fragmentation Issues: An Example

Cisco.com



```
SF_PE#config t
Enter configuration commands, one per line. End
with CNTL/Z.
SF_PE(config)#pseudowire-class NY-PW-DYNAMIC
SF_PE(config-pw-class)#ip dfbit set
SF_PE(config-pw-class)#ip pmtu
SF_PE(config-pw-class)#end
```

```
SF_PE#sh l2tun session all vcid 40 | in PMTU|DF
Session PMTU enabled, path MTU is 1500 bytes
DF bit on, ToS reflect disabled, ToS value 0, TTL value 255
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

104

Fragmentation Issues: An Example (Cont.)

Cisco.com

```
SF_CE#ping ip
Target IP address: 10.1.1.2
Repeat count [5]: 1
Datagram size [100]:
Timeout in seconds [2]:
Extended commands [n]: y
Source address or interface:
Type of service [0]:
Set DF bit in IP header? [no]: y
Validate reply data? [no]:
Data pattern [0xABCD]:
Loose, Strict, Record, Timestamp, Verbose[none]: v
Loose, Strict, Record, Timestamp, Verbose[V]:
Sweep range of sizes [n]: y
Sweep min size [36]: 1449
Sweep max size [18024]: 1452
Sweep interval [1]:
Type escape sequence to abort.
Sending 4, [1449..1452]-byte ICMP Echos to 10.1.1.2, timeout is 2 seconds:
Packet sent with the DF bit set
Reply to request 0 (52 ms) (size 1449)
Reply to request 1 (60 ms) (size 1450)
Unreachable from 10.1.1.2, maximum MTU 1450 (size 1451)
Unreachable from 10.1.1.2, maximum MTU 1450 (size 1452)
Success rate is 50 percent (2/4), round-trip min/avg/max = 52/56/60 ms
```

L2TPv3 session overhead = 20 (IPv4) + 8 (L2TPv3 Session Header) + 4 (L2-specific sublayer) + 18 (dot1Q vlan header)
= 50 Bytes

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

105

Debug Dynamic Sessions

Cisco.com

- **Verify that the pseudowire-class and l2tp-class configurations are complete and correct**
- **Verify that the control connection is correctly established**
- **Verify that the L2TP session is successfully established between the pair of ACs**
- **Troubleshoot any data plane issues by identifying the direction and point of failure**

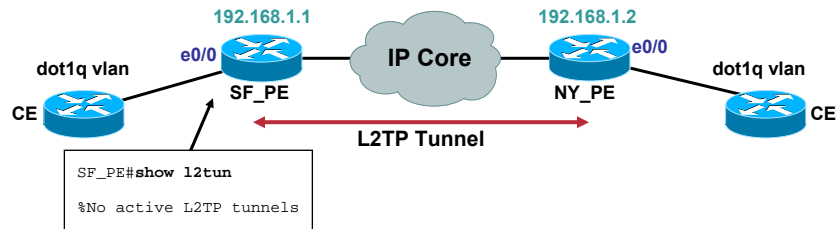
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

106

Control Connection Doesn't Come Up

Cisco.com



- Useful debugs for control connection problems

```
debug vpdn l2x-event
```

```
debug vpdn l2x-error
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

107

Control Connection Doesn't Come Up

Cisco.com

```
SF_PE#sh debug
VPN:
  L2X protocol events debugging is on
  L2X protocol errors debugging is on
SF_PE#
*Apr 28 00:39:37.185: Tnl/Sn7322/56088 L2TP: Create session
*Apr 28 00:39:37.185: Tnl7322 L2TP: SM State idle
*Apr 28 00:39:37.185: Tnl7322 L2TP: O SCCRQ
*Apr 28 00:39:37.185: Tnl7322 L2TP: Control channel retransmit delay set to 1 seconds
*Apr 28 00:39:37.185: Tnl7322 L2TP: Tunnel state change from idle to wait-ctl-reply
*Apr 28 00:39:37.185: Tnl7322 L2TP: SM State wait-ctl-reply
*Apr 28 00:39:38.213: Tnl7322 L2TP: O Resend SCCRQ, flg TLS, ver 3, len 142, tnl 0, ns 0, nr 0
*Apr 28 00:39:38.213: Tnl7322 L2TP: Control channel retransmit delay set to 2 seconds
*Apr 28 00:39:40.201: Tnl7322 L2TP: O Resend SCCRQ, flg TLS, ver 3, len 142, tnl 0, ns 0, nr 0
*Apr 28 00:39:40.201: Tnl7322 L2TP: Control channel retransmit delay set to 4 seconds
*Apr 28 00:39:44.213: Tnl7322 L2TP: O StopCCN
*Apr 28 00:39:44.213: Tnl7322 L2TP: Tunnel state change from wait-ctl-reply to shutting-down
```

- The SF_PE is not getting a response to its SCCRQ, but at the same time it seems to be getting the peer's SCCRQ, and it promptly responds with its SCCRQ

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

108

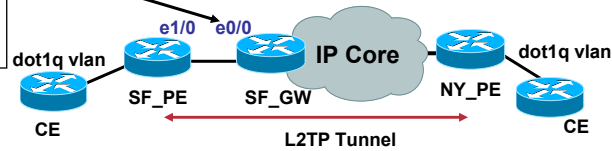
Control Connection Doesn't Come Up (Cont.)

Cisco.com

```
*Apr 28 00:51:09.797: L2TP: I SCCRP from NY_PE tnl 44366
*Apr 28 00:51:09.797: Tnl31927 L2TP: Got a challenge in SCCRP, NY_PE
*Apr 28 00:51:09.797: Tnl31927 L2TP: New tunnel created for remote NY_PE, address
192.168.1.2
*Apr 28 00:51:09.797: Tnl31927 L2TP: O SCCRP to NY_PE tnlid 44366
*Apr 28 00:51:09.797: Tnl31927 L2TP: Control channel retransmit delay set to 1 seconds
*Apr 28 00:51:09.797: Tnl31927 L2TP: Tunnel state change from idle to wait-ctl-reply
*Apr 28 00:51:10.805: Tnl31927 L2TP: O Resend SCCRP, flg TLS, ver 3, len 164, tnl
44366, ns 0, nr 1
*Apr 28 00:51:10.805: Tnl31927 L2TP: Control channel retransmit delay set to 2 seconds
*Apr 28 00:51:10.805: L2TP: I SCCRP from NY_PE tnl 44366
*Apr 28 00:51:10.805: Tnl31927 L2TP: Tunnel exists, must be a duplicate SCCRP
```

So it looks like SF_PE is getting the control connection packets from its peer, but its messages never made it to the other side. It turned out that ip protocol 115 is blocked in the IP core from SF_PE!!!

```
interface Ethernet0/0
 ip access-group 119 in
!
access-list 119 permit tcp any any
access-list 119 permit udp any any
access-list 119 permit ospf any any
access-list 119 deny ip any any
```



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

109

Authentication Failures

Cisco.com

```
*Apr 28 08:53:24.235: Tnl56375 L2TP: O SCCRP
*Apr 28 08:53:24.235: Tnl56375 L2TP: Control channel retransmit delay set to 1 seconds
*Apr 28 08:53:24.235: Tnl56375 L2TP: Tunnel state change from idle to wait-ctl-reply
*Apr 28 08:53:24.235: Tnl56375 L2TP: SM State wait-ctl-reply
*Apr 28 08:53:24.307: L2TP: I SCCRP from NY_PE tnl 44437
*Apr 28 08:53:24.307: Tnl57078 L2TP: Got a challenge in SCCRP, NY_PE
*Apr 28 08:53:24.307: Tnl57078 L2TP: New tunnel created for remote NY_PE, address 192.168.1.2
*Apr 28 08:53:24.307: Tnl57078 L2TP: O SCCRP to NY_PE tnlid 44437
*Apr 28 08:53:24.307: Tnl57078 L2TP: Control channel retransmit delay set to 1 seconds
*Apr 28 08:53:24.307: Tnl57078 L2TP: Tunnel state change from idle to wait-ctl-reply
*Apr 28 08:53:24.343: Tnl56375 L2TP: I SCCRP from NY_PE
*Apr 28 08:53:24.343: Tnl56375 L2TP: Got a challenge from remote peer, NY_PE
*Apr 28 08:53:24.343: Tnl56375 L2TP: Got a response from remote peer, NY_PE
*Apr 28 08:53:24.343: Tnl56375 L2TP: Tunnel auth failed for NY_PE
*Apr 28 08:53:24.343: Tnl56375 L2TP: Expected
A6 46 04 B6 F5 77 02 29 4F B3 13 58 B6 AE F3 67
*Apr 28 08:53:24.343: Tnl56375 L2TP: Got
80 41 1D EC 34 75 45 C6 5A 54 E1 5D 9B 44 5A 3B
*Apr 28 08:53:24.343: Tnl56375 L2TP: O StopCCN to NY_PE tnlid 63270
```

