



Layer 2 Transport and Tunneling (L2VPN) Application and Deployment

ACC-2000

Session Number
Presentation_ID

© 2004 Cisco Systems, Inc. All rights reserved.

1

Associated Sessions

Cisco.com

- **ACC-1000** Introduction to Layer 2 Transport and Tunneling Technologies (L2VPN)
- **ACC-2001** Sizing and Scaling Metro Layer 2 Services
- **ACC-3001** Troubleshooting Layer 2 Transport and Tunneling (L2VPN) Technologies
- **RST-1607** QoS in MPLS Networks
- **RST-2603** Deploying MPLS Traffic Engineering

ACC-2001
8508;096;02003DX

© 2004 Cisco Systems, Inc. All rights reserved.

2

General Prerequisites

Cisco.com

- **Why L2VPN technology is becoming ever important to Service Providers?**
- **Good understanding of L2VPN technologies operation (AToM, L2TPv3)**
- **Basic understanding of network design principles**
- **General comprehension of Quality of Service principles (this will be discussed)**

ACC-2001
9308;e96a;0d0;3DX

© 2004, Cisco Systems, Inc. All rights reserved.

3

L2VPN Deployments – *Global Summary*

Cisco.com

Layer 2 VPN Adoption Hits Primetime!

- **Global Customer Deployments : 45**
- **Deploying in 12 Months : 107**
- **Top Service Deployed: Ethernet over MPLS**
- **12 Month Planned VPLS Deployments : 16**

L2VPN Deployment – Objectives

Cisco.com

- Review the motivating factors for L2VPN adoption
- Outline common service requirements for L2VPN and how they are being addressed
- Introduce the L2VPN command syntax and discuss what QoS options are recommended in delivering today's VPWS services
- Cover how advanced networks can offer guaranteed bandwidth and PW circuit protection
- Discuss Provisioning, Management and Monitoring options available for L2VPNs
- Look at how some Service Providers have started to utilize L2VPN technology for competitive advantage

AGENDA

Deployment Objectives



L2VPN Deployment – What is your objective?

Cisco.com

L2VPN Deployment Motivators:

- CAPEX / OPEX reduction through network consolidation?
- Extending the service portfolio by leveraging existing infrastructure?

Common Questions:

- Have I evaluated the Return on Investment (ROI) for undertaking this project?
- What are the characteristics of the existing / planned services that I wish to implement?
- Is my underlying infrastructure in place to support my existing / planned Service Level Agreements?

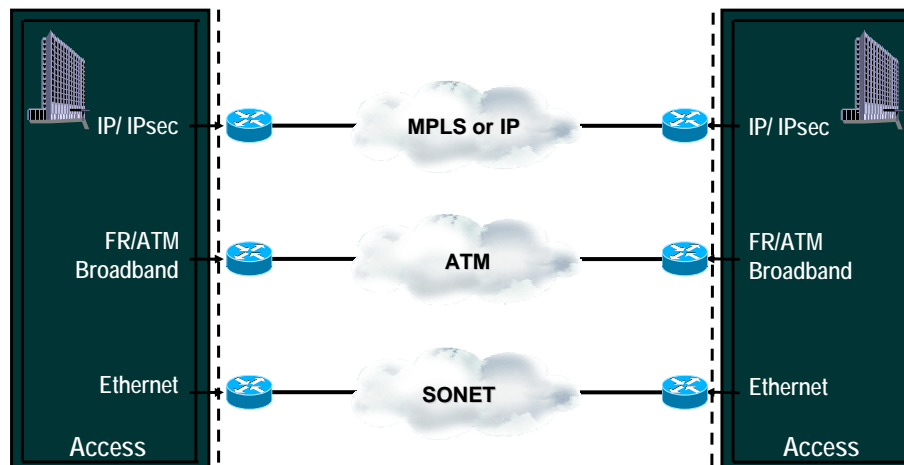
ACC-2001
93089:096a:0006:31X

© 2004, Cisco Systems, Inc. All rights reserved.

7

Motivation for L2VPNs – *I've really got to consolidate these networks!!*

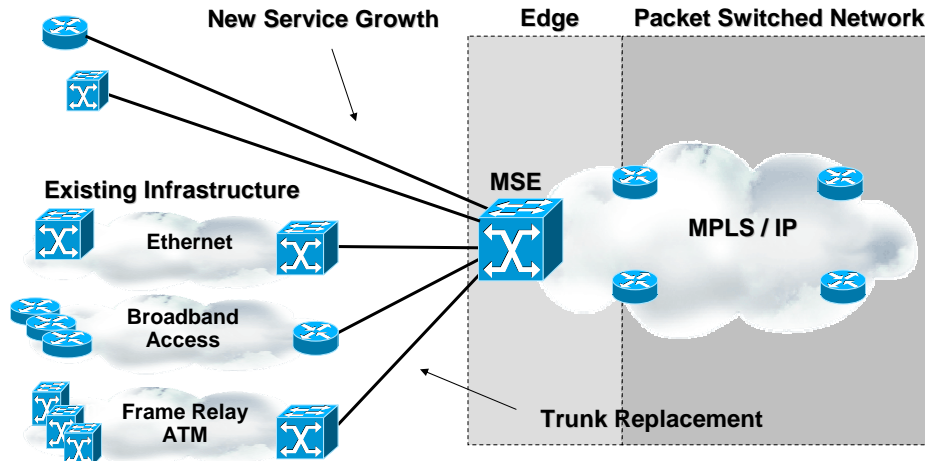
Cisco.com



Multiple Access Services Require Multiple Core Technologies = \$\$\$ High Costs / Complex Management

Motivation for L2VPNs – How can I leverage my packet infrastructure?

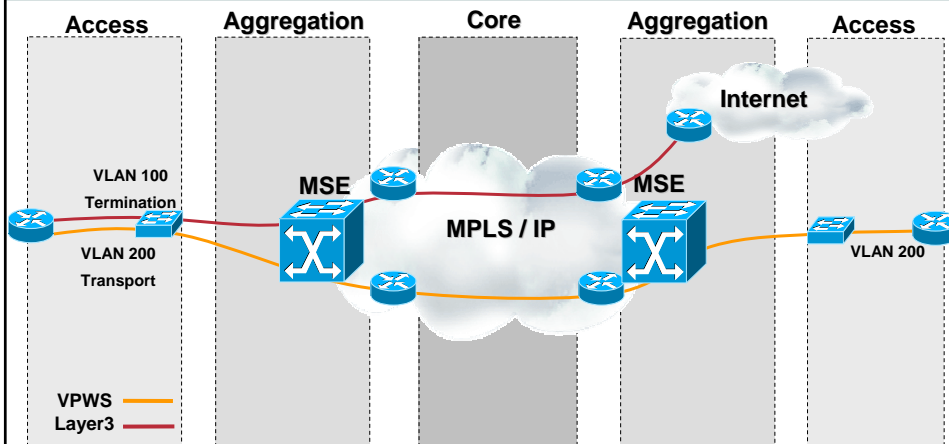
Cisco.com



- Reduce overlapping core expense; consolidate trunk lines
- Offer multiservice / common interface (i.e. Ethernet MUX = L2, L3 & Internet)
- Maintain existing revenues from legacy services

Motivation for L2VPNs – What value-add can I offer my customers?

Cisco.com



- Fast becoming the access technology of choice
- Layer 2, Layer 3 and Internet Services on a common port
- Extends the reach of Metro Area Ethernet Networks

Network Foundation



L2VPN Deployment – *Objectives – High Level*

Cisco.com

- **Building a foundation that will support the same level of SLAs offered over existing infrastructure**
- **This includes:**
 - Availability
 - Resiliency
 - Predictability
 - Management & Monitoring (Fault Detection)
 - Troubleshooting Tools

L2VPN Deployment – *Laying the Groundwork for Successful Deployment*

Cisco.com

The ‘Need to Knows’ of your infrastructure:

- What is the aggregate bandwidth requirements for converged services?
- What are the minimum platform requirements to run the planned services?
 - Which RPs, PAs and Line Cards are supported?
- What software features will be required to meet all of my planned needs? Such as:
 - L2VPN Functionality (like-to-like, any-to-any, etc.)
 - OAM Capability
 - Quality of Service (QoS) Requirements
 - IGP, EGP, and TE requirements
 - Cisco Express Forwarding (CEF, dCEF)

ACC-2001
9308:996:000:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

13

Availability & Resiliency Fundamentals



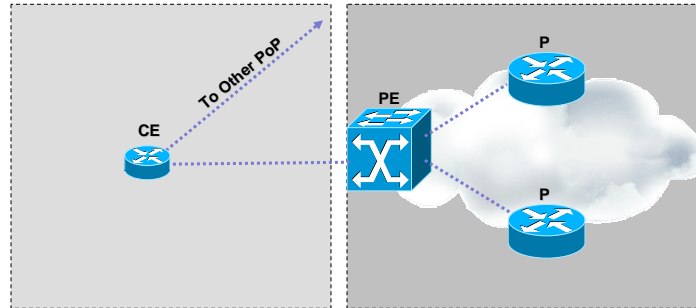
ACC-2001
9308:996:000:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

14

L2VPN Deployment – Physical Evaluation – Provider Edge

Cisco.com



- Customer Edge (CE) devices can have a single or dual attachment (outside SP responsibility)
- Provider Edge (PE) devices at a minimum, **MUST** have dual uplinks to the core
- (Optional) Route Processor redundancy, NSF/SSO capabilities, etc.

