

L2 VPNs

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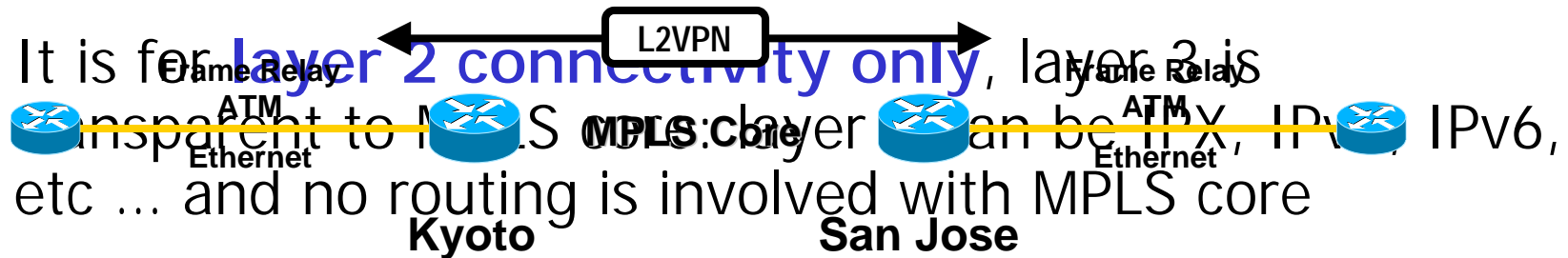
Agenda

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- Topics:
 - **L2VPN Introduction**
 - L2VPN Models
 - Quality of Service
 - L2VPN End-to-End Connectivity
 - IETF Drafts

What is L2VPN?

- L2VPN provides end-to-end layer 2 connection to an office in Kyoto to an office in San Jose over a SP's MPLS core
- It can be Ethernet, Frame Relay, ATM, HDLC, PPP, etc ...
- It is for **layer 2 connectivity only**, layer 3 is transparent to L2VPN. L2VPN can be ATM, Ethernet, etc ... and no routing is involved with MPLS core
- It is deployed over MPLS core but IP core (L2TPv3) deployments exist



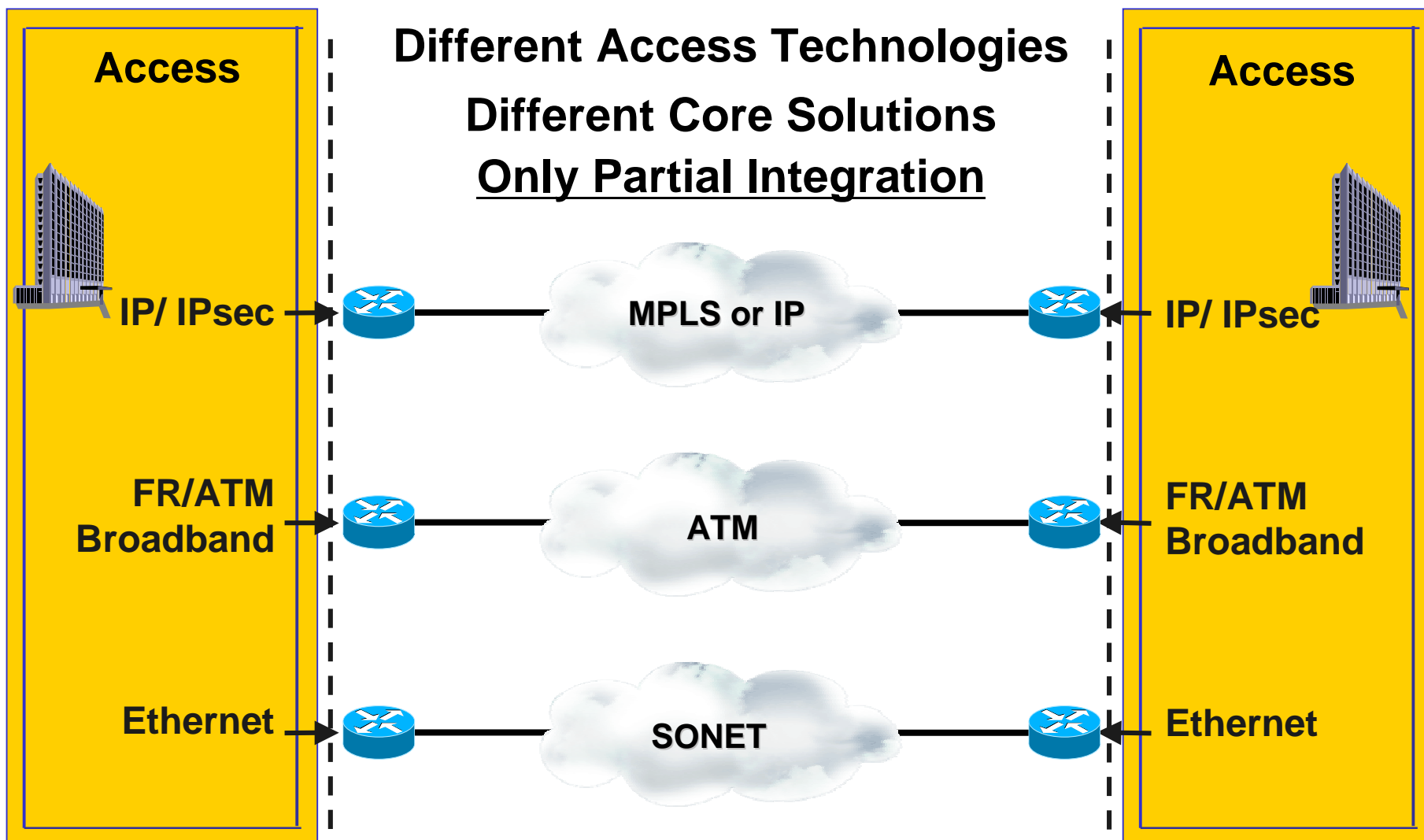
Why is L2VPN needed?

- Allows SP to have a **single infrastructure** for both IP and legacy services
 - Migrate legacy ATM and Frame Relay services to MPLS/IP core without interruption to existing services
 - Provisioning new L2VPN services is **incremental (not from scratch)** in existing MPLS/IP core
 - **Capital and Operational savings** of converged IP/MPLS network
- SP provides new **point-2-point** or **point-2-multipoint** services
 - Customer can have their own routing, qos policies, security mechanisms, etc
...
- Based on IETF drafts that promote open architecture and vendor interoperability

VPN Deployments Today

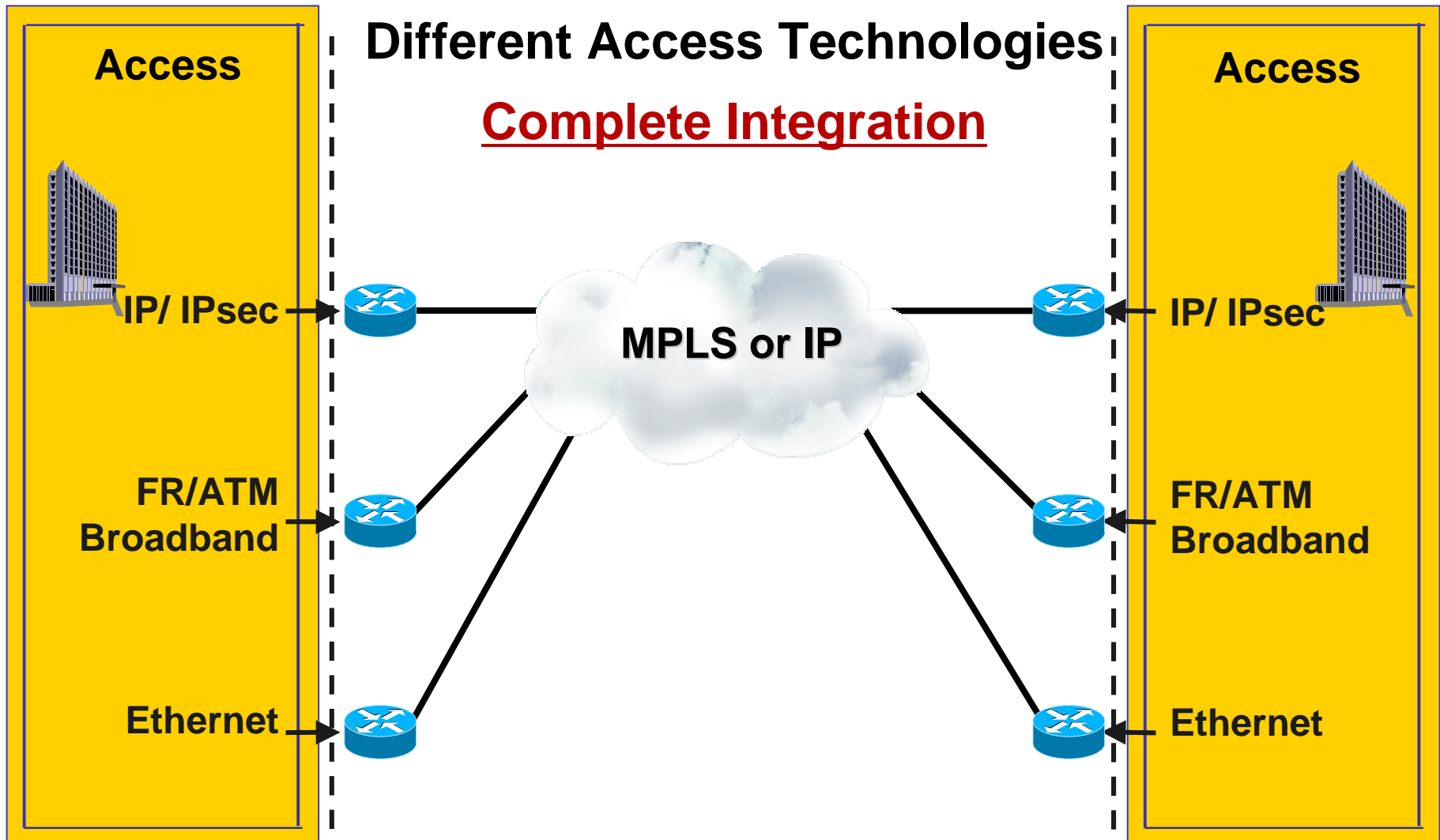
Technology & VPN Diversity

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Consolidated Core supports ...