Let's Doublecheck the Configurations

SF_PE

```
l2tp-class v3-test-class
 authentication
 password 0 cisco
 cookie size 4
```

NY_PE

```
l2tp-class v3-test-class
 authentication
 password 0 cicso
 cookie size 4
```

Password Mismatch!

```
debug vpdn l2x-events
debug vpdn l2x-errors
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

110

Debug Static Sessions

Cisco.com

- No control connection is necessary for static L2TPv3 sessions
- Session parameters are hard coded in the configurations
- Common issues in AC, PW, and data plane
- If traffic is not flowing from CE to CE, then need to determine
 1. In which direction traffic is failing
 2. The furthest point traffic can reach in that direction

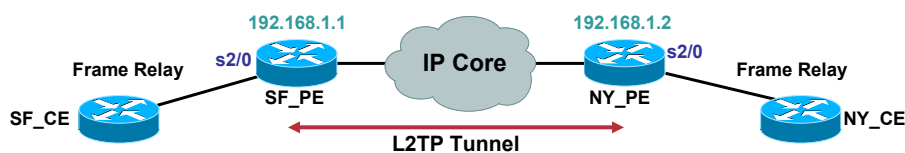
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

111

Debug Static Sessions: An Example

Cisco.com



Problem: Can't Ping from SF_CE to NY_CE

- We know this is a **static** session, so control connection is not involved; we'll look at the **data path** by first checking the interface status on the CE's

```
SF_CE#sh int s2/0 | in protocol  
Serial2/0 is up, line protocol is up
```

```
NY_CE#sh int s2/0 | in protocol  
Serial2/0 is up, line protocol is up
```

- Let's now send some traffic and see how far they can go and where they are failing

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

112

Debug Static Sessions: An Example (2)

Cisco.com

```
SF_CE#ping 20.1.1.2 repeat 100 timeout 0
Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 20.1.1.2, timeout is 0 seconds:
.....
Success rate is 0 percent (0/100)
SF_CE#sh frame pvc

PVC Statistics for interface Serial2/0 (Frame Relay DTE)

Local          Active      Inactive    Deleted     Static
Switched       0           0           0           0
Unused         0           0           0           0

DLCI = 100, DLCI USAGE = LOCAL, PVC STATUS = ACTIVE, INTERFACE = Serial2/0

input pkts 0          output pkts 100      in bytes 0
out bytes 10400      dropped pkts 0       in pkts dropped 0
out pkts dropped 0   out bytes dropped 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 0 bits/sec, 0 packets/sec
5 minute output rate 1000 bits/sec, 1 packets/sec
pvc create time 02:05:57, last time pvc status changed 00:03:45
SF_CE#
SF_CE#sh int s2/0 | in packets out
103 packets output, 10439 bytes, 0 underruns
```

We Send 100 Pings

Packets Sent on the PVC

Packets Went out the Serial Interface

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

113

Debug Static Sessions: An Example (3)

Cisco.com

Let's Now Check if the Packets Are Entering the Local PE and Forwarded out the Corresponding L2TPv3 Session

```
SF_PE#sh int s2/0 | in packets in
104 packets input, 10452 bytes, 0 no buffer
SF_PE#
SF_PE#
SF_PE#sh l2tun session l2tp packet vcid 50
Session Information Total tunnels 1 sessions 3

LocID   RemID   TunID   Pkts-In  Pkts-Out  Bytes-In  Bytes-Out
555     666     0       0        100       0         10400
SF_PE#
SF_PE#sh int e1/0 | in packets out
107 packets output, 18518 bytes, 0underruns
```

So We Received the Packets on the Serial intf

Packets Are Forwarded out the Correct L2TPv3 Session

Packets Delivered to the IP Network

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

114

Debug Static Sessions: An Example (4)

Cisco.com

- Hmm, so packets are going out of the local PE, are they getting to the remote PE?

```
NY_PE#sh int e0/0 | in packets in
101 packets input, 14694 bytes, 0 no buffer
NY_PE#
NY_PE#sh l2tun session packets vcid 50
Session Information Total tunnels 1 sessions

```

LocID	RemID	TunID	Pkts-In	Pkts-Out	Bytes-In	Bytes-Out
555	666	0	0	0	0	0

Packets Are Coming In

But Not Decapsulated!!!

- Packets are received from the ip network on the remote PE, but they are not decapsulated with the L2TP session; so we know where this is failing, but why? More data plane debugs may help here

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

115

Debug Static Sessions: An Example (5)

Cisco.com

```
NY_PE#debug ip cef drop
IP CEF drops debugging is on
NY_PE#debug vpdn packet
VPDN packet debugging is on
```

- We now send some more traffic

```
*Apr 27 23:00:00.109: L2X:CEF From tunnel: Received 146 byte pak
*Apr 27 23:00:00.109: L2X:CEF From tunnel: 146 byte pak dropped
*Apr 27 23:00:00.109: CEF-Drop: Packet de-encap for 192.168.1.2 -- L2TP
```

- So problem is CEF is dropping packets on the receiver, most likely due to unmatched layer2 rewrite information; we know packets are decapsulated based on the L2TPv3 session header, and since this is hard coded with static sessions, let's doublecheck the config

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

116

Debug Static Sessions: An Example (6)

Cisco.com

SF_PE

```
connect To_NY Serial2/0 100 l2transport
xconnect 192.168.1.2 50 encapsulation l2tpv3 manual pw-class NY-PW-STATIC
l2tp id 555 666
l2tp cookie local 4 500
l2tp cookie remote 4 600
```

NY_PE

```
connect To_SF Serial2/0 100 l2transport
xconnect 192.168.1.1 50 encapsulation l2tpv3 manual pw-class SF-PW-STATIC
l2tp id 555 666
l2tp cookie local 4 600
l2tp cookie remote 4 500
```

The Session IDs Should Be Mirrored!

- Aha, so we see the problem—the session IDs are configured the same on the PE's while they should be mirrored; after we correct the configuration on the NY_PE, the static session now works!

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

117

Debug Static Sessions: Summary

Cisco.com

- Verify the Xconnect configurations are complete and correct with static session parameters properly matched on the PEs
- The above problem maybe easily fixed by inspecting the PE router configurations without going through the troubleshooting exercise described; but this demonstrates a common technique for troubleshooting forwarding path issues

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

118

Summary of Useful Debugs

Cisco.com

- debug vpdn l2x-event
- debug vpdn l2x-error
- debug xconnect event
- debug xconnect error
- debug acircuit event
- debug acircuit error
- debug frame-relay pseudowire
- debug vpdn packet
- debug vpdn l2x-packet

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

119

AToM AND L2TPv3 INTERWORKING



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

120

Interworking Modes and Features

Cisco.com

- The AC are terminated locally!!!
- There are 2 types of Interworking (AKA any-2-any):
 - Ethernet (AKA bridged)—Ethernet frames are extracted from the AC and sent over the PW; VLAN Tag is removed; CEs can run Ethernet, BVI or RBE
 - IP (AKA routed)—IP packets are extracted from the AC and sent over the PW

	AToM	L2TPv3	IP Mode	Ethernet
Frame Relay to Ethernet/VLAN	Yes	Yes	Yes	Yes
Frame Relay to PPP	Yes	Yes	Yes	No
Frame Relay to ATM AAL5	Yes	No	Yes	No
Ethernet/VLAN to ATM AAL5	Yes	No	Yes	Yes
Ethernet to VLAN	Yes	Yes	Yes	Yes

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

121

Interworking Problems

Cisco.com

- Q: What's the most common problem in interworking scenarios?
- A: Mismatching MTUs due to different MTU defaults:
 - MTU == 1500 by default for serial and Ethernet
 - MTU == 4470 by default for HSSI, ATM and POS
- Problem in port mode to VLAN mode:
 - BPDU gets sent across from VLAN mode and causing problems on port mode because port mode are expecting BPDU with VLAN dot1q header

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

122

MTU Problems with Interworking

Cisco.com

- Scenario: Interworking serial interface (MTU 4460) to Ethernet interface (MTU 1500); we want to change MTU on the serial side
- Q: How do we go about doing that?
- A1: Changing mtu on serial to 1500...hmmm...that will effect every DLCI on that interface...bad idea
- A2: Modify mtu per DLCI under connect mode :-)

