Cisco IOS® MPLS Virtual Private LAN Service (VPLS) Technical Deployment Overview

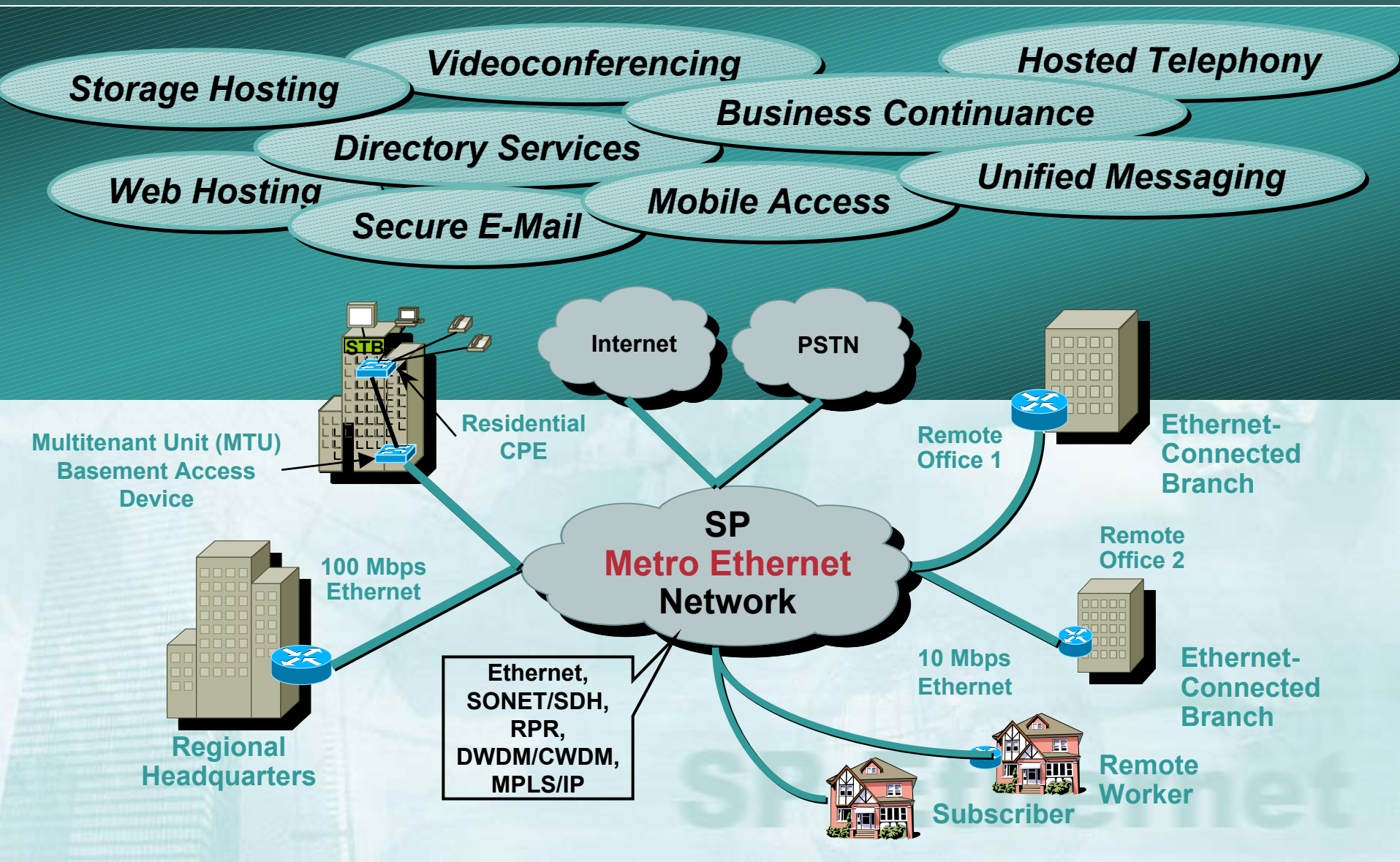
Enabling Innovative Services

Agenda

- Introduction
- VPLS Technical Overview
- VPLS Architectures
- Deployment Scenarios
- Summary

Introduction

Metro Ethernet: Emerging Multiservice Access Opportunity



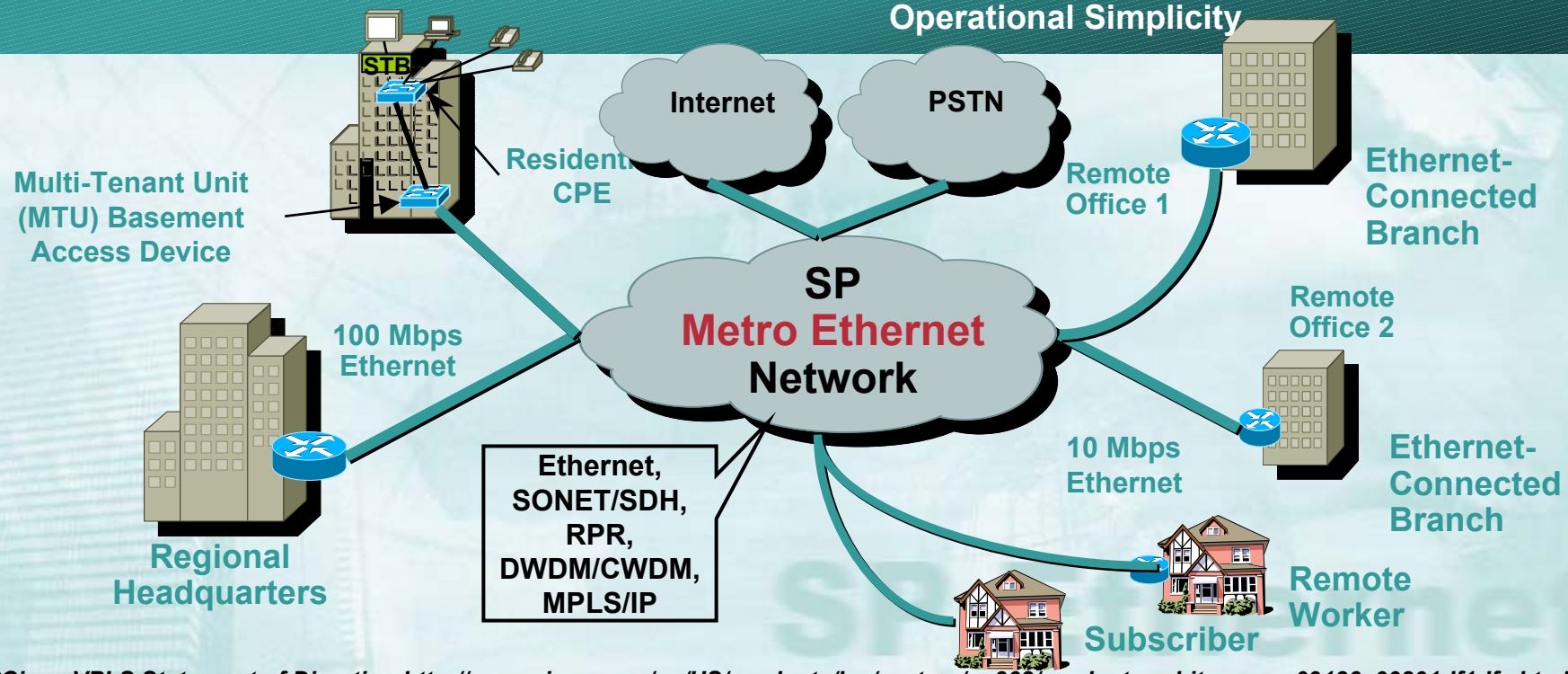
Metro Ethernet: Business Drivers*

Service Provider

- Revenue Growth
  - New, Differentiated Services
  - Expanded Enterprise Penetration
- Cost Efficiencies
  - Network Convergence
  - Flexible Bandwidth Provisioning
  - Best Value for Increased Bandwidth

Enterprise

- Business Demands
  - Increased Productivity
  - Peer-to-Peer Applications
- Service Expectations
  - Scalable Bandwidth (from 1Mbps to 1Gbps)
  - Customized Services
  - Multipoint Connectivity
  - Operational Simplicity

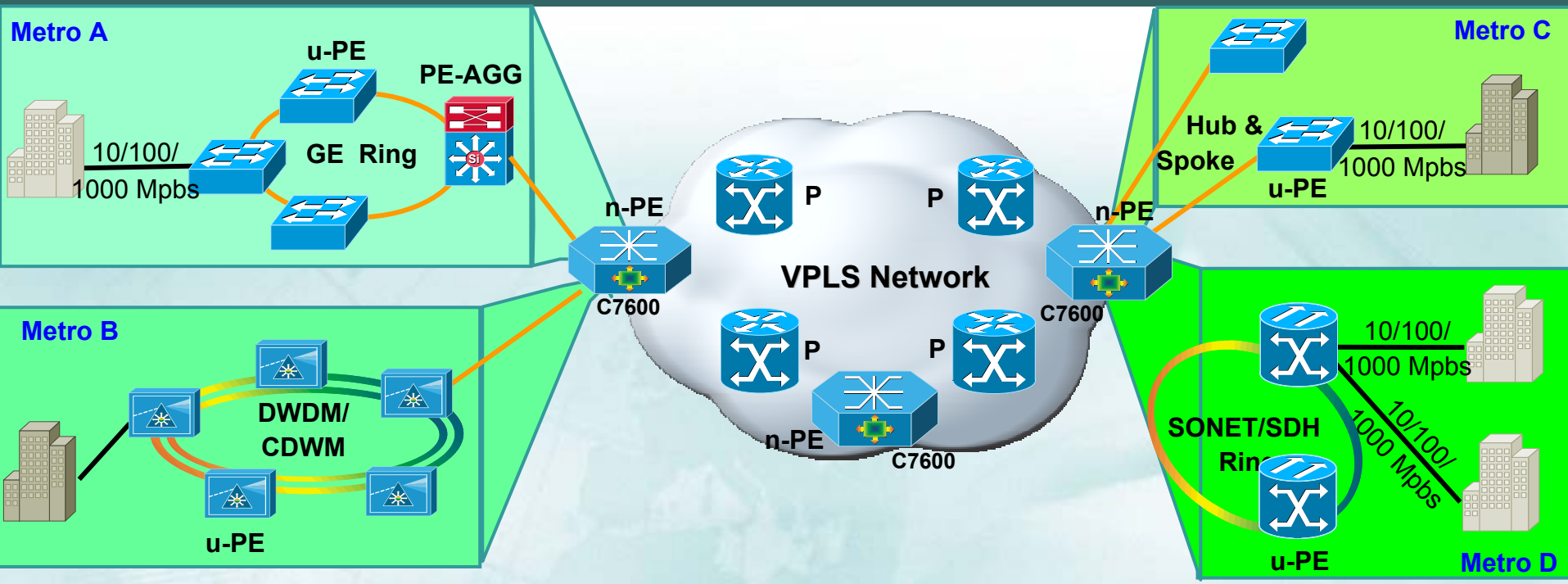


*Cisco VPLS Statement of Direction http://www.cisco.com/en/US/products/hw/routers/ps368/products_white_paper09186a00801df1df.shtml

The Ethernet Advantage

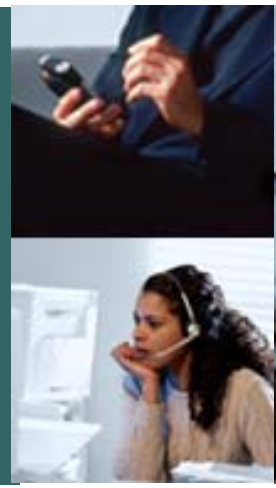
- Connectionless, IP aware-operation
- Distributed intelligence
- Inexpensive, scalable bandwidth options
- L2 VPNs
  - Point-to-point
  - Multipoint
- L3 VPNs
- High speed transport enables innovative services and applications
  - Storage, IP video conferencing
- Value added services
  - IP Telephony
  - IP video conferencing
  - High speed, bBusiness class Internet
  - Managed Security
  - Managed Storage

