



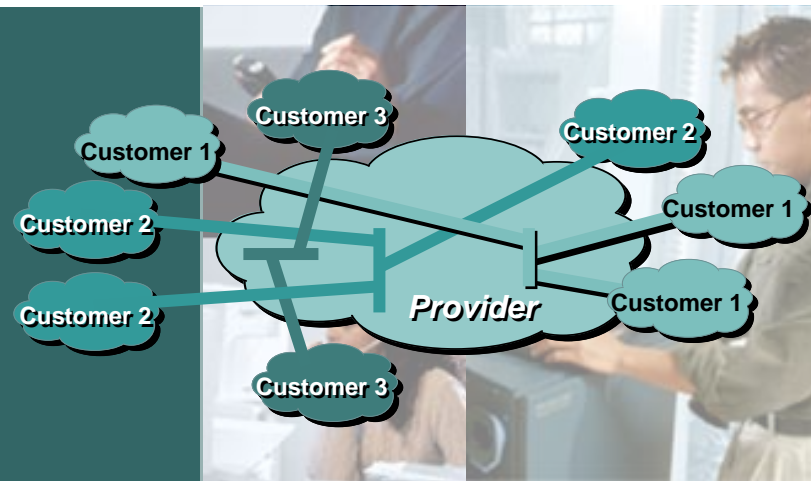
# ETHERNET Transport Service in Wide Area Network

**Bertrand Duvivier**

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**14 January 2005**

# Ethernet in WAN ?



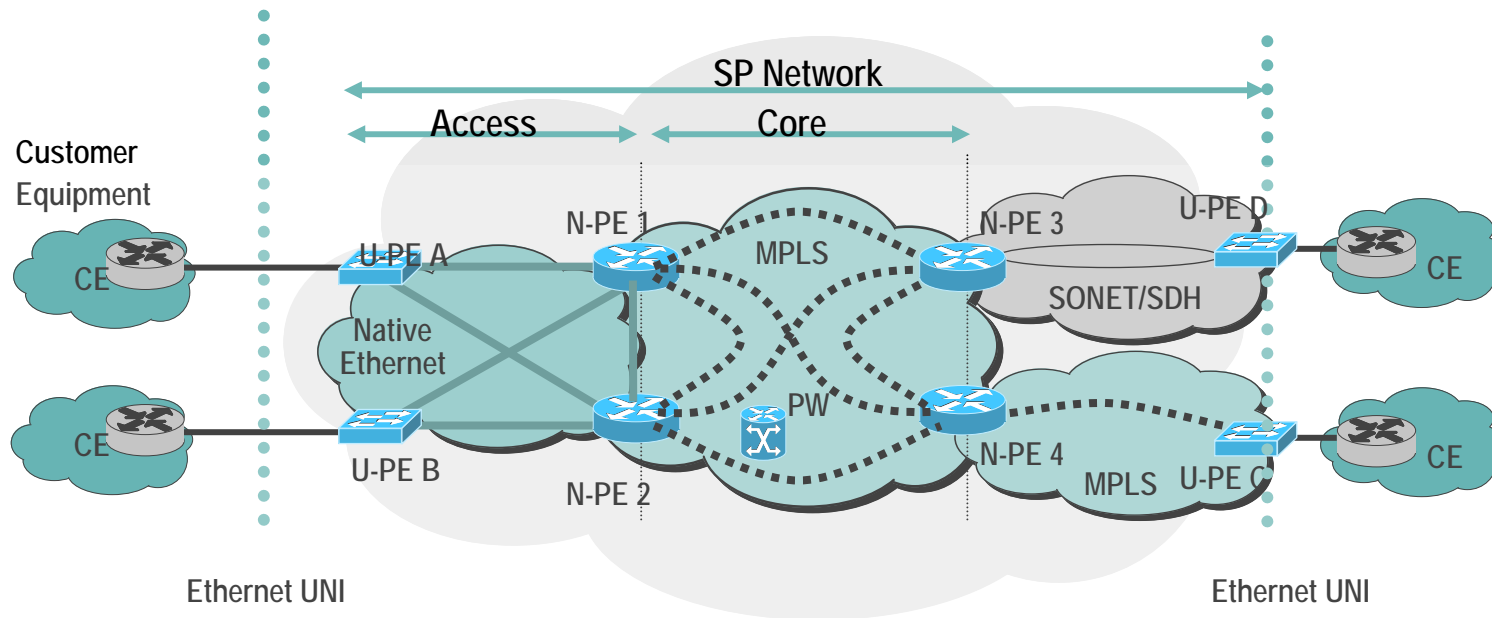
# Why and what is Ethernet in WAN

- **Ethernet is cost effective**
- **High BW**
- **Frame based protocol**
- **Well known protocol by end-customers**

**--- YES, in LAN or MAN ---**

# Ethernet in WAN

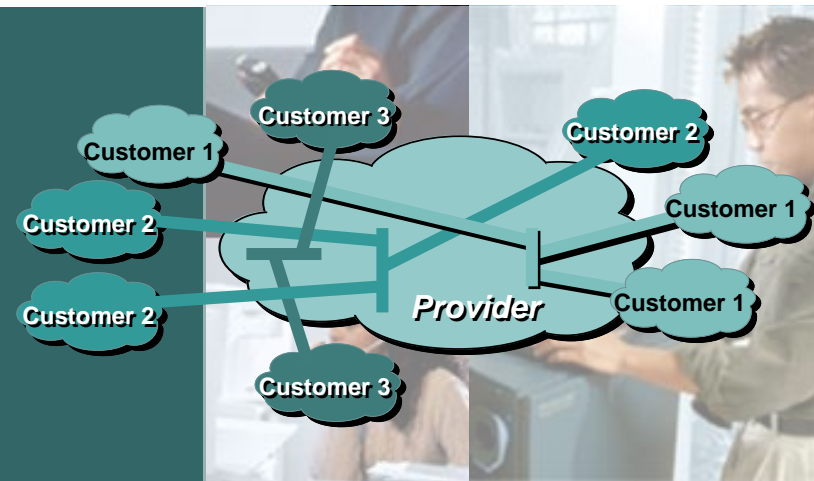
## Some scenarios



# In WAN Ethernet required

- **Architecture/Services (ITU-T & MEF)**
  - **General Architecture**
  - **QoS - Performance and Services definition**
- **How to transported Ethernet over Wan (IETF and IEEE)**
  - **Over IP/MPLS** **PWE3, VPLS**
  - **Provider Bridge (QinQ, M/RSTP)** **IEEE-802.1AD, ...**
- **Tools (IEEE & IETF)**
  - **UNI Signaling** **E-LMI**
  - **Link OAM's (Physical)** **IEEE-802.3AH**
  - **Service OAM's (Mac)** **IEEE-802.1AG**
  - **PWE3 and VPLS OAM's** **IETF-VCCV, IETF-VPLS-OAM**
  - **Autodiscovery** **IETF- LDP/BGP/RADIUS/LDAP**
- **Scalability (IEEE & IETF)**
  - **MAC scalability** **IEEE-802.1AK**
  - **Maybe new way** **VPLSv2 idea in consideration**

# Ethernet WAN and Standard bodies



# Standard bodies involved in ETHERNET transport over WAN



# Two main IETF working groups

- **PWE3** (*draft-ietf-pwe3...*)

**Focusing on L2 point-to-point circuit emulation**

- **encapsulation and service emulation of pseudo wires**

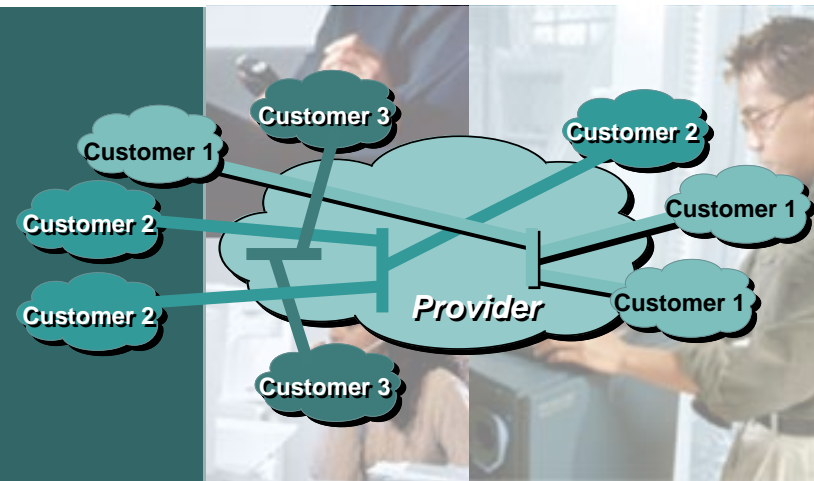
FR, ATM, Ethernet, PPP, HDLC

- **L2VPN** (*draft-ietf-l2vpn...*)

**Focusing on service provisionning**

- Thru multiple point-to-point: **VPWS**
- Thru bridged L2 multi-points: **VPLS**
- Thru routed L2 Multi-points: **IPLS**

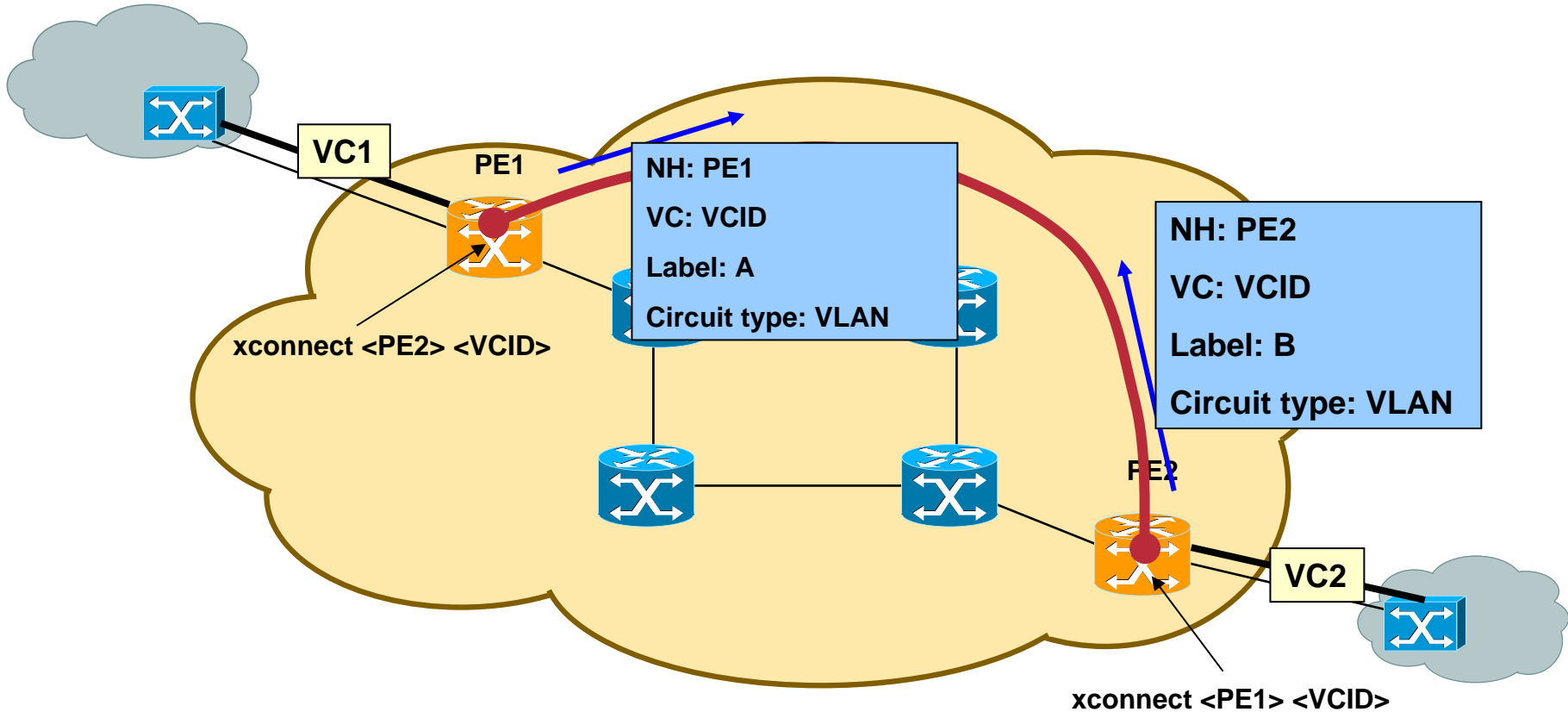
# Emulated Ethernet Wire in WAN (IETF PWE3)