```
interface Serial3/0
  mtu 4460
  encapsulation frame-relay
  frame-relay lmi-type ansi
  frame-relay intf-type nni
!
connect Ser_to_Eth Serial3/0 100 l2transport
  mtu 1500 ! To match remote side only on this DLCI
  xconnect 10.0.0.203 100 encapsulation mpls ! To Ethernet l2-with mtu 1500
```

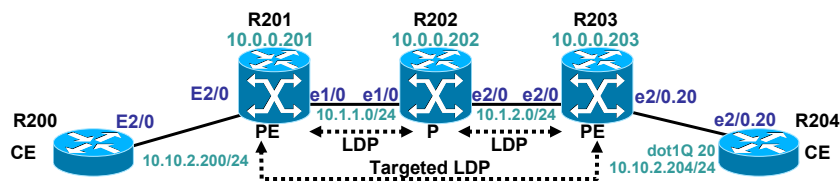
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

123

Ethernet 2 VLAN Bridged Example

Cisco.com



R201

```
pseudowire-class atom-iw-eth-vlan
  encapsulation mpls
  interworking ethernet
!
interface Ethernet2/0
  no ip address
  no ip directed-broadcast
  no cdp enable
  xconnect 10.0.0.203 2 pw-class atom-iw-eth-vlan
!
```

Need to Match

R203

```
pseudowire-class atom-iw-eth-vlan
  encapsulation mpls
  interworking ethernet
!
interface Ethernet2/0
  no ip address
  no ip directed-broadcast
!
interface Ethernet2/0.20
  encapsulation dot1Q 20
  no ip directed-broadcast
  xconnect 10.0.0.201 2 pw-class atom-iw-eth-vlan
!
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

124

Ethernet 2 VLAN Bridged Example

Cisco.com

New Command Output

```
R203#show mpls l2transport vc 2 detail
Local interface: Et2/0.20 up, line protocol up, Eth VLAN 20 up
MPLS VC type is Ethernet, interworking type is Ethernet
Destination address: 10.0.0.201, VC ID: 2, VC status: up
Preferred path: not configured
Default path: active
[snip]
R203#show mpls l2transport binding 2
Destination Address: 10.0.0.201, VC ID: 2
Local Label: 19
Cbit: 1, VC Type: Ethernet, GroupID: 0
MTU: 1500, Interface Desc: n/a
VCCV Capabilities: Type 1, Type 2
Remote Label: 24
Cbit: 1, VC Type: Ethernet, GroupID: 0
MTU: 1500, Interface Desc: n/a
VCCV Capabilities: Type 1, Type 2
R203#
```

Note VC Type Is Ethernet for Both Ends!!!

```
*Apr 27 14:34:19.075: ATOM LDP [10.0.0.201]: Sending label mapping msg
vc type 5, cbit 1, vc id 2, group id 0, vc label 19, status 0, mtu 1500
*Apr 27 14:35:47.907: ATOM LDP [10.0.0.201]: Received label mapping msg
vc type 5, cbit 1, vc id 2, group id 0, vc label 24, status 0, mtu 1500
```

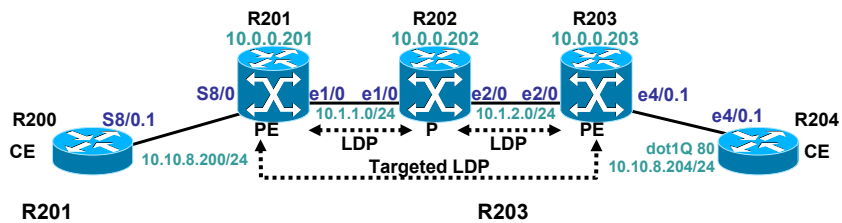
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

125

Frame Relay 2 VLAN Routed Example

Cisco.com



```
pseudowire-class atom-iw-fr-vlan
encapsulation mpls
interworking ip
!
interface Serial8/0
no ip address
no ip directed-broadcast
encapsulation frame-relay IETF
frame-relay intf-type dce
!
connect fr-vlan Serial8/0 80 l2transport
xconnect 10.0.0.203 80 pw-class atom-iw-fr-vlan
!

pseudowire-class atom-iw-fr-vlan
encapsulation mpls
interworking ip
!
interface Ethernet4/0
no ip address
no ip directed-broadcast
!
interface Ethernet4/0.1
encapsulation dot1Q 80
no ip directed-broadcast
xconnect 10.0.0.201 80 pw-class atom-iw-fr-vlan
!
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

126

Frame Relay 2 VLAN Routed Example

Cisco.com

New VC Type 11!!! [0x000B What Type Is That?]

```
R203#show mpls l2transport vc 80 detail
Local interface: Et4/0.1 up, line protocol up, Eth VLAN 80 up
MPLS VC type is IP, interworking type is IP
Destination address: 10.0.0.201, VC ID: 80, VC status: up
Preferred path: not configured
Default path: active
[snip]
R203#show mpls l2transport binding 80
Destination Address: 10.0.0.201, VC ID: 80
Local Label: 16
Cbit: 1, VC Type: IP, GroupID: 0
MTU: 1500, Interface Desc: n/a
VCCV Capabilities: Type 1, Type 2
Remote Label: 25
Cbit: 1, VC Type: IP, GroupID: 0
MTU: 1500, Interface Desc: n/a
VCCV Capabilities: Type 1, Type 2
R203#
```

Note VC Type Is IP for Both Ends!!!

```
*Apr 27 14:59:55.971: ATOM LDP [10.0.0.201]: Sending label mapping msg
vc type 11, cbit 1, vc id 80, group id 0, vc label 16, status 0, mtu 1500
*Apr 27 15:03:06.423: ATOM LDP [10.0.0.201]: Received label mapping msg
vc type 11, cbit 1, vc id 80, group id 0, vc label 25, status 0, mtu 1500
```

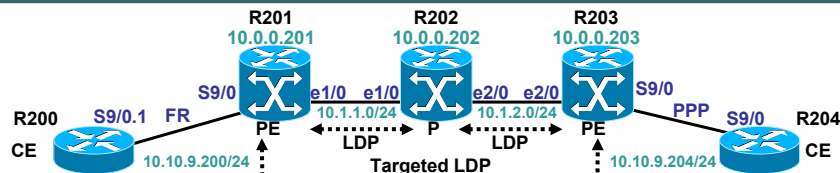
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

127

Frame Relay 2 PPP Routed Example

Cisco.com



<pre>R201 pseudowire-class fr-ppp encapsulation mpls interworking ip ! interface Serial9/0 no ip address no ip directed-broadcast encapsulation frame-relay IETF frame-relay intf-type dce ! connect fr-vlan Serial9/0 90 l2transport xconnect 10.0.0.203 90 pw-class fr-ppp !</pre>	<p>Remote CE's IP Address</p> <p>Need to Match</p>	<pre>R203 pseudowire-class fr-ppp encapsulation mpls interworking ip ! interface Serial9/0 no ip address no ip directed-broadcast encapsulation ppp ppp ipcp address proxy 10.10.9.200 xconnect 10.0.0.201 90 pw-class fr-ppp !</pre>
--	--	---

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

128

Frame Relay 2 PPP Routed

Cisco.com

- Q: Does PPP run in the PE now? Let's see `debug ppp negotiation`
- A: Indeed! PPP [LCP and IPCP] terminates on the PE, IPv4 is transported!!!