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Layer 3 and Layer 2 VPN Characteristics

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LAYER 3 VPNS

- SP devices forward customer packets based on **Layer 3 information** (e.g. IP addresses)
- SP is involved in customer IP routing
- Support for **any access** or backbone technology
- **IP** specific
- **Foundation for L4–7 services!**
- Example: RFC 2547bis VPNs (L3 MPLS-VPN)

LAYER 2 VPNS

- SP devices forward customer frames based on **Layer 2 information** (e.g. DLCI, VPI/VCI, MAC, VLAN ID)
- Enterprise stays in **control** of L3 policies (Routing, QoS)
- No SP involvement in customer IP routing
- **Multiprotocol** support
- Example: FR—ATM—Ethernet

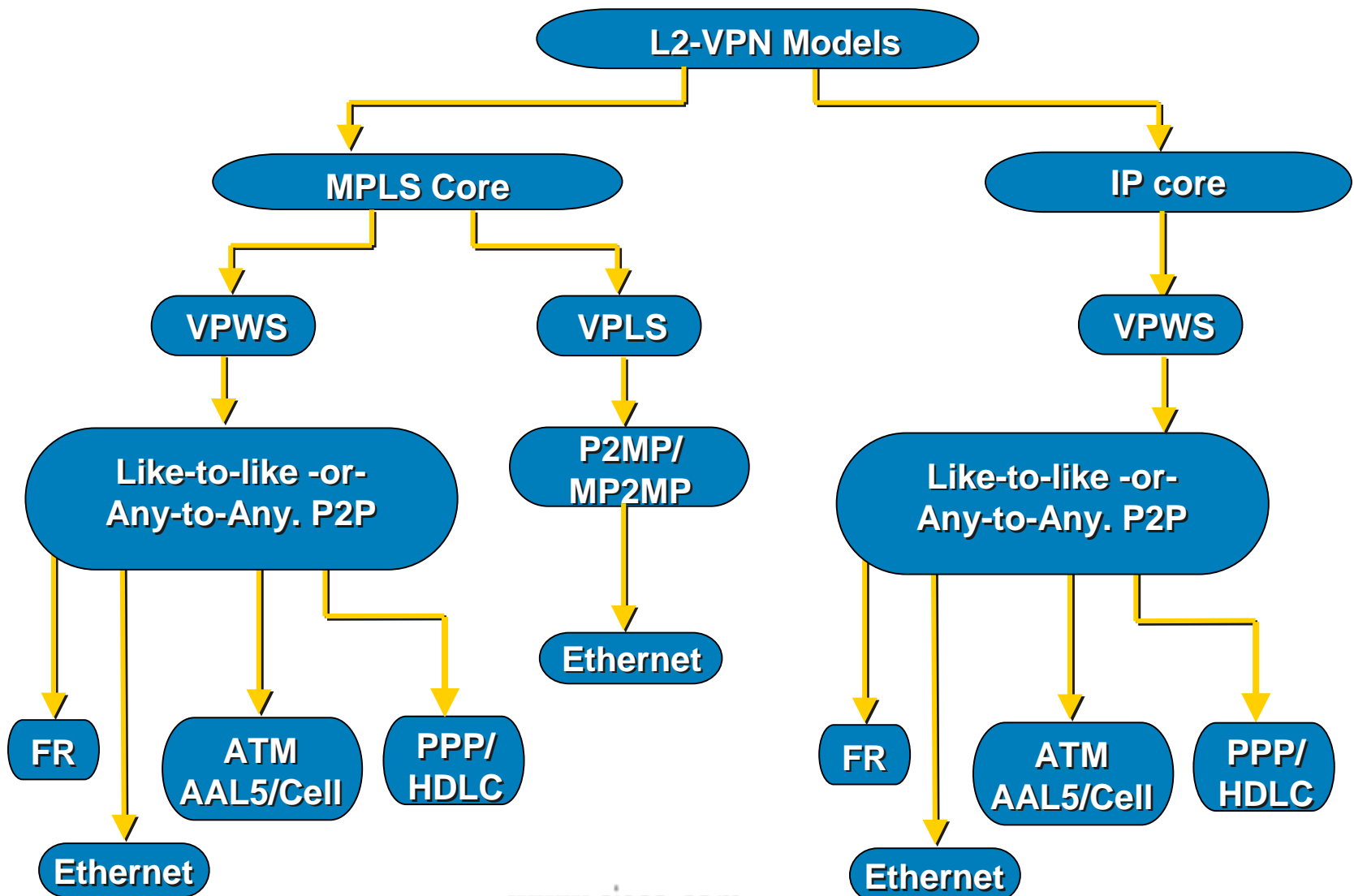
The Choice of L2VPN over L3VPN Will Depend on **How Much Control** the Enterprise Wants to Retain.
L2 VPN Services Are **Complementary** to L3 VPN Services

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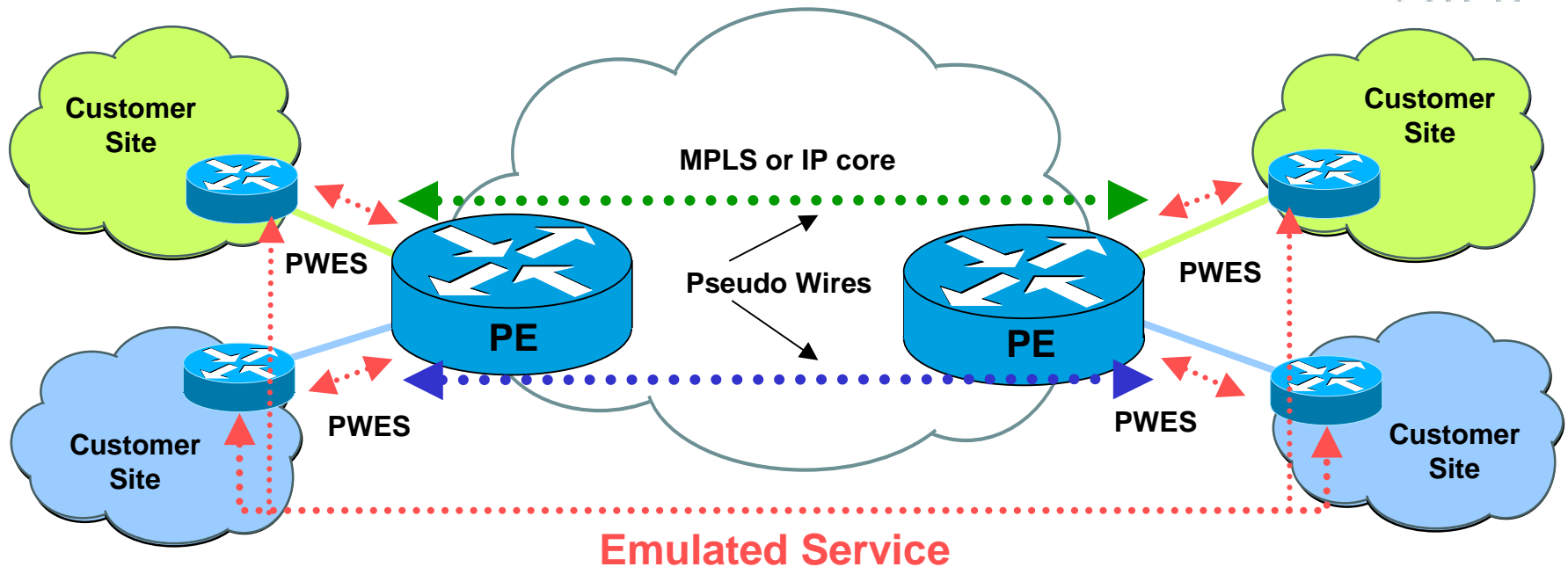
- Topics:
 - L2VPN Introduction
 - **L2VPN Models**
 - Quality of Service
 - Tunnel Stitching
 - IETF drafts
 - Summary

L2VPN Models



Pseudo Wire Reference Model

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A pseudo-wire (PW) is a connection between two provider edge (PE) devices which connects two pseudo-wire end-services (PWESs)

Emulated Services:

- Ethernet
- 802.1Q (VLAN)
- ATM VC or VP
- HDLC
- PPP
- Frame Relay VC

VPWS Pseudo Wire – Basic Building Blocks

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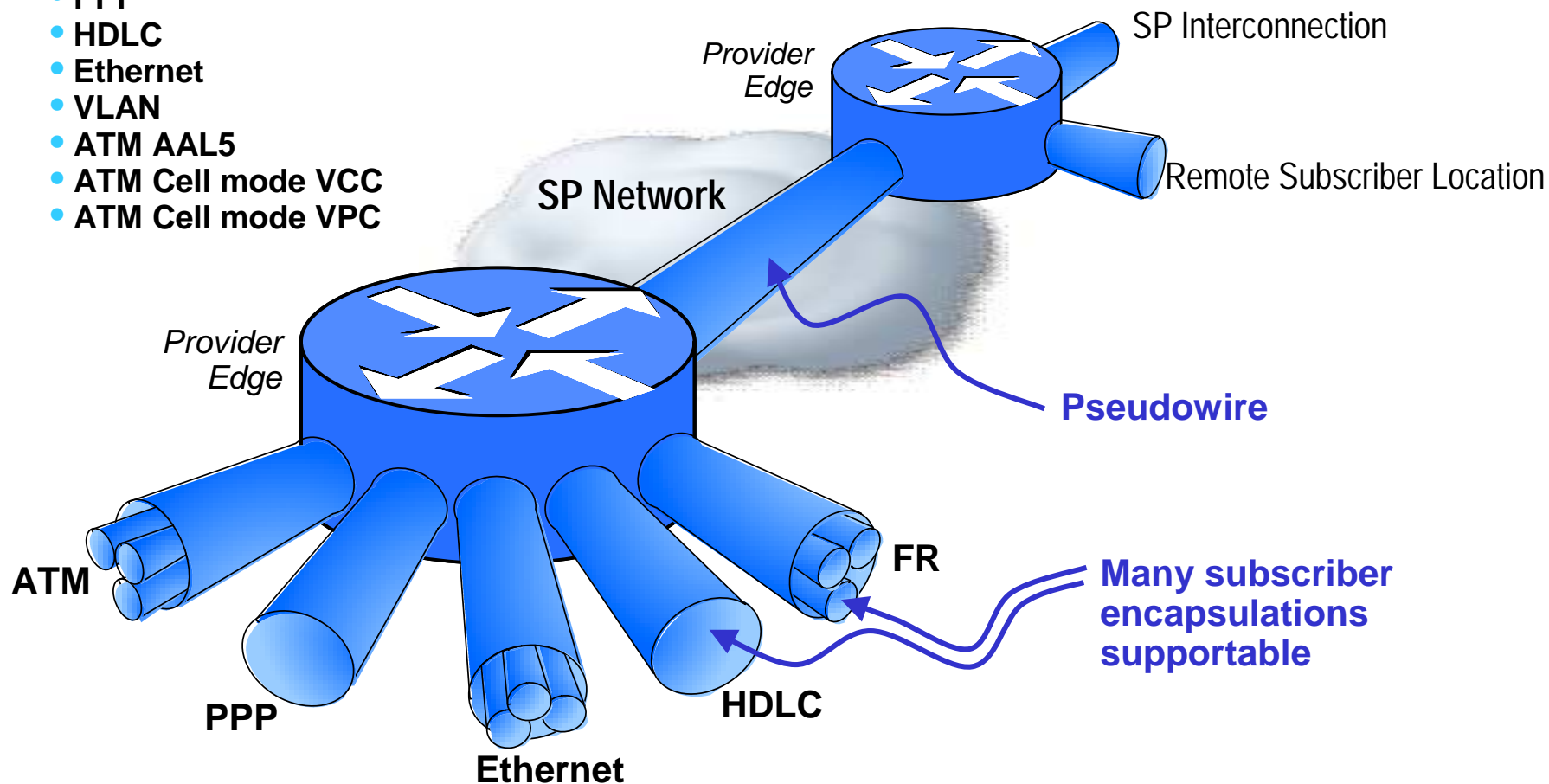
- 'Emulated Circuits' use 3 layers of encapsulation
 - **Tunnel Header**
 - to get PDU from ingress to egress PE; could be an MPLS label, GRE tunnel, L2TP tunnel
 - **Demultiplexer field**
 - to identify individual circuits within a tunnel; could be an MPLS label or GRE key
 - **Emulated VC encapsulation**
 - information on enclosed Layer-2 PDU; implemented as a 32-bit control word
 - **L2 PDU data**

VPWS - Encapsulations

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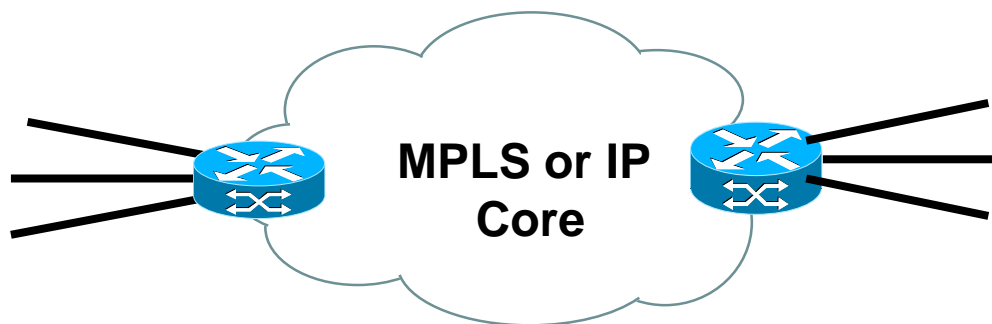
- Pseudo wire encapsulations include:

- Frame Relay
- PPP
- HDLC
- Ethernet
- VLAN
- ATM AAL5
- ATM Cell mode VCC
- ATM Cell mode VPC



- **Like-to-Like Transport Connectivity:**
 - Pseudo Wire end-points of the **same** attachment circuit type
- **Any-to-Any Transport Connectivity:**
 - Pseudo Wire end-points of **disparate** attachment circuit type

Frame Relay
ATM
Ethernet
VLAN
PPP
HDLC

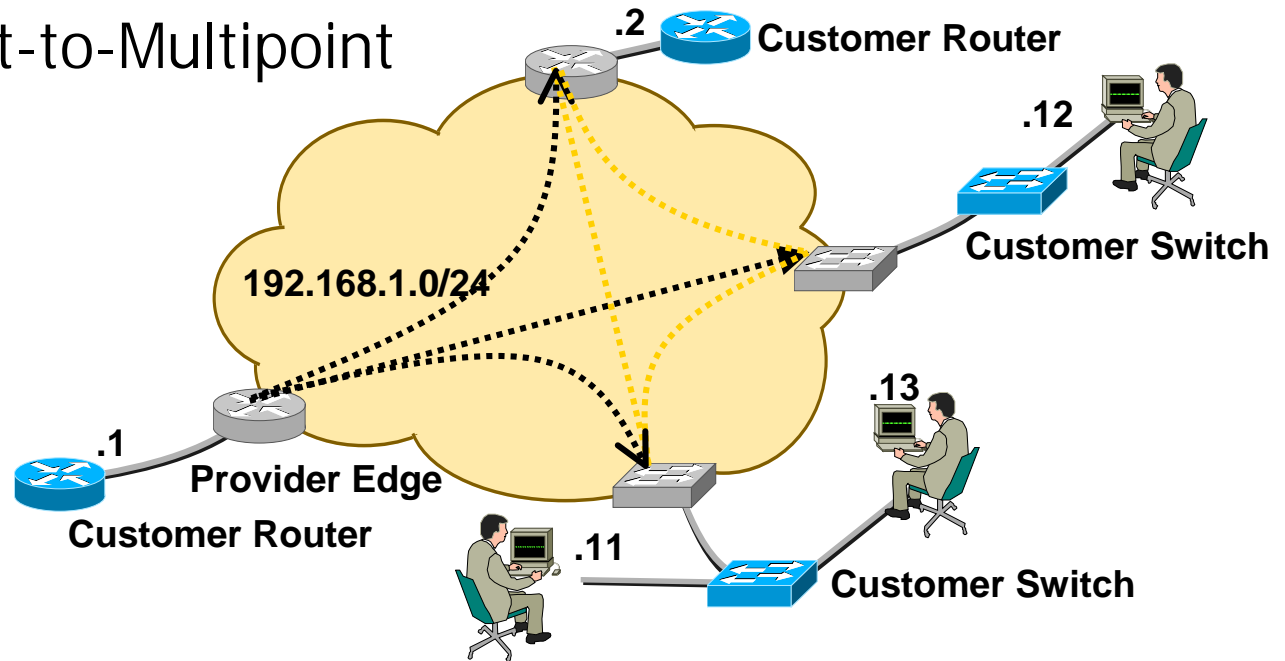


Frame Relay
ATM
Ethernet
VLAN
PPP
HDLC

VPLS – Virtual Private LAN Services

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Point-to-Multipoint



- Single bridge domain (1 VLAN)
- Single subnet
- Single SLA
- Single protection attributes
- Single availability attributes
- Mac-address learning and forwarding

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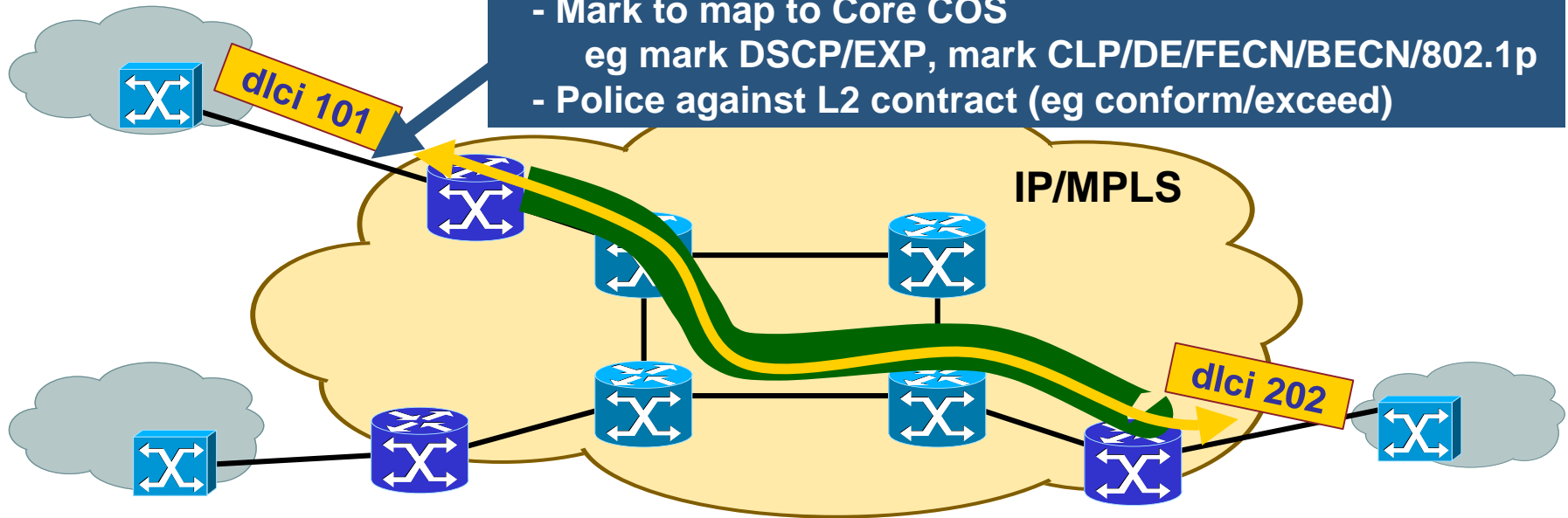
- Topics:
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VPWS Edge QoS: Ingress Edge