# PWE3:

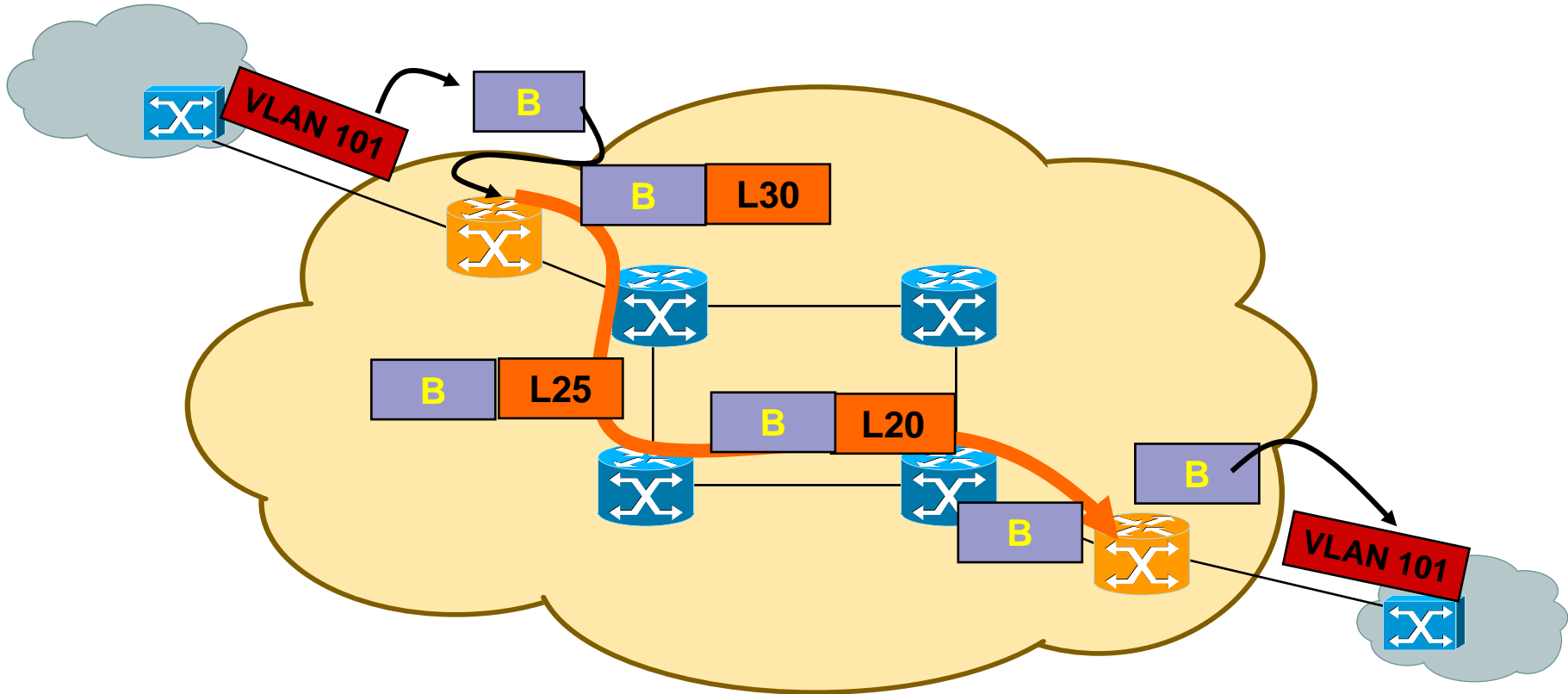
## VC Label distributed through directed LDP session

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[draft-ietf-pwe3-control-protocol-xx.txt](#)

# PWE3: *Label forwarding*

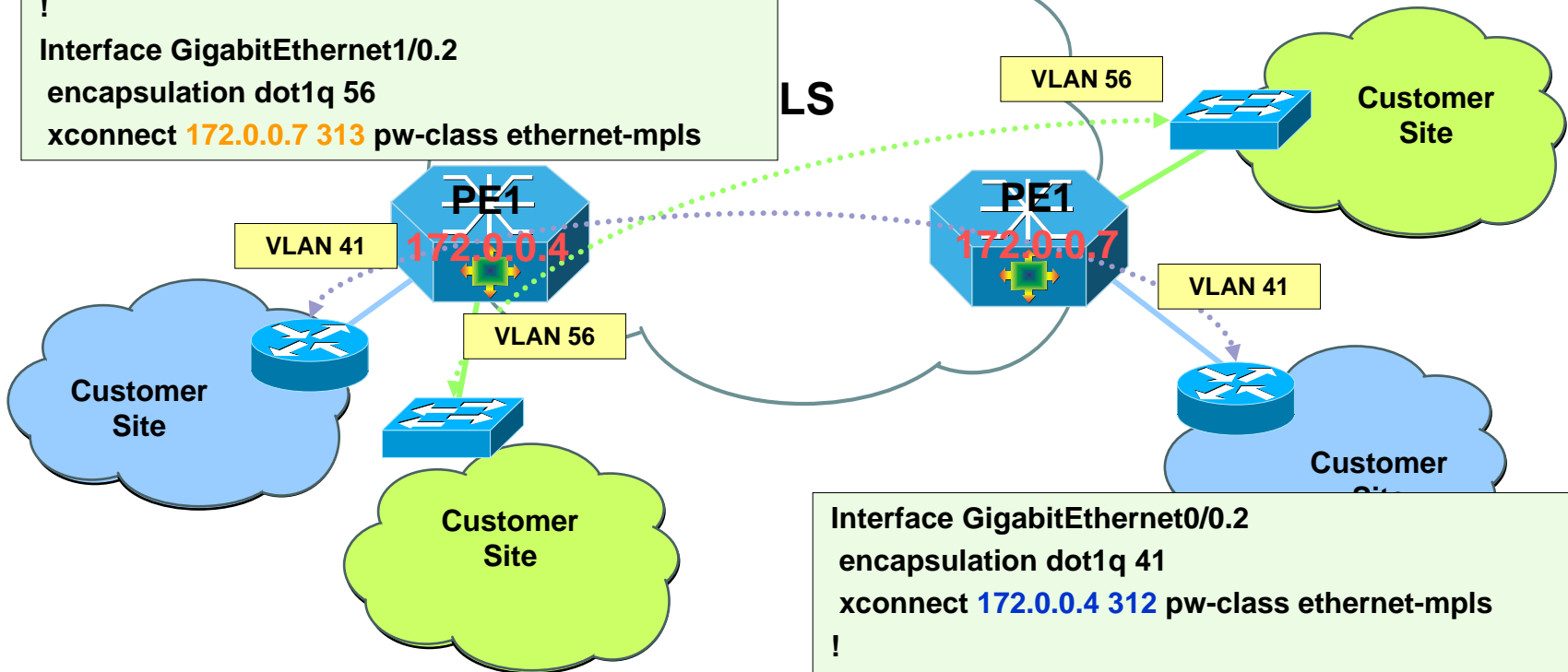


[draft-ietf-pwe3-ethernet-encap-xx.txt](#)

# Ethernet 802.1q VLAN Transport

```
Interface GigabitEthernet0/0.2
 encapsulation dot1q 41
 xconnect 172.0.0.7 312 pw-class ethernet-mps
 !
Interface GigabitEthernet1/0.2
 encapsulation dot1q 56
 xconnect 172.0.0.7 313 pw-class ethernet-mps
```

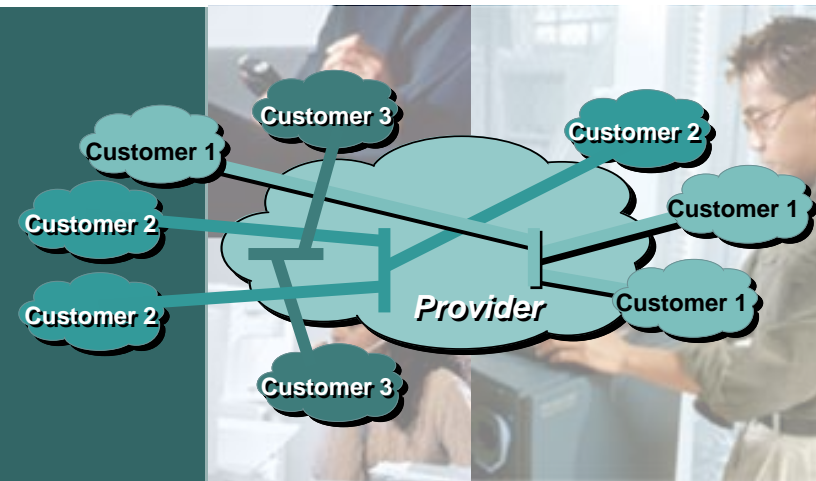
LS



```
Interface GigabitEthernet0/0.2
 encapsulation dot1q 41
 xconnect 172.0.0.4 312 pw-class ethernet-mps
 !
Interface GigabitEthernet1/0.2
 encapsulation dot1q 56
 xconnect 172.0.0.4 313 pw-class ethernet-mps
```

## Ethernet LAN emulated in WAN

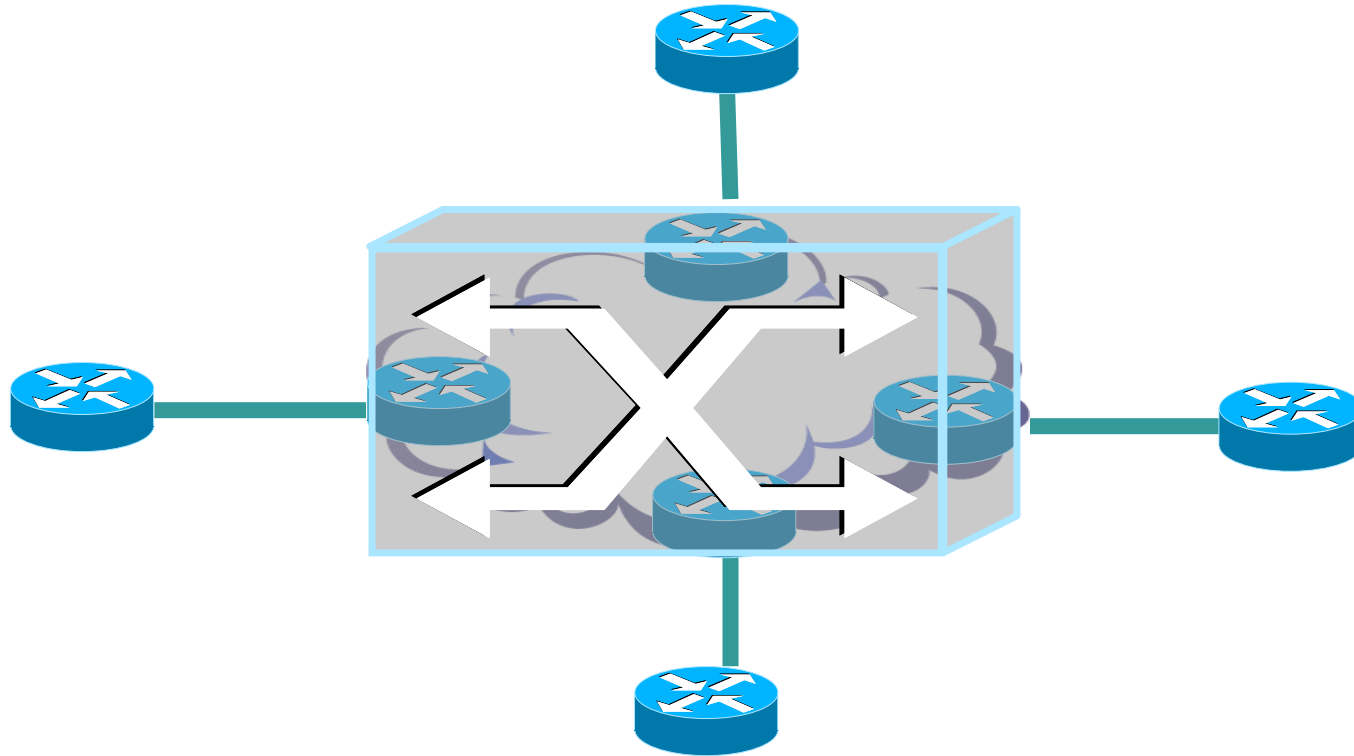
### - Basic (IETF VPLS)



draft-ietf-l2vpn-vpls-ldp-xx.txt (LDP based)

draft-ietf-l2vpn-vpls-xx.txt (BGP based)