```
R203# ! This is the PPP Attachment Circuit side
*Apr 27 15:40:09.151: Se9/0 PPP: Treating connection as a dedicated line
*Apr 27 15:40:09.151: Se9/0 PPP: Phase is ESTABLISHING, Active Open
*Apr 27 15:40:09.151: Se9/0 LCP: O CONFREQ [Closed] id 64 len 10
*Apr 27 15:40:09.151: Se9/0 LCP: MagicNumber 0xBBE3F5C2 (0x0506BBE3F5C2)
*Apr 27 15:40:09.203: Se9/0 LCP: I CONFREQ [REQsent] id 3 len 10
*Apr 27 15:40:09.203: Se9/0 LCP: MagicNumber 0xBBE406FE (0x0506BBE406FE)
*Apr 27 15:40:09.203: Se9/0 LCP: O CONFACK [REQsent] id 3 len 10
*Apr 27 15:40:09.203: Se9/0 LCP: MagicNumber 0xBBE406FE (0x0506BBE406FE)
*Apr 27 15:40:09.203: Se9/0 LCP: I CONFACK [ACKsent] id 64 len 10
*Apr 27 15:40:09.203: Se9/0 LCP: MagicNumber 0xBBE3F5C2 (0x0506BBE3F5C2)
*Apr 27 15:40:09.203: Se9/0 LCP: State is Open
*Apr 27 15:40:09.203: Se9/0 PPP: XCONNECT has gated NCP starts
*Apr 27 15:40:09.203: Se9/0 PPP: Phase is UP
*Apr 27 15:40:09.203: Se9/0 PPP: XCONNECT is preventing NCP starts
*Apr 27 15:40:09.215: Se9/0 PPP XCONNECT request to START IPCP using 0.0.0.0
*Apr 27 15:40:09.215: Se9/0 IPCP: O CONFREQ [Closed] id 4 len 10
*Apr 27 15:40:09.215: Se9/0 IPCP: Address 10.10.9.200 (0x03060A0A09C8)
*Apr 27 15:40:10.335: %LINEPROTO-5-UPDOWN: Line protocol on Interface Serial9/0, changed state to up
*Apr 27 15:40:11.231: Se9/0 IPCP: TIMEOUT: State REQsent
*Apr 27 15:40:11.231: Se9/0 IPCP: O CONFREQ [REQsent] id 5 len 10
*Apr 27 15:40:11.231: Se9/0 IPCP: Address 10.10.9.200 (0x03060A0A09C8)
*Apr 27 15:40:11.243: Se9/0 IPCP: I CONFREQ [REQsent] id 7 len 10
*Apr 27 15:40:11.243: Se9/0 IPCP: Address 10.10.9.204 (0x03060A0A09CC)
*Apr 27 15:40:11.243: Se9/0 IPCP: O CONFACK [REQsent] id 7 len 10
*Apr 27 15:40:11.243: Se9/0 IPCP: Address 10.10.9.204 (0x03060A0A09CC)
*Apr 27 15:40:11.243: Se9/0 IPCP: I CONFACK [ACKsent] id 5 len 10
*Apr 27 15:40:11.243: Se9/0 IPCP: Address 10.10.9.200 (0x03060A0A09C8)
*Apr 27 15:40:11.243: Se9/0 IPCP: State is Open
R203#
ACC-3001
9745_05_2004_c3 © 2004 Cisco Systems, Inc. All rights reserved. 129
```

Frame Relay 2 PPP Routed

Cisco.com

- Q: When do we need `ppp ipcp address proxy` command?
- A: If the PE performs address resolution with local CE
Alternatively, configure `peer default IP address` in the local CE

```
R204#show ip route connected | include Serial9/0
C 10.10.9.0/24 is directly connected, Serial9/0
C 10.10.9.200/32 is directly connected, Serial9/0 ! Installed through IPCP
R204#
```

- Q: How can I see if PE negotiated LCP and IPCP?
- A: Use the `show interface` command in the PE

```
R203#show interfaces serial 9/0
Serial9/0 is up, line protocol is up
Hardware is HD64570
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely 255/255, load 1/255
Encapsulation PPP, loopback not set
Keepalive set (10 sec)
LCP Open
Open: IPCP
Last input 00:00:03, output 00:00:03, output hang never
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

130

Local Switching Support

Cisco.com

L2 Attachment Type	L2 Attachment Type
Ethernet Port/VLAN	Frame
Ethernet Port/VLAN	ATM
Ethernet Port/VLAN	Ethernet Port/VLAN
ATM	ATM
ATM	Frame

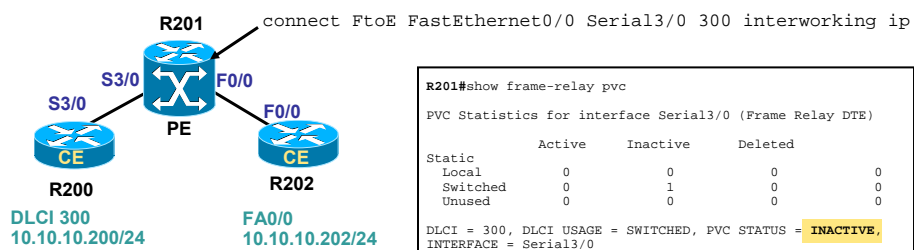
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

133

FR to Ethernet Local Switching Troubleshooting

Cisco.com



```

R201#show connection all
-----
ID   Name           Segment 1           Segment 2           State
-----
2    FtoE           Fa0/0.10           Se3/0 300           DOWN
    
```

```

R201#show connection id 1
Connection: 1 - Frame
Current State: ADMIN UP
Segment 1: FastEthernet0/0 up
Segment 2: Serial3/0 301 down <-- Frame-relay circuit down.
Interworking Type: ip
    
```

Frame Relay Link Possible Down

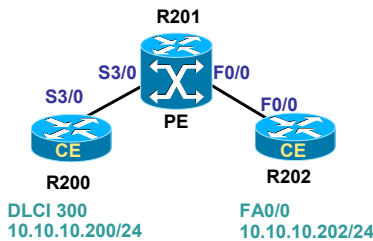
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

134

Troubleshooting FR Problems for Local Switching

Cisco.com



```
R201(config)interface serial 3/0
R201(config)#frame-relay intf-type dce

R201#show interfaces ser 3/0
Serial3/0 is up, line protocol is up

R201#show frame-relay pvc

PVC Statistics for interface Serial3/0 (Frame
Relay DCE)

DLCI = 300, DLCI USAGE = SWITCHED, PVC STATUS =
INACTIVE, INTERFACE = Serial3/0
```

```
R201#show connection all
```

ID	Name	Segment 1	Segment 2	State
2	FtoE	Fa0/0	Se3/0 300	OPER DOWN

```
R201#debug frame-relay pseudowire
```

```
bad condition when possible Frame-Relay interface down on ce or PE
00:06:09: FRoPW [Se3/0, 100]: acmgr_circuit_down
00:06:09: FRoPW [Se3/0, 100]: Setting pw segment DOWN
00:06:09: FRoPW [Se3/0, 100]: SW AC update circuit state to down
00:07:04: FRoPW [Se3/0, 100]: PW nni_pvc_status set INACTIVE
00:07:04: FRoPW [Se3/0, 100]: Local up, sending acmgr_circuit_up
00:07:04: FRoPW [Se3/0, 100]: Setting pw segment DOWN
00:07:04: FRoPW [Se3/0, 100]: SW AC update circuit state to down
00:07:04: FRoPW [Se3/0, 100]: PW nni_pvc_status set INACTIVE
```

Frame Relay Link Is Up but **OPER DOWN**
NOTE: Possible Problem on Ethernet; if Ethernet Is Not Operational, DLCI Status Will Be INACTIVE