VPLS Overview for Metro Ethernet

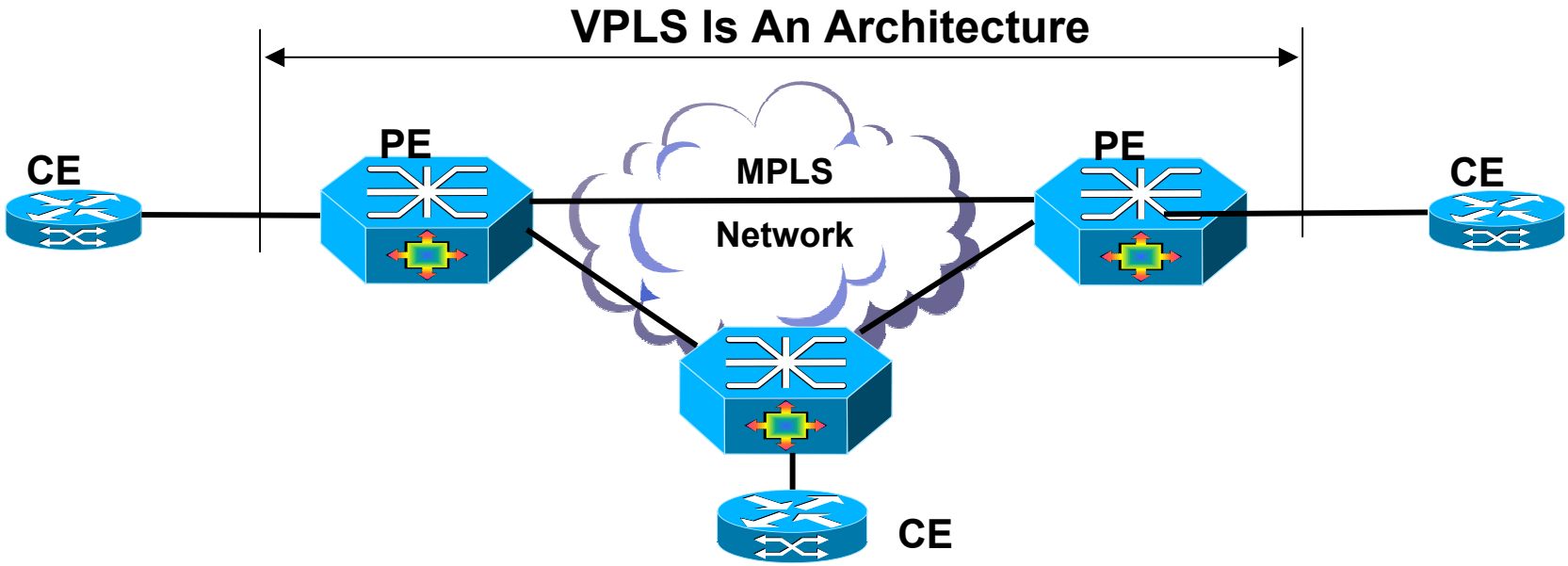


- Delivers Ethernet-based multipoint L2 VPN service
- Enhances L2 VPN scalability (geographic sites & no. of customers)
- Leverages existing SP MPLS Core
- Supports operational speeds of GB to 10 GB
- On track for IETF standardization: Draft Lasserre-Kompella
- Uses familiar Ethernet user network interface

VPLS Technical Overview



Virtual Private LAN Services (VPLS)

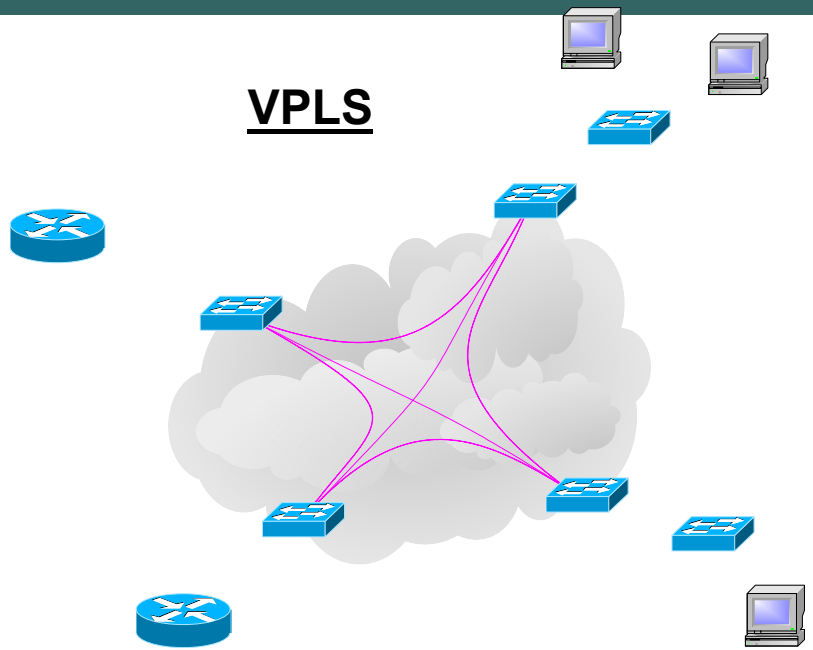


- VPLS defines an architecture that delivers Ethernet Multipoint Services (EMS) over an MPLS network
- VPLS operation emulates an IEEE Ethernet bridge
- Two VPLS drafts in existance

  Draft-ietf-l2vpn-vpls-ldp-01 ← Cisco's Implementation

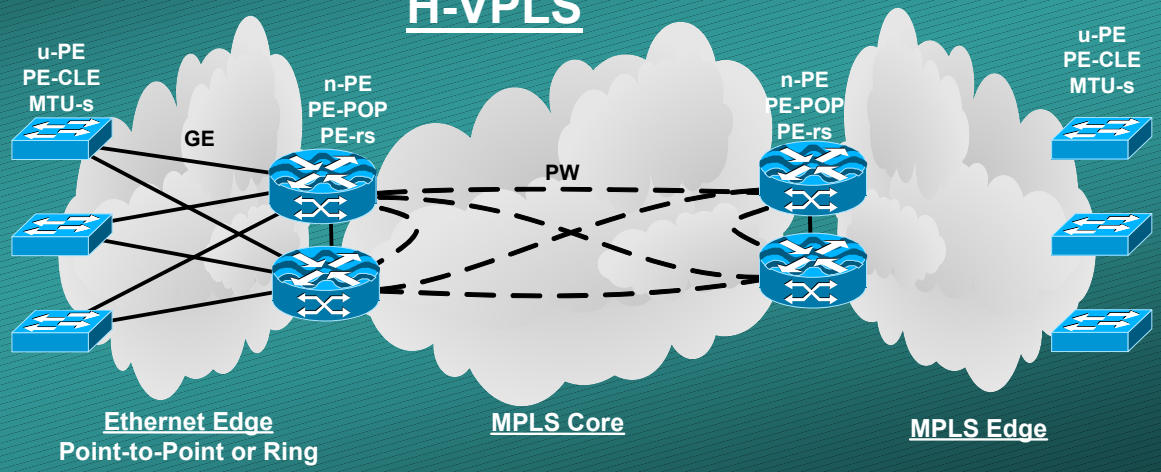
  draft-ietf-l2vpn-vpls-bgp-01

VPLS & H-VPLS

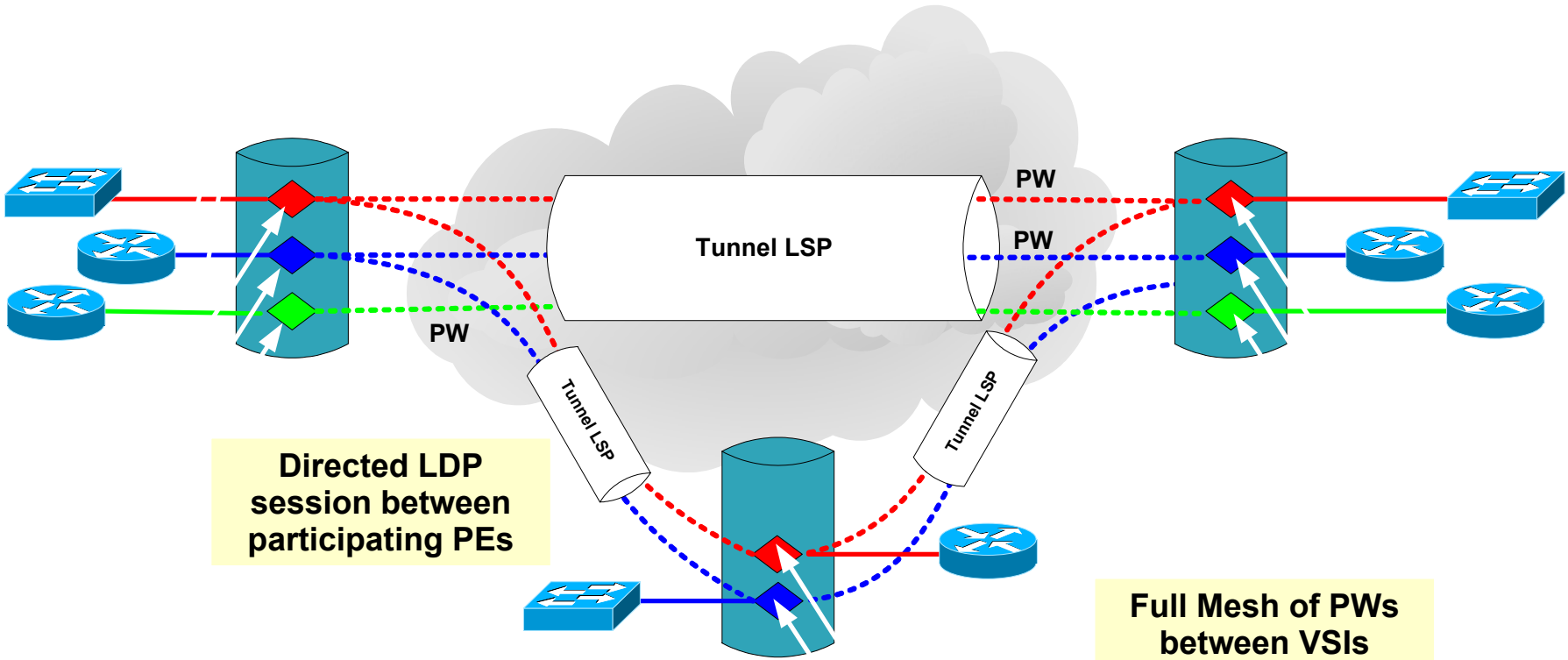


- **VPLS Direct Attachment**
  - Single Flat Hierarchy
  - MPLS to the Edge

- **H-VPLS**
  - Two Tier Hierarchy
  - MPLS or Ethernet Edge
  - MPLS Core



VPLS Components



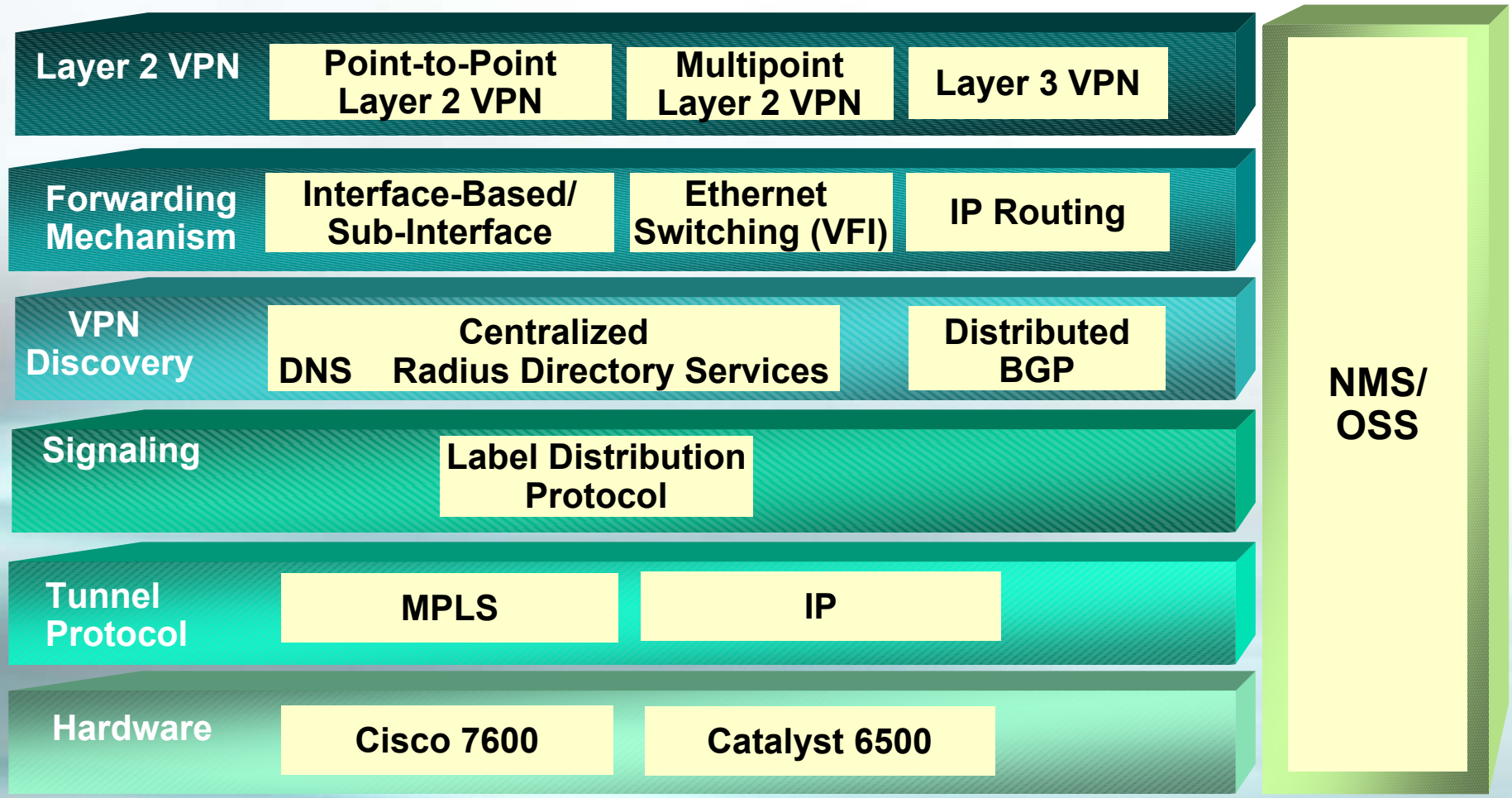
Legend

CE	- Customer Edge Device
n-PE	- network facing-Provider Edge
VSI	- Virtual Switch Instance
PW	- Pseudo-Wire
Tunnel LSP	- Tunnel Label Switch Path that provides PW transport