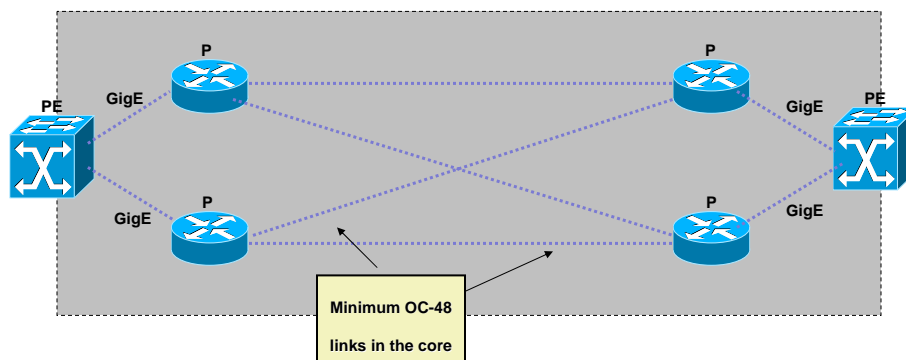
9508:096:000:31X

© 2004, Cisco Systems, Inc. All rights reserved.

15

L2VPN Deployment – Physical Evaluation – Provider Core

Cisco.com



- Provider (P) Nodes **MUST** have alternate paths to PoPs
- Bandwidth **MUST** account for failure loads on alternate paths
- Traffic Engineering can add a precise science to design through the use of Fast ReRoute (FRR) Link and Node protection

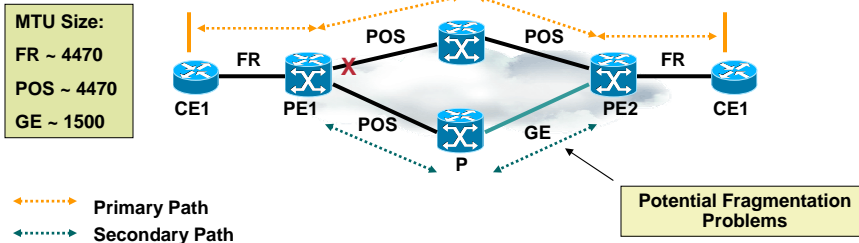
9508:096:000:31X

© 2004, Cisco Systems, Inc. All rights reserved.

16

L2VPN Deployment – Path MTU Calculation / ICMP PMTU

Cisco.com



- It is important to calculate the max MTU for all links in the network to link fragmentation in the core:
 - Supported via “ip pmtu” (L2TPv3) command provides ICMP notification to the offending sender.
 - In AToM “mtu <x>” or “mpls mtu <x>”, Example:
Core MTU >= (Edge MTU + Transport header + AToM header + (MPLS label stack))
- Quick Fix: Set Gigabit interfaces to support Jumbo frames
- Optionally, set customer facing interface to lower value

9508;096;000;31X

© 2004, Cisco Systems, Inc. All rights reserved.

17

L2VPN Deployment – Physical Evaluation – Platforms

Cisco.com

Primary Platform Support (12.0S / 12.2S):

- 7200

Platforms with processor redundancy options:

- 7300
- 7500
- 7600
- 10720
- 12000
- 10000 ← Coming soon

Limited L2VPN Support in IOS T Train:

- 1700
- 2600
- 3700
- 7400

ACC-2001
9508;096;000;31X

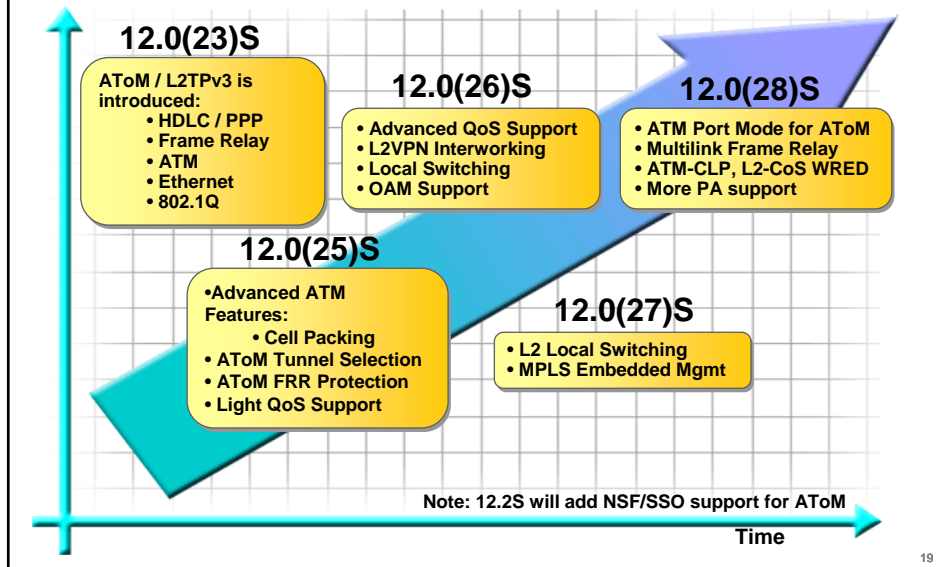
Note: Check CCO online for specific interface, most are supported.

© 2004, Cisco Systems, Inc. All rights reserved.

18

L2VPN Deployment – Software Evaluation – Feature History

Cisco.com



19

L2VPN Deployment – Software – Key Features

Cisco.com

Required:

- Cisco Express Forwarding enabled (CEF) (AToM, L2TPv3)
- Functioning IGP with PE ← → PE connectivity (OSPF, ISIS)
- Label Distribution Protocol (LDP) on links (AToM only)

Optional:

- RSVP for Traffic Engineering & Fast Re-Route support
- Layer 2 Quality of Service features
 - Marking
 - Policing
 - Shaping
 - Queuing
- OAM Support

ACC-2001
8508;086;0200;3DX

© 2003, Cisco Systems, Inc. All rights reserved.

20

The XConnect CLI



L2VPN Deployment – Introducing the XConnect Command Line Interface

Cisco.com

XConnect Characteristics:

- Modular design allows application specific pseudo-wire characteristics to be applied easily to many individual VCs
- XConnect can be applied at Port, Sub-if, VP and VC level depending on access circuit (AC) type
- Control Channel can be tailored to fit the application

Key Components:

- The XConnect command, *xconnect*
- The *pseudowire-class*
- For L2TPv3 only, the *l2tp-class*

L2VPN Deployment – The XConnect Command

Cisco.com

- **xconnect** *peer-ip-address* *vcid* *pseudowire-parameters* [sequencing {transmit | receive | both}]
 - *peer-ip-address* (This is the destination Loopback address)
 - *vcid* (Unique number for a pseudowire, must match at both PEs)
 - *pseudowire-parameters* [sequencing {transmit | receive | both}]

Example, 802.1Q:

```
interface FastEthernet5/1.500
 encapsulation dot1q 500
 xconnect 172.18.255.3 500 pw-class vlan-hi-priority
```

ACC-2001
93089:0963:0063:DX

© 2003, Cisco Systems, Inc. All rights reserved.

23

L2VPN Deployment – The Pseudowire-Class Command

Cisco.com

- **pseudowire-class** [*pw-class-name*]
 - *pw-class-name* (Use names that identify classes purpose)

L2TPv3 Example:

```
pseudowire-class vlan-hi-priority
 encapsulation l2tpv3
 ip local interface Loopback0
 ip pmtu
 ip tos value 5
```

AToM Example:

```
pseudowire-class atom_te41
 encapsulation mpls
 sequencing both
 preferred-path interface Tunnel41 /
 disable-fallback
```

- Provides the characteristics for a group of PWs (This part scales!)
- Can be re-applied to many L2 services with common requirements
- Typically, one will define 3 to 4 pseudowire-classes on a PE

93089:0963:0063:DX

© 2003, Cisco Systems, Inc. All rights reserved.

24

L2VPN Deployment – The L2TP-Class Command

Cisco.com

- **l2tp-class** [*l2tp-class-name*]
 - *l2tp-class-name* (Name it something meaningful)
 - (i.e., *l2tp-class partner-x*)

Example:

```
l2tp-class default
hostname PE3
password 0 cisco
cookie size 8
```

- This applies to L2TPv3 only and is optional
- Allows the admin to adjust:
 - Control Channel Timing, Authentication and Maintenance parameters
 - Example: retransmit {initial retries *initial-retries* | retries *retries* | timeout {max | min} *timeout*}

0308:080:000:31X

© 2004, Cisco Systems, Inc. All rights reserved.