# VPLS ( Transparent LAN Services)



**- The network will simulate a L2 switch**

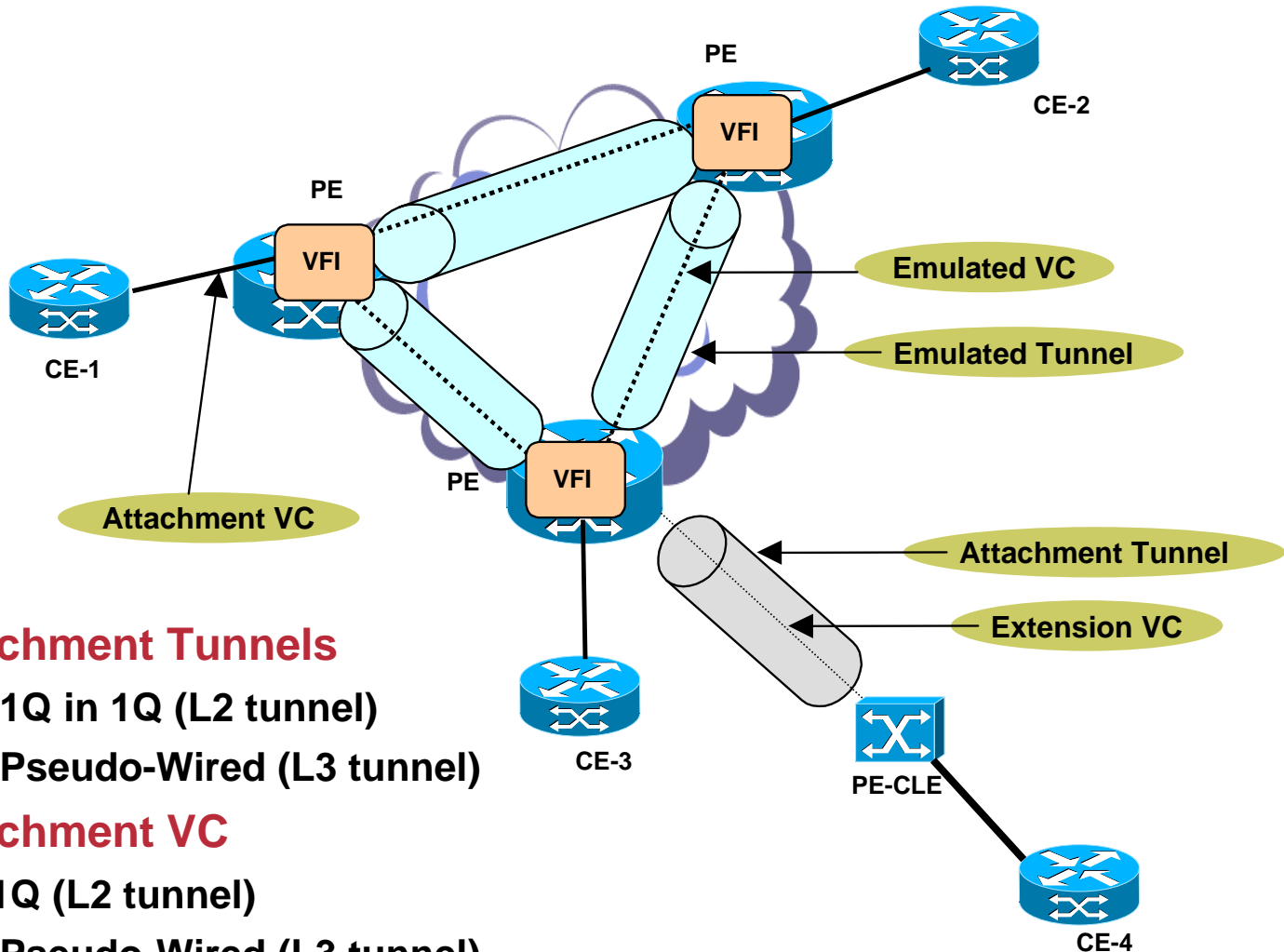
# Virtual Forwarding Instance

## VFI is a virtual bridge group

*Table instances per customer and per Customer VLAN*

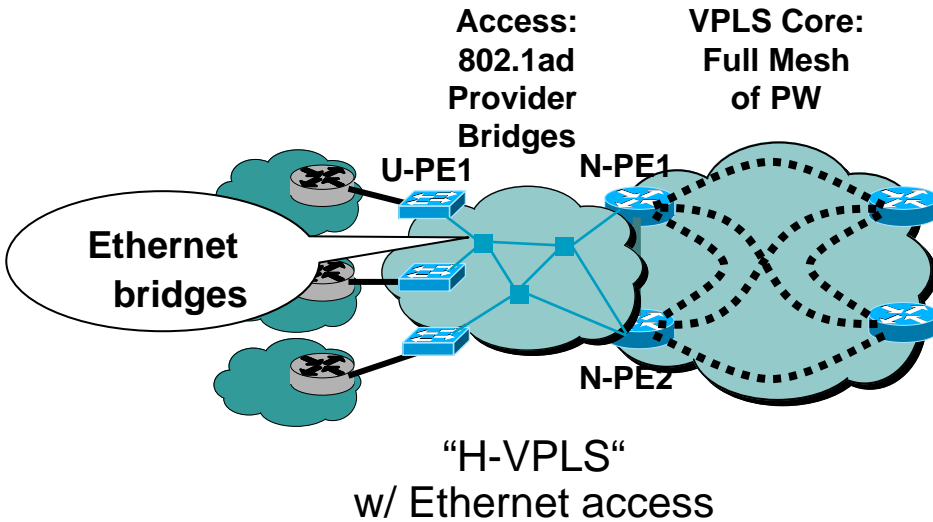
- **performs on a per Emulated VC basis:**
  - **Learning**/aging of MAC address
  - **Flooding**
  - **Forwarding** (unicasting, broadcasting, multicasting)
  - Running Spanning Tree Protocol (STP) if needed
- **distributed VSI's interconnexion**
  - **Full-mesh** of **Emulated VCs** per VPLS.
    - Encap. based on **PWE3**
  - Network “**split-horizon**” to prevent loops

# VPLS – Building blocks

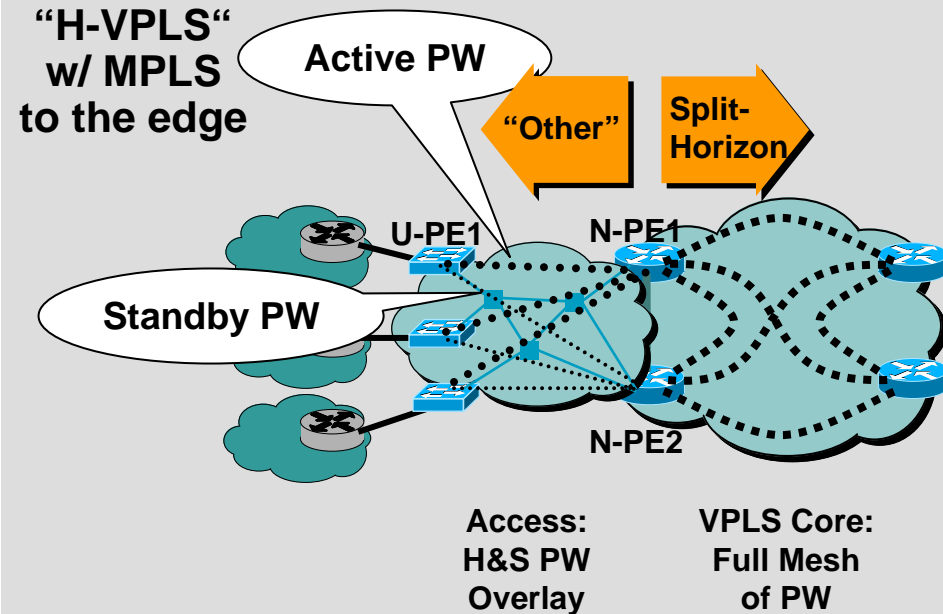


- **Attachment Tunnels**
  - 1Q in 1Q (L2 tunnel)
  - Pseudo-Wired (L3 tunnel)
- **Attachment VC**
  - 1Q (L2 tunnel)
  - Pseudo-Wired (L3 tunnel)

# H-VPLS flavors



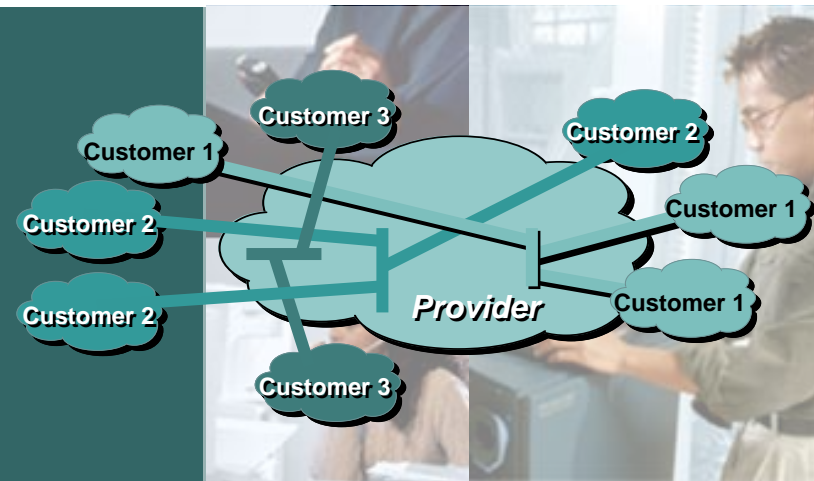
- IEEE 802.1ad Provider Bridges in the Access running 802.1s/w MSTP/RSTP, VPLS core (full-mesh of PW w/ split-horizon for loop-avoidance)



- MPLS edge and core
  - Full-mesh of PW in core, split-horizon
  - Hub & Spoke access PW for access. Only one PW per U-PE active at a time

# Ethernet TOOLS

## - Auto-discovery

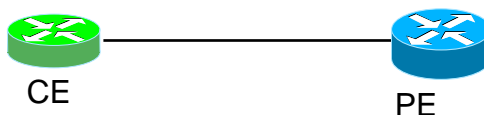


# Goals for this short talk

- **Introduce some new L2VPN authorization concepts**
- **Provide context for these within L2VPN/VPLS auto-discovery**
- **Provide some examples of how AUTODISCOVERY could be used for L2VPN authorization and “zero-touch” provisioning.**