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Ingress Edge QoS Mechanisms:

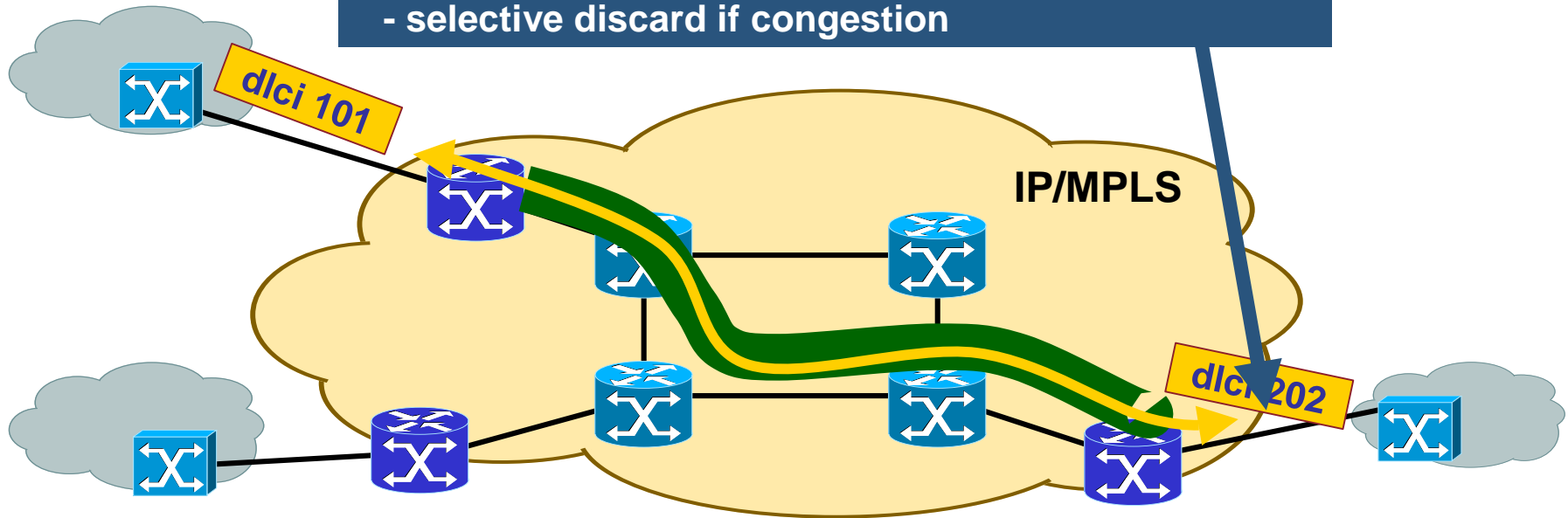
- Classify traffic
 - eg which L2 circuit (DLCI, PVC, VLAN)
 - eg L2 QoS marking (CLP/DE, 802.1p COS)
- Mark to map to Core COS
 - eg mark DSCP/EXP, mark CLP/DE/FECN/BECN/802.1p
- Police against L2 contract (eg conform/exceed)



VPWS Edge QoS: Egress Edge

Egress Edge QoS Mechanisms:

- Classify traffic
- Schedule on egress interface (possibly based on popped EXP values)
- selective discard if congestion



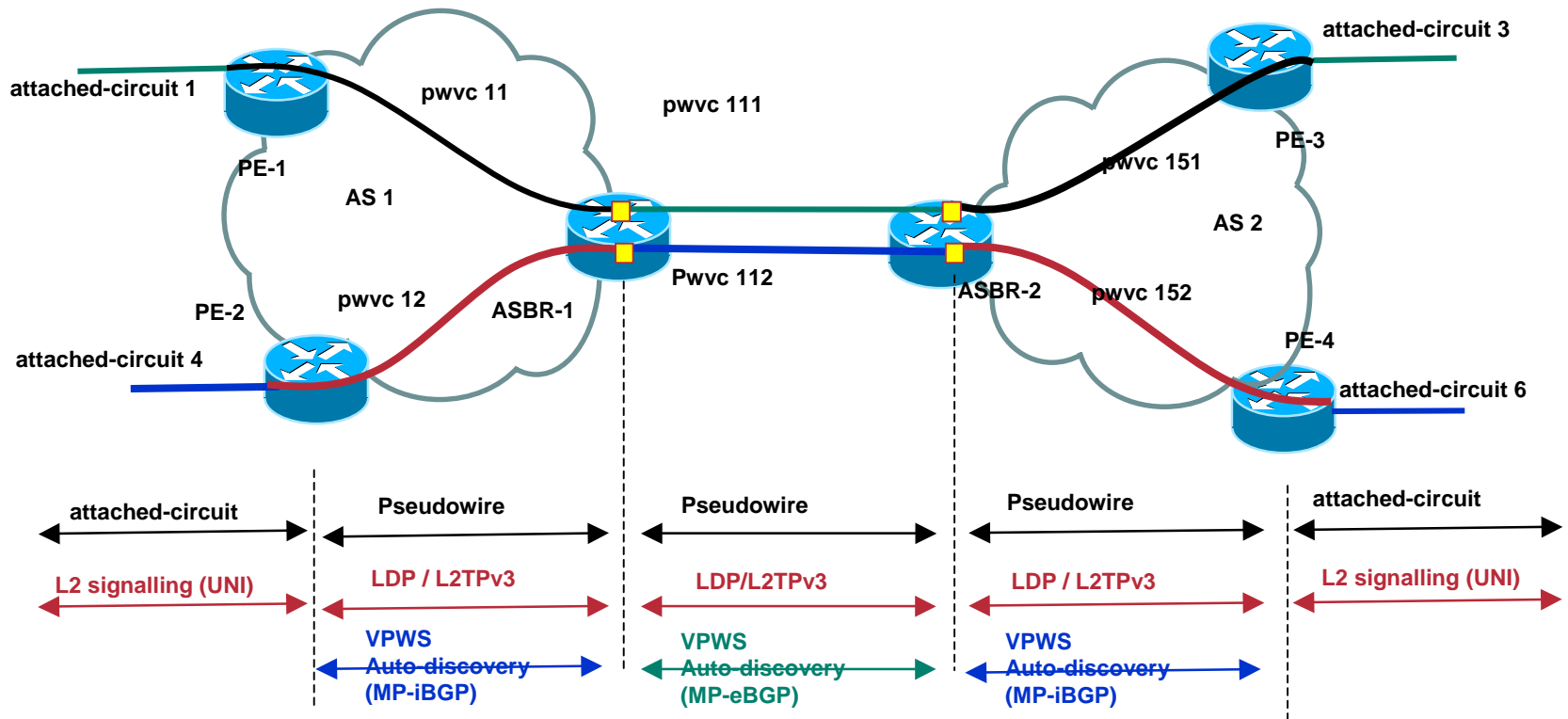
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 - **L2VPN End-to-End Connectivity**
 - IETF Drafts

L2VPN End to End Connectivity

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Pseudo Wire Stitching Model

IETF Drafts

- [1] RFC 3031 - Multiprotocol Label Switching Architecture
- [2] RFC 3036 - LDP Specification
- [3] RFC 2547 - BGP/MPLS VPNs
- [4] RFC 3107 - Carrying Label Information in BGP-4
- [5] draft-martini-l2circuit-encap-mpls-06.txt
- [6] draft-martini-l2circuit-trans-mpls-13.txt
- [7] draft-ietf-l2vpn-signaling-01.txt
- [8] draft-sajassi-l2vpn-interworking-01.txt
- [9] draft-shah-l2vpn-arp-mediation-03.txt
- [10] Pseudowire Setup and Maintenance using LDP- draft-ietf-pwe3-control-protocol-14.txt
- [11] Service Provider requirements for PWs- draft-willis-pwe3-requirements-00.txt
- [12] PWE3 Architecture- draft-ietf-pwe3-arch-07.txt
- [13] Encapsulation Methods for Transport of Ethernet Frames Over IP/MPLS Networks- draft-ietf-pwe3-ethernet-encap-08.txt
- [14] Pseudo Wire Switching-draft-martini-pwe3-pw-switching-01.txt
- [15] Frame Relay over Pseudo-Wires- draft-ietf-pwe3-frame-relay-03.txt
- [16] PWE3 Control Word- draft-bryant-mcpherson-pwe3-cw-00.txt
- [17] Encapsulation Methods for Transport of ATM Over MPLS Networks- draft-ietf-pwe3-atm-encap-07.txt
- [18] PWE3 ATM Transparent Cell Transport Service- draft-ietf-pwe3-cell-transport-01.txt
- [19] Pseudo Wire (PW) Management Information Base- draft-ietf-pwe3-pw-mib-05.txt

Summary

- L2VPN provides transport of Layer-2 PDUs across an MPLS/IP backbone
- VPWS is a point-to-point L2VPN
 - It allows Like-to-Like and Any-to-Any transport connectivity
- VPLS is a point-to-multipoint L2VPN
- L2VPN QoS has capabilities to maintain strict SLA requirements comparable to L2 switches