25

L2TPv3 – Basic Example of FR with different priorities

Cisco.com

```
frame-relay switching
!
pseudowire-class FR-CIR
encapsulation l2tpv3
sequencing both
ip local interface Loopback0
ip tos value 5
!
pseudowire-class FR-NO-CIR
encapsulation l2tpv3
ip local interface Loopback0
ip tos value 0
!
connect fr-cir-1 ser2/0 500 l2transport
xconnect 172.18.255.3 500 pw-class FR-CIR
connect fr-no-cir-1 ser2/0 501 l2transport
xconnect 172.18.255.3 501 pw-class FR-NO-CIR
```

← Turn Frame Relay Switching On

Establish PW characteristics that reflect the service you wish to provide.

Note: PW class is data plane only and the ToS values are in the outer delivery header.

← Apply to correct DLCIs

0308:080:000:31X

© 2004, Cisco Systems, Inc. All rights reserved.

26

Predictability



ACC-2001
E5X09:096:0200:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

27

L2VPN Deployment – *Things to Consider...*

Cisco.com

Back to the original L2VPN objectives:

Trunk Replacement / Convergence or New Services?

Convergence:

- How to protect my existing service classes, if any?
- When and where to enforce them?
- What tools are available to me to ensure success?
- What options exist to provide network resiliency?

New Services:

- How do I get the most out of my new service offering?
- In the absence of a legacy access network, where do I apply my policies?

ACC-2001
E5X09:096:0200:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

28

Service Level Agreements – Why are they important?

Cisco.com

The quality level of an SLA dictates the cost of the service!

- Service Providers require tools to measure and predict service delivery; vital to customer retention ([Network Perspective](#))
- Enterprise ITs often provide Service Guarantees based on application criticality. (Budget dictates service) ([Network and / or User Perspective](#))
- Common Components:
 - Availability
 - Predictability
 - Resiliency
 - Service
 - Credit, etc.

ACC-2001
9308;986;000;3DX

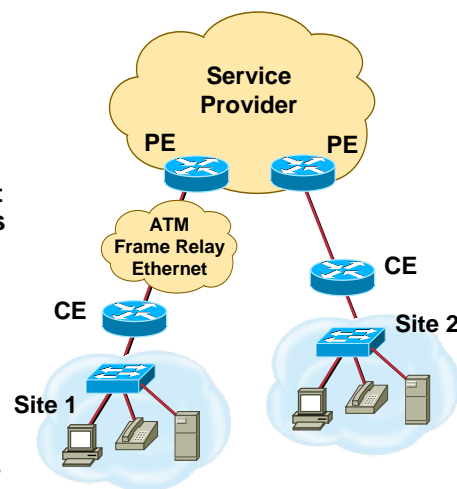
© 2003, Cisco Systems, Inc. All rights reserved.

29

L2VPN Deployment – The Layer-2 Service Level Agreement (SLA)

Cisco.com

- Point to point guarantees are the basis for the SLA
 - Delay
 - Delay Variation
 - Loss
- In a port trunking environment the FR / ATM / Ethernet access network may enforce SLA
 - Marking, Policing
 - Queuing, Shaping, etc.
- Pay-as-you-grow services can be implemented for many service encaps
- Service Provider Equipment is transparent to the Customer



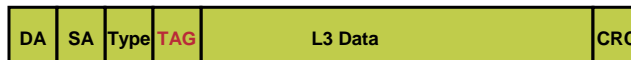
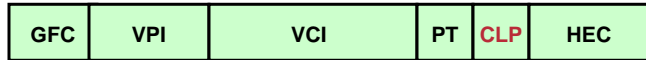
ACC-2001
9308;986;000;3DX

© 2003, Cisco Systems, Inc. All rights reserved.

30

Service – What priority options does the SP Have to work with?

Cisco.com



- Provide Service on Port, Layer 2 or Layer 3 Info
- Enforcing sub-rate leased line access
- L2 PDUs provide options for setting frame priority (ex: CLP, DE, 802.1p)
- L2 PVC or Inner L3 Precedence

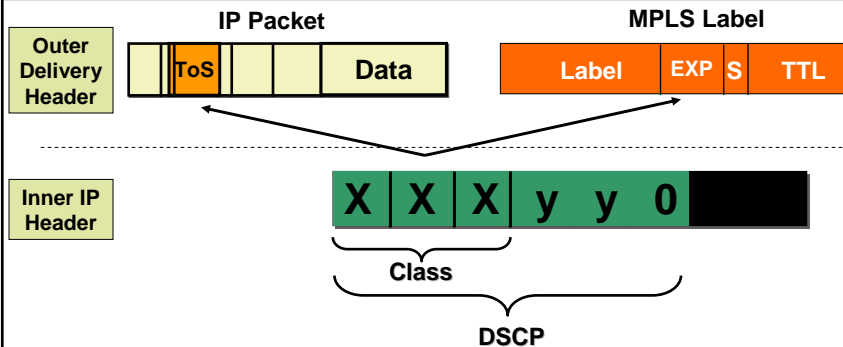
ACC-2001
9309:986:0003DX

© 2004, Cisco Systems, Inc. All rights reserved.

31

L2VPN Deployment – Precedence Equivalence: MPLS / IP

Cisco.com



- IP Precedence is the most often used in determining different traffic priorities (0 – 7)
- Most SPs implement 3 – 5 traffic classes (Best Effort → Mission Critical)
- Enforce policies through shaping, marking, policing

ACC-2001
9309:986:0003DX

© 2004, Cisco Systems, Inc. All rights reserved.

32

L2VPN Deployment What QoS tools are available?

Cisco.com

Modular QoS CLI (MQC):

- **Shaping** – When transmit rates are higher than expected buffering or queuing is used delay excess traffic, opposite of policing
- **Marking** – The ability to differentiated packets by setting properties within the Layer 2 or Layer 3 header like the IP precedence, or L2 Class of Service or drop priority.
- **Policing** – Used to drop or remark with a lower priority IP Precedence or MPLS EXP bits in traffic that is in excess of contract.
- **Queuing** – Congestion management by giving correct priority to traffic classes one can manage time-sensitive applications without penalizing lower priority traffic. (CBWFQ)
- **Policers or MQC definition will be set at incoming DLCI (class-map, match command) or pw-vc definition (future)**
- **Dual-Rate Policer required to enforce non-port speed PIR profiles**

ACC-2001
E9089:096a:0060:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

33

Network Convergence : Trunk Replacement



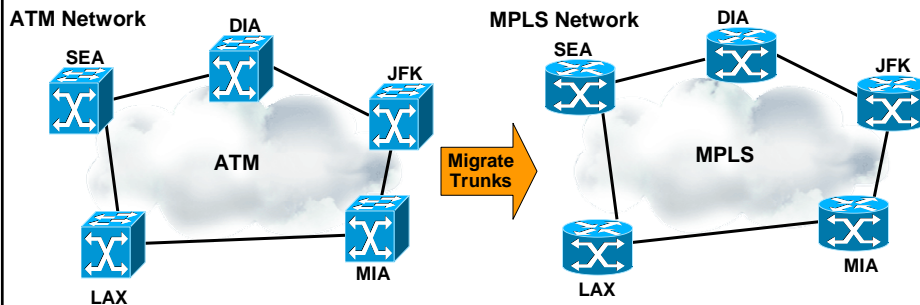
ACC-2001
E9089:096a:0060:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

34

Network Convergence – ATM Trunk Replacement - Overview

Cisco.com



- Service provider is maintaining two networks: ATM for traditional ATM and FR services & an MPLS network, offering L3VPN services
- ATM network is offering multiple Classes of Service
- Need to move ATM trunks to the MPLS network in the same PoPs
- How does the Service Provider maintain existing service levels?

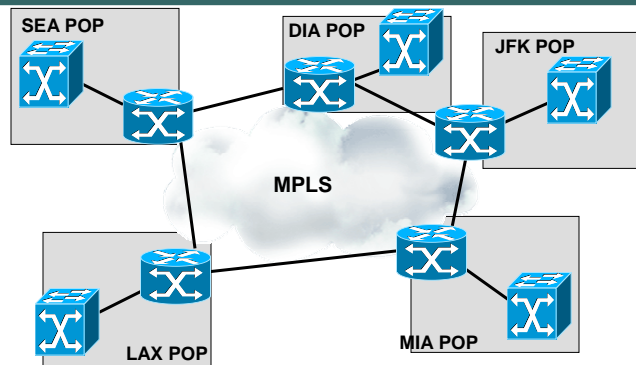
93089-0980-2000-31X

© 2004, Cisco Systems, Inc. All rights reserved.