VPN & VPLS Desirable Characteristics

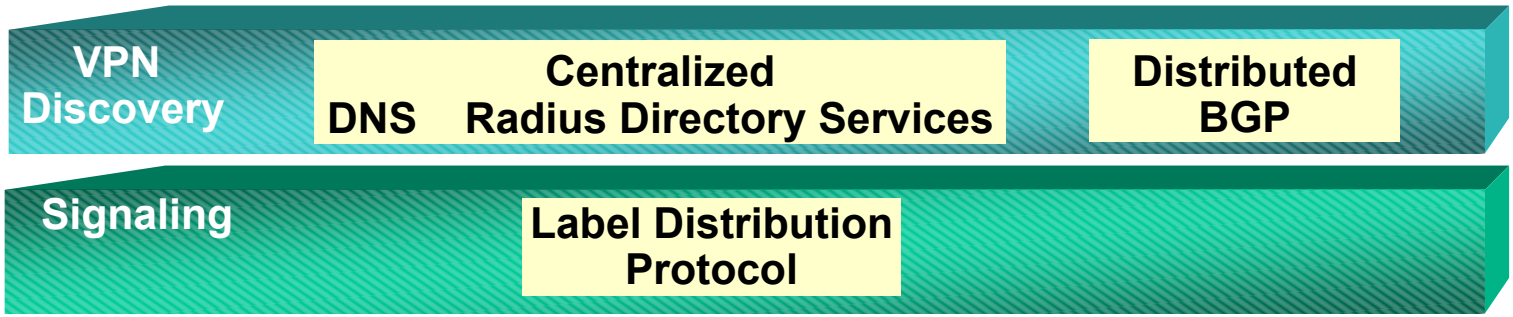
- **Auto-discovery of VPN membership**
  - **Reduces VPN configuration and errors associated with configuration**
- **Signaling of connections between PE devices associated with a VPN**
- **Forwarding of frames**
  - **AToM uses Interface based forwarding**
  - **VPLS uses IEEE 802.1q Ethernet Bridging techniques**
- **Loop prevention**
  - **MPLS Core will use a full mesh of PWs and "split-horizon" forwarding**
  - **H-VPLS edge domain may use IEEE 802.1s Spanning Tree, RPR, or SONET Protection**

Cisco VPLS Building Blocks



A Comprehensive Solution: Robust, Flexible, Scalable, Manageable

VPLS Auto-discovery & Signaling



- **Draft-ietf-l2vpn-vpls-ldp-01 does not mandate an auto-discovery protocol**
  - **Can be BGP, Radius, DNS, AD based**
- **Draft-ietf-l2vpn-vpls-ldp-01 describes using Targeted LDP for Label exchange and PW signaling**
  - **PWs signal other information such as Attachment Circuit State, Sequencing information, etc**
  - **Cisco IOS supports Targeted LDP for AToM and Virtual Private LAN Services**

VPLS: Layer 2 Forwarding Instance Requirements

A Virtual Switch MUST operate like a conventional L2 switch!

Flooding / Forwarding:

- MAC table instances per customer and per customer VLAN (L2-VRF idea) for each PE
- VSI will participate in learning, forwarding process
- Uses Ethernet VC-Type defined in pwe3-control-protocol-xx

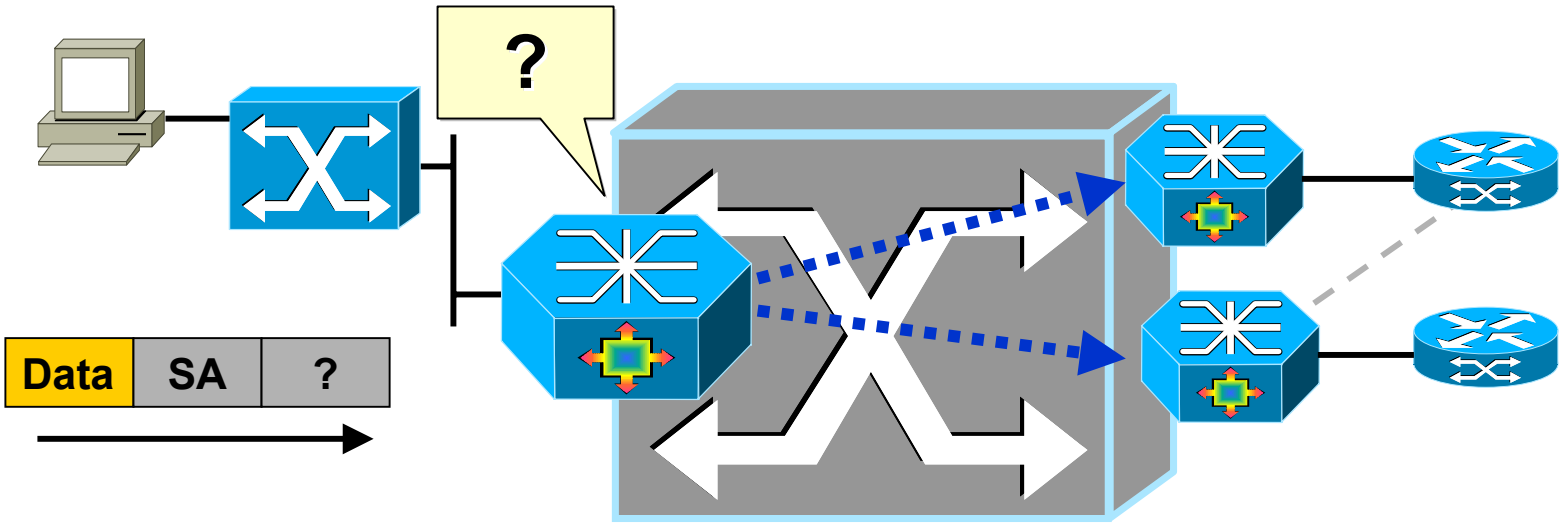
Address Learning / Aging:

- Self Learn Source MAC to port associations
- Refresh MAC timers with incoming frames
- New additional MAC TLV to LDP

Loop Prevention:

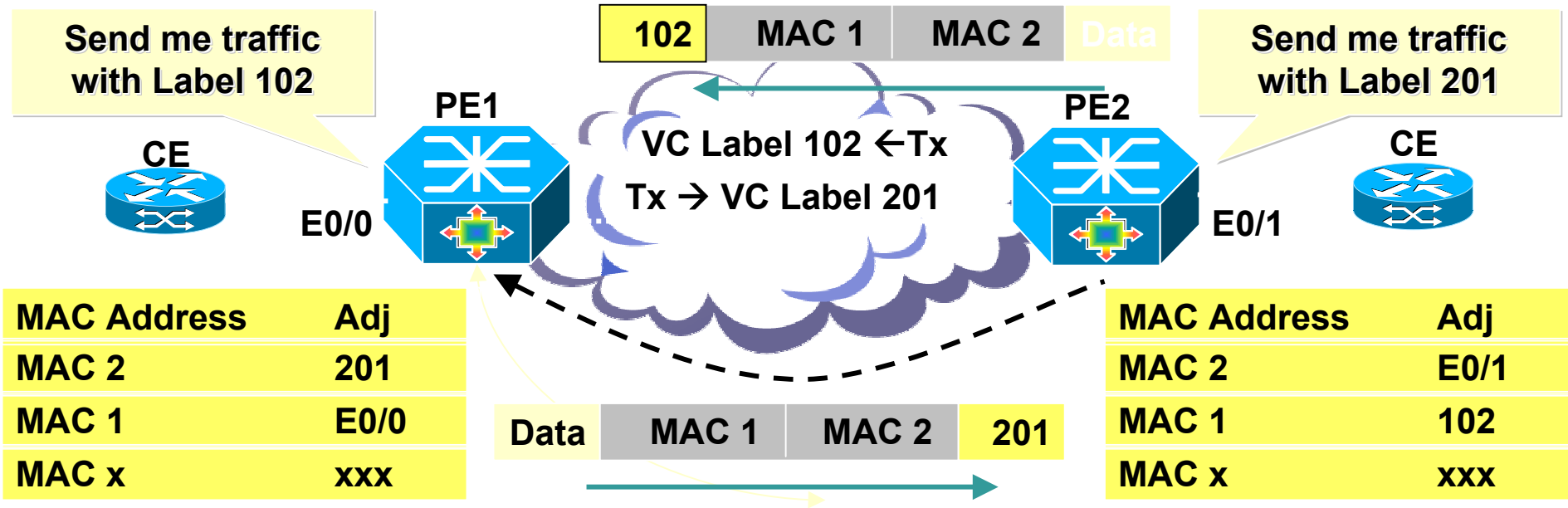
- Create partial or full-mesh of EoMPLS VCs per VPLS
- Use “split horizon” concepts to prevent loops
- Announce EoMPLS VPLS VC tunnels

VPLS Overview: Flooding & Forwarding



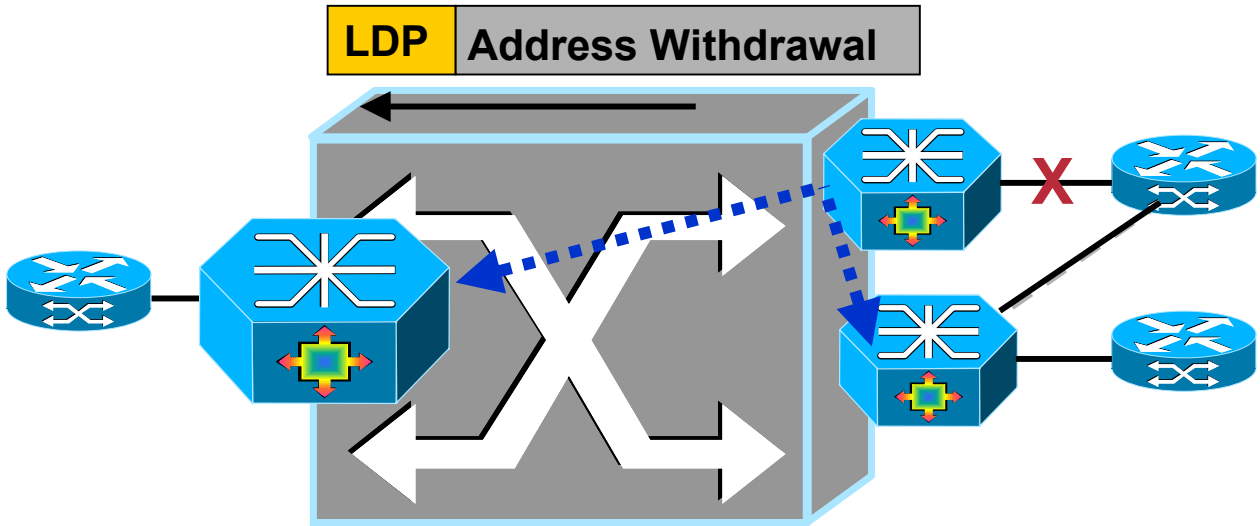
- Flooding (Broadcast, Multicast, Unknown Unicast)
- Dynamic learning of MAC addresses on PHY and VCs
- Forwarding
  - -Physical port
  - -Virtual circuit

VPLS Overview: MAC Address Learning



- Broadcast, Multicast, and unknown Unicast are learned via the received label associations
- Two LSPs associated with an VC (Tx & Rx)
- If inbound or outbound LSP is down, then the entire circuit is considered down