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

135

debug acircuit event When You Disable an Interface

Cisco.com

Zero Because Local Switching!!!

```
R201#debug acircuit event
```

```
22:07:30: ACLIB [0.0.0.0, 0]: SW AC interface DOWN for Ethernet interface Fa0/0
22:07:30: ACLIB [0.0.0.0, 0]: Setting new AC state to Ac-Idle
22:07:30: ACLIB: Update switching plane with circuit DOWN status
22:07:30: ACLIB [0.0.0.0, 0]: SW AC interface DOWN for Ethernet interface Fa0/0
22:07:30: Fa0/0 ACMGR: Receive <Circuit Down> msg
22:07:30: Fa0/0 ACMGR: circuit down event,FSP state chg connected to sip up, action is p2p down
22:07:30: Se3/0 ACMGR: Rcv SIP msg: resp peer-to-peer msg, hdl A1000031, sss_hdlA7000032
22:07:30: Se3/0 ACMGR: remote down event, SIP state chg connected to both down, action is
circuit disconnect req
22:07:30: ACLIB: Update switching plane with circuit DOWN status
22:07:30: Se3/0 ACMGR: Receive <Circuit Up> msg
22:07:30: Se3/0 ACMGR: circuit up delayed event, SIP state chg both down to sip up, action is
p2p up forwarding
22:07:30: Fa0/0 ACMGR: Receive <Remote Up Notification> msg
22:07:30: Fa0/0 ACMGR: remote up event, FSP sip up state no chg, action is ignore
22:07:38: ACLIB [0.0.0.0, 0]: Sent ICMP RDP solicitation message
22:07:38: ACLIB: Added circuit to retry queue, type 5, id 3, idb Fa0/0
```

- To display errors and events that occur on the attachment circuits (the circuits between the (PE) and (CE) routers), use the **debug acircuit**

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

136

debug acircuit event When You Enable an Interface

Cisco.com

Zero Because Local Switching!!!

```

Interface FastEthernet 0/0
no shutdown
22:10:13: ACLIB [0.0.0.0, 0]: SW AC interface UP for Ethernet interface Fa0/0
22:10:13: ACLIB: Added circuit to retry queue, type 5, id 3, idb Fa0/0
22:10:13: ACLIB [0.0.0.0, 0]: pthru_intf_handle_circuit_up() calling acmgr_circuit_up
22:10:13: ACLIB [0.0.0.0, 0]: Setting new AC state to Ac-Connecting
22:10:13: ACLIB: Update switching plane with circuit UP status
22:10:13: ACLIB [0.0.0.0, 0]: SW AC interface UP for Ethernet interface Fa0/0
22:10:13: ACLIB [0.0.0.0, 0]: pthru_intf_handle_circuit_up() ignoring up event.
Already connected or connecting.
22:10:13: ACLIB [0.0.0.0, 0]: pthru_intf_handle_circuit_up() ignoring up event.
Already connected or connecting.
22:10:13: Fa0/0 ACMGR: Receive <Circuit Up> msg
22:10:13: Fa0/0 ACMGR: circuit up event, FSP state chg sip up to connected, action is send
connected msg
22:10:13: ACLIB: pthru_intf_response hdl is 57000035, response is 2
22:10:13: ACLIB [0.0.0.0, 0]: Setting new AC state to Ac-Connected
22:10:13: Se3/0 ACMGR: Rcv SIP msg: resp peer-to-peer msg, hdl A1000031, sss_hdl A7000032
22:10:13: Se3/0 ACMGR: remote up event, SIP state chg sip up to connected, action is
respond forwarded
22:10:13: ACLIB: Update switching plane with circuit UP status
22:10:15: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
22:10:16: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
22:10:23: ACLIB [0.0.0.0, 0]: Sent ICMP RDP solicitation message
22:10:23: ACLIB: Added circuit to retry queue, type 5, id 3, idb Fa0/0
    
```

- Problem on FE administratively down

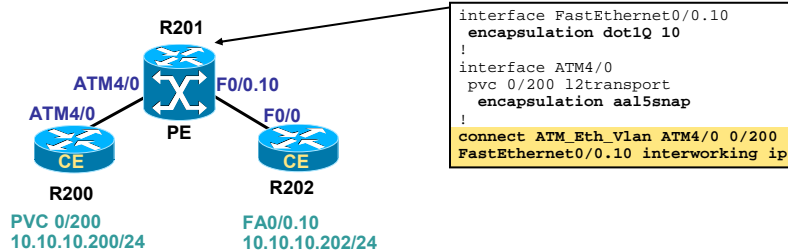
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

137

ATM to Ethernet Local Switching Troubleshooting

Cisco.com



```

R2101#show atm vc
          VCD /
Interface Name          VPI  VCI Type  Encaps  Peak Avg/Min Burst  Sts
4/0       4              0    200 PVC    SNAP    149760  N/A      UP
    
```

```

R2101#show connection id 4
Connection: 4 - ATM_Eth_Vlan
Current State: OPER DOWN
Segment 1: ATM4/0 AAL5 0/200 up
Segment 2: FastEthernet0/0.10 admin down
Interworking Type: ip
    
```

ATM VC UP But Cross Connection
from Ethernet to ATM Still Down

- So problem is in interface most likely due to interface down

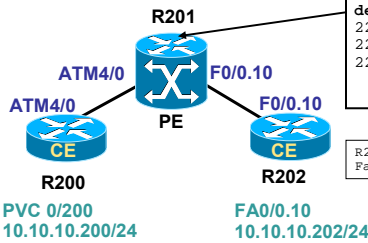
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

138

Debug ATM Local Switching

Cisco.com



```
debug atm l2transport
22:50:15: ATM L2trans(ATM4/0): VC 0/200, remote down
22:50:15: ATM L2trans(ATM4/0): ckt_type 2, ckt_id 4 UP
22:50:15: ATM L2trans(ATM4/0): VC 0200, response is
connect forwarding
```

```
R2101#show interfaces fastEthernet 0/0.10
FastEthernet0/0.10 is administratively down, line protocol is down
```

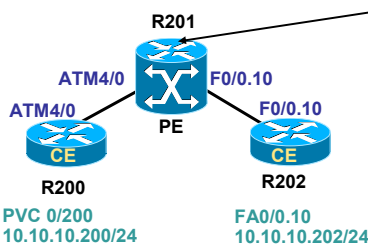
```
R2101#show connection all
ID Name Segment 1 Segment 2 State
-----
4 ATM_Eth_Vlan AT4/0 AAL5 0/200 Fa0/0.10 OPER DOWN
```

```
R2101(config-subif)#no shutdown
23:00:29: ATM L2trans(ATM4/0): VC 0/200, response is connect forwarded
```

```
R2101#show connection all
ID Name Segment 1 Segment 2 State
-----
4 ATM_Eth_Vlan AT4/0 AAL5 0/200 Fa0/0.10 UP
```

ATM to FR Local Switching Sample Configuration

Cisco.com



```
ip cef
frame-relay switching
!
interface Serial3/0
encapsulation frame-relay
frame-relay lmi-type ansi
frame-relay intf-type dce
!
interface ATM4/0
!
connect atm_to_frame Serial3/0 100 ATM4/0
1/100 interworking ip
```

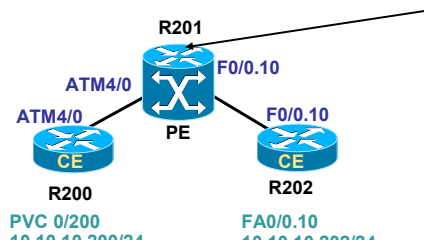
```
R2101#show atm vc
VCD /
Interface Name VPI VCI Type Encaps Peak Kbps Avg/Min Burst Cells Sts
4/0 5 1 100 PVC-A SNAP 149760 N/A UP
```

```
R2101#show connection all
ID Name Segment 1 Segment 2 State
-----
5 atm_to_frame Se3/0 100 AT4/0 AAL5 1/100 UP
```

- PVC-A Status ATM4/0 does not have l2transport 1/100 encapsulation set

ATM to Frame Encapsulation Not Set

Cisco.com



```
ip cef
frame-relay switching
!
interface Serial3/0
encapsulation frame-relay
frame-relay lmi-type ansi
frame-relay intf-type dce
!
interface ATM4/0
!
connect atm_to_frame Serial3/0 100 ATM4/0
1/100 interworking ip
```

```
R2101(config)#interface atm 4/0
R2101(config-if)#pvc 1/100 l2transport
R2101(cfg-if-atm-l2trans-pvc)#encapsulation aal5snap
```

```
R2101#show atm vc
```

Interface	VCD / Name	VPI	VCI	Type	Encaps	Peak Kbps	Avg/Min Kbps	Burst Cells	Sts
4/0	5	1	100	PVC	SNAP	149760	N/A		UP

Encapsulation Change to Type PVC from PVC-A

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

141

Let's Do a Poll...