35

Network Convergence – ATM Trunk Replacement - Overview

Cisco.com



- Two methods of replacing the service:
 - Virtual Path Trunking (Paths represent different Classes of Service)
 - Port Trunking (All traffic is generically grouped into priority class)
- Most policies are still enforced in the ATM network

93089-0980-2000-31X

© 2004, Cisco Systems, Inc. All rights reserved.

36

Network Convergence – ATM Trunk Replacement – VP Trunk: CBR

Cisco.com

```
class-map match-any atm-cbr
  match any
!
policy-map atm-cbr
  class atm-cbr
    police rate 3000000 bps conform-action set-mpls-exp-imposition-transmit 5 /
    exceed-action drop
!
pseudowire-class atom-default
  encapsulation mpls
  sequencing both
!
interface ATM1/0
  atm mcpt-timers 30 60 90
  atm pvp 8 12transport
  cell-packing 10 mcpt-timer 1
  xconnect 172.18.255.3 8 pw-class atom-default
  service-policy input atm-cbr
```

- This configuration assumes all CBR traffic has been groomed into a common Virtual Path Identifier (VPI)
- The service-policy is applied to the ingress port ; does not account for core output policies. (policies reflect uni-directional flow)

03083:0963:0003:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

39

ATM QoS Parameter Definitions – ATMF UNI 4.0 specification

Edge

Cisco.com

It is imperative that the L2VPN solution provide faithfulness of the emulated service for ATM. The CoS conformity should be based on the following applicable components to ensure the ATM SLA

- **PCR: Peak Cell Rate:** this indication provide in number of Cells how much cells could be admitted per second.
- **SCR: Sustain Cell Rate:** this information provide in number of Cells how much cells are in contract per second.
- **CDVT: Cell Delay Variation Tolerance:** inform on max Jitter accepted in ms
- **MBS: Maximum Burst Size:** determine in number of cells that could burst in extra from SCR bucked
- **CLP:** Bit in ATM Cell who determine if cell is mark in contract or exceeding the contract

ACC-2001
03083:0963:0003:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

40

Traffic Contract and Conformance Definition From ATM Traffic Management Specification 4.0



Cisco.com

ATM CoS	PCR policer CLP class	PCR exceed action	SCR color based policer	SCR exceed Action
CBR ₁	CLP 0+1	Drop	No SCR	No SCR
CBR _{off}	No PCR	No PCR	No SCR	No SCR
UBR ₁	CLP 0+1	Drop	No SCR	No SCR
UBR ₂	CLP 0+1 ⁽¹⁾	Drop	No SCR	No SCR
VBR ₁	CLP 0+1	Drop	CLP 0+1	Drop
VBR ₂	CLP 0+1	Drop	CLP 0	Drop
VBR ₃	CLP 0+1	Drop	CLP 0	Mark CLP 1
VBR ₄	CLP 0+1	Drop	No SCR	No SCR
VBR _{off}	No PCR CLP 0+1	No PCR	No SCR	No SCR

ACC-2001
#BXB#e#B#0#0#3DX

© 2003, Cisco Systems, Inc. All rights reserved.

41

New Services : Frame Relay Example



ACC-2001
#BXB#e#B#0#0#3DX

© 2003, Cisco Systems, Inc. All rights reserved.

42

New Services – What Are Common Service Requirements?

Cisco.com

Frame Relay Service:

- Talking to service providers we could define 4 service classes for a FR network:
 - FR-1: Bandwidth guarantee
 - FR-2: CIR+EIR (a la VBR-3)
 - FR-3: CIR+EIR (a la VBR-1)
 - FR-4: CIR 0

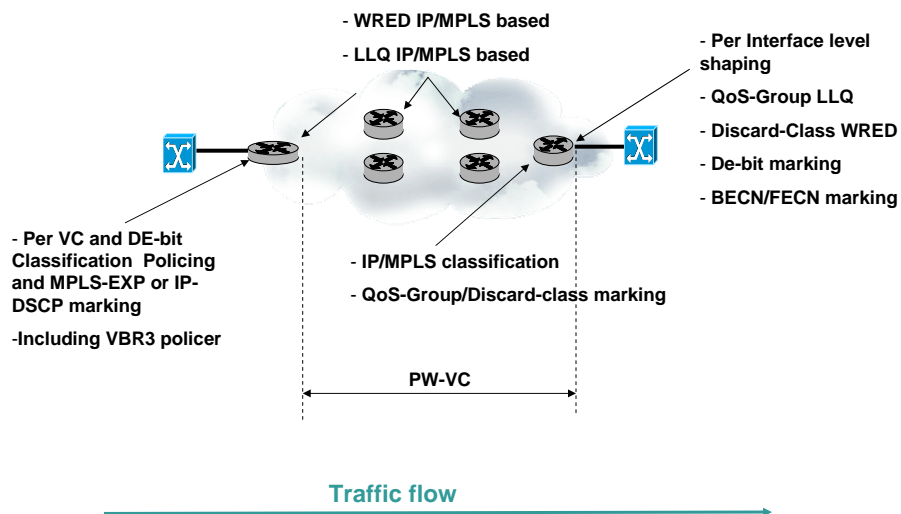
ACC-2001
9309:996:0003DX

© 2004, Cisco Systems, Inc. All rights reserved.

43

The Complete Picture

Cisco.com



ACC-2001
9309:996:0003DX

© 2004, Cisco Systems, Inc. All rights reserved.

44

L2VPN Deployment – Frame Relay - Service Class → EXP / DSCP Values

Cisco.com

	CIR	EIR	CIR EXP CIR DSCP	EIR EXP EIR DSCP
FR-1 (Voice class)	X	---	5 (LLQ) EF	
FR-2 (Video class)	X	Y	4 (CB1) AF11	3 AF12
FR-3 (Business class)	X	Y	2 (CB2) AF21	1 AF 22
FR-4 (Best effort class)	---	Y		0 (BE) BE

ACC-2001
E90B9:0963:0060:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

45

L2VPN Deployment – Frame Relay – Marking / Policing Options

Cisco.com

Two methods depending of interface type:

- **UNI interface:** Policers or Marking definition will be attached (via MQC semantic) to incoming pw-vc definition.
- **NNI interface:** SP wants group few FR DLCI within unique Policer or MQC definition and therefore we will need to match multiple DLCI within same class with following new MQC mechanism:

```
"MATCH FR-DLCI [DLCI-ID]"
```

ACC-2001
E90B9:0963:0060:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

46

UNI service-policy – Current IOS Support

Cisco.com

```
policy-map fr-dlci101-input-cir
class class-default
  police 256000 2560 conform set-mps-exp-transmit 5 exceed-action drop
```



```
map-class frame-relay fr-switching-4-0-101
service-policy input fr-dlci101-input-cir
```



```
interface Serial4/0
!
frame-relay interface-dlci 110 switched
class fr-switching-4-0-101
```

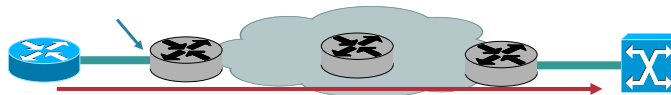
ACC-2001
9309:98:206:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

47

NNI service-policy : Current IOS Support

Cisco.com



```
class-map match-all dlci-group-rt
  match dlci 105
  match dlci 200
  match dlci 315

class-map match-all dlci-group-be
  match dlci 106
  match dlci 523

policy-map fr-dlci-nni-input
class dlci-group-rt
  set mpls-exp 0
  police 512000 5120 conform transmit exceed-action drop
class dlci-group-be
  set mpls-exp 5
  police 384000 3840 conform transmit exceed-action drop
interface Serial11/0
service-policy input fr-dlci-nni-input
```

9309:98:206:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

48

L2VPN Deployment – Frame Relay – FR-2 & FR-3 (CIR + EIR)

Cisco.com



```
policy-map fr-dlci102-input-video
class class-default
  police cir 128000 <nb> pir 380000 <eb>
    conform-action set-mpls-exp-transmit 2
    exceed-action set-mpls-exp-transmit 1
    violate-action drop

connect <blue VPN> serial1/0 102 l2transport
xconnect route 1.0.0.8 321 pw-class fr-atom
service-policy input fr-dlci102-input-video <- Future Syntax, use port level
```

This method will be generally used with FRF-2 & FR-3 Service Class

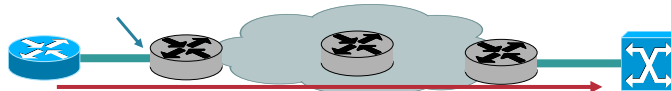
ACC-2001
9309:996:206:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

49

L2VPN Deployment – Frame Relay – Best Effort

Cisco.com



```
policy-map fr-dlci104-input-be
class class-default
  set mpls-exp 0

connect <blue VPN> serial1/0 104 l2transport
xconnect route 1.0.0.8 321 pw-class fr-atom
service-policy input fr-dlci104-input-be <- not support yet like this
```