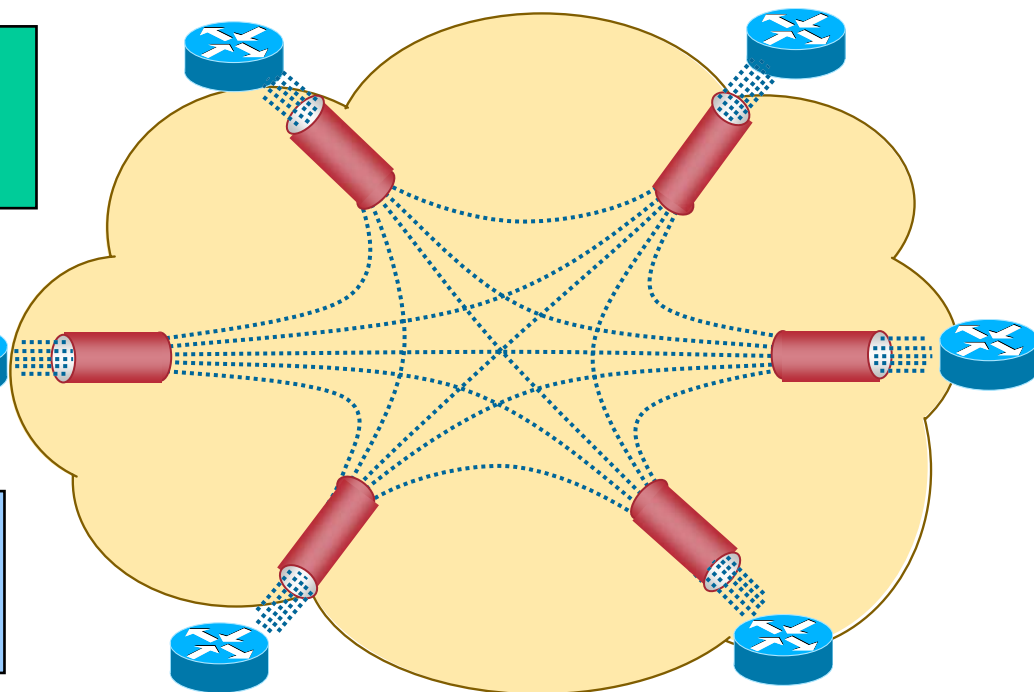
# L2VPN Authorization Steps

## 1. CE/AC Authorization – *Attachment Circuit to VPN ID*



## 2. VPN Authorization – *VPN ID to PE Membership*

## 3. PW Authorization – *PE Membership to PW signaling*



- Each step is independent and may be performed by any combination of local configuration, RADIUS, BGP, etc.

# PE Auto-discovery vs. “zero touch” provisioning

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- **PE Auto-discovery**

**Focus on Authorization Step 2 only.**

**PEs speak to one another (via BGP or some other router-router protocol) and “discover” their topology.**

**Targeted at VPLS only**

- **“Zero-touch” provisioning**

**Maps the identity of a CE or AC to a service.**

**Applies to VPWS (ATM, FR, Ethernet, etc), VPLS, IPLS, etc.**

**All service mappings reside in a RADIUS database.**

**Router dynamically receives config for circuits which are active**

# Zero-touch authorization

- PE is deployed with very simple config, pointing towards a RADIUS/LDAP server
- Interfaces are designed to detect a “First Sign of Life” (FSOL). For PVCs, this could be the first data packet received on a given circuit. For SVCs, CE-PE signaling (EAP 802.1x, ILMI, etc).
- When the FSOL occurs, a string serving as identity for the interface or CE is sent to the RADIUS server for authorization.
- The RADIUS server returns interface parameters, VPN membership, Pseudowire setup information, etc.

# L2VPN Authorization Schema

**Router ID +  
Interface name,  
SAI, or CE Identity**

**AC Record**

- SAI (AGI+SAII)
- Service Type (VPLS, VPWS, IPLS, etc)
- Circuit-specific Parameters (QoS, etc)

**AGI (VPN ID)**

**VPN Record**

- PE Router ID + SAI,
- PE Router ID + SAI,
- PE Router ID + SAI

**Router ID + SAI**

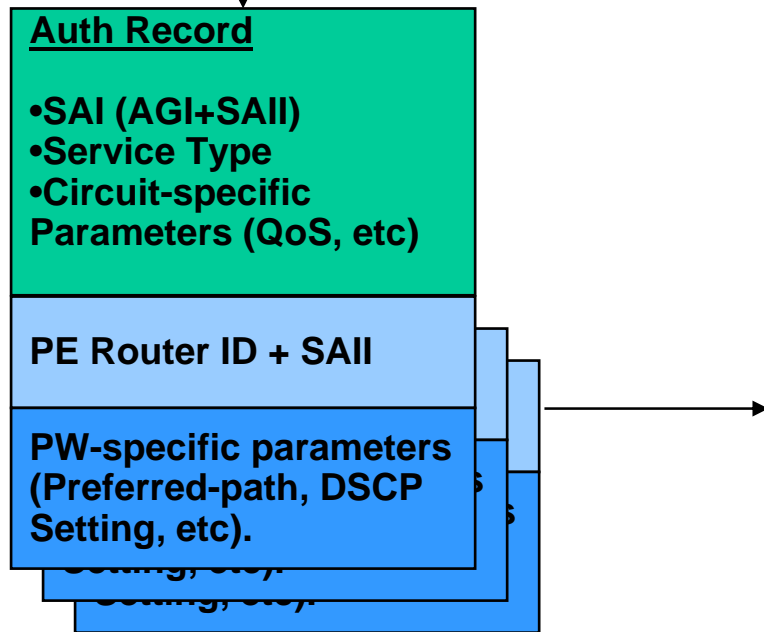
**Pseudowire Record**

- PW-specific parameters (TE Tunnel mapping, DSCP Setting, etc).

- **Defined using IETF “Single-Sided Signaling” nomenclature**
- **3 records in schema does not necessarily imply 3 off-box transactions**

# Collapsed Schema

Router ID +  
Interface name, SAI,  
or CE identity



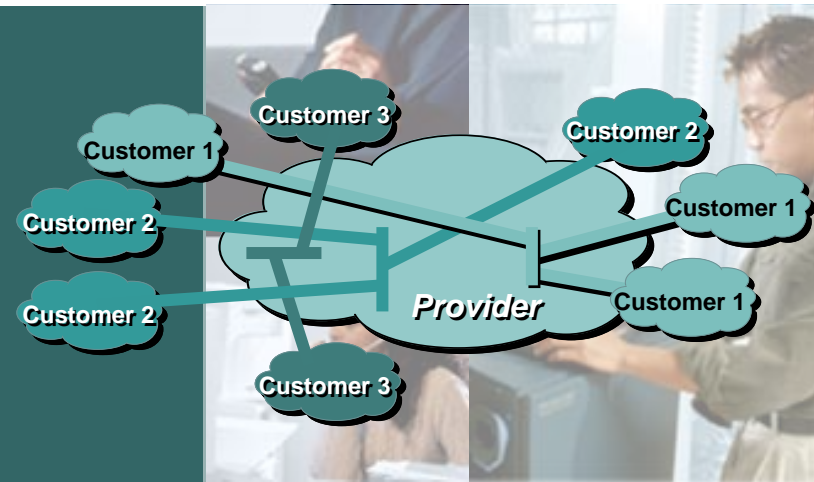
- Parameters collapsed into single record to reduce the quantity of RADIUS transactions
- Particularly suited for VPWS, or VPLS with a limited number of PEs.
- Generic rule for PW setup: If Router ID from Auth Record is different from the local Router ID, use SAI as TAI in PW signaling (LDP)

# Solutions for Auto-discovery

Auto-discovery Protocols	AC Authorization	VPN Authorization	PW Authorization
LDP (pt-pt prtl)	No	YES	YES
BGP (pt-mpt prtl)	No	YES	No (or via LDP)
RADIUS (server based prtl)	YES	YES	YES
LDAP (server based prtl)	YES	YES	YES