Cisco.com

- Would MTU mismatches prevent a circuit to come up in the “local switching” case?

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

142

Let's Do a Poll...

Cisco.com

- Would MTU mismatches prevent a circuit to come up in the “local switching” case?
- NO, because in the “local switching” case there is no signaling

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

143

Summary of Useful Debugs

Cisco.com

- debug connection
- show connection all
- debug xconnect event
- debug xconnect error
- debug frame-relay pseudowire
- debug acircuit event
- debug acircuit error
- show frame-relay pvc
- show frame-relay lmi

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

144

Summary

Cisco.com

- Motivations Behind L2VPNs
- AToM Troubleshooting
- Layer 2 Tunneling Protocol Version 3
- AToM and L2TPv3 Interworking
- Local Switching
- Q&A

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

145

Thank You!

Cisco.com

- Carlos Pignataro cpignata@cisco.com
- Dmitry Bokotey dbokotey@cisco.com
- Wen Zhang wzhang@cisco.com

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

146

Q AND A



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

147

Recommended Reading

Cisco.com

- **Layer 2 VPN Architectures ISBN: 1587051680 “coming soon”**
- **MPLS and VPN Architectures Vol 2 ISBN: 1587051125**
- **MPLS and VPN Architectures Vol 1 ISBN: 1587050811**

Available on-site at the Cisco Company Store

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

148

Complete Your Online Session Evaluation!

Cisco.com

- WHAT:** Complete an online session evaluation and your name will be entered into a daily drawing
- WHY:** Win fabulous prizes! Give us your feedback!
- WHERE:** Go to the Internet stations located throughout the Convention Center
- HOW:** Winners will be posted on the onsite Networkers Website; four winners per day

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

149

CISCO SYSTEMS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

150

APPENDIX



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

151

Data Plane: Imposition

Cisco.com

- Label imposition is performed on the Ingress PE also called “label imposition router”
- This router receives a Layer 2 PDU in the ingress interface and encapsulates it for the MPLS backbone (i.e. performs label imposition)
- The packets arriving on the EoMPLS-configured PE interfaces will receive a two-level label stack imposed by the ingress PE
- To impose labels on packets, the ingress PE router maintains tables, which associates an EoMPLS VC with an ‘Output interface’ and ‘imposed label stack’
- The ingress PE then switches the packet to the appropriate outgoing MPLS interface which will in turn route the packet to the egress LER for the VC in question

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

152

Data Plane: Disposition

Cisco.com

- Label disposition refers to label removal from a packet; it is performed at the egress PE also called “label disposition router”
- This router receives a packet, strips the bottom (VC) label, and sends the remaining Layer 2 frame out of the egress interface
- After label imposition, the packets travel across the MPLS core network via standard label switching and arrive at the egress PE
- The packet received by the egress PE may have only the VC label if its neighbor (i.e. penultimate router) pops the tunnel label prior to forwarding the packet (PHP)

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

153

ETHERNET OVER MPLS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

154

Hardware Platforms: 7600

Cisco.com

From the RP

```
cat13#sh mpls l2 vc det
vcid: 200, local groupid: 24, remote groupid: 102 (vc is up)
client: Vl200 is up, destination: 1.2.2.1, Peer LDP Ident: 1.2.1.1:0
local label: 215, remote label: 215, tunnel label: implc-null
outgoing interface: s0/0, next hop: point2point
Local MTU: 1500, Remote MTU: 1500
Remote interface description: Vlan200
imposition: LC Programmed ← Imposition rewrite resolved
current imposition/last disposition slot: 2/32
Packet totals(in/out): 6246/6159
byte totals(in/out): 536999/444722
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

155

Hardware Platforms: 7600

Cisco.com

From the LC: Imposition

```
CWTLC-Slot2#show mpls l2 imposition detail
label:0 vc_id:200 label:215 vlan:200 ! 0 is Tunnel label, 215 is VC label
output pkts: 82 output bytes: 5917 priority: 0 active: yes
MPLS Detailed info:
  Impose Rewrite:
    215          Enet/MPLS impose      0          PO2/2          point2point
    MAC/Encaps=14/18, MTU=4470, Tag Stack{215}
    00000210000000005DC57880A0800 000D7100 ! Actual imposition rewrite
    Ethernet II                      MPLS shim

Used by the Toaster
CWTLC detailed info: if_number 28 oper:PUSH 1(1) func_tbl:0x1 flags:0x0
t VLAN          tun lbl  vc lbl  MAC Address      cos2exp
- x---(d---) d----- d----- ----- x----- ! X: hex; d: dec;
0 00C8(0200) 00000000 00000215 0000.0000.0000 76543210

VLAN          V S  p en VPN  intf trnk ltl          ! Tx VLAN Table
x---(d---) - - - - - -----
00C8(0200) v 03 0 01 0000 0401 0000 0061

txvc lkhhd l2hd tx_q hi_q          ! Tx VC Table
-----
0401 0100 FF03 00D2 0000
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

156

Hardware Platforms: 7600

Cisco.com

From the LC: Imposition

```
CWTLIC-Slot2#show mpls l2 disposition detail
Vlan200 vcid: 200 vc label: 215
input pkts: 83 input bytes: 7137
CWTLIC detailed info: if_number 28
t vclbl VLAN      Type      impidx intfid rx_q
- d---- x---(d---) ----- x----- x----- x---
0 00215 00C8(0200) vlan      000061 000401 00D3
1 00215 00C8(0200) vlan      000061 000801 0054
```

- debug mpls l2transport vlan control
Ethernet VLAN transport over MPLS, control interactions
- debug mpls l2transport vlan distributed
Ethernet VLAN transport over MPLS, distributed switching

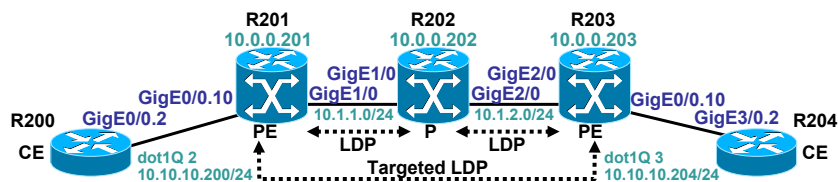
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

157

VLAN ID Rewrite Configuration

Cisco.com



```
R201
interface GigabitEthernet0/0.2
encapsulation dot1Q 2
no ip directed-broadcast
no cdp enable
xconnect 10.0.0.203 2 encapsulation mpls
remote circuit id 3

R203
interface GigabitEthernet3/0.2
encapsulation dot1Q 3
no ip directed-broadcast
no cdp enable
xconnect 10.0.0.201 2 encapsulation mpls
remote circuit id 2
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

158

Checking VLAN ID Rewrite in a C12K

Cisco.com

In R201 in Slot 0 ['using attach' or 'execute-on']:

Interface ↙ ↘ VLAN-Id

```
LC-Slot0#show controllers eompls forwarding-table 0 2
Port # 0, VLAN-ID # 2, Table-index 2
EoMPLS configured: 1
tag_rew_ptr = D001BB58
Leaf entry? = 1
FCR index = 20
**tagrew_psa_addr = 0006ED60
**tagrew_vir_addr = 7006ED60
**tagrew_phy_addr = F006ED60
[0-7] loq 8800 mtu 4458 oq 4000 ai 3 oi 04019110 (encaps size 4)
cw-size 4 vlanid-rew 3
gather A30 (bufhdr size 32 EoMPLS (Control Word) Imposition profile 81)
2 tag: 18 18
counters 1182, 10 reported 1182, 10.
Local OutputQ (Unicast): Slot:2 Port:0 RED queue:0 COS queue:0
Output Q (Unicast): Port:0 RED queue:0 COS queue:0
```

1 Means Port Is Configured to Transport Layer 2 VLAN Packets

Shows Which Slot and Port the Tunneled Packets Exit from to Enter the MPLS Backbone

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

159

A Couple of CEF Details

Cisco.com

Note That We Are Creating CEF RAW Adjacencies