This method will generally be used with FR-4 Service Class

ACC-2001
9309:996:206:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

50

L2VPN Deployment – Examples Summary

Cisco.com

- Defined the common L2 → L3 mechanisms available for implementing class delineation
- Displayed configuration surrounding the various traffic classes that would be seen in a Frame Relay environment.
 - Attend the Deploying QoS in MPLS Networks session for agonizing detail.
- Displayed how ATM traffic can be trunked across an IP/MPLS network

ACC-2001
9309:996:000:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

51

Advanced Topics: MPLS-TE / FRR



ACC-2001
9309:996:000:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

52

L2VPN Deployment – Advanced Topics: MPLS-TE w / FRR Highlights

Cisco.com

MPLS-TE:

- Allows MPLS enabled cores to utilize optimized paths for differing traffic requirements.
- Optimizes SPF-only routing behavior
- Can make sure underutilized links get used. (Equal/Unequal load balancing)

Fast Re-Route (FRR):

- Provides alternate path protection for Link & Node failure
 - **NODE FAILURE**
 - Power failure, hardware crash, maintenance
 - **LINK FAILURE**
 - Fiber cut, Carrier Loss, ADM failure
- Provides the mechanism to protect AToM PWs through the MPLS core
- Reduces fail over times experienced with normal routing convergence

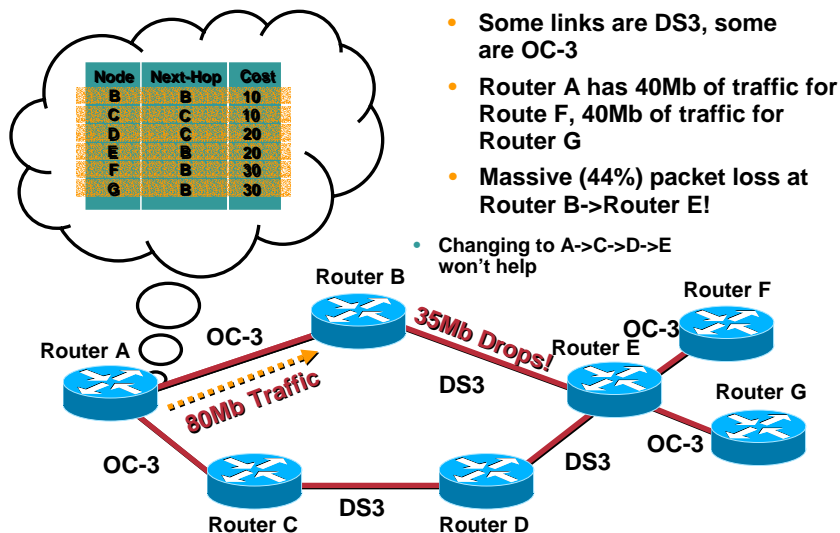
ACC-2001
93089:096:000:31X

© 2003, Cisco Systems, Inc. All rights reserved.

53

L2VPN Deployment – SPF Algorithms can cause problems!

Cisco.com



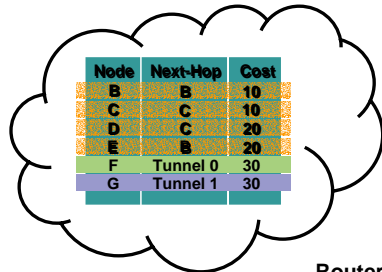
ACC-2001
93089:096:000:31X

© 2003, Cisco Systems, Inc. All rights reserved.

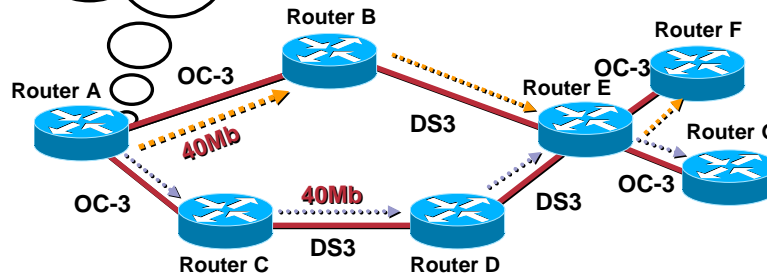
54

L2VPN Deployment – What MPLS Traffic Engineering Addresses

Cisco.com



- Router A sees all links
- Router A computes paths on properties other than just shortest cost
- Like a L2 PVC, but **no IGP adjacency** over the 'PVC'!!



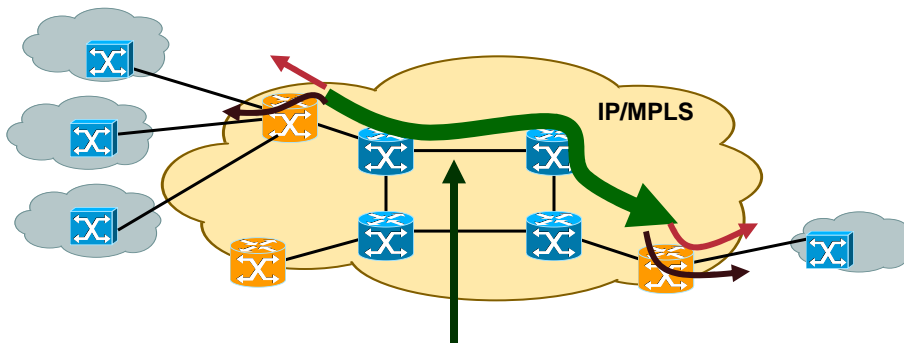
ACC-2001
93083:0963:006:31X

© 2004, Cisco Systems, Inc. All rights reserved.

55

L2VPN Deployment – Advanced Topics: MPLS-TE Benefits for AToM

Cisco.com



Core TE Mechanisms:

- Using Traffic Engineering allows bandwidth reservation = predictable service guarantees (RSVP is the key)
- Can also be used to utilize low use links due to SPF default behaviour

ACC-2001:0963:006:31X

© 2004, Cisco Systems, Inc. All rights reserved.

56

L2VPN Deployment – Advanced Topics: Tunnel Selection

Cisco.com

```
preferred path [interface tunnel tunnel-number | peer /
{ip address | host name}] [disable-fallback]
```

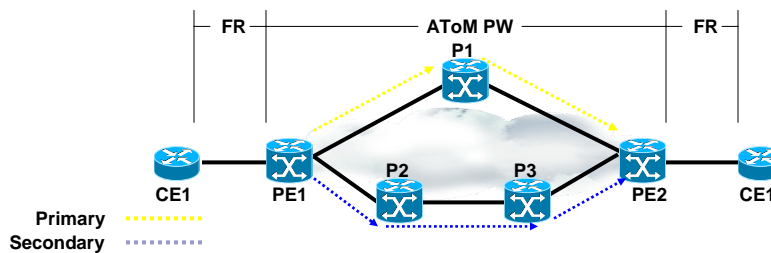
```
pseudowire-class my-path-pref
  encapsulation mpls
  preferred-path interface tunnel 1 disable-fallback
!
interface fastEthernet <slot/port>.<subif-id>
  encapsulation dot1Q 150
  xconnect 172.18.255.3 1000 pw-class my-path-pref
```

- This configuration will allow one to direct which path pseudowires are to take throughout the network
- The tunnel head end / tail end must be on the PEs

L2VPN Deployment – Advanced Topics: Fast Re-Route (MPLS-TE/FRR)

Cisco.com

You Can Minimize packet loss, thus increasing guarantees!



- FRR builds an alternate path to be used in case of a network failure (Link or Node) / local repair negates convergence delays
- No special configuration for AToM PWs other than Tunnel Selection
- An FRR protected tunnel will support all the traffic traversing the link

© 2008 Cisco Systems, Inc. All rights reserved.

© 2008 Cisco Systems, Inc. All rights reserved.

58

L2VPN Deployment – Advanced Topics: FRR Configuration Example

Cisco.com

```
pe-atl# sh run
...
pseudowire-class fe-te
encapsulation mpls
preferred-path interface Tunnell disable-fallback
...
interface Tunnell
ip unnumbered Loopback0
no ip directed-broadcast
tunnel source Loopback0
tunnel destination 172.0.0.3
tunnel mode mpls traffic-eng
tunnel mpls traffic-eng priority 7 7
tunnel mpls traffic-eng bandwidth 10
tunnel mpls traffic-eng path-option 1 explicit identifier 1
tunnel mpls traffic-eng fast-reroute
...
ip explicit-path identifier 1 enable
next-address 172.0.0.2 (PE-NYC)
next-address 172.0.0.4 (PE-BRU)
next-address 172.0.0.3 (PE-PAR)
```

ACC-2001
93089:0963:2046:31DX

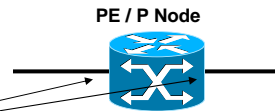
© 2004, Cisco Systems, Inc. All rights reserved.

59

MPLS Fast Re-Route – What Is Required to Enabled it?