# Ethernet TOOLS

## - OAM's



## ***“OAM Requirements for monitoring:***

### ***First:***

***Possibility to monitor the E2E connectivity (CE to CE)***

***Possibility to do fault detection  
(segment monitoring (AC, PW))***

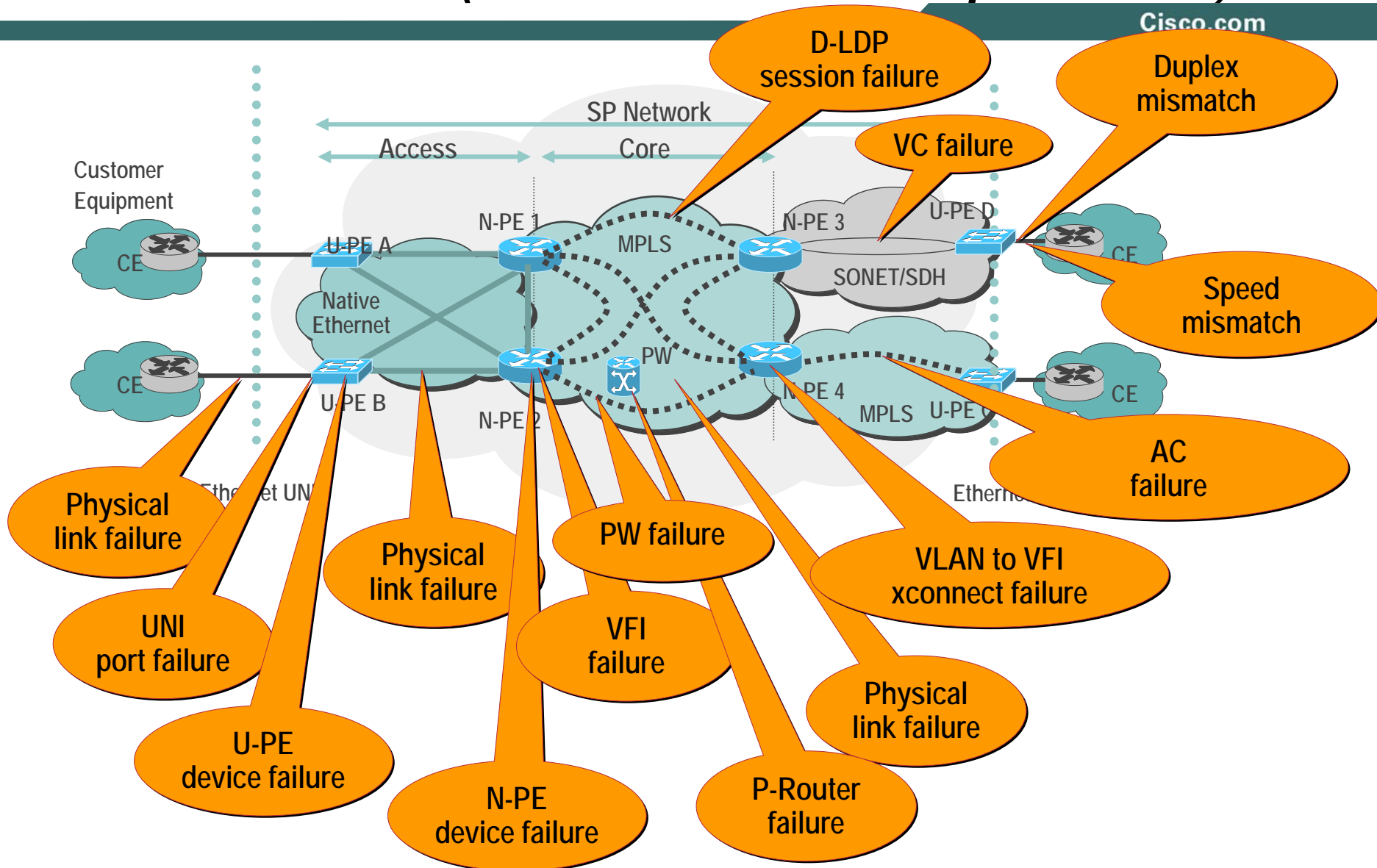
### ***Second:***

***Performance management for E2E services  
(delay, loss, etc...)”***

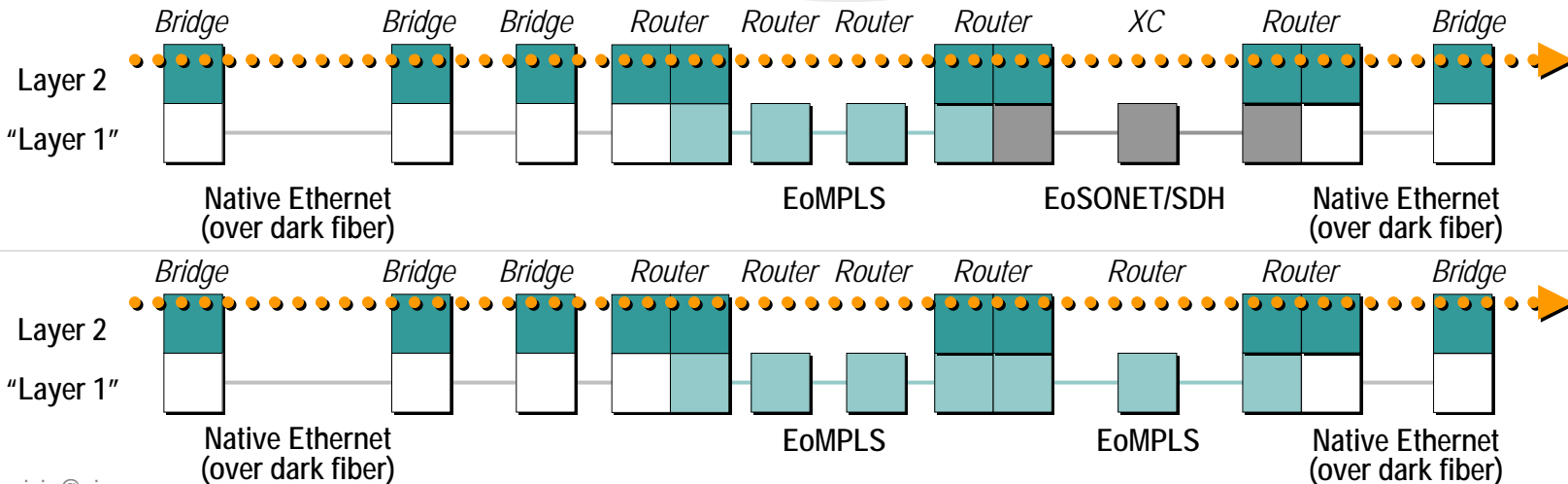
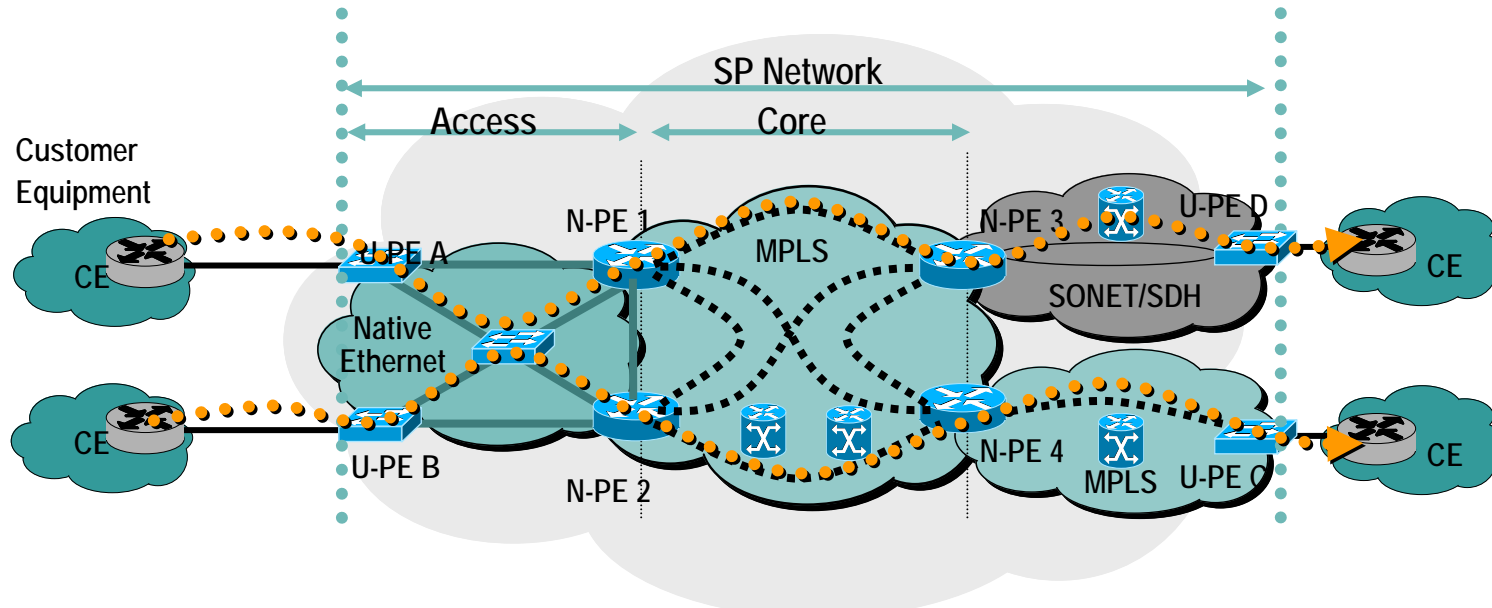
An EMEA PTT

# Problem Domain

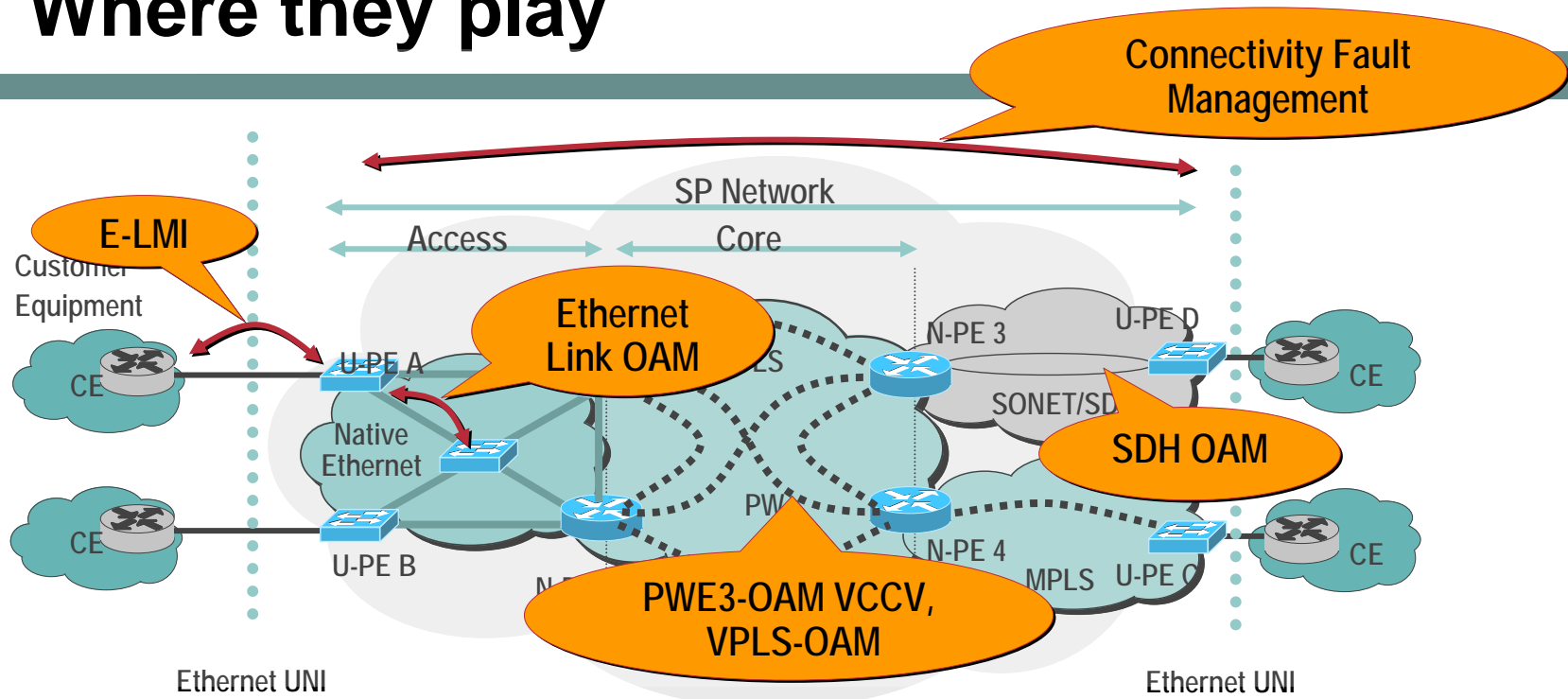
*Some scenarios (not even close to comprehensive)*



# OAM & Layering



# E-OAM and LMI: Where they play



- **E-LMI: CE configuration, L2 connectivity management**
- **Link-Layer OAM: Per Link OAM's**
- **Connectivity Fault Management: Per Service/VLAN OAM's**
- **PWE3 OAM's : draft-ietf-pwe3-vccv-xx.txt**
- **Performance Management : ITU-T working group**

# Standard Bodies and Forums

- **Several standard bodies are working on Ethernet CFM**

## ITU-T SG 13



Ethernet Layer Network Architecture (G.8010 SG 15)

Ethernet OAM Functionality (Y.ethoam SG 13)

Requirements for OAM functions in Ethernet based networks (Y.1730 – SG 13)

## IEEE

802.3ah – Ethernet in the First Mile (Physical OAM)

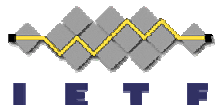
802.1ag – Connectivity Management (Per VLAN OAM)

MEF began the work on fault management and has deferred the detailed work to the other standards bodies

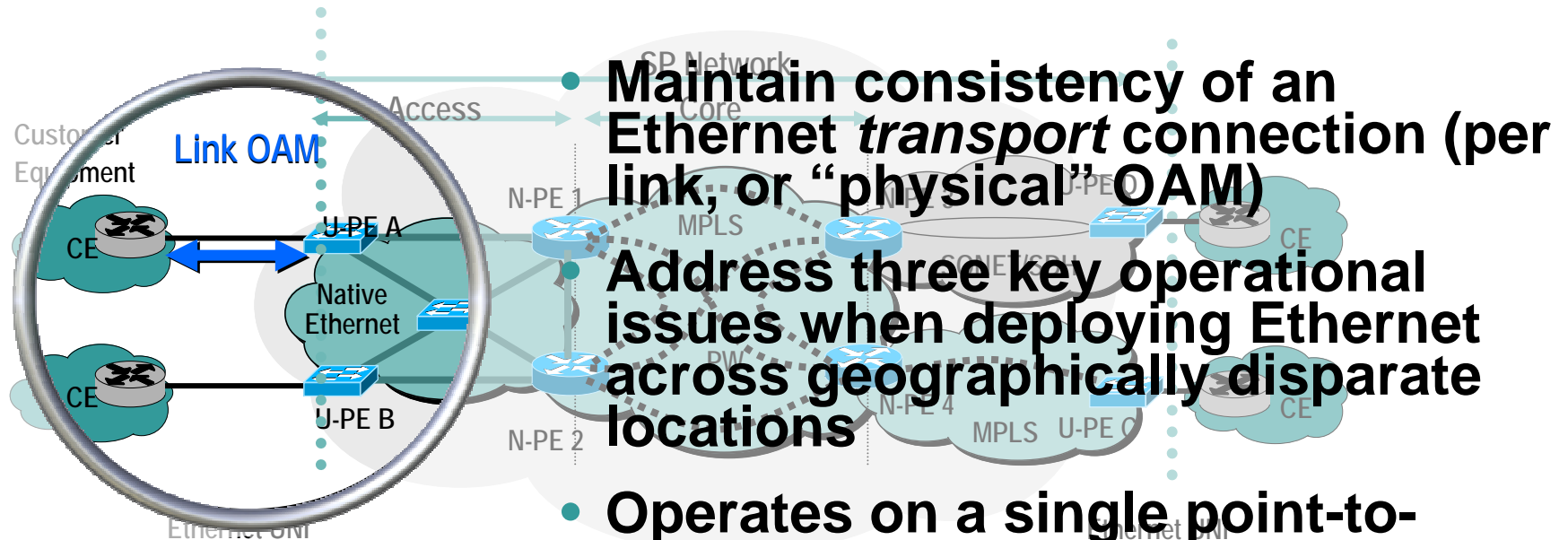
IETF is tracking the work in fault management, in the other standards bodies, in the context of PWE3, VPLS