Open Discussion

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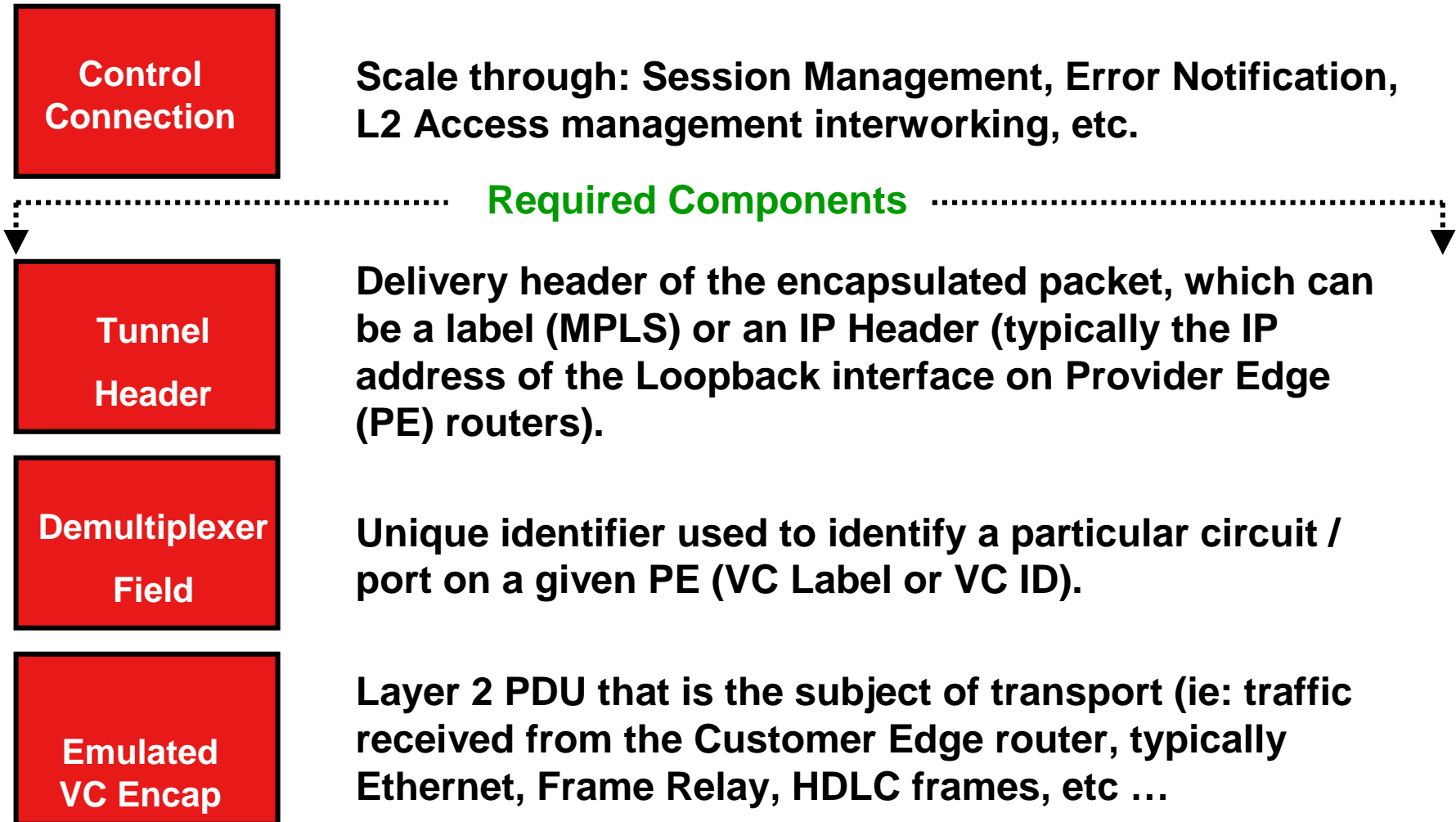
Question & Answer

Backup slides

- Pseudo wire emulation edge to edge (PWE3)
 - A mechanism that emulates the essential attributes of a service (such as a T1 leased line or FR) over a PSN
- Packet switched network (PSN)
 - Within the context of PWE3, this is a network using IP or MPLS as the mechanism for packet forwarding
- Attachment circuit (AC)
 - Physical or VC attaching a CE to a PE.
- One PW connects two ACs
 - Creates VCs between two CEs
- Packet switching tunnel
 - A tunnel across a PSN inside which one or more PW can be carried

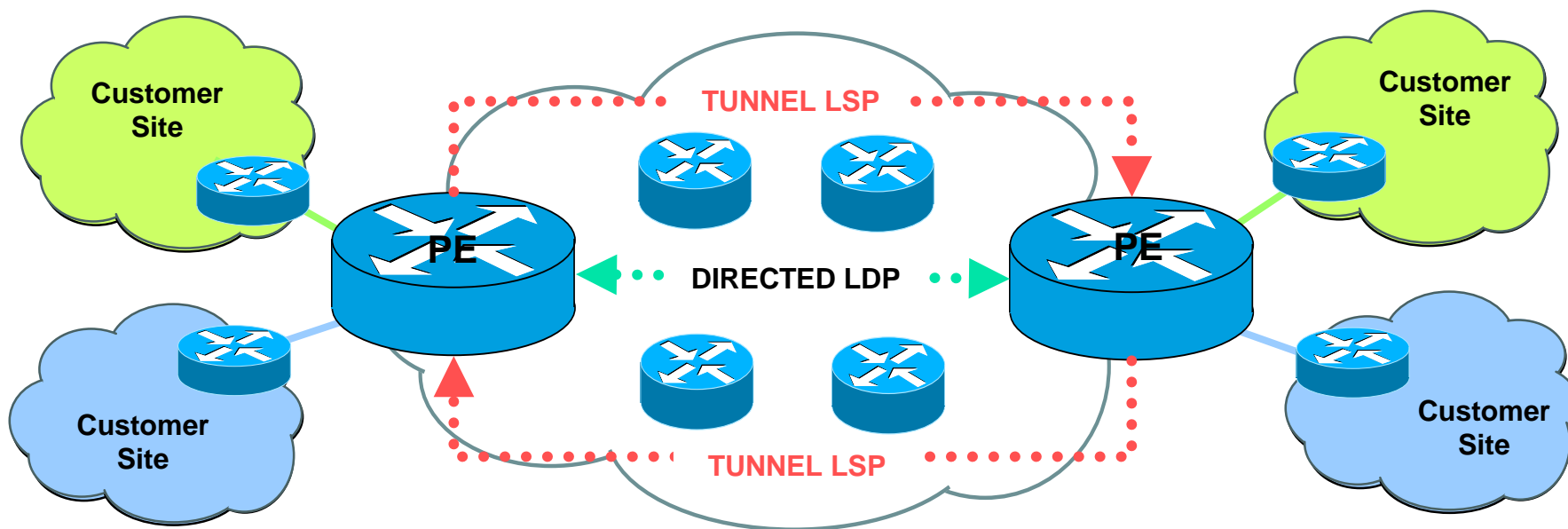
VPWS Pseudo Wire – Basic Building Blocks

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“Connectivity between PEs assumed; verified through ICMP or LSP ping.”

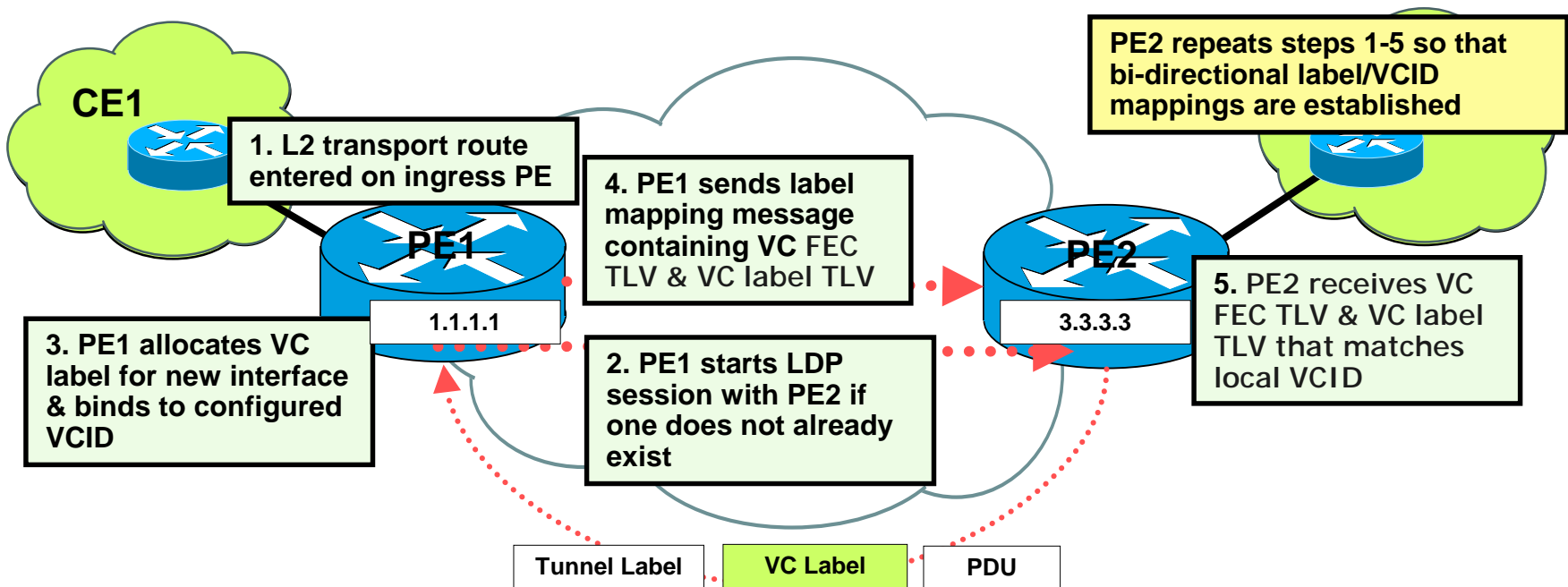
VPWS – Label Distribution



- Tunnel LSPs between PE routers
 - to transport PW PDU from PE to PE using **tunnel labels**
- MPLS core: Directed LDP session between PE routers
- IP core: L2TP control channel between PE routers
 - to exchange VC info, such as **VC labels** and **control word**