Cisco.com

```
mpls label protocol ldp
mpls traffic-eng tunnels
mpls ldp router-id Loopback1 force
!
interface POS0/0
ip address 1.1.0.2 255.255.255.252
mpls traffic-eng tunnels
mpls traffic-eng backup-path <Tunnel Name>
pos ais-shut pos report lrdi
ip rsvp bandwidth 155000 155000
```



- MPLS-TE Tunnels configured on ingress PEs
- All core interfaces must have MPLS-TE configured for RSVP to work
- Fast Reroute Protection configured on TE Tunnel
- Preferred-path is directed to local TE Tunnel
- XConnect configured with destination peer address plus the pseudo-wire class of the appropriate tunnel

93089:0963:2046:31DX

© 2004, Cisco Systems, Inc. All rights reserved.

60

L2VPN Deployment – Advanced Topics Summary

Cisco.com

Covered:

- Benefits of using Traffic Engineering w / Tunnel Selection
- Fast Re-Route

Not Covered:

- Fast IGP (OSPF, ISIS Tweaks)
- Fast LDP

RST-2603 – ‘Deploying MPLS Traffic Engineering’ for the details

ACC-2001
9309:996a:0000:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

61

Monitoring & Troubleshooting



ACC-2001
9309:996a:0000:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

62

Management / Maintenance – Overview

Cisco.com

What tools are available for managing and monitoring the performance & health of my network?

- Provisioning
 - CLI
 - IP Solutions Center
 - Tunnel Builder Pro
- Monitoring
 - Service Assurance Agent (SAA)
 - Netflow
 - MIBs
- Troubleshooting
 - MPLS LSP Ping, Traceroute & VCCV

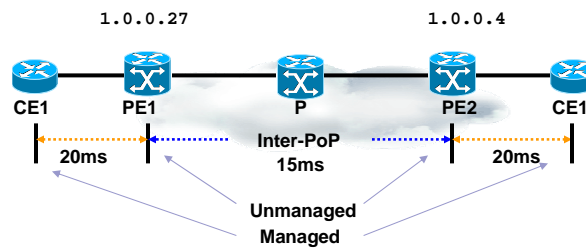
ACC-2001
9309:996:206:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

63

L2VPN Deployment – How Do I Monitor Service?

Cisco.com



- External Probes between POPs, and
- Embedded agents in customer CPE
- SAA is an embedded “Active” software agent in Cisco IOS
- UDP Echo & UDP Jitter Probes use intelligent time-stamps (Interrupt level receive, etc.)

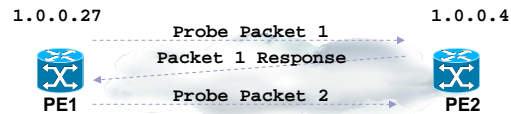
ACC-2001
9309:996:206:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

64

L2VPN Deployment – Monitoring - SAA Configuration Example

Cisco.com



```
PE1(config)#rtr 200
PE1(config-rtr)#type jitter dest-ip 1.0.0.4 dest-port 99 num-packets 20
interval 20
PE1(config)#rtr schedule 1 life forever start-time now
```

```
PE2# conf t
PE2(config)#rtr responder
```

- Probes NOT required on all PEs to get bi-directional delay statistics; rtr responder only
- Run RTR ATM / Frame-Relay or L3 on CEs for customer verification ← Keep the SP honest

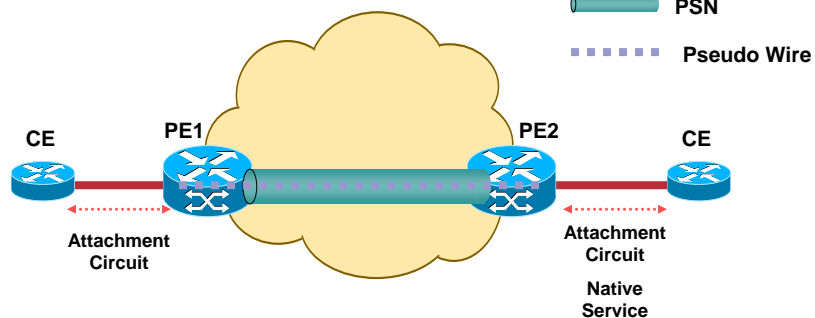
ACC-2001
0308;096;020;3DX

© 2003, Cisco Systems, Inc. All rights reserved.

65

MPLS Embedded Management – Virtual Circuit Connection Verification (VCCV)

Cisco.com



- Multiple PSN Tunnel Types
MPLS, IPSEC, L2TP, GRE,...
- Motivation
One tunnel can serve many pseudo-wires.
MPLS LSP ping is sufficient to monitor the PSN tunnel (PE-PE connectivity), but not VCs inside of tunnel.

ACC-2001
0308;096;020;3DX

© 2003, Cisco Systems, Inc. All rights reserved.

66

MPLS Embedded Management – VCCV Overview

Cisco.com

- **Mechanism for connectivity verification of PW**
- **Features**
 - Works over MPLS or IP networks
 - In-band CV via control word flag or out-of-band option by inserting router alert label between tunnel and PW labels
 - Works with BFD, ICMP Ping and/or LSP ping

ACC-2001
E908:98a:000:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

67

MPLS Embedded Management – VC Connection Verification (VCCV)

Cisco.com

- **Control packets inband of the AToM tunnels are intercepted by the egress PE**
- **A new martini interface parameter is defined**
- **VCCV capability is negotiated when the AToM tunnel is brought up**
- **VCCV marks the payload as control packet for switching purpose.**

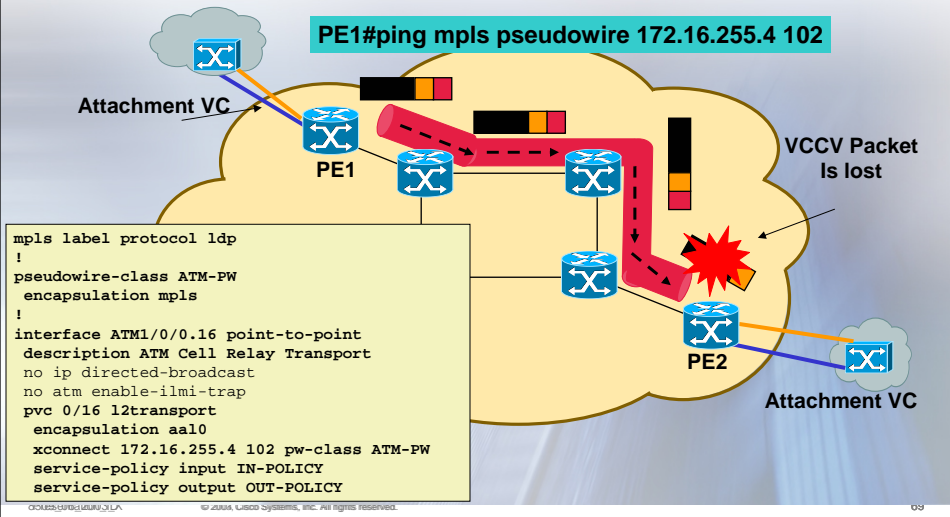
ACC-2001
E908:98a:000:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

68

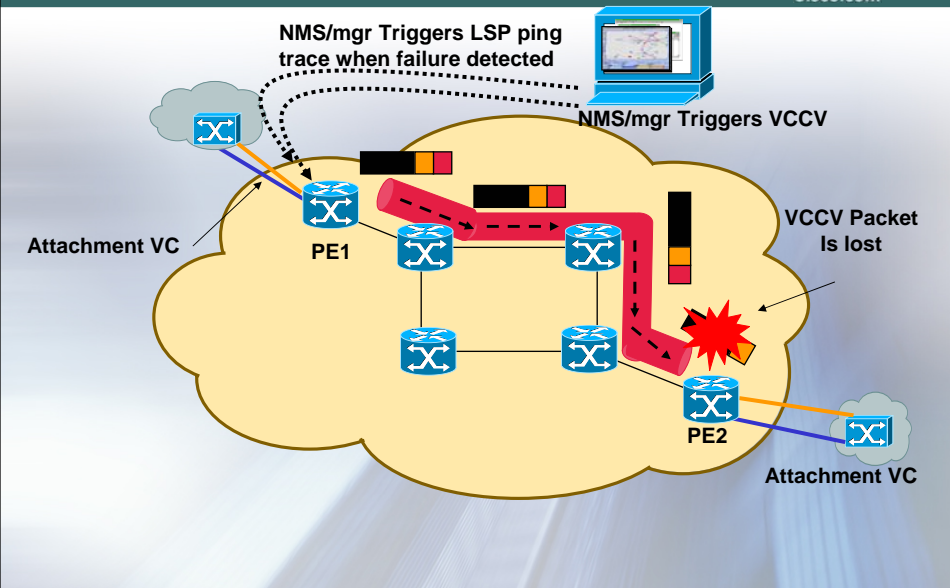
MPLS Embedded Management – Connectivity Trace Using VCCV