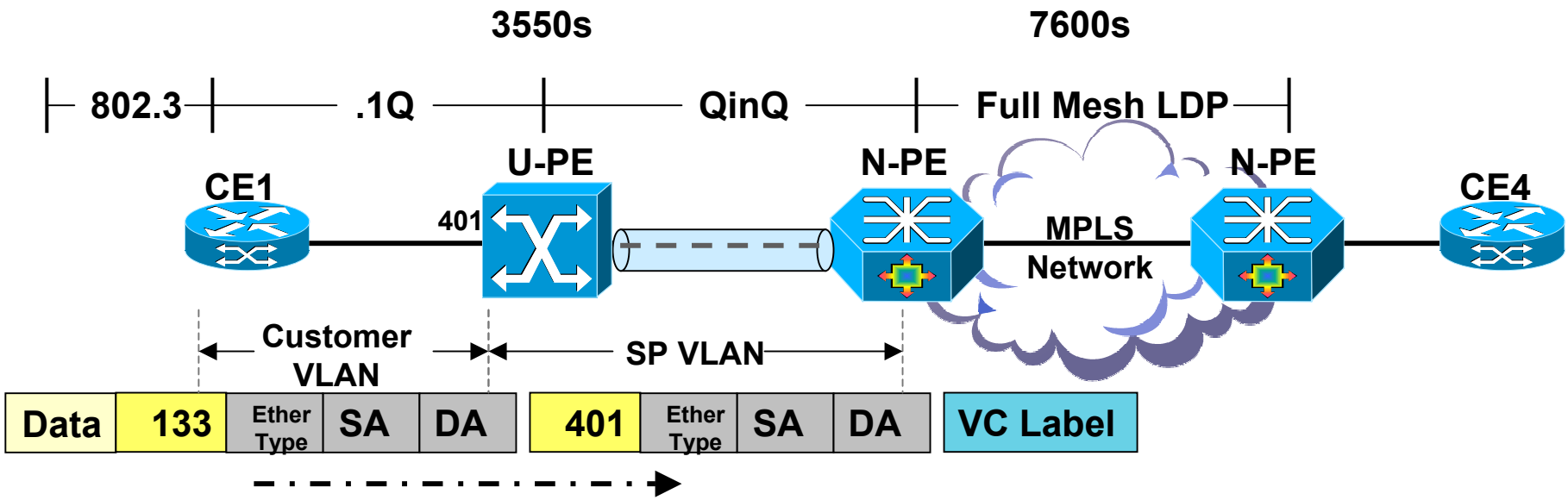
VPLS Overview: MAC Address Withdrawal



- Primary link failure triggers notification message
- PE removes any locally learned MAC addresses and sends LDP address withdrawal (RFC3036) to remote PEs in VPLS
- New MAC TLV is used

VPLS Overview: Data Forwarding in Ethernet Edge H-VPLS

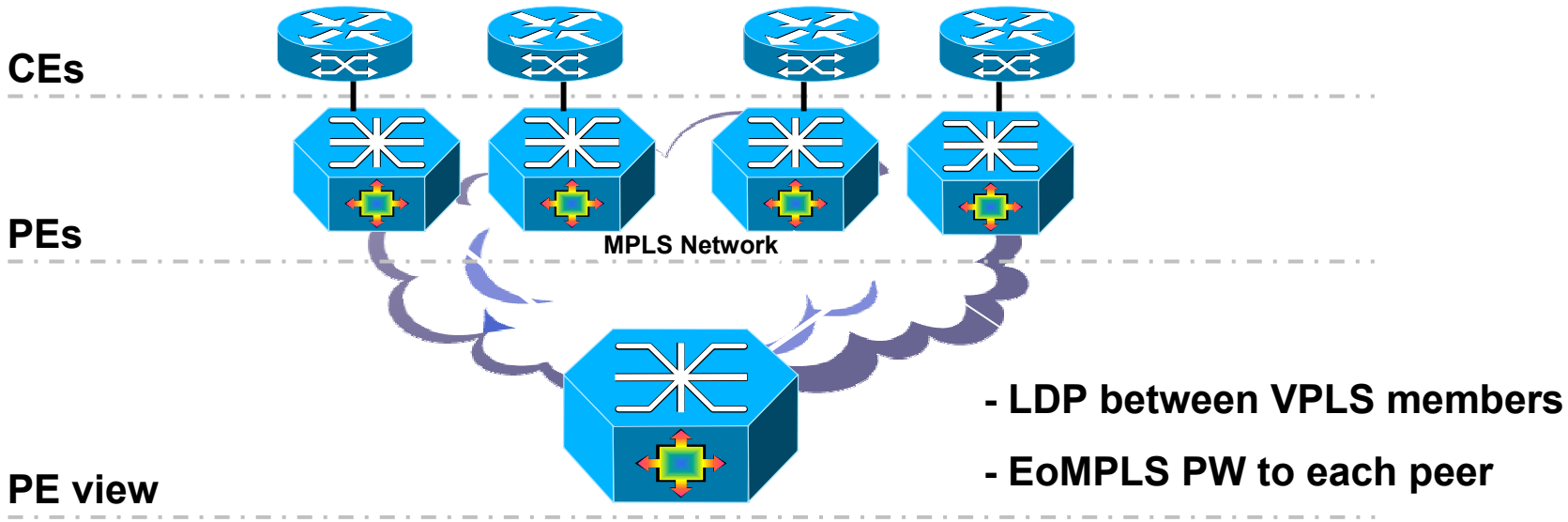
Topology 2: L2VPN, Ethernet Virtual Circuit Service (Distributed PE)



- Customer frames / VLANs are forwarded only
- Service delimiters are local to PE

  .1q tags, VC-labels, RFC1483, etc.
- Allows for hierarchical design options

VPLS Overview: VPLS Loop Prevention



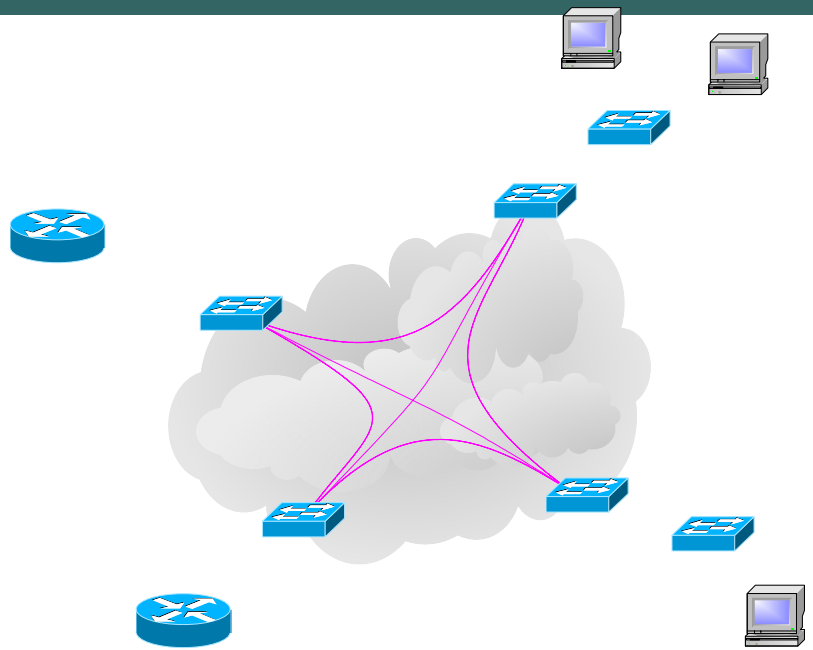
- Each PE has a P2MP view of all other PEs it sees it self as a root bridge, split horizon loop protection
- Full mesh topology obviates STP requirements in the service provider network
- Customer STP is transparent to the SP / customer BPDUs are forwarded transparently
- Traffic received from the network will not be forwarded back to the network

VPLS Overview: VPLS Learning

- **Unqualified**
  - Single port assigned for all customer VLANs
  - Single broadcast domain for all customer VLANs
  - Single MAC address space (no overlap!)
- **Qualified**
  - Each VLAN has its own VPLS instance
  - A VLAN has its own broadcast space and MAC address space
  - Customer MAC addresses MAY overlap
  - One FIB per customer VLAN
  - Broadcast domain limited to VLAN scope

VPLS Architectures

VPLS & H-VPLS



- **VPLS**
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  - MPLS to the Edge

192.168.11.12/24

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  - Two Tier Hierarchy
  - MPLS or Ethernet Edge
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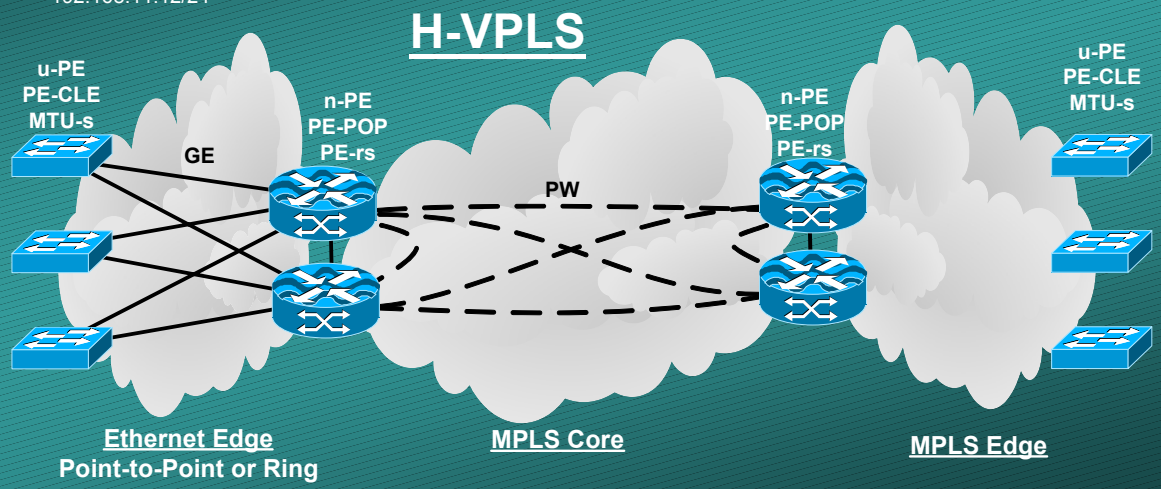
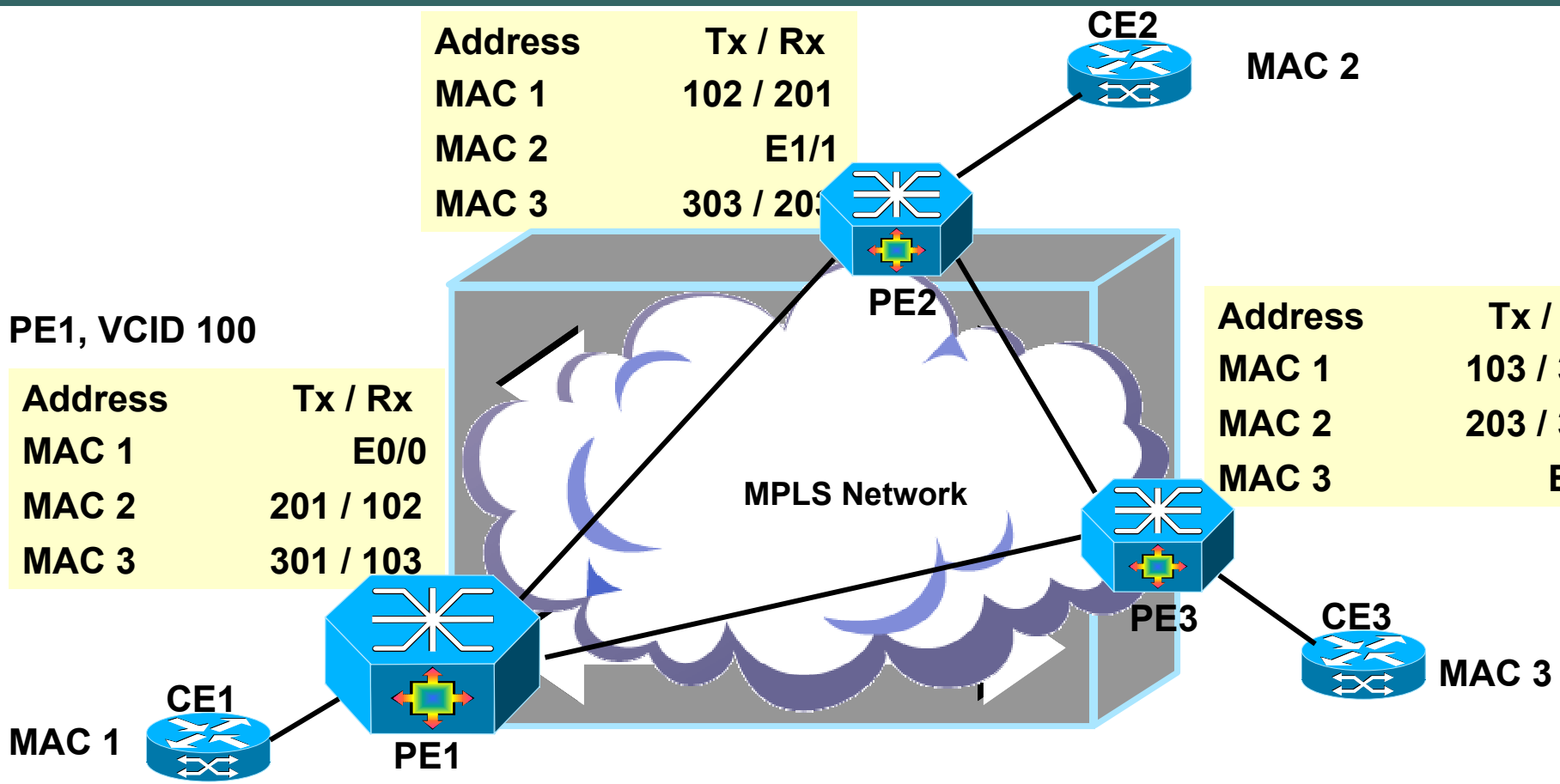