MFA is defining OAM-Interworking as part of their MPLS-Interworking models

- **These standard bodies share common membership and are cooperating fully**
- **Cisco has strong presence in all of these organizations**



# Link OAM (IEEE 802.3ah)



- **Maintain consistency of an Ethernet *transport* connection (per link; or “physical” OAM)**
- **Address three key operational issues when deploying Ethernet across geographically disparate locations**
- **Operates on a single point-to-point link between 2 devices**
- **Slow protocol using packets called OAMPDUs which are never forwarded, or include in preamble.**
- **Standardized as part of IEEE 802.3ah (Ethernet in the first mile)**

# 802.3ah OAM – Key Functions

- **Link monitoring**

basic error definitions for Ethernet so entities can detect failed and degraded connections

- **Fault signaling**

mechanisms for one entity to signal another that it has detected an error

- **Remote loopback**

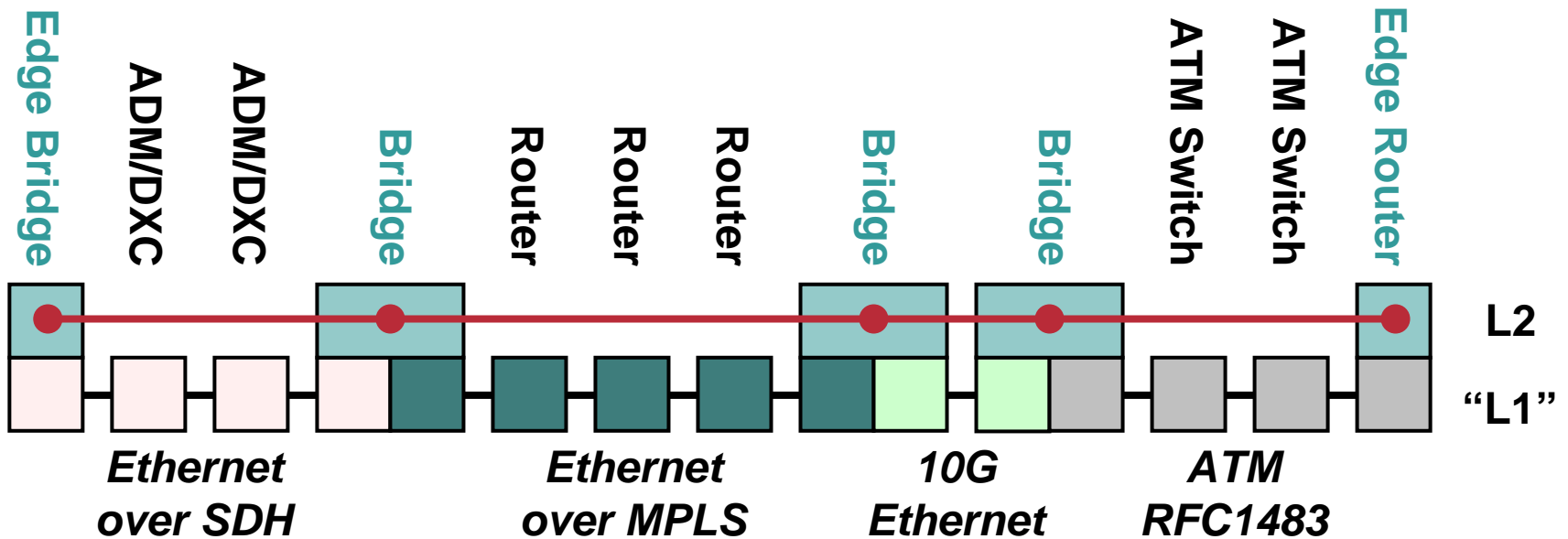
used to troubleshoot networks, allows one station to put the other station into a state whereby all inbound traffic is immediately reflected back onto the link

- **OAM Discovery**

Discover OAM support and capabilities per device

# What is Ethernet Connectivity Fault Management?

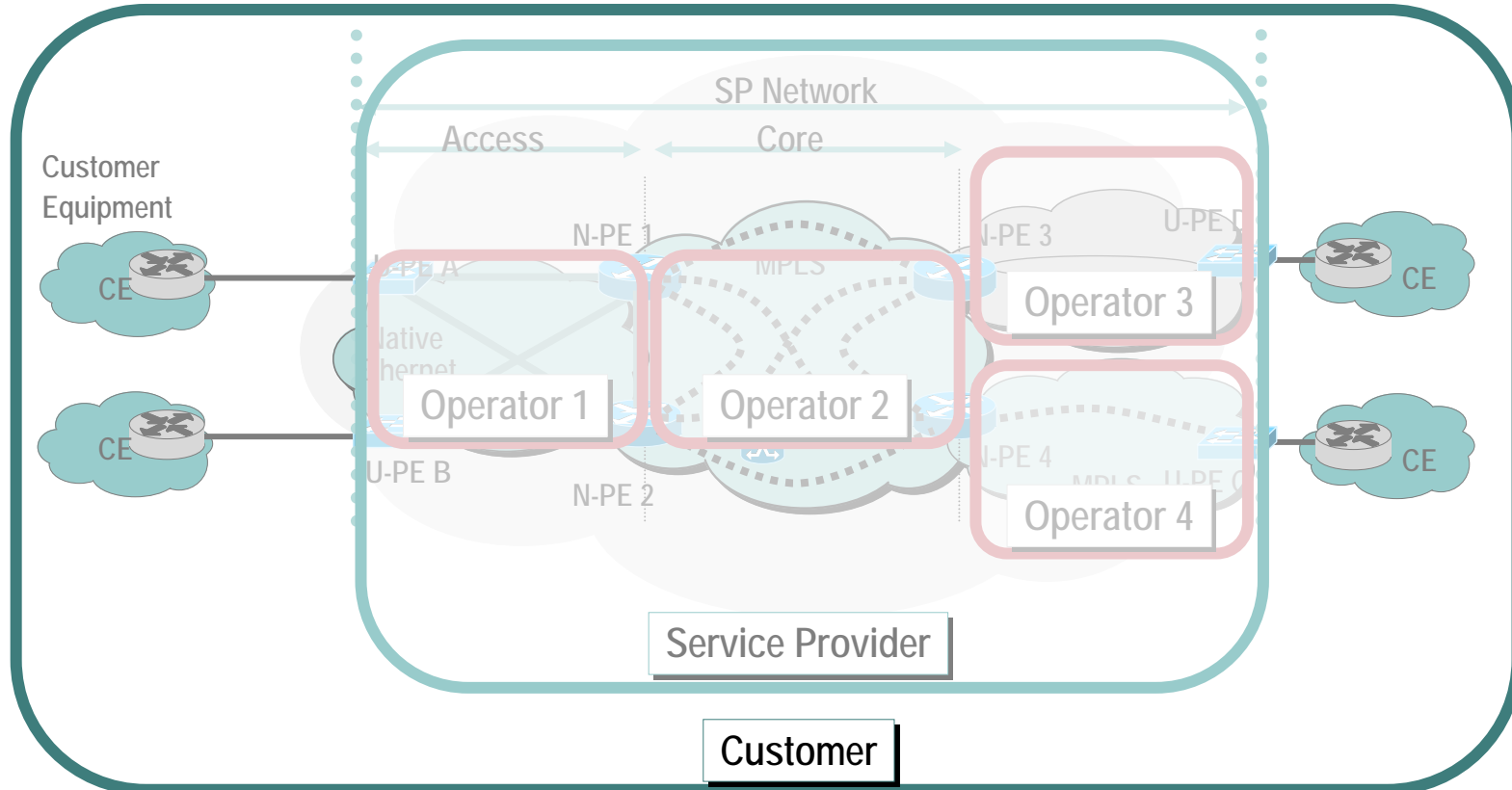
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- **Connectivity Fault Management:**  
**(From P802.1AG PAR)**

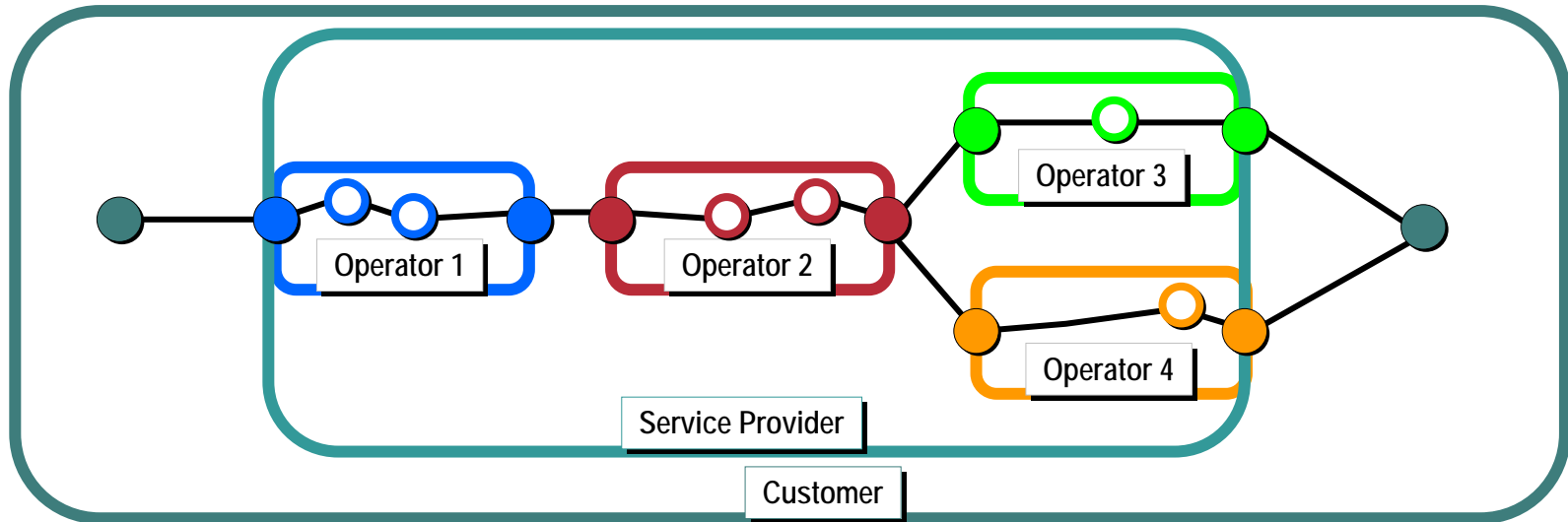
*“... protocols, procedures, and managed objects to support transport fault management ... discovery and verification of the path, through bridges and LANs, taken for frames ... detection and isolation of a connectivity fault to a specific bridge or LAN”.*