Cisco.com



Example of Operation – CV/Trace Using VCCV and LSP Ping

Cisco.com



L2VPN Deployment – Embedded Management - VCCV Switching types

Cisco.com

Two types of switching modes:

1. Type 1 involves defining the upper nibble of the control word as a Protocol Id (PID) field.
2. Type 2 involves shimming a MPLS Router Alert Label between the IGP label stack and VC label

```
R3#sh mpls l2transport binding 10
Destination Address: 10.200.0.1, VC ID: 10
Local Label: 16
  Cbit: 0, VC Type: Ethernet, GroupID: 0
  MTU: 1500, Interface Desc: n/a
  VCCV Capabilities: Type 2
Remote Label: 69
  Cbit: 0, VC Type: Ethernet, GroupID: 0
  MTU: 1500, Interface Desc: n/a
  VCCV Capabilities: Type 2
```

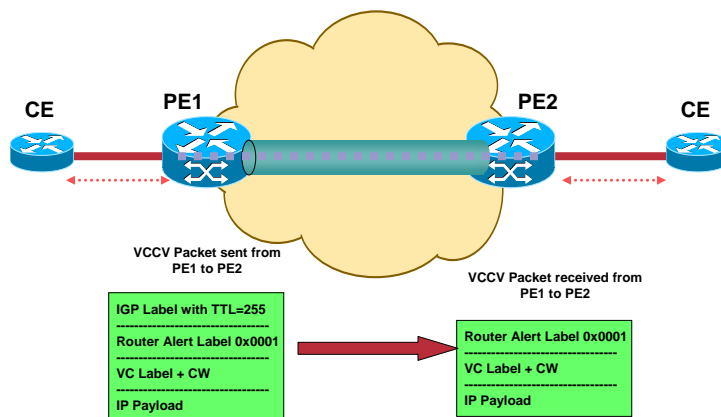
ACC-2001
E5089:0963:0003:1DX

© 2003, Cisco Systems, Inc. All rights reserved.

71

L2VPN Deployment – Troubleshooting - VCCV Ping (Type 2)

Cisco.com



ACC-2001
E5089:0963:0003:1DX

© 2003, Cisco Systems, Inc. All rights reserved.

72

LSP Ping – L2 Circuit Type

Cisco.com

```
R3#ping mpls pseudowire <IPv4 peer IP addr > <VC ID>?
destination Destination address or address range
exp          EXP bits in mpls header
interval     Send interval between requests in msec
pad          Pad TLV pattern
repeat       Repeat count
reply        Reply mode
size         Packet size
source       Source specified as an IP address
sweep        Sweep range of sizes
timeout      Timeout in seconds
ttl          Time to live
verbose      verbose mode for ping output
```

ACC-2001
9309:986:206:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

73

L2VPN Deployment – Management - Useful MIBs

Cisco.com

ATM AAL5 over MPLS and ATM Cell Relay over MPLS:

- ATM MIB (ATM-MIB)
- CISCO AAL5 MIB (CISCO-AAL5-MIB)
- Cisco Enterprise ATM Extension MIB (CISCO-ATM-EXT-MIB)
- Supplemental ATM Management Objects (CISCO-IETF-ATM2-PVCTRAP-MIB)

Ethernet over MPLS

- CISCO-ETHERLIKE-CAPABILITIES
- Ethernet MIB (ETHERLIKE-MIB)

Frame Relay over MPLS

- Cisco Frame Relay MIB (CISCO-FRAME-RELAY-MIB)

HDLC and PPP over MPLS

- MPLS LDP MIB (MPLS-LDP-MIB)

All Service Types:

- Interface MIB (IF-MIB)
- MPLS LDP MIB (MPLS-LDP-MIB)

ACC-2001
9309:986:206:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

74

L2VPN Deployment – Management, Monitoring - Summary

Cisco.com

- Many options exist and are being developed for provisioning, monitoring and maintaining your L2VPN
- Service Level Monitoring can be achieved with SAA from both the Enterprise and Service Provider's perspective
- MPLS Embedded management overcomes the limited diagnostics capabilities with ICMP

ACC-2001
E90B9:696a:0000:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

75

L2VPNs In Play



ACC-2001
E90B9:696a:0000:31DX

© 2003, Cisco Systems, Inc. All rights reserved.

76

L2VPN Application – Objectives

Cisco.com

- **Demonstrate 2 cases of how L2VPNs are being utilized for :**
 - Core Convergence / Consolidation
 - New Services / Revenue Generation

ACC-2001
E908:096:000:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

77

L2VPN Applications – Tier 2 SP – Basic Overview

Cisco.com

Provider Profile:

- Tier 2 Service Provider
- Acquisition of 2 smaller Service Providers
 - Retail DSL
 - MPLS VPNs
 - Business VoIP
 - L2VPN
- Applications:
 - MPLS VPN
 - Cell Relay over MPLS
 - AToM VP / VC Mode
- **Goals: Reduce OPEX of 2 cores; consolidate into one**

ACC-2001
E908:096:000:3DX

© 2004, Cisco Systems, Inc. All rights reserved.

78

L2VPN Applications – IP/MPLS Core Network - Overview

Cisco.com



First SP Network:

- **2.5 Gbit/s Backbone with 8 core sites**
- **Fully MPLS enabled**
- **270 PoPs**
 - Interconnects with ILEC
 - 240000 dial-in ports
 - Covers the whole country
- **74 ADSL broadband PoPs**
 - ADSL ISP
 - Covers the whole country

ACC-2001
9308:996:200:3DX

© 2003, Cisco Systems, Inc. All rights reserved.

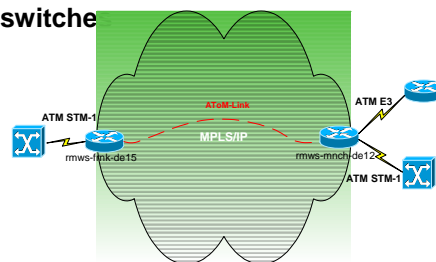
79

L2VPN Applications – ATM Core Network - Overview

Cisco.com

Second SP Core:

- **155 Mbit/s ATM backbone**
- **18 core sites, Lucent CBX ATM switches**
- **450 SDSL PoPs**
 - Interconnects with ILEC
 - 8000 CPEs
 - Lucent Stinger DSLAMs
 - Covers the whole country



Objective:

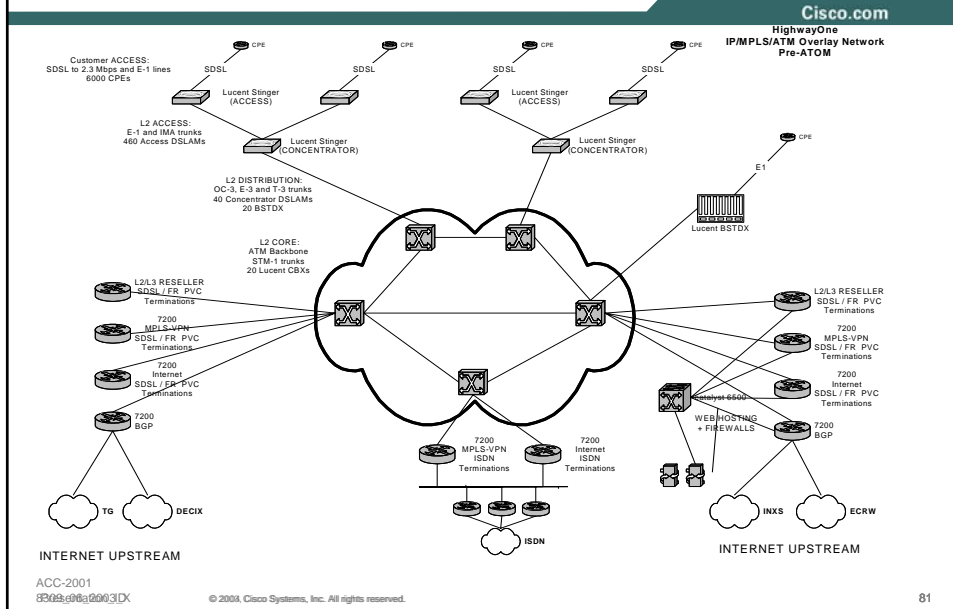
Use AToM to remove the ATM core that is providing xDSL Lucent Stinger DSLAMs aggregation services and migrate to MediaWays (MPLS core) (removed 10 switches thus far)