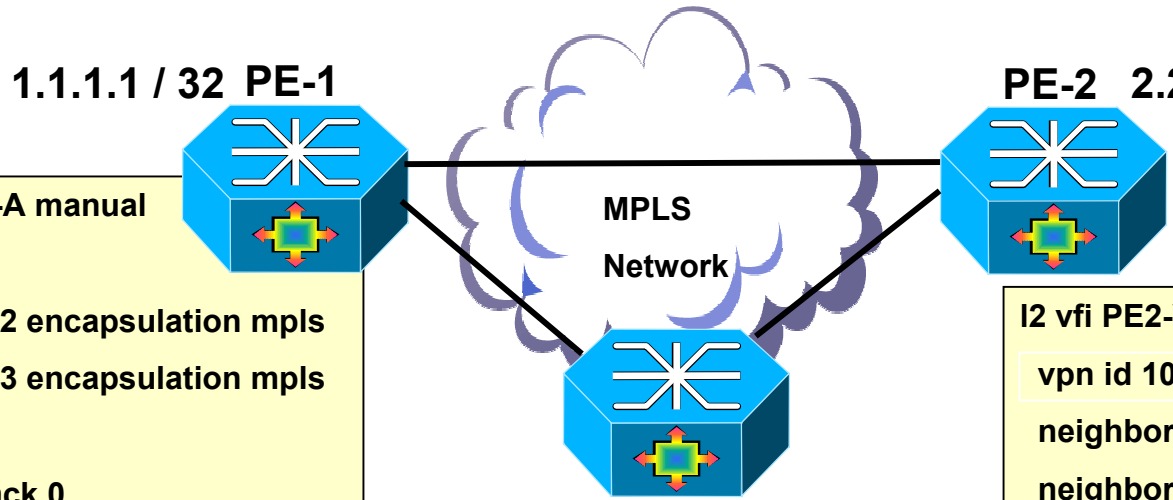
VPLS Overview: Illustrated – Direct Attachment (Flat)



- Port or P-VLAN based membership in the VSI in PEs
- All packet replication occurs on PEs

VPLS: Configuration Example PE → PE

Create a L2 VFI with a full mesh of participating VPLS PE nodes

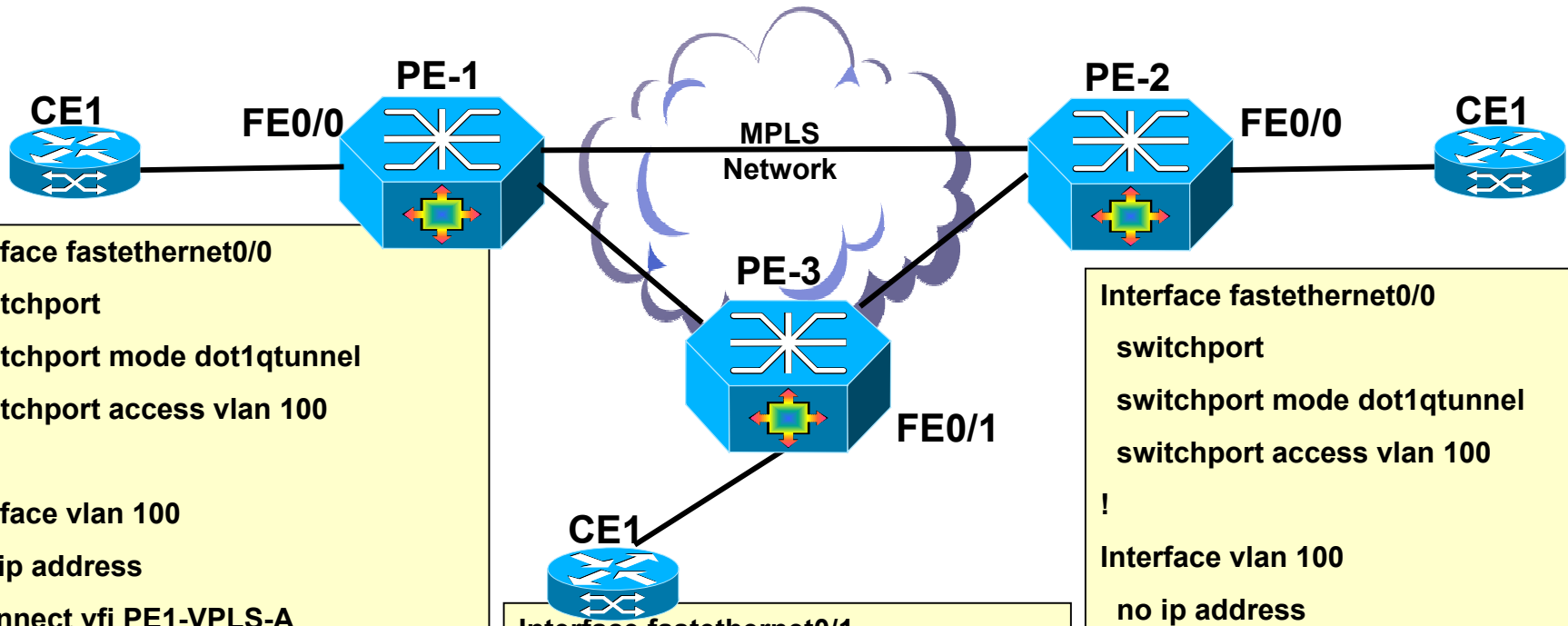



```
l2 vfi PE1-VPLS-A manual
 vpn id 100
  neighbor 2.2.2.2 encapsulation mpls
  neighbor 3.3.3.3 encapsulation mpls
!
Interface loopback 0
  ip address 1.1.1.1 255.255.255.255
```

```
l2 vfi PE2-VPLS-A manual
 vpn id 100
  neighbor 1.1.1.1 encapsulation mpls
  neighbor 3.3.3.3 encapsulation mpls
!
Interface loopback 0
  ip address 2.2.2.2 255.255.255.255
```

```
l2 vfi PE3-VPLS-A manual
 vpn id 100
  neighbor 1.1.1.1 encapsulation mpls
  neighbor 2.2.2.2 encapsulation mpls
!
Interface loopback 0
  ip address 3.3.3.3 255.255.255.255
```

VPLS: Configuration Example PE → CE




```
Interface fastethernet0/0
  switchport
  switchport mode dot1qtunnel
  switchport access vlan 100
!
Interface vlan 100
  no ip address
 xconnect vfi PE1-VPLS-A
!
vlan 100
  state active
```

```
Interface fastethernet0/1
  switchport
  switchport mode dot1qtunnel
  switchport access vlan 100
!
Interface vlan 100
  no ip address
 xconnect vfi PE3-VPLS-A …etc.
```

```
Interface fastethernet0/0
  switchport
  switchport mode dot1qtunnel
  switchport access vlan 100
!
Interface vlan 100
  no ip address
 xconnect vfi PE2-VPLS-A
!
vlan 100
  state active
```

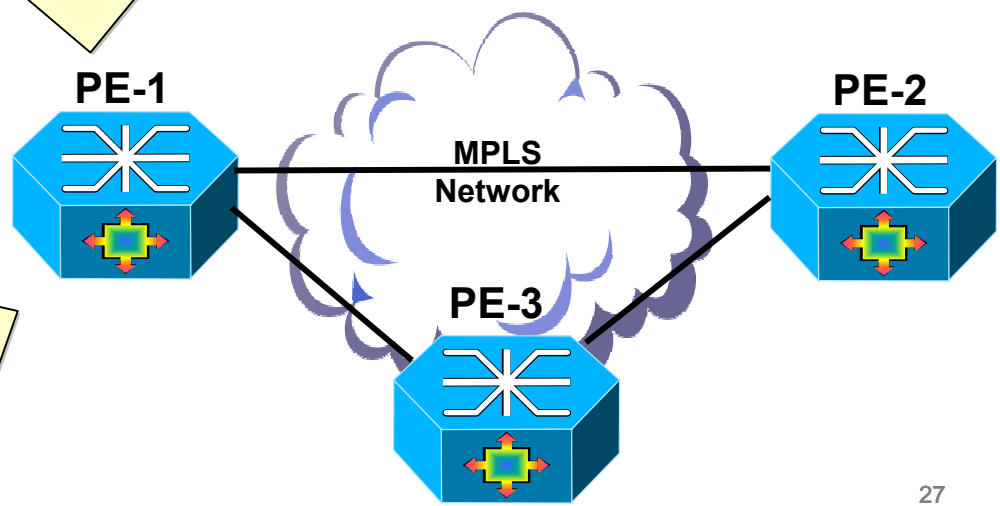
VPLS: Sample Output


```
VPLS1#show mpls l2 vc

Local intf     Local circuit          Dest address    VC ID      Status
-------------  ---------------------- --------------- ---------- ----------
Vi1            VFI                    22.22.22.22     100        DOWN
Vi1            VFI                    22.22.22.22     200        UP
Vi1            VFI                    33.33.33.33     100        UP
Vi1            VFI                    44.44.44.44     100        UP
Vi1            VFI                    44.44.44.44     200        UP
```

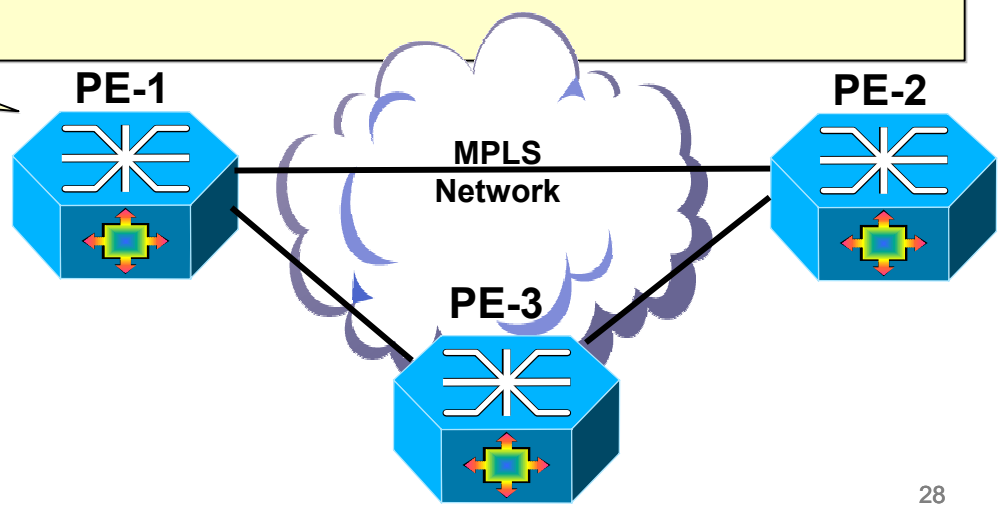
```
PE-1#show vfi  PE1-VPLS-A
  WORD  VFI name

PE-1#show vfi  PE1-VPLS-A
VFI name: VPLSA, state: up
  Local attachment circuits:
    Vlan100
  Neighbors connected via pseudowires:
    2.2.2.2  3.3.3.3
```



VPLS: Sample Output (Cont)


```
VPLS1#show mpls l2transport vc vcid 200 detail
Local interface: Vi1 up, line protocol up, VFI
  Destination address: 22.22.22.22, VC ID: 200, VC status: up
    Tunnel label: imp-null, next hop point2point
    Output interface: PO2/1, imposed label stack {16}
    MPLS VC labels: local 18, remote 16
    Group ID: local 200, remote 200
    MTU: local 1500, remote 1500
    Remote interface description:
  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
…..cont…for all VPLS PWs sharing a common VC ID
```



Use common AToM "show" commands

VPLS Architecture: Characteristics - Direct Attachment (Flat)

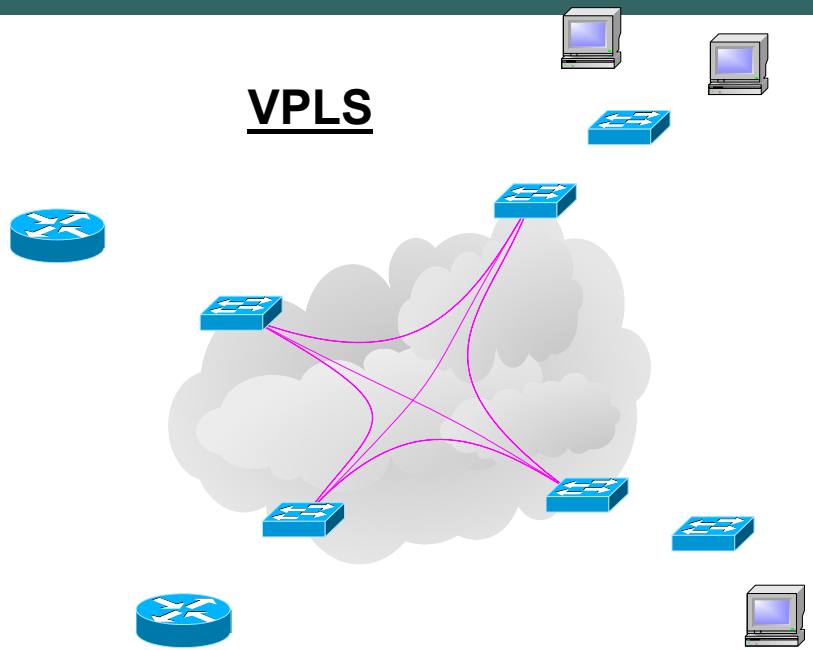
Overview:

- Okay for small customer implementations
- Simple provisioning
- Full mesh of directed LDP sessions required between participating PEs
- VLAN and Port level support (no QinQ)

Drawbacks:

- No hierarchical scalability
- Scaling issues:
  - PE packet replication
  - Full mesh causes classic - N*(N-1) / 2 concerns

VPLS & H-VPLS



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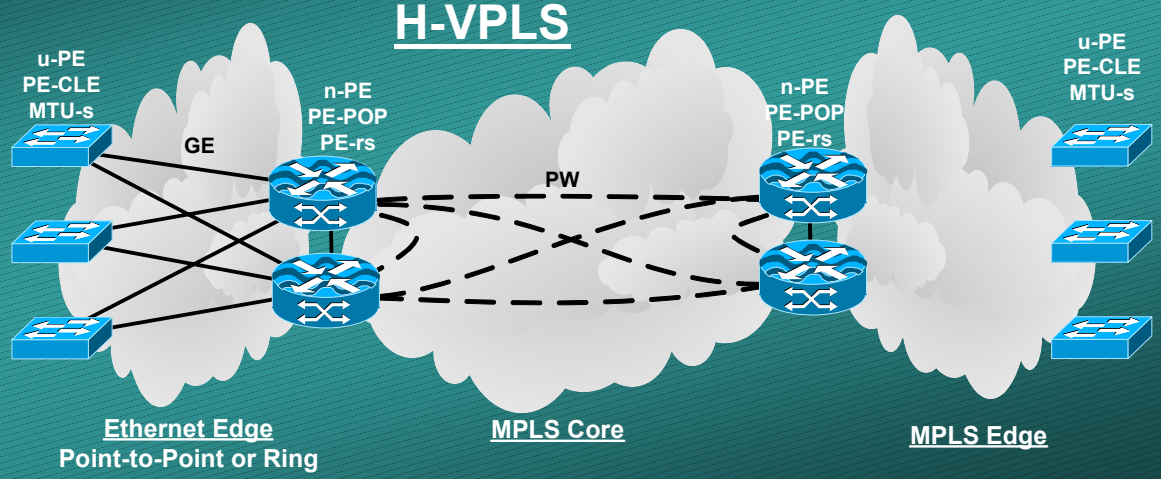
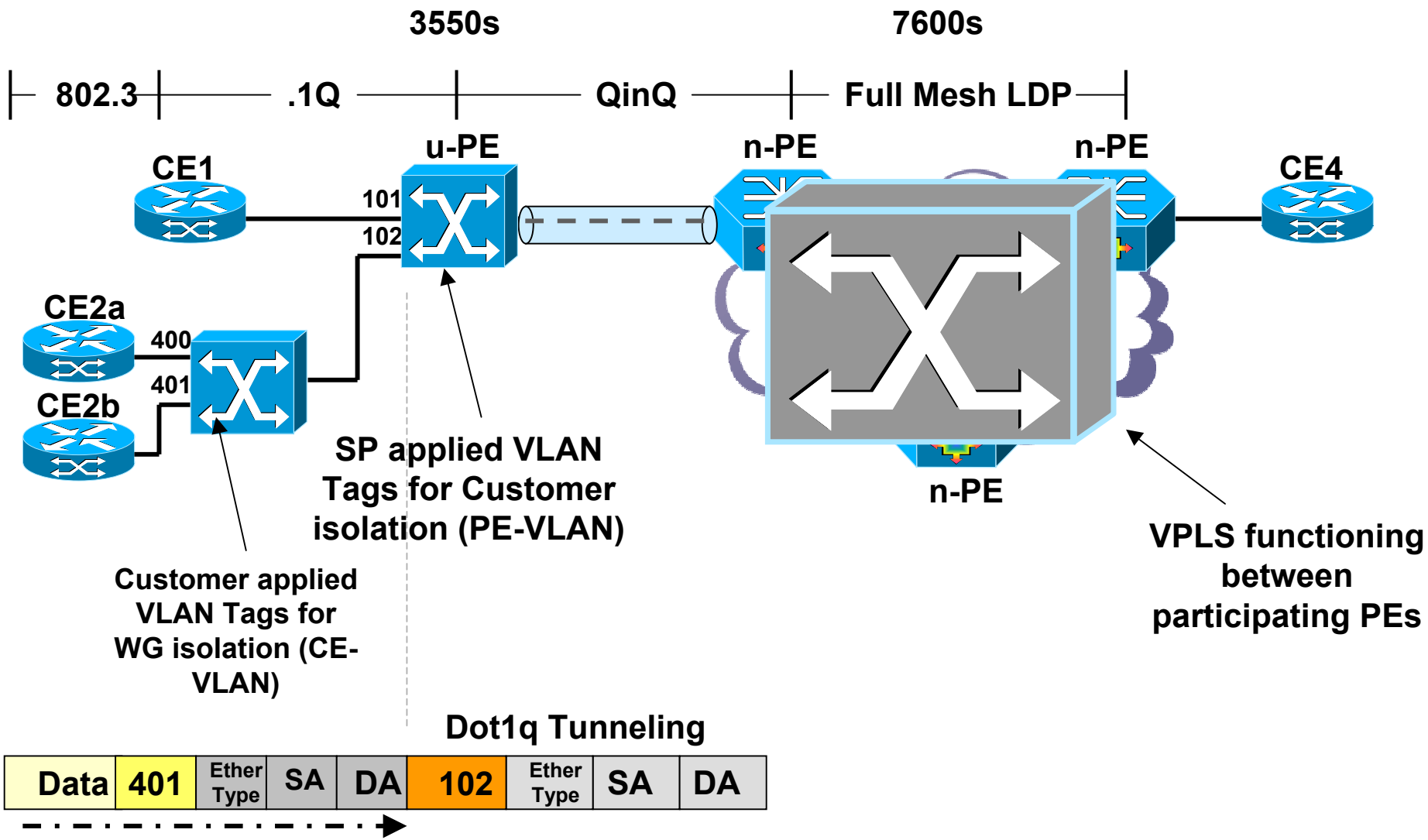
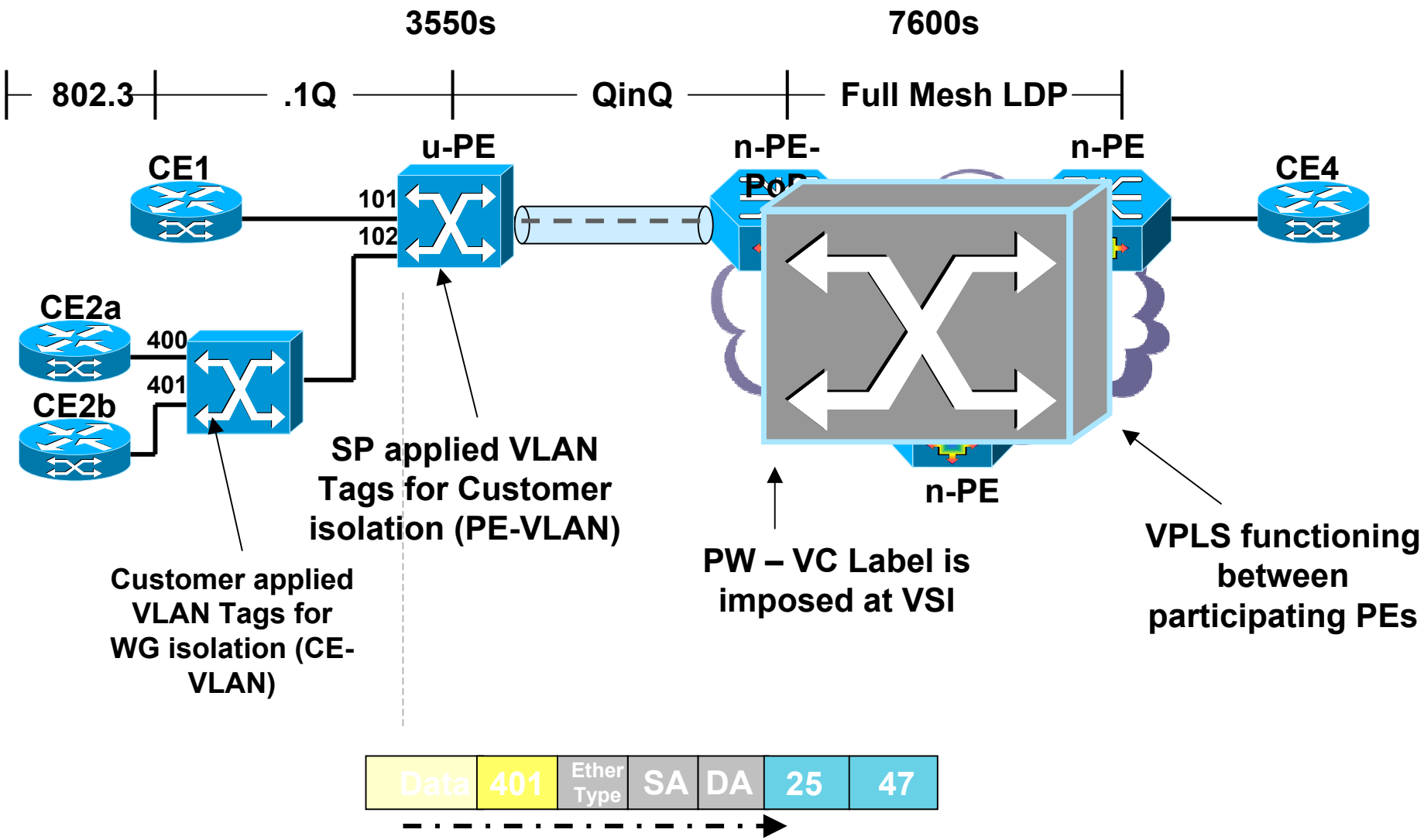


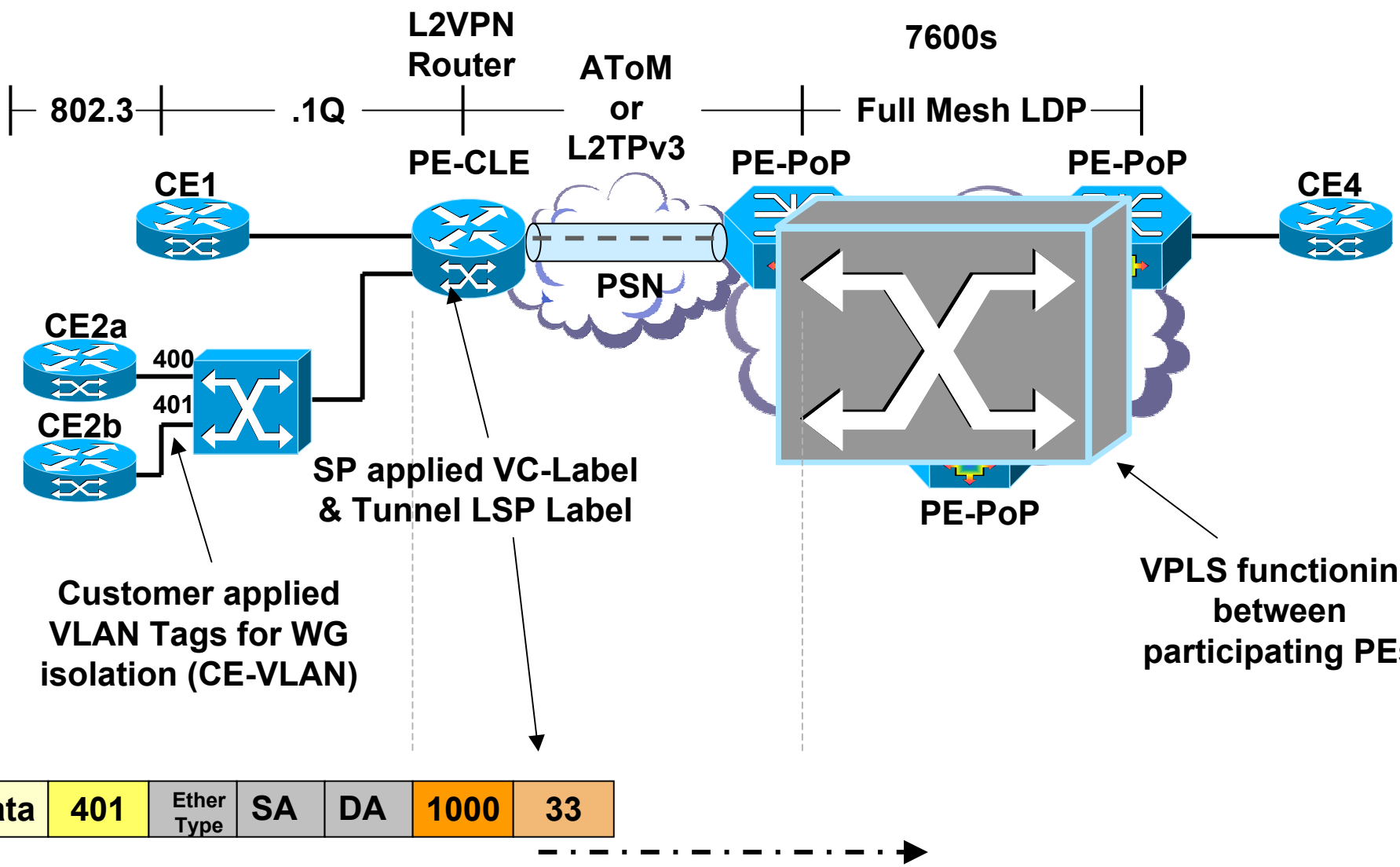
VPLS Architecture: Architecture – Ethernet Edge H-VPLS