```
R203#show cef idb | include Int|AC
Interfaces          FIndex IIndex Subblocks
Ethernet0/0.10     15     15 AC Xconnect vlan
Ethernet2/0.20     16     16 AC Xconnect vlan
Ethernet3/0        5       5 AC Xconnect
Ethernet4/0.1     17     17 AC Xconnect vlan
Serial5/0          7       7 AC Xconnect
Serial6/0          8       8 AC Xconnect
Serial9/0         11     11 AC Xconnect

R203#show adjacency
Protocol Interface          Address
RAW      Ethernet3/0          point2point(4)
RAW      Serial5/0            point2point(4)
RAW      Serial6/0            point2point(4)
RAW      Serial7/0            point2point(3) ! FR doesn't appear above
RAW      Serial9/0            point2point(3)
RAW      Ethernet0/0.10     point2point(4)
RAW      Ethernet2/0.20     point2point(4)
RAW      Ethernet4/0.1     point2point(4)
TAG      Ethernet1/0         10.1.2.202(14)
IP       Ethernet1/0         10.1.2.202(22)
R203#
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

160

A Couple of CEF Details

Cisco.com

- In 12.2S the following commands are also available:

show cef non-ip

show mpls infrastructure { lfd | lsd } rewrite detail

LFD: Label Forwarding Database

LSD: Label Switch Database

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

161

HDLC AND PPP OVER MPLS



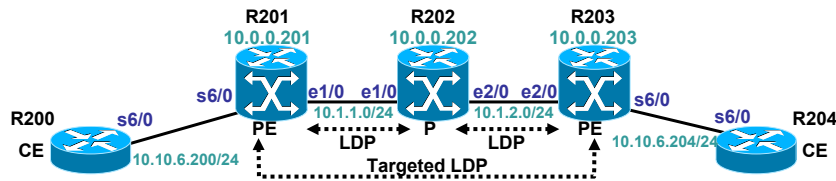
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

162

Configuration: PPPoMPLS

Cisco.com



- Configuration is the same as EoMPLS changing the 'encapsulation'

R201

```
interface Serial6/0
no ip address
no ip directed-broadcast
encapsulation ppp
no cdp enable
xconnect 10.0.0.203 60 encapsulation mpls
```

R203

```
interface Serial6/0
no ip address
no ip directed-broadcast
encapsulation ppp
no cdp enable
xconnect 10.0.0.201 60 encapsulation mpls
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

163

Cisco's HDLC

Cisco.com

- It's proprietary because:
 - It does not perform windowing or retransmission
 - Higher layer protocol identification method is not standardized
- Its frame format and bit stuffing technique are per the ANSI T1.618 standard
- It doesn't matter for AToM, since AToM only checks flag 0x7E and FCS!!!

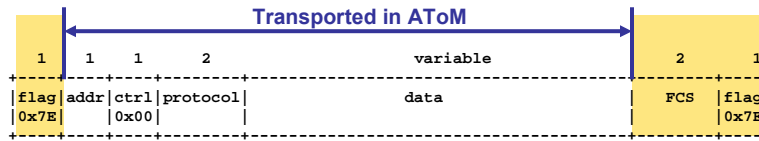
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

164

Cisco's HDLC: Frame Format

Cisco.com



flag = start/end of frame = 0x7E
(Other special characters: Idle = 0xFF, Abort = 0x7F)

address = this is really a frame type field
0x0F = Unicast Frame
0x80 = Broadcast Frame (used if upper layer packet is a broadcast)
0x40 = Padded Frame
0x20 = Compressed Frame

Protocol = the Ethernet type of the encapsulated data:
0x0800 IP
0x4242 DSAP/SSAP for IEEE bridge spanning protocol
0x6003 DECnet phase IV
0x6558 Bridged Ethernet/802.3 packet
0x8035 cisco SLARP
0x8038 DEC bridge spanning tree protocol
0x809b Apple EtherTalk
0x80f3 Appletalk ARP
0x8137 Novell IPX
0xFEFE ISO CLNP/ISO ES-IS DSAP/SSAP

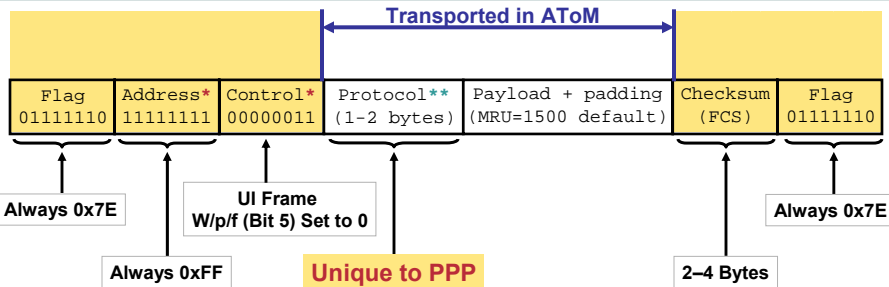
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

165

PPP: Frame Format

Cisco.com



- Standard method for transporting **multiprotocol** datagrams over point-to-point links
- Modeled after HDLC frame w/addition of protocol field
- PPP frame size ranges from 10 bytes to 4 bytes (when PFC and ACFC compression are enabled, and w/o ending flag)
- Ending flag only needed on single frame or final frame of a sequence

*Omitted When Address and Control Field Compression (ACFC) Is Used
**Only 1 Byte When Protocol Field Compression (PFC) Is Used

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

166

HDLC and PPP over MPLS

Cisco.com

- HDLC

The whole packet is transported

HDLC flags and Frame Check Sequence (FCS) bits are removed at ingress

- Point-to-Point Protocol

Exclude media-specific framing information: The ingress PE router removes the flags, address, control field, and the FCS

PPP PDU is transported in its entirety, including the protocol field (whether compressed using PFC or not)

Consequences: The following will not work (unless using HDLCoMPLS ;^):

Frame Check Sequence (FCS) Alternatives

Address-and-Control-Field-Compression (ACFC)

Asynchronous-Control-Character-Map (ACCM)

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

167

Decoding an HDLCoMPLS Packet

Cisco.com

- Captured using `debug mpls l2transport packet data`

```
*Apr 22 15:16:09.703: ATOM imposition: out Et1/0, size 110, EXP 0x0, seq 0, control word 0x0
*Apr 22 15:16:09.703: XX XX XX XX XX XX YY YY YY YY YY YY 88 47 00 01
                        SA MAC          DA MAC          etype top_shim-->
                        MPLS
                        Unic

*Apr 22 15:16:09.703: 10 FF 00 01 11 02 00 00 00 00 0F 00 08 00 45 C0
                        <--top_shim VC_Label Ctrl-word | | | Begins IP Packet
                        Label=17 Label=17 | | | etype = IPv4
                        S=0 S=1 | | | Control
                        TTL=255 TTL=2 | | | Address = Unicast Frame

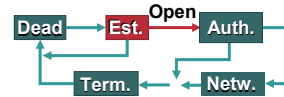
*Apr 22 15:16:09.703: 00 50 CD 2C 00 00 01 59 FB 91 0A 0A 05 C8 E0 00
*Apr 22 15:16:09.703: 00 05 02 01 00 30 0A 0A 0B C8 00 00 00 00 C0 F2
*Apr 22 15:16:09.703: 00 00 00 00 00 00 00 00 00 00 FF FF FF 00 00 0A
*Apr 22 15:16:09.703: 12 01 00 00 00 28 00 00 00 00 00 00 00 0A 0A
*Apr 22 15:16:09.703: 0B CC FF F6 00 03 00 01 00 04 00 00 00 01
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