# Different Service Domains... ...result in different OAM Domains



**The Domain-Onion: Visibility of each domain is limited to its border elements with its peering domains and its own internal elements**

# Ethernet OAM Concepts: *Maintenance Points*



## Maintenance Points (MP)

IEEE MAC, Interface, Port

### ● Maintenance End Points (MEP)

MP located at the edge of a domain

### ○ Maintenance Intermediate Points (MIP)

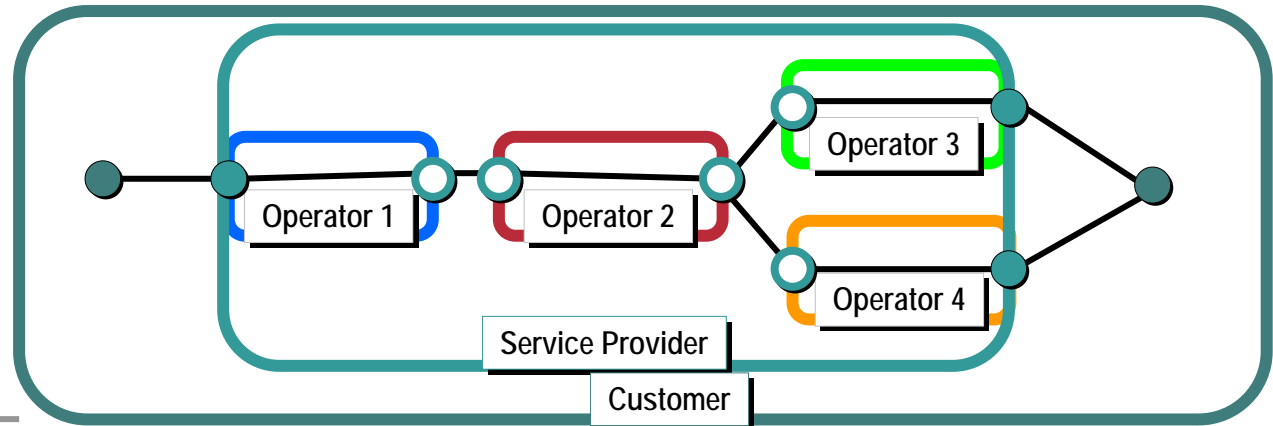
MP located within a domain

System administrators use MEPs to initiate and monitor CFM activity and report the results

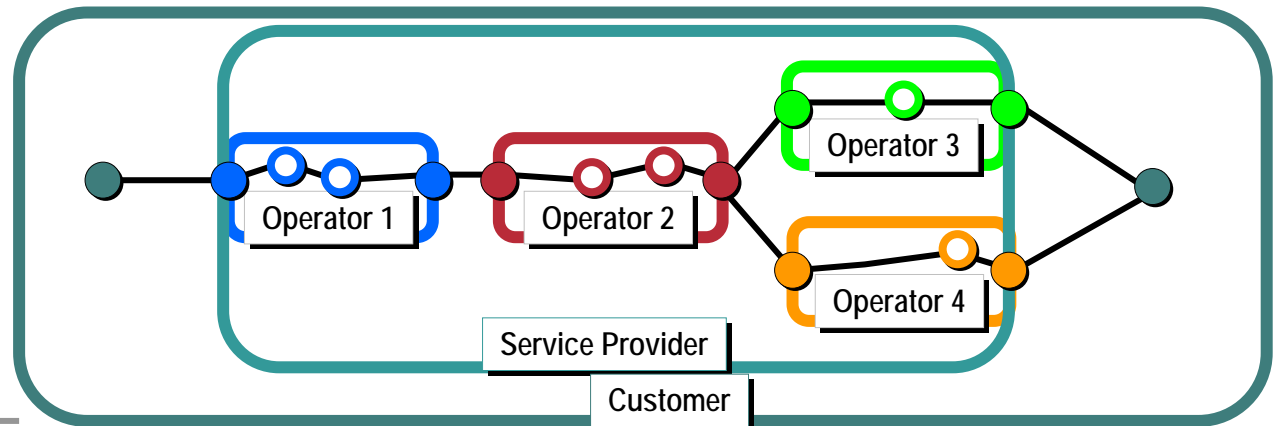
MIP passively receive and respond to CFM packets initiated by MEPs

# Different views – Operator and Provider: *Nested MPs*

**Provider Level View**

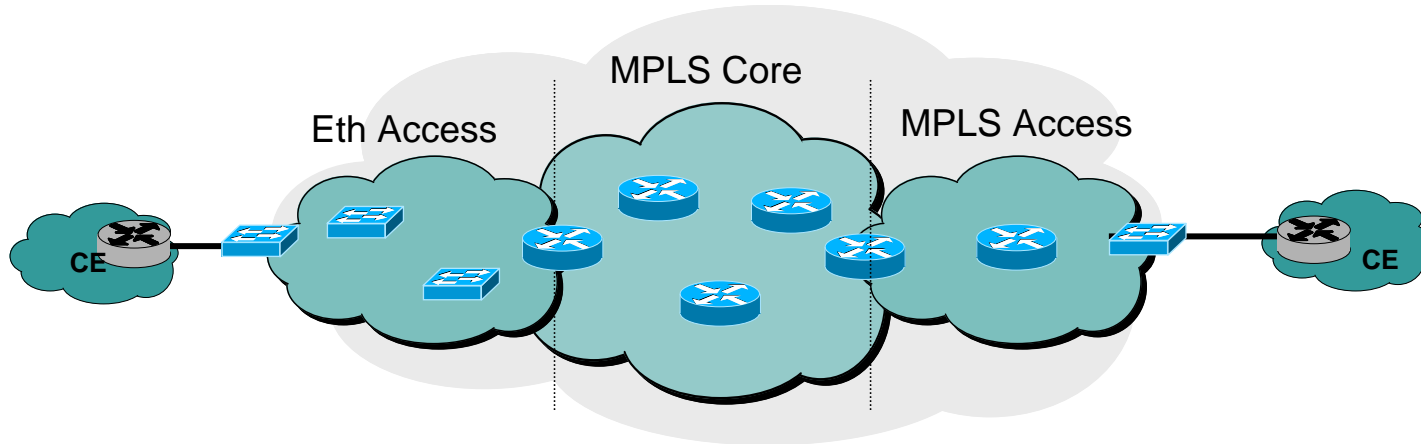


**Operator Level View**



**Each level's MEPs are the next-higher-level's MEPs and MIPs**  
**Each level's MIPs are invisible to all higher levels**