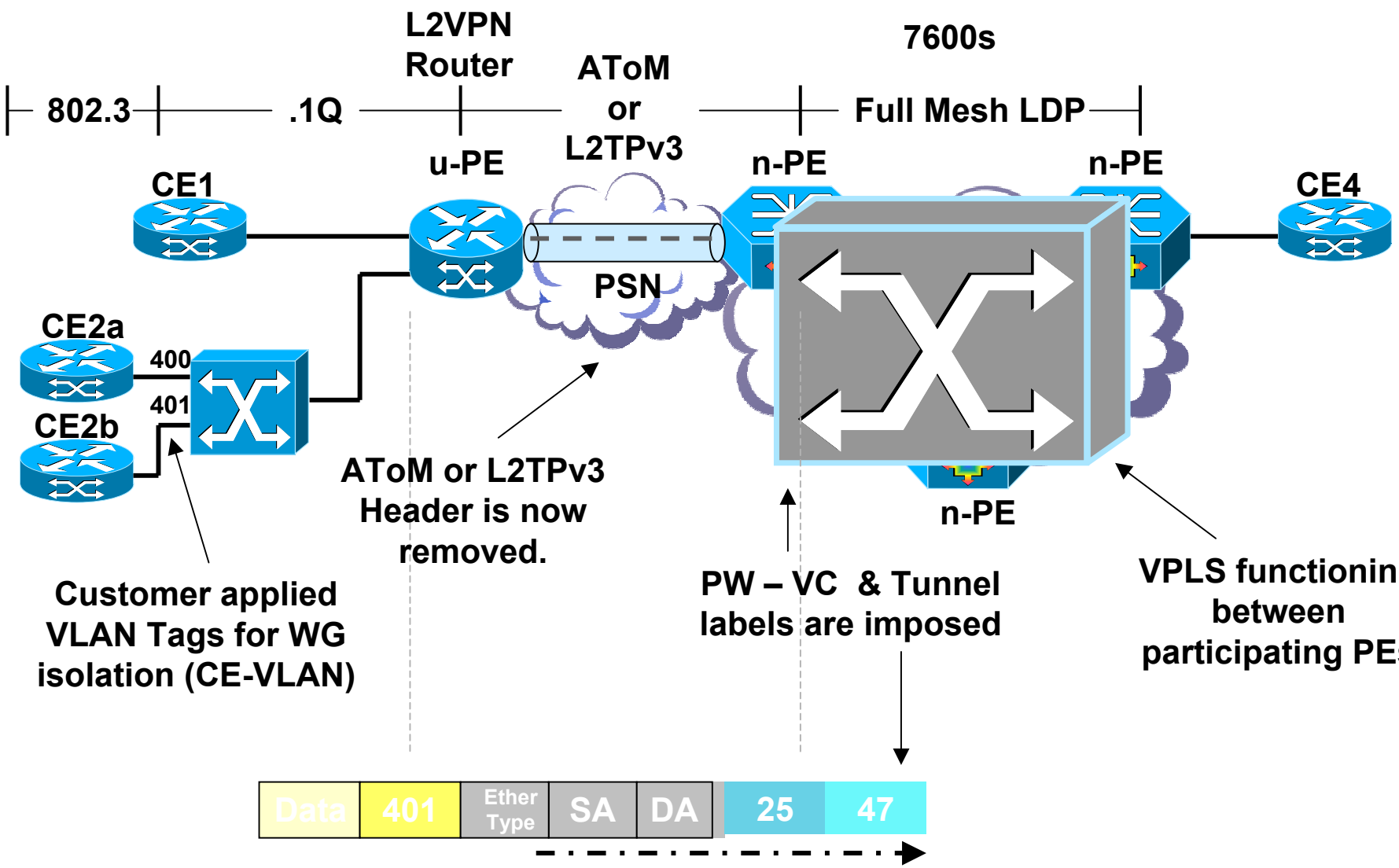
VPLS Architecture: Architecture – Ethernet Edge H-VPLS



VPLS Architecture: Architecture – MPLS Edge H-VPLS



VPLS Architecture: Architecture – MPLS Edge H-VPLS



VPLS Architecture: Characteristics – H-VPLS

Benefits:

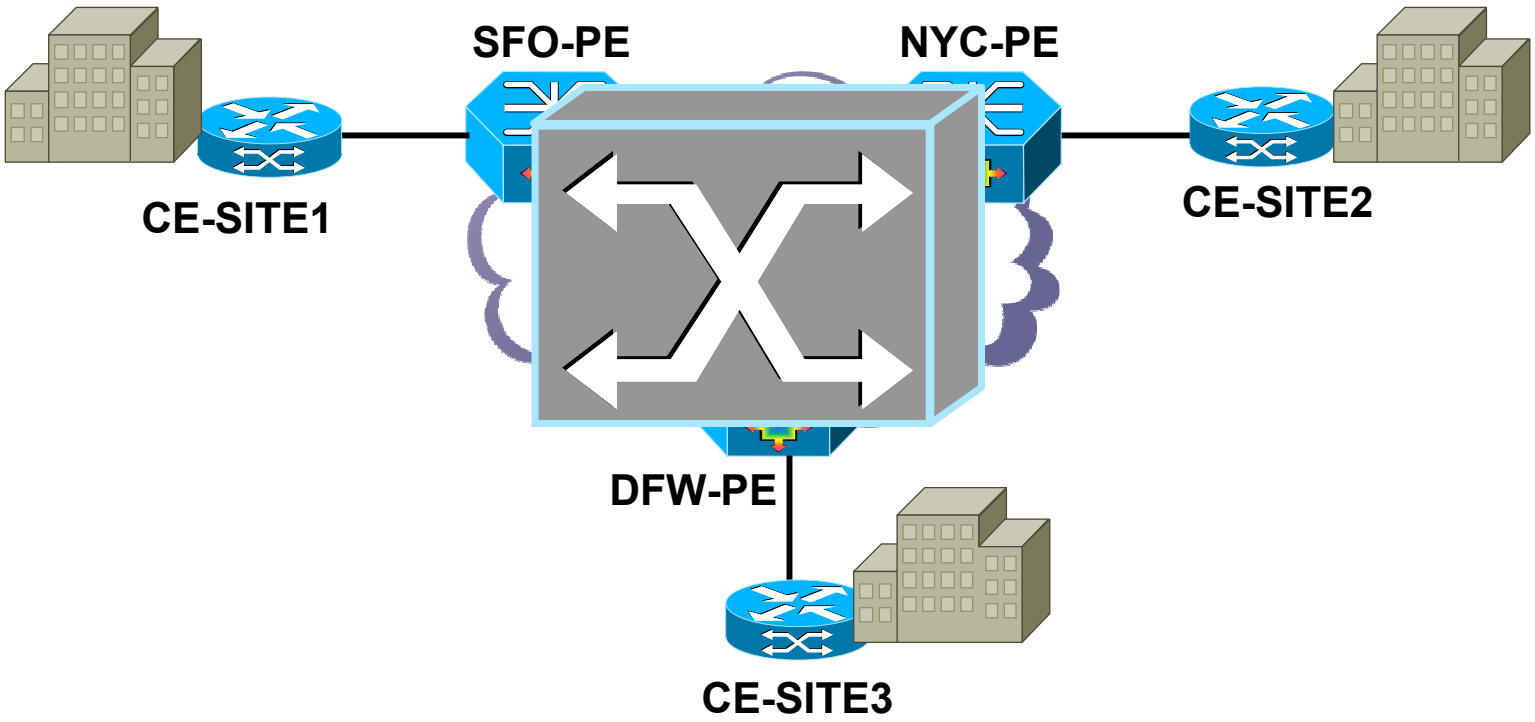
- Best for larger scale deployment
- Reduction in packet replication and signaling overhead on PEs
- Full mesh for core tier (Hub) only
- Attachment VCs “virtual switch ports” effected through Layer 2 tunneling mechanisms (AToM, L2TPv3, QinQ)
- Expansion affects new nodes only (no re-configuring existing PEs)

Drawbacks:

- More complicated provisioning
- MPLS Edge H-VPLS requires MPLS to u-PE
  - Complex operational support
  - Complex network design
  - Expensive Hardware support

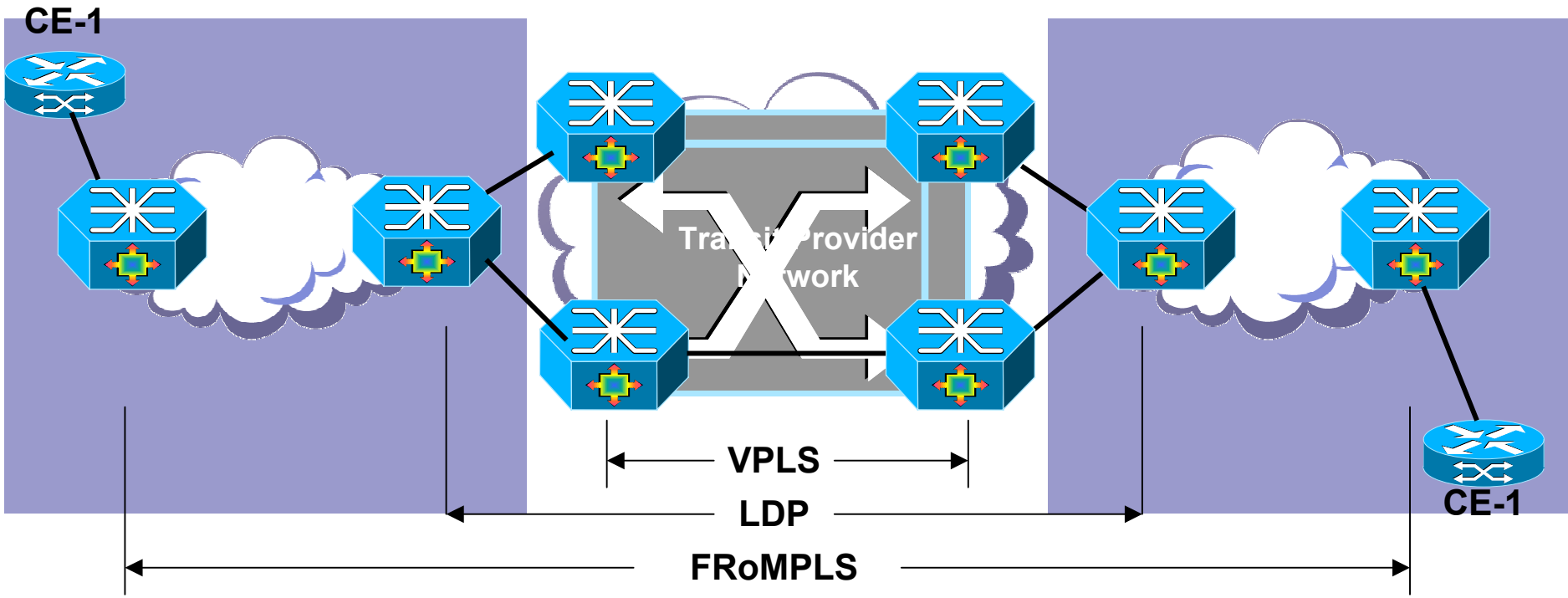
VPLS Deployment Scenarios

VPLS Deployment: SMB Connectivity



- New Layer 2 multipoint service offering
- Enterprise maintains routing and administrative autonomy
- Layer 3 protocol independence
- Full mesh between customer sites