168

Debug PPP Negotiation in CE



Cisco.com

- Notice the two-way hand shaking

```
May 1 15:02:57.763: Se6/0 LCP: O CONFREQ [REQsent] id 135 len 14
May 1 15:02:57.763: Se6/0 LCP:   AuthProto PAP (0x0304C023)
May 1 15:02:57.763: Se6/0 LCP:   MagicNumber 0x1F7A2545 (0x05061F7A2545)
May 1 15:02:57.783: Se6/0 LCP: I CONFREQ [REQsent] id 108 len 14
May 1 15:02:57.783: Se6/0 LCP:   AuthProto PAP (0x0304C023)
May 1 15:02:57.783: Se6/0 LCP:   MagicNumber 0x1F7A2A52 (0x05061F7A2A52)
May 1 15:02:57.783: Se6/0 LCP: O CONFACK [REQsent] id 108 len 14
May 1 15:02:57.783: Se6/0 LCP:   AuthProto PAP (0x0304C023)
May 1 15:02:57.783: Se6/0 LCP:   MagicNumber 0x1F7A2A52 (0x05061F7A2A52)
May 1 15:02:57.783: Se6/0 LCP: I CONFACK [ACKsent] id 135 len 14
May 1 15:02:57.783: Se6/0 LCP:   AuthProto PAP (0x0304C023)
May 1 15:02:57.783: Se6/0 LCP:   MagicNumber 0x1F7A2545 (0x05061F7A2545)
May 1 15:02:57.783: Se6/0 LCP: State is Open
```

```
0x0304C023
  ^  ^  ^
  |  |  |
  |  |  | Value = C023 = PAP
  |  |  | Length = 4 Octets
  |  |  | Type = Authentication Method
  |  |  | (RFC 1172)
```

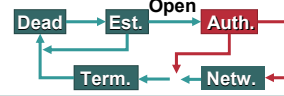
```
0x05061F7A2545
  ^  ^  ^
  |  |  |
  |  |  | Value = 0x1F7A2545
  |  |  | Length = 6 Octets
  |  |  | Type = Magic Number
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

171

Debug PPP Negotiation in CE



Cisco.com

- Notice the two-way hand shaking

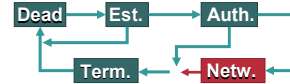
```
May 1 15:02:57.783: Se6/0 PPP: Phase is AUTHENTICATING, by both [0 sess, 1 load]
May 1 15:02:57.803: Se6/0 PAP: O AUTH-REQ id 11 len 18 from "router1"
May 1 15:02:57.835: Se6/0 PAP: I AUTH-REQ id 11 len 18 from "router2"
May 1 15:02:57.847: Se6/0 PAP: Authenticating peer router2
May 1 15:02:57.847: Se6/0 PAP: O AUTH-ACK id 11 len 5
May 1 15:02:57.863: Se6/0 PAP: I AUTH-ACK id 11 len 5
May 1 15:02:57.863: Se6/0 PPP: Phase is UP [0 sess, 2 load]
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

172

Debug PPP Negotiation in CE



Cisco.com

```
May 1 15:02:57.863: Se6/0 IPCP: O CONFREQ [Closed] id 17 len 10
May 1 15:02:57.863: Se6/0 IPCP:   Address 10.1.1.1 (0x03060A010101)
May 1 15:02:57.863: Se6/0 CDPCP: O CONFREQ [Closed] id 17 len 4
May 1 15:02:57.863: Se6/0 IPCP: I CONFREQ [REQsent] id 17 len 10
May 1 15:02:57.863: Se6/0 IPCP:   Address 10.1.1.2 (0x03060A010102)
May 1 15:02:57.863: Se6/0 IPCP: O CONFACK [REQsent] id 17 len 10
May 1 15:02:57.863: Se6/0 IPCP:   Address 10.1.1.2 (0x03060A010102)
May 1 15:02:57.863: Se6/0 CDPCP: I CONFREQ [REQsent] id 18 len 4
May 1 15:02:57.863: Se6/0 CDPCP: O CONFACK [REQsent] id 18 len 4
May 1 15:02:57.875: Se6/0 IPCP: I CONFACK [ACKsent] id 17 len 10
May 1 15:02:57.875: Se6/0 IPCP:   Address 10.1.1.1 (0x03060A010101)
May 1 15:02:57.875: Se6/0 IPCP: State is Open
May 1 15:02:57.875: Se6/0 CDPCP: I CONFACK [ACKsent] id 17 len 4
May 1 15:02:57.875: Se6/0 CDPCP: State is Open
May 1 15:02:57.983: Se6/0 IPCP: Install route to 10.1.1.2
                          ! ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
                          ! /32 Route
```

```
0x03060A010101
  ^   ^   ^
  |   |   |
  |   |   | Value = 0x0A010101 = 10.1.1.1
  |   |   | Length = 6 Octets
  |   |   | Type = IP Address (RFC 1332)
```

- Notice the two-way hand shaking

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

173

Show Interface from the CE

Cisco.com

- Note that PPP is up and running

```
R200#show interfaces serial 6/0
Serial6/0 is up, line protocol is up
Hardware is HD64570
Internet address is 10.10.6.200/24
MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely 255/255, load 1/255
Encapsulation PPP, loopback not set
Keepalive set (10 sec)
LCP Open
Open: OSICP, IPCP, CDPCP
Last input 00:00:02, output 00:00:02, output hang never
Last clearing of "show interface" counters never
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

174

FRAME RELAY OVER MPLS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

177

Frame Relay: Terms

Cisco.com

- **DLCI**—Data Link Connection Identifier
10 bit address for a Frame Relay connection; it only has local significance; DLCI's 16-1007 are definable on Cisco routers
- **FECN**—Forward Explicit Congestion Notification
This bit may be flipped by nodes in the cloud when it experiences congestion in its path to the destination remote FRAD
- **BECN**—Backward Explicit Congestion Notification
This bit may be flipped by nodes in the cloud when packets in the opposite direction of this packet experience congestion
- **DE**—Discard Eligible
This bit may be flipped by nodes in the cloud to indicate that packet exceeded the rate the carrier has committed to transport; packets with the DE bit set may be intentionally dropped by Frame Relay nodes in the face of congestion

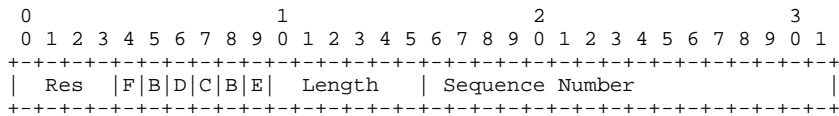
ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

178

FRoPW Header (AKA Control Word)

Cisco.com



Res (bits 0 to 3):

Reserved bits. They are set to zero on transmission and ignored on reception.

F (bit 4): FR FECN (Forward Explicit Congestion Notification) bit.

B (bit 5): FR BECN (Backward Explicit Congestion Notification) bit.

D (bit 6): FR DE bit indicates the discard eligibility.

C (bit 7): FR frame C/R (command/response) bit.

B, E (bits 8 and 9):

B and E are fragmentation bits and their functionality is specified in [draft-ietf-pwe3-fragmentation-04.txt].

Length (bits 10 to 15):

The length field is used in conjunction with the padding of short FRoPW packets when the link layer protocol requires a minimum frame length.

Sequence number (Bit 16 to 31):

If it is not used, it is set to zero by the sender and ignored by the receiver. Otherwise it specifies the sequence number of a FRoPW packet.

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

179

FRoMPLS Traffic Policing

Cisco.com

- FRoMPLS uses the “connect” command using a main interface to create an AToM tunnel, identified by the PVC/DLCI
- Even though configuring sub-interfaces on switched DLCI is not a regular practice, we will do so, in this case, for applying policing parameters
- That is, the policing parameters are tied to a sub-interface, and a special command, “switched-fr-dlci” is implemented under a sub-interface, that ties the DLCI number specified, with the sub-interface
- Then the service policy is applied on the sub-interface, that virtually applies the policy to the PVC/DLCI specified by the “switched-fr-dlci” command; so we use sub-interfaces, for FRTP

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

180

Why switched-fr-dlci?

Cisco.com

- Since we can't apply policy on a sub-interface, with switched DLCI, we have used the new CLI command, **switched-fr-dlci**, that specifies the DLCI
- This avoids the necessity of a "frame-relay interface-dlci" command, which can potentially create pvc
- This will still let us do the connect command on the main interface, while applying the policing policy on a sub-interface

```
class-map match-any frtp-class
  match any
!
policy-map frtp-policy
  class frtp-class
    police cir 8000 bc 1000 pir 9000 be 5000 conform-action transmit exceed-
action set-frde-transmit violate-action drop
!
interface POS1/0.103 point-to-point
  service-policy input frtp-policy
  switched-fr-dlci 103
!
connect frompls POS1/0 103 l2transport
xconnect 10.0.0.203 103 encapsulation mpls
```

ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

181

CISCO SYSTEMS



ACC-3001
9745_05_2004_c3

© 2004 Cisco Systems, Inc. All rights reserved.

182