ACC-2001
9308:996:200:3DX

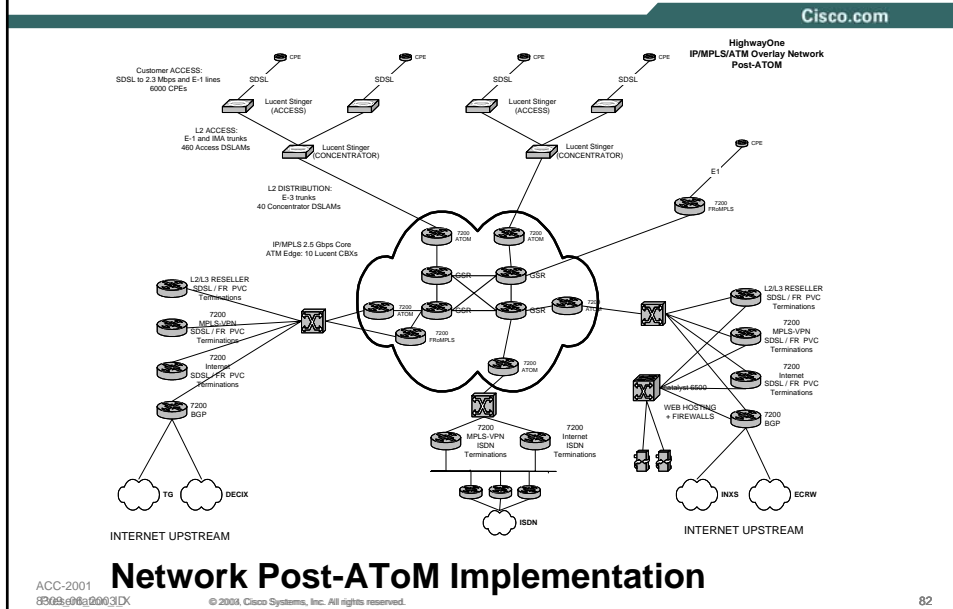
© 2003, Cisco Systems, Inc. All rights reserved.

80

L2VPN Applications – ATM Core Network - Details



L2VPN Applications – Tier 2 SP – EMEA



Network Post-AToM Implementation

L2VPN Applications – Network Consolidation - Benefit Summary

Cisco.com

- **Converge 2 SP cores into 1**
 - Leveraged existing high speed data network
 - Reduces Operating Expense (OPEX)
 - Reduce ATM trunking expenses
 - Removal of 10 CBX Switches
 - Cancellation of Service Contracts on obsolete equipment
- **Key Enablers:**
 - ATM Cell Relay VP Mode
 - Cell Packing
 - Local Switching

ACC-2001
9309:096:0003DX

© 2001, Cisco Systems, Inc. All rights reserved.

83

L2VPN Applications – New Service Offering – Problem Statement

Cisco.com

Provider Profile:

- Tier 1 Service Provider with traditional voice & data services.

Problem:

- Existing L3 data network is massively underutilized
- Upgrading legacy L2 ATM/FR network with switches is undesirable.
- Would like to offer more competitive L2 options.
- Possibly migrate FR switches to IP backbone.

Q: How can the Service Provider take advantage of the unused bandwidth on their existing L3 packet infrastructure?

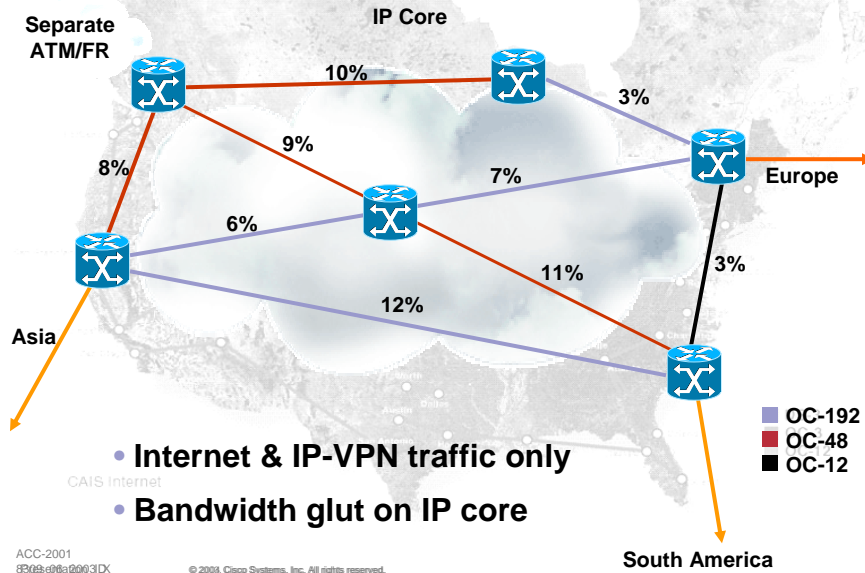
ACC-2001
9309:096:0003DX

© 2001, Cisco Systems, Inc. All rights reserved.

84

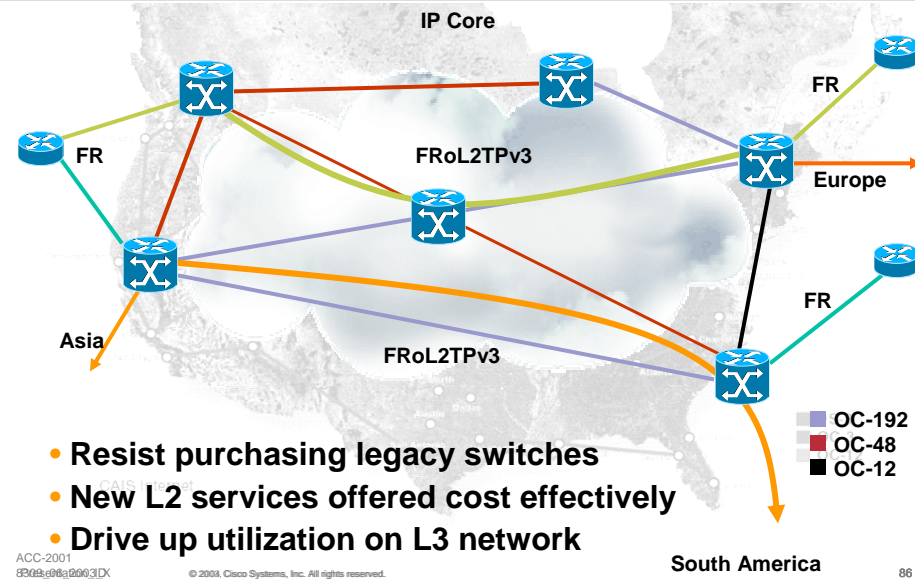
L2VPN Applications – New Service Offering – Underutilized Core

Cisco.com



L2VPN Applications – New Service Offering – Post Implementation

Cisco.com



L2VPN Applications – QoS Configuration

Cisco.com

```
class-map match-all dlci200
  match fr-dlci 200
class-map match-all dlci201
  match fr-dlci 201
policy-map Serial2-1-in
  class dlci200
    police cir 256000 bc 128000 be 256000 conform-action set-prec-transmit 5
    exceed- / action set-prec-transmit 0
  class dlci201
    police cir 128000 conform-action set-prec-transmit 5 exceed-action drop
interface Serial2/1
  frame-relay intf-type dce
  service-policy input Serial2-1-in
```

- Setup class-maps to match on the incoming DLCI
- Set up policing functions, customers are directly connecting to the PEs
- Set the appropriate IP precedence for conforming traffic

New Service – Preparation

Cisco.com

- **Global IP Infrastructure was Already Operational**
- **Update PE software to support L2TPv3 based services (Frame Relay, Ethernet, HDLC/PPP)**
- **Configure QoS policies to reflect service strategy**
 - Configured for FR service models w / egress policing
 - Substrate services for virtual leased line, TLS
- **Start configuring L2TPv3 based L2VPN Services**
 - Configured PW classes with relevant ToS, Sequencing and Path MTU discovery

ACC-2001
E5049:096:0200:31X

© 2003, Cisco Systems, Inc. All rights reserved.

88

Consolidation – Benefit Summary

Cisco.com

- **Leverage existing packet infrastructure to offer new source of revenue**
 - 150 + Customers utilizing the service
 - 2500 + Pseudowires operational
- **Utilize well-known native IP infrastructure**
 - Minimal OPEX expenditure for support
- **Enterprise benefits:**
 - Reduces monthly WAN recurring costs
 - Maintain well known Layer 2 service
 - Future Layer 3 service opportunity

ACC-2001
9308;986;000;3DX

© 2004, Cisco Systems, Inc. All rights reserved.

89

L2VPN Deployment – Summary – Add it All Up..

Cisco.com

- **Setup Services with QoS / TE, etc.**
- **Setup MQC Actions to reflect Policies**
- **Build appropriate Pseudo-wire classes**
- **Enabled advanced features (MPLS-TE, DS-TE, etc.)**
- **Allocate BW for customers and don't over subscribe CIR, CBR commitments**
- **Implement FRR for resiliency**
- **Implement SAA for monitoring response times**
- **Start provisioning PWs..**

ACC-2001
9308;986;000;3DX

© 2004, Cisco Systems, Inc. All rights reserved.

90



NETWORKERS 2004

Thank You!

ematkovi@cisco.com

Please Complete Your Evaluation

Session ACC-2000



CISCO SYSTEMS