VPLS Deployment: Layer 2 Multipoint Transit Provider



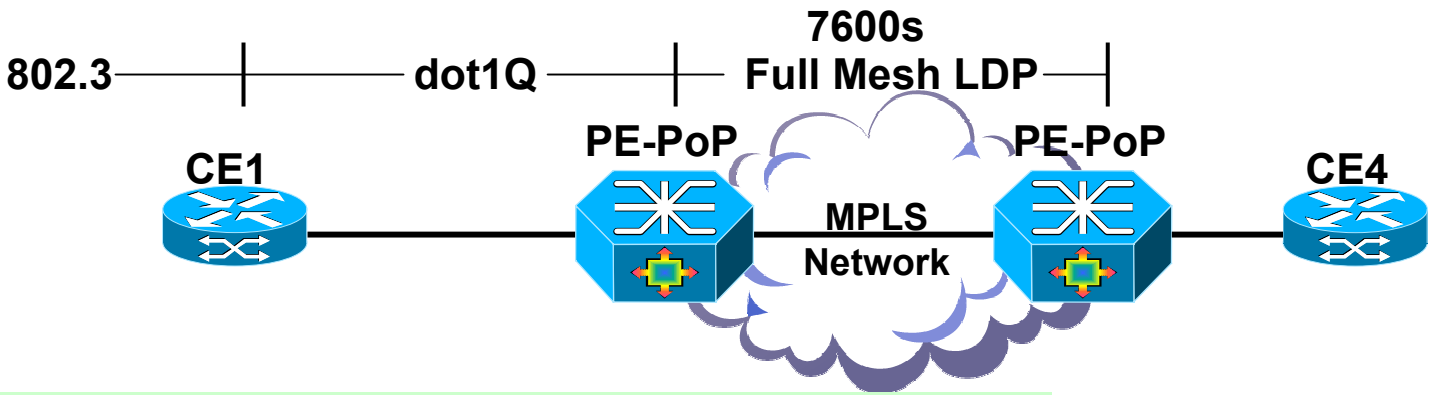
- SP-As PEs appear back to back and packets are forwarded
- No LDP or Route exchange with transit provider
- Provides optimal traffic path to carrier's PE

Summary

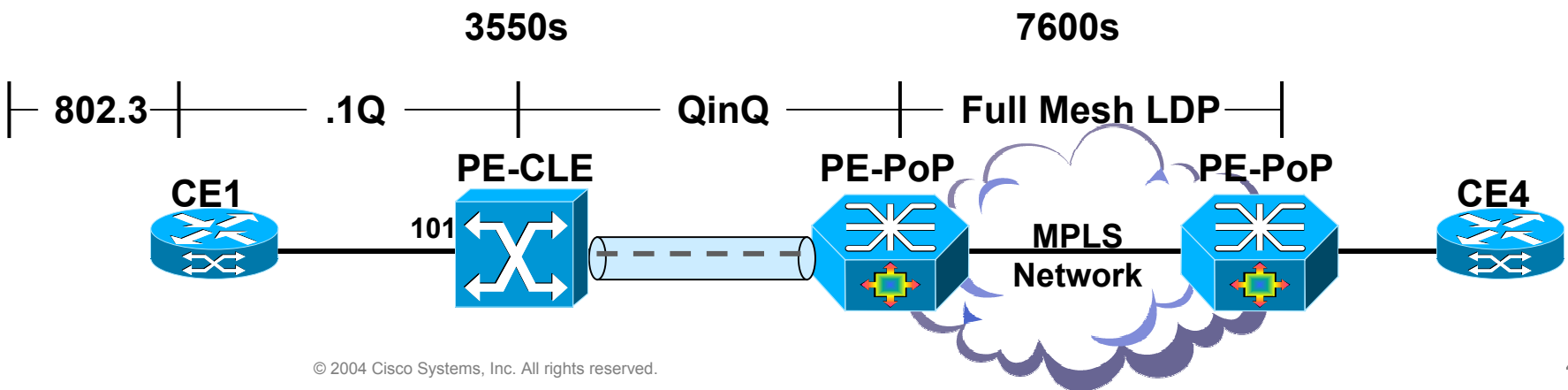
Phase I – Architecture Support

Service Definitions Supported

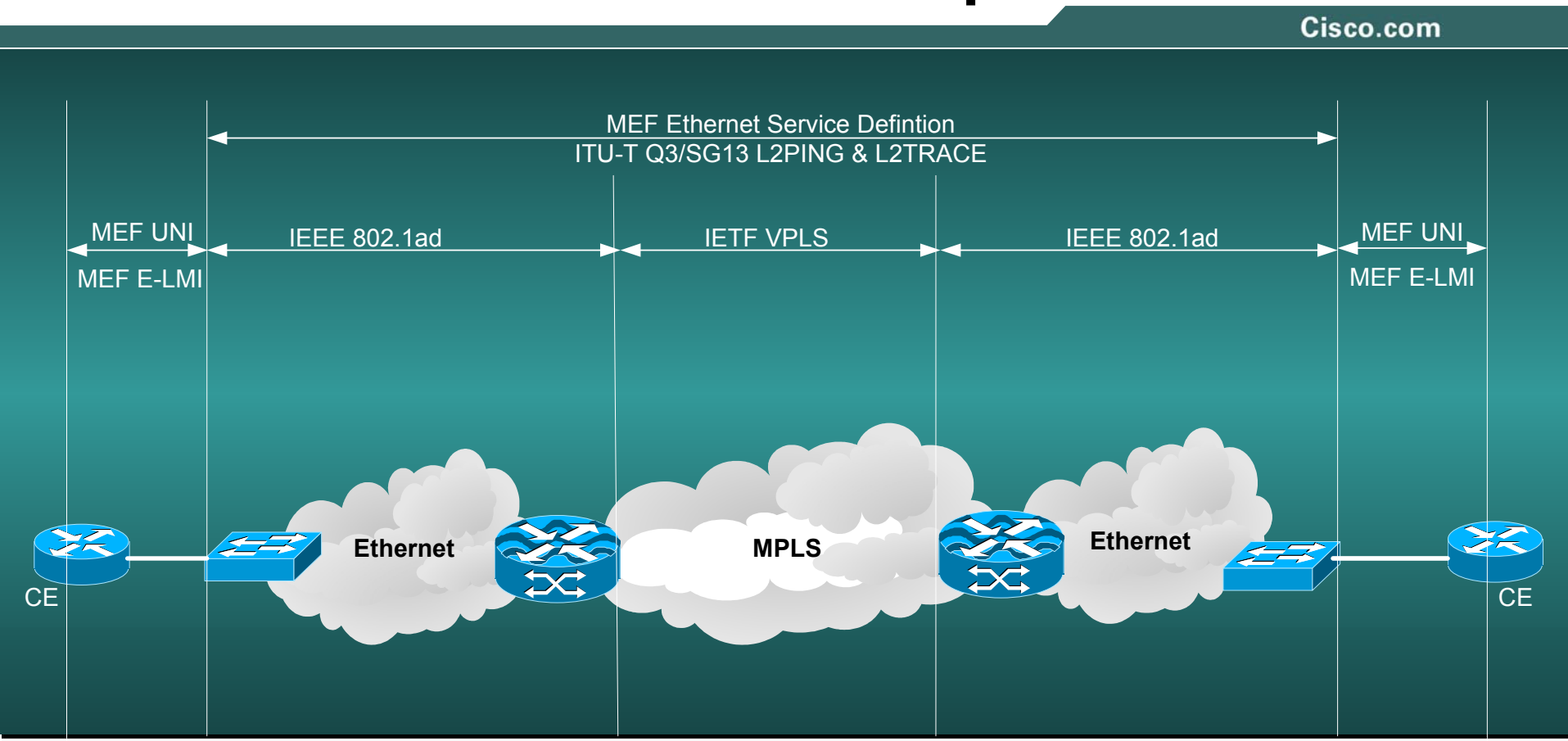
Topology 1: L2VPN, Transparent LAN Service (Non-distributed PE)



Topology 2: L2VPN, Ethernet Virtual Circuit Service (Distributed PE)



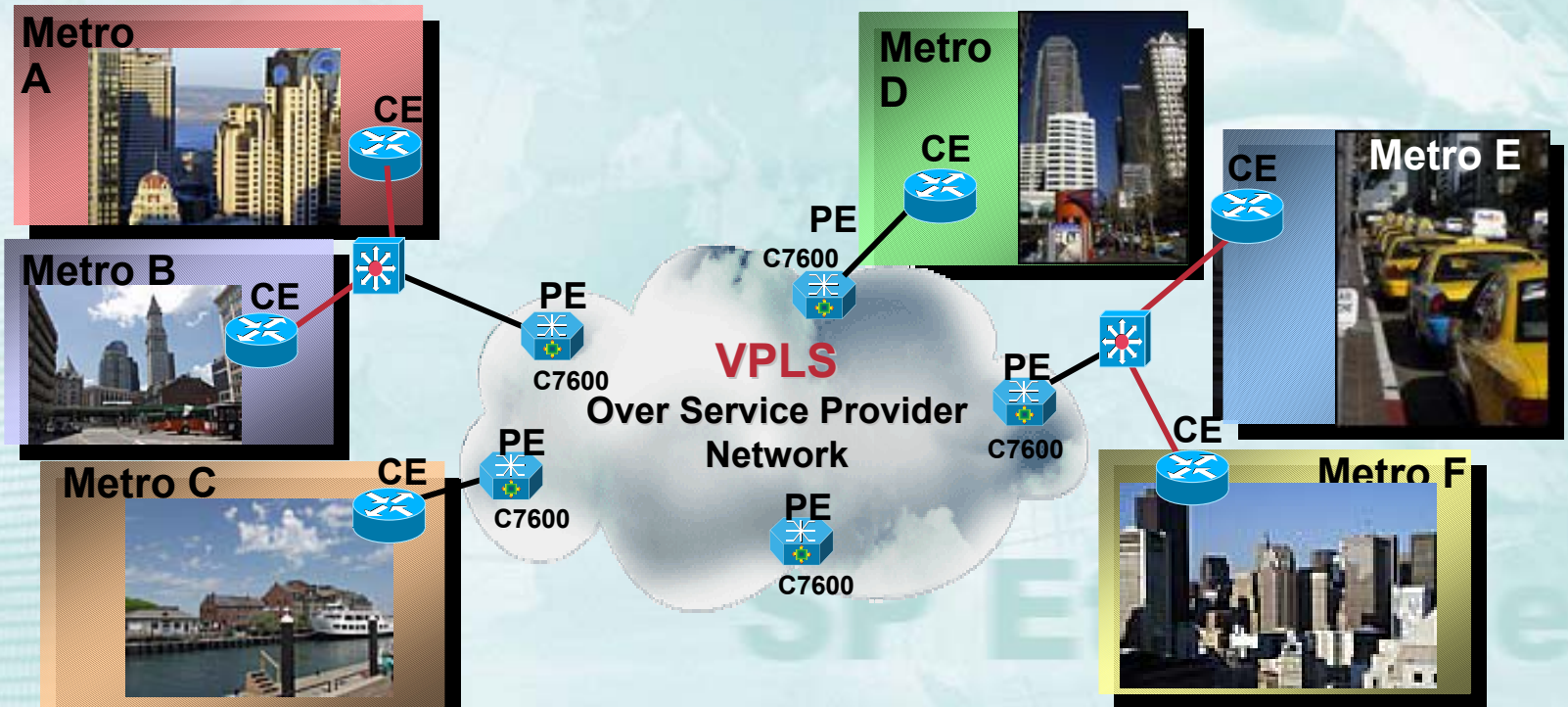
Ethernet Standards Development



- **IETF VPLS is a part of an overall Ethernet solution**
  - **IEEE 802.1ad Provider Bridges**
  - **ITU SG12 Ethernet OAM – L2TRACE & L2PING**
  - **MEF Ethernet E-LMI, E-UNI and Ethernet Service Definitions**

Cisco VPLS Summary

- Fills L2 multipoint VPN gap between customer requirements and existing L2VPN point-to-point technologies
- Expands the service portfolio to for existing MPLS networks
- Has wide-industry support for LDP-based VPLS implementations & wide coordination between Ethernet focused standards bodies (IETF, IEEE, MEF, ITU)
- Cisco is actively driving development of standards and liaising between Forum's to ensure the rapid development of standards and interoperable solutions



World-Class Customer Support

- 2,000 Technical Support Professionals
- 1,600+ Support Engineers* (400 CCIEs) on 24x7
- 630+ Depots and 10,000 Field Engineers in 120 countries*
- 85,000+ Assisted cases/ month
- 321,000 Customer issues resolved/month
- 75% TAC Web resolved: of 25% assisted, 64% were web-initiated
- 98% Material availability
- 92% Orders submitted online, 55% "no touch"
- 60% Change orders submitted online

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Customer Advocacy Mission

Accelerate customer success with Cisco through innovative services and world-class people, partners, process, and tools.

* Internal & Outsource Partners

Cisco leads in the MPLS Market

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Americas	EMEA	AsiaPac/Japan

Some 200 Customers (MPLS Core & L2/L3 Edge)

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