# Connection Management – 4 Main “Tools”



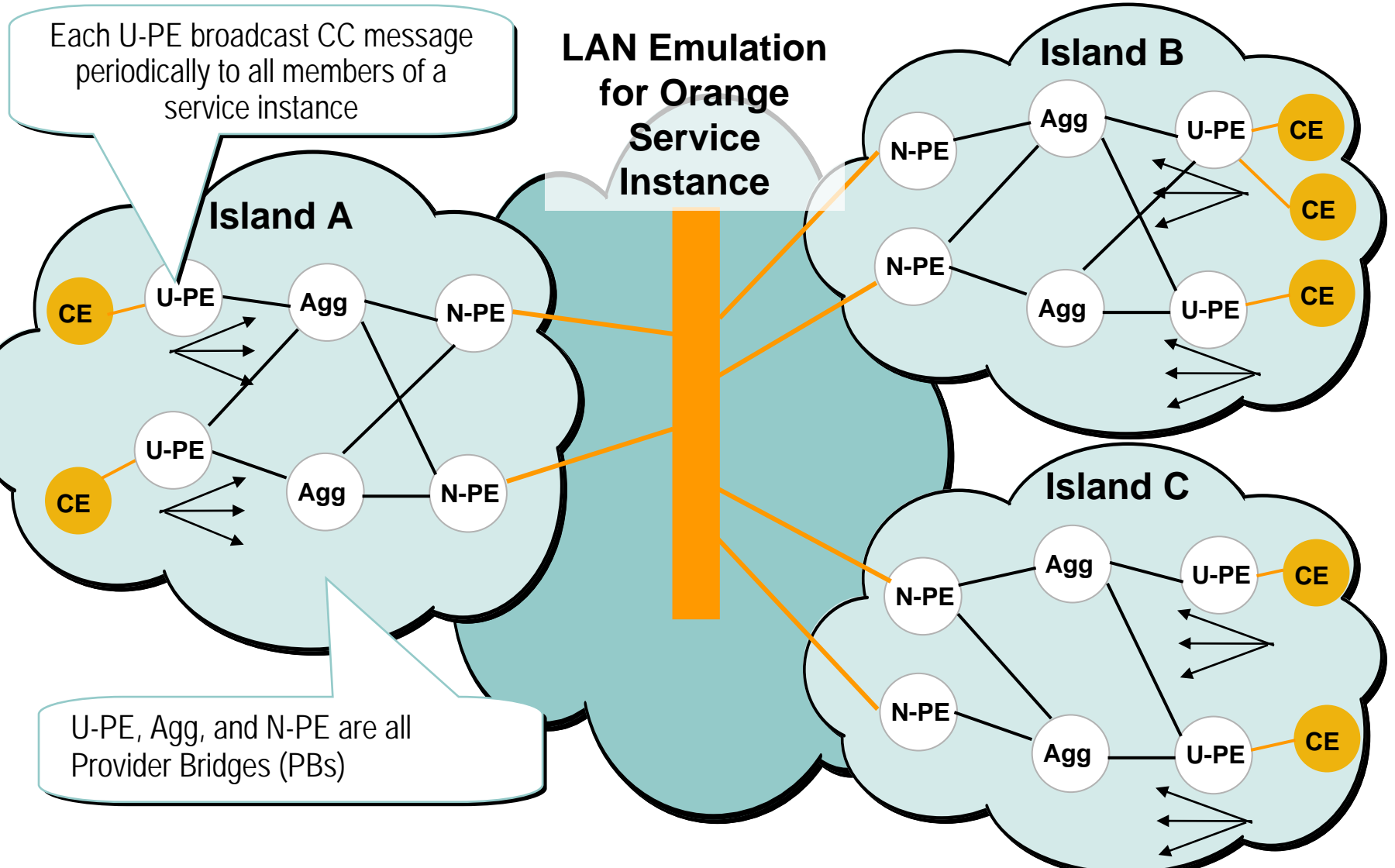
**Continuity  
Check**

**Traceroute**

**Loopback  
(Ping)**

**Alarm Indication  
Signal (AIS)**

# Fault Detection: Continuity Check

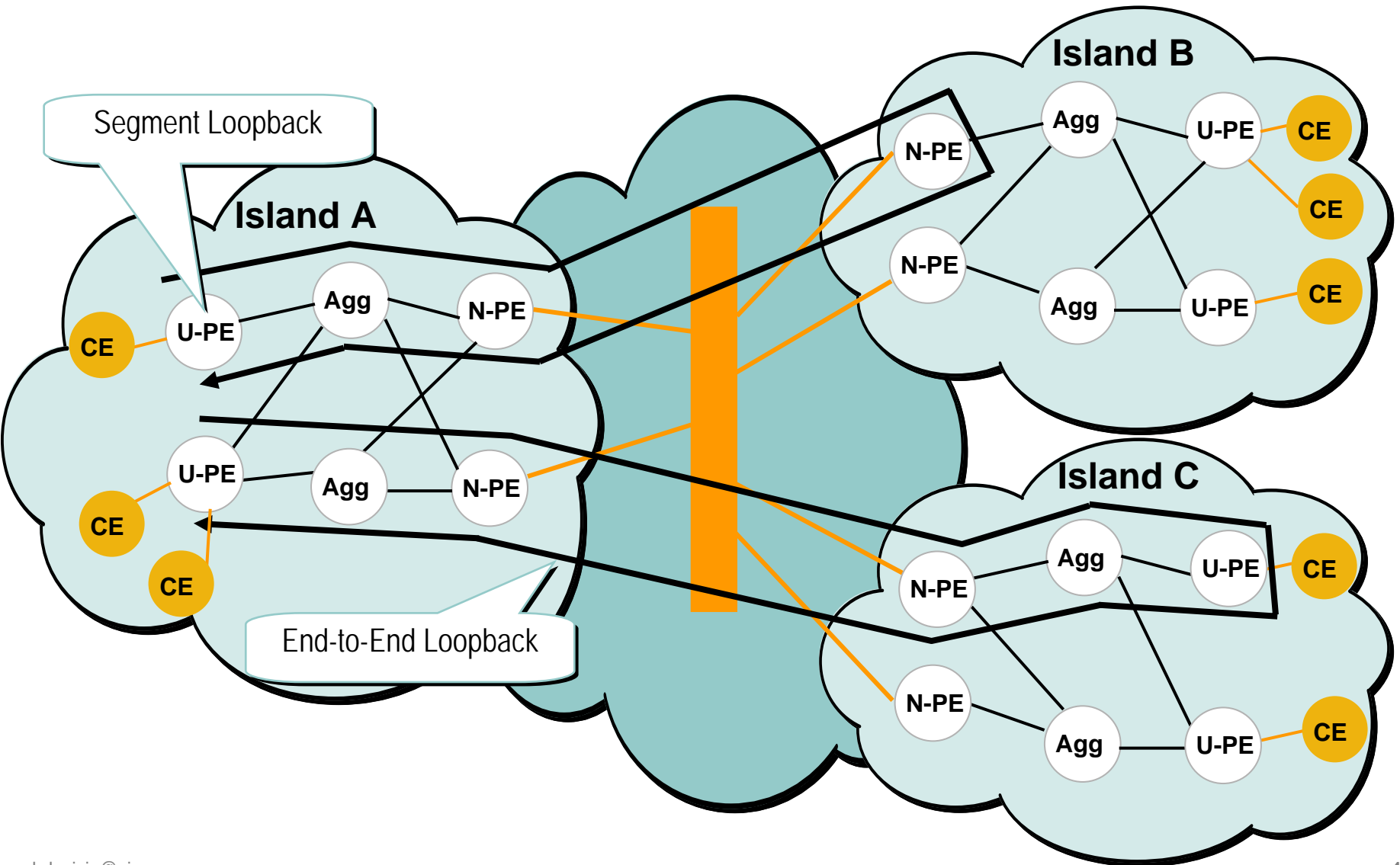


Each U-PE broadcast CC message periodically to all members of a service instance

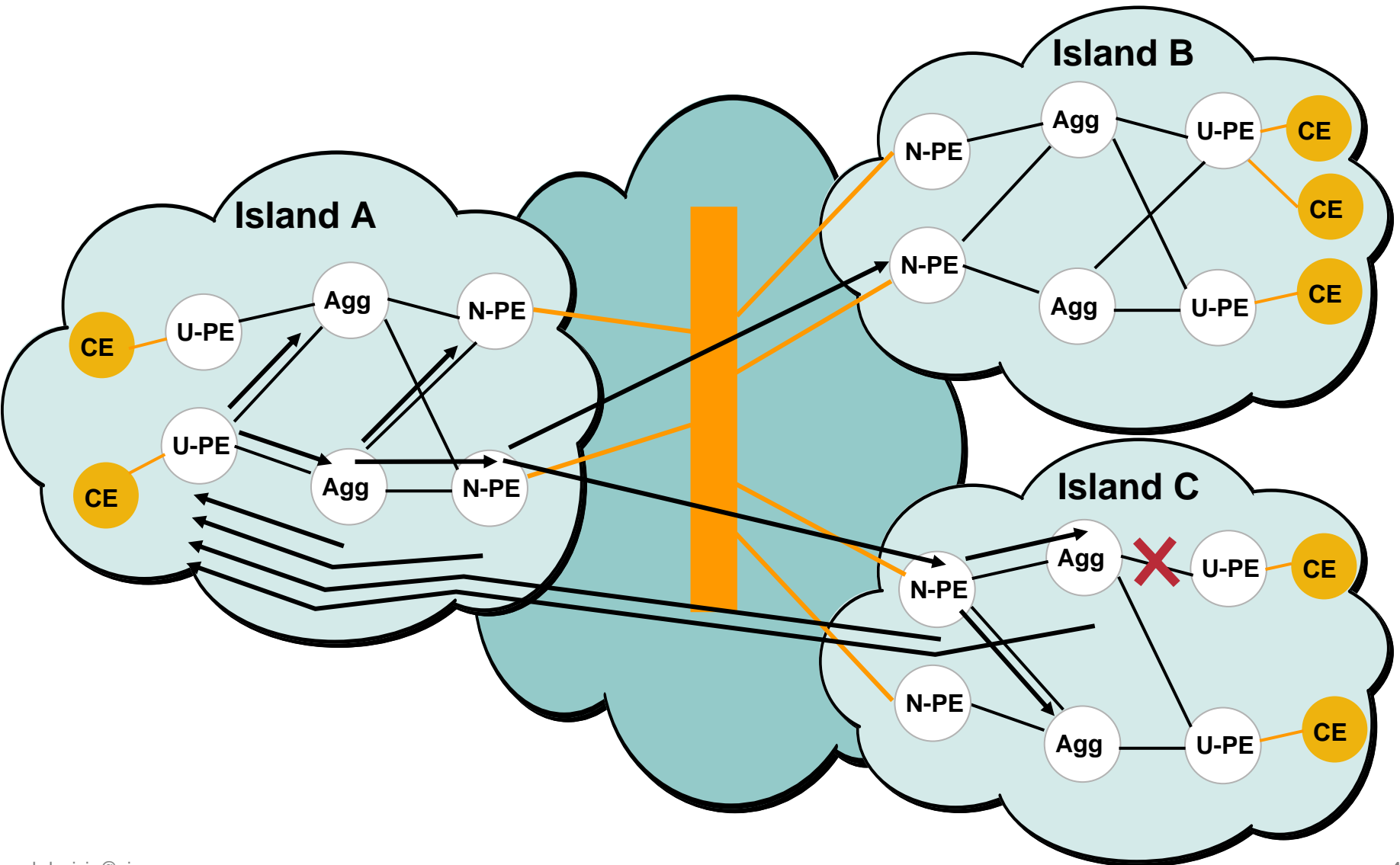
LAN Emulation for Orange Service Instance

U-PE, Agg, and N-PE are all Provider Bridges (PBs)

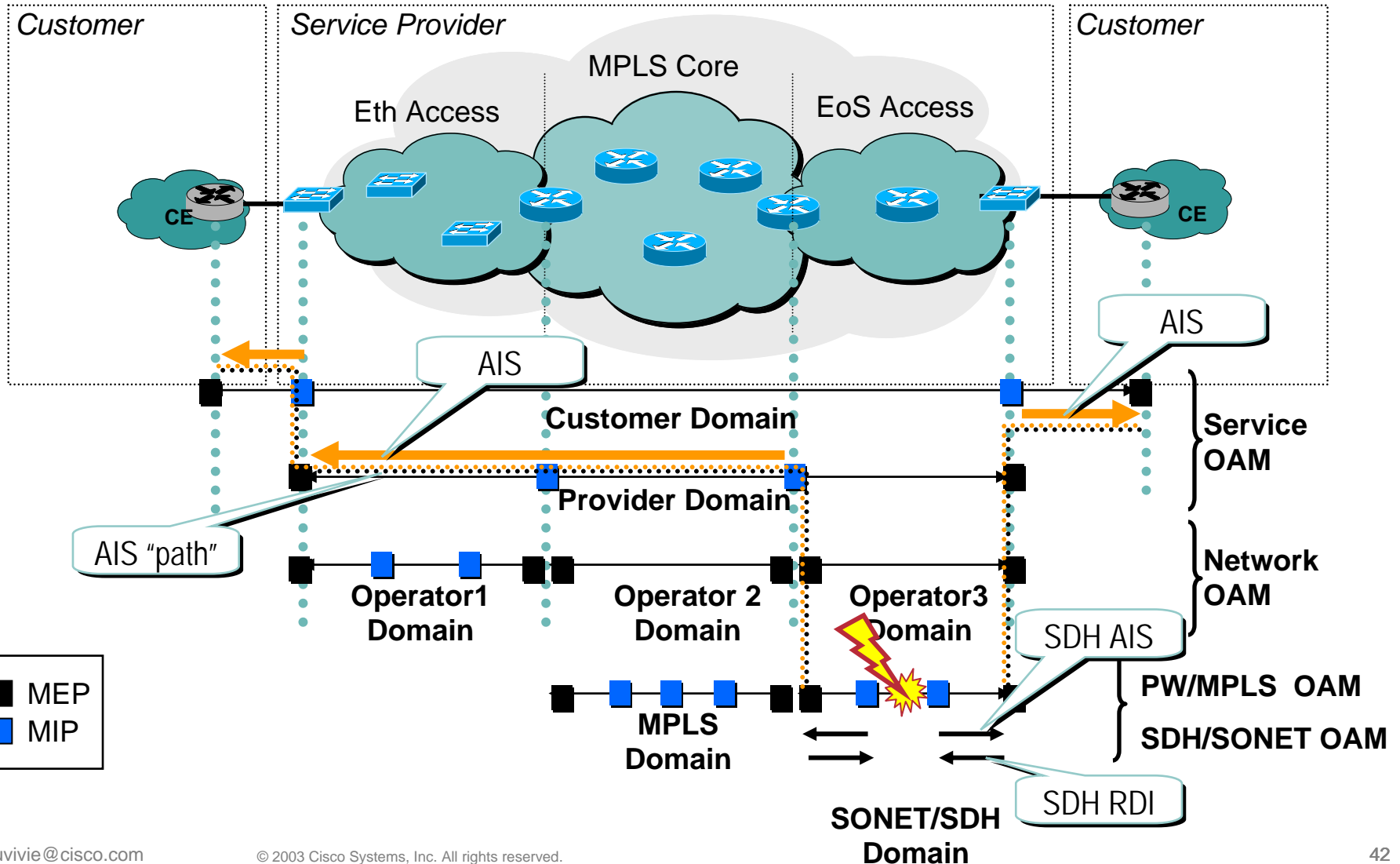
# Fault Verification: Loopback Test



# Fault Isolation: Path Trace

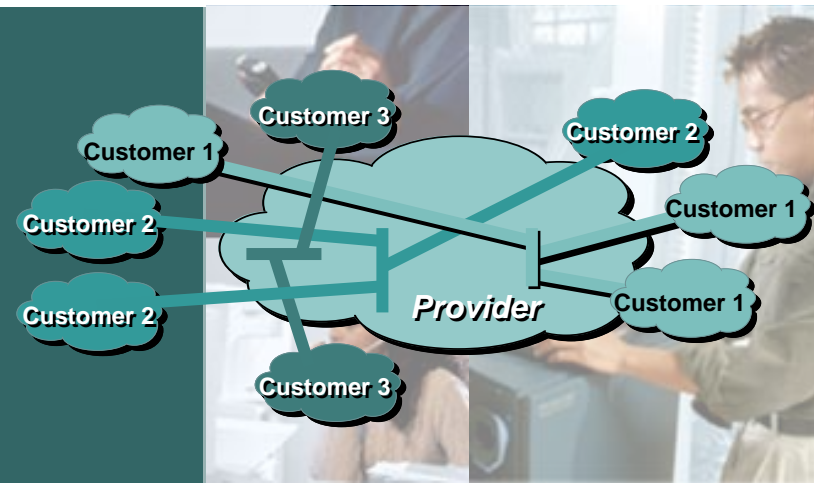