VPWS – Label Mapping Exchange

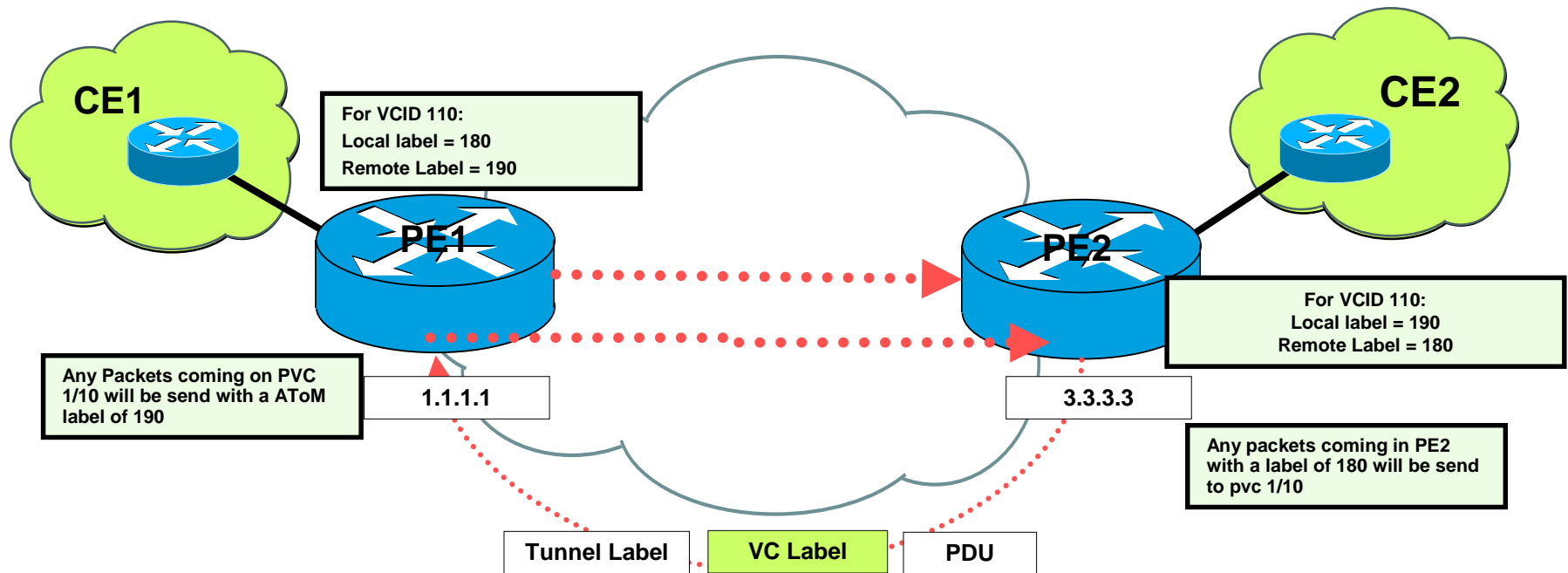
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Bi-directional Label/VCID mapping exchange

VPWS – After Label Mapping Exchange

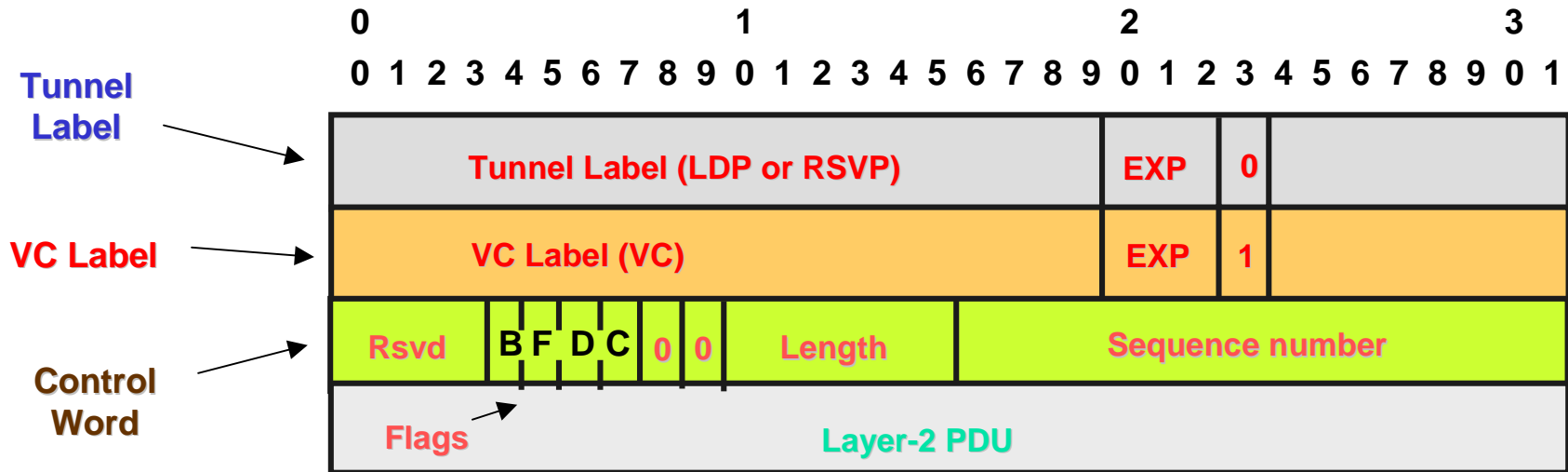
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Bi-directional Label/VCID mapping exchange

VPWS – Generic Packet Format

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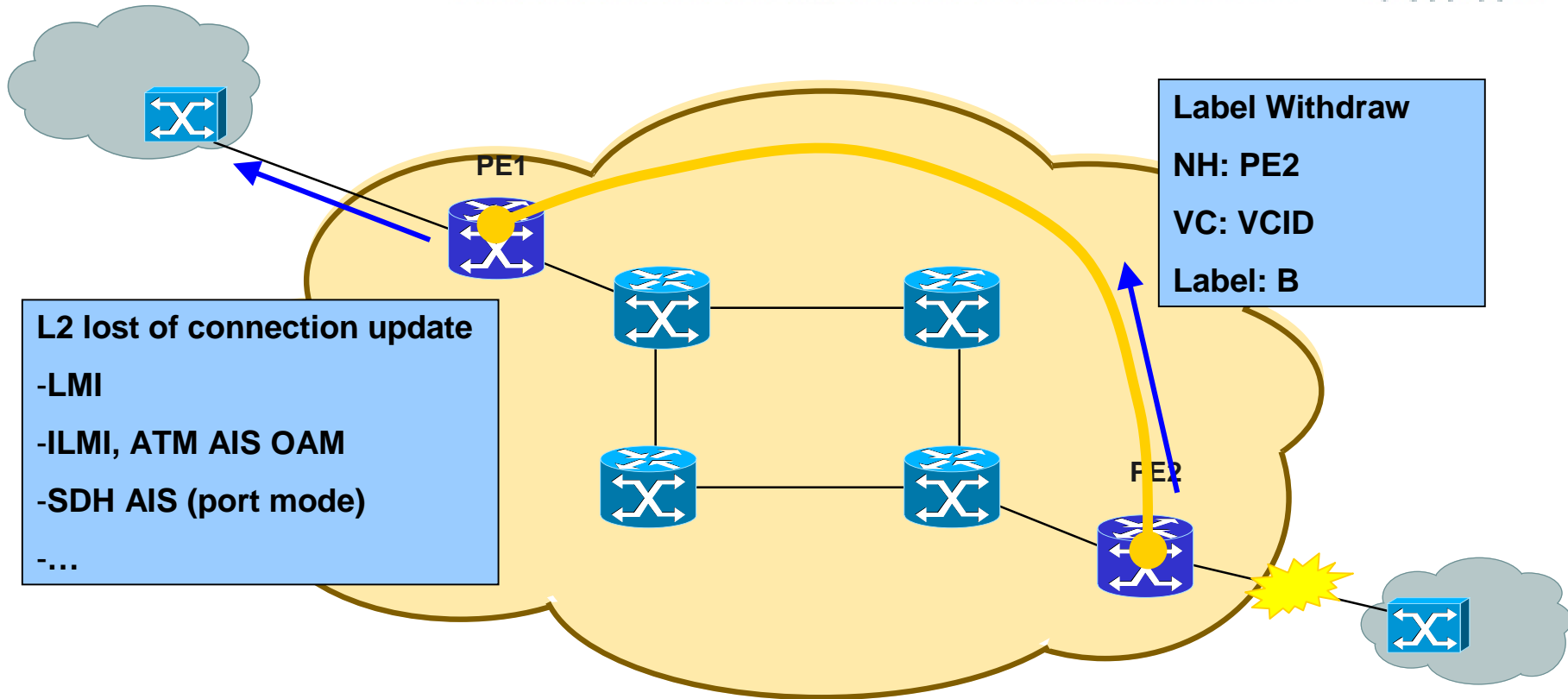


- When transporting layer 2 protocol over an IP or MPLS backbone:
 - Sequence number of the packets needs to be preserved
 - Control bits carried in layer 2 frame may need to be transported
 - Small packets are padded if the minimum MTU of media > actual packet size

Control Word	
Encap.	Required
CR	No
AAL5	Yes
Eth	No
FR	Yes
HDLC	No
PPP	No

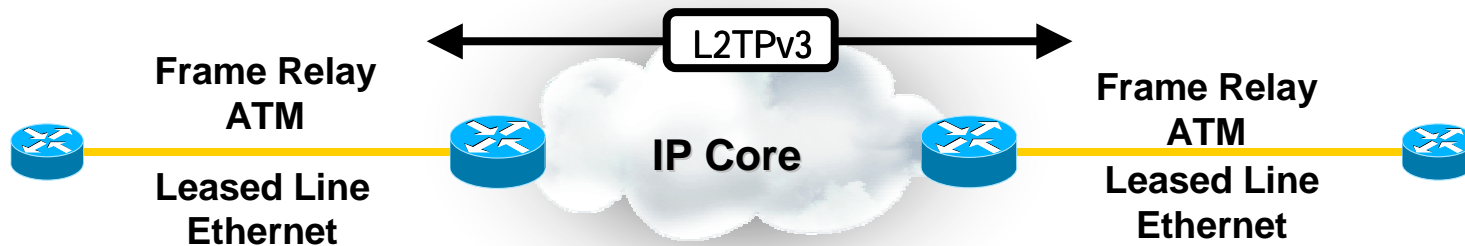
L2VPN: Loss of connectivity and Label Withdraw

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Layer 2 Tunneling Protocol version 3

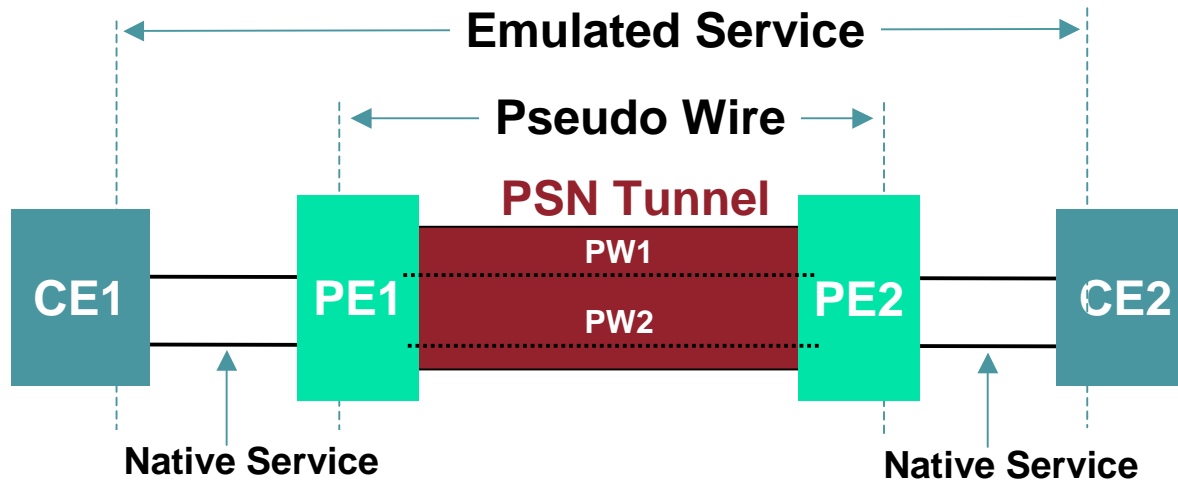
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- L2TPv3 for customers that prefer a **native IP** network
- Provides ability to **transport layer 2** traffic across IP packet-based core networks
- A **standards track** open architecture allows extensibility to many transport types
- Configuration on the **edge routers** (PEs) only!

Virtual Circuit Connection Verification (VCCV)

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- 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

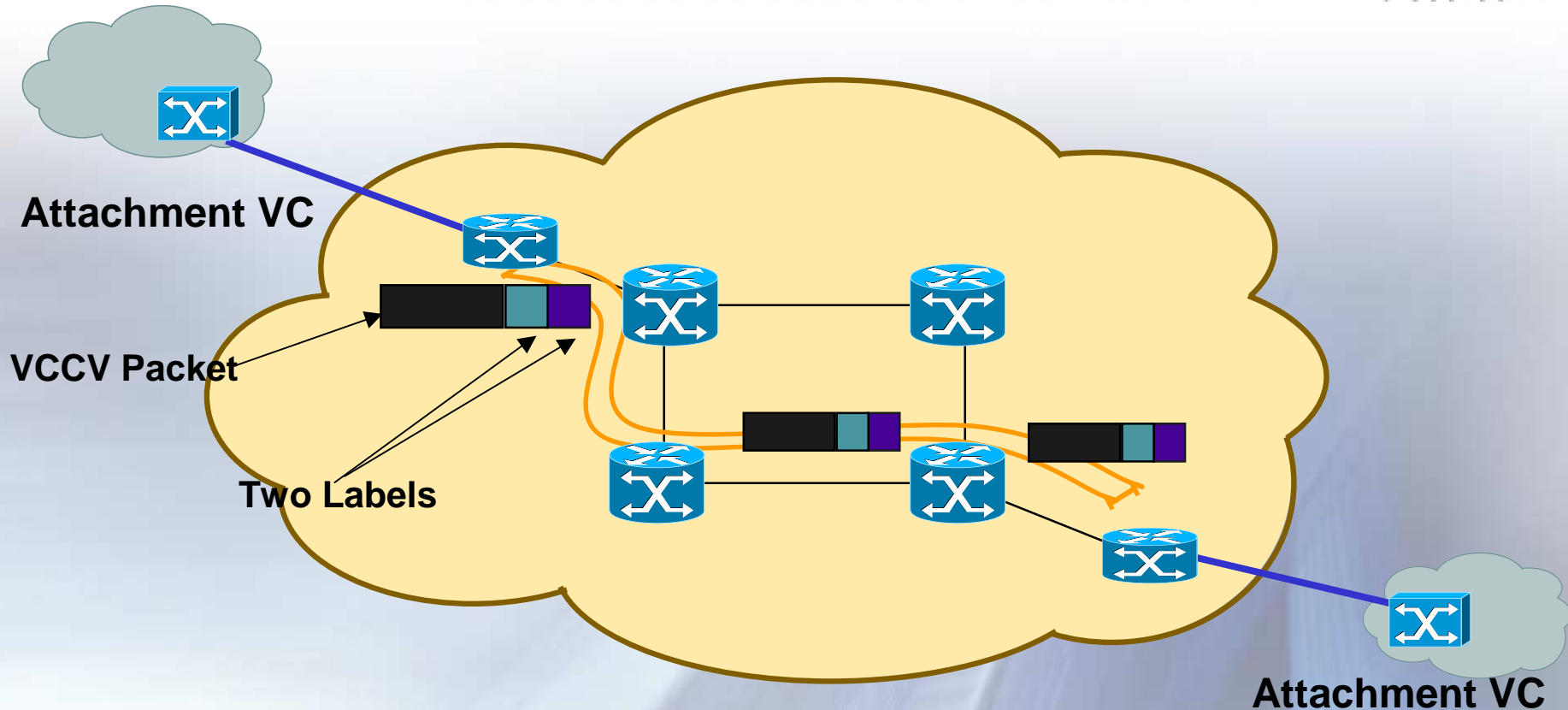
VCCV Overview

- Mechanism for connectivity verification of PW
- Really a control channel
- 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
- VCCV results may drive OAM/LMI injection on corresponding AC(s)
- <http://www.ietf.org/internet-drafts/draft-ietf-pwe3-vccv-02.txt>

PWE3 OAM Example

Connection Verification

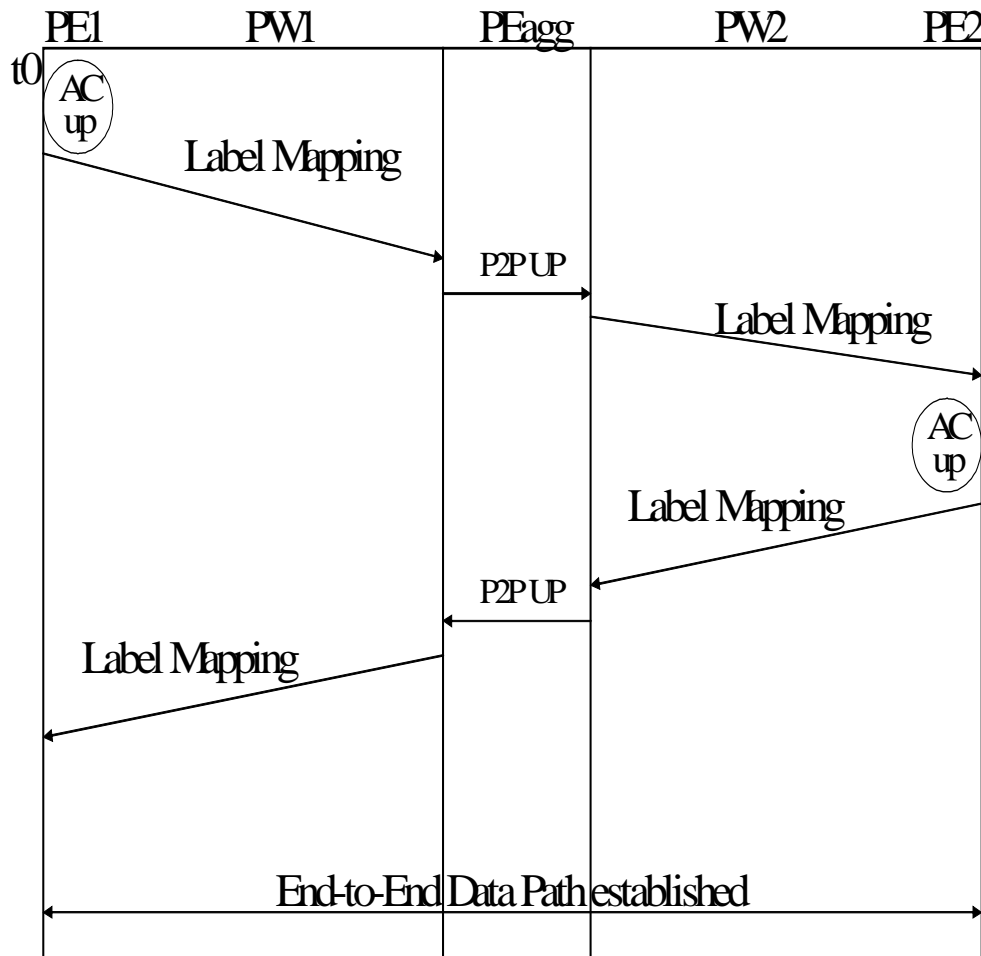
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- Verify/Trace Path of LSP Tunnels between PEs.
- Verify/Trace Emulated services (e.g. ATM, FR) mapped to Attachment VCs
- Trace/Verify packets must take same path as data packets.

L2VPN: MPLS to MPLS Tunnel Stitching Protocol Setup

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- At the pseudo wire stitch point ASBR2 will send VC **label X** to ASBR1
- ASBR1 will swap its VC label with **label X**
- Point-to-point session is up
- End to end data path is established

Some Currently Defined VC-Types

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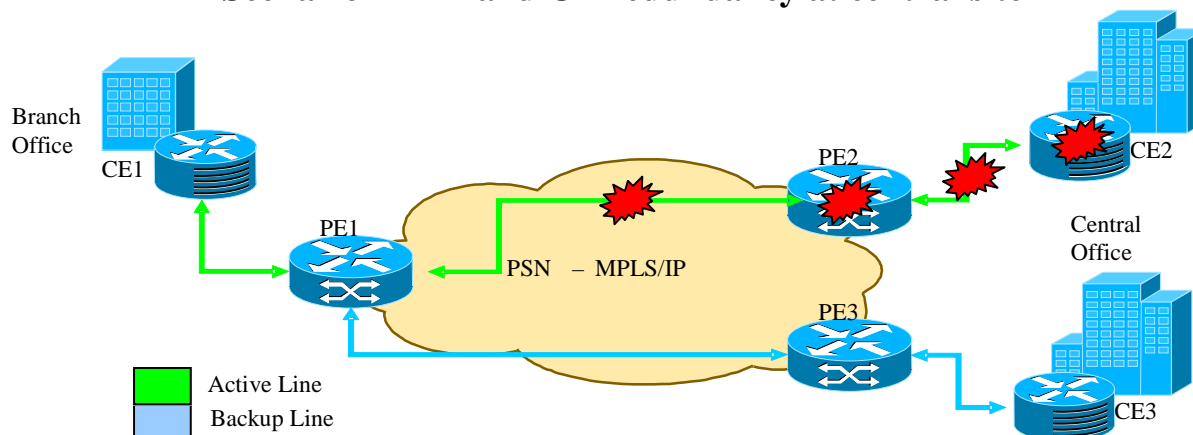
<u>PW type</u>	<u>Description</u>	
0x0001	Frame Relay DLCI	<i>! Frame Relay</i>
0x0002	ATM AAL5 SDU VCC transport	<i>! ATM AAL5 SDU</i>
0x0003	ATM transparent cell transport	<i>! ATM Cell Port Mode</i>
0x0004	Ethernet Tagged Mode	<i>! Ethernet VLAN</i>
0x0005	Ethernet	<i>! Ethernet</i>
0x0006	HDLc	<i>! HDLC</i>
0x0007	PPP	<i>! PPP</i>
0x0008	SONET/SDH Circuit Emulation Service Over MPLS (CEM) [Note1]	
0x0009	ATM n-to-one VCC cell transport	<i>! ATM Cell VC Mode</i>
0x000A	ATM n-to-one VPC cell transport	<i>! ATM Cell VP Mode</i>
0x000B	IP Layer2 Transport	<i>! Interworking IP</i>
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 (SAToP)	
0x0012	Structure-agnostic T1 (DS1) over Packet (SAToP)	
0x0013	Structure-agnostic E3 over Packet (SAToP)	
0x0014	Structure-agnostic T3 (DS3) over Packet (SAToP)	
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)

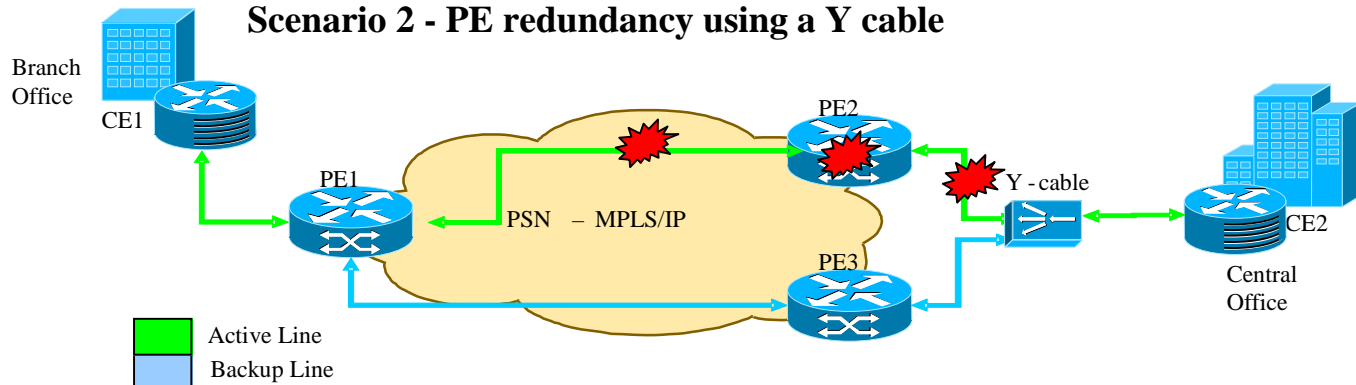
L2VPN Redundancy Scenarios

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Scenario 1 - PE and CE redundancy at central site

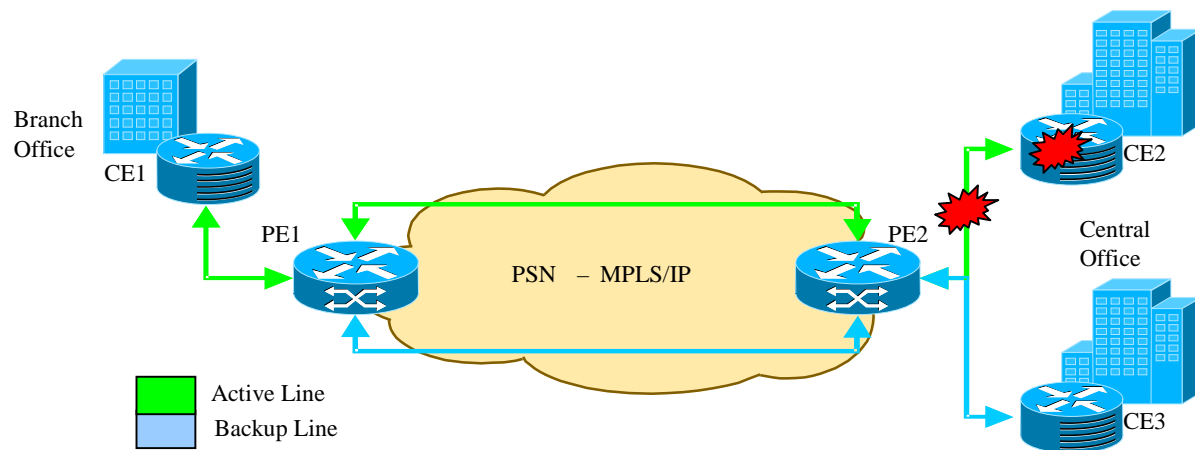


Scenario 2 - PE redundancy using a Y cable

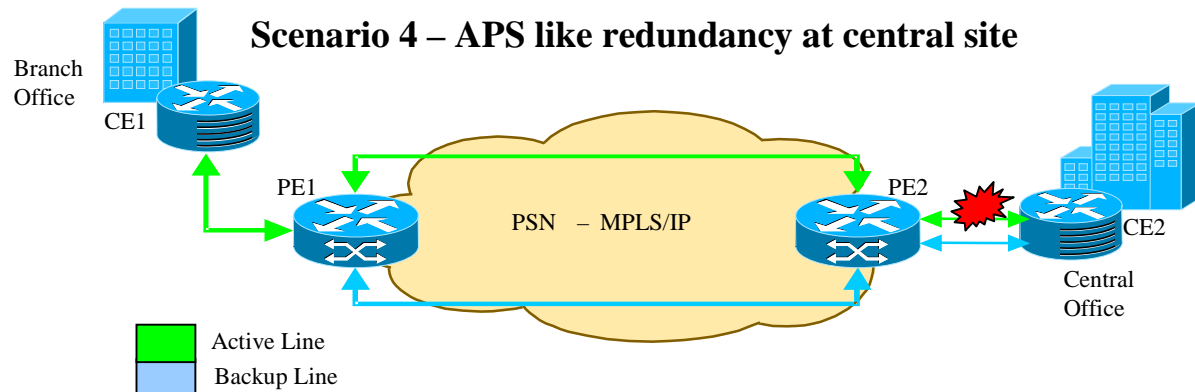


L2VPN Redundancy Scenarios

Scenario 3 - Circuit redundancy at central site



Scenario 4 - APS like redundancy at central site



L2VPN End to End Redundant Solution

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- By combining L2VPN stitching and redundancy SPs can:
 - Offer end to end L2VPN services across multiple BGP domains
 - Protect primary end to end L2VPN path with a backup path
 - Apply security profiles when L2VPN path enters an un-trusted domain
 - Apply QoS policing and shaping to maintain SLAs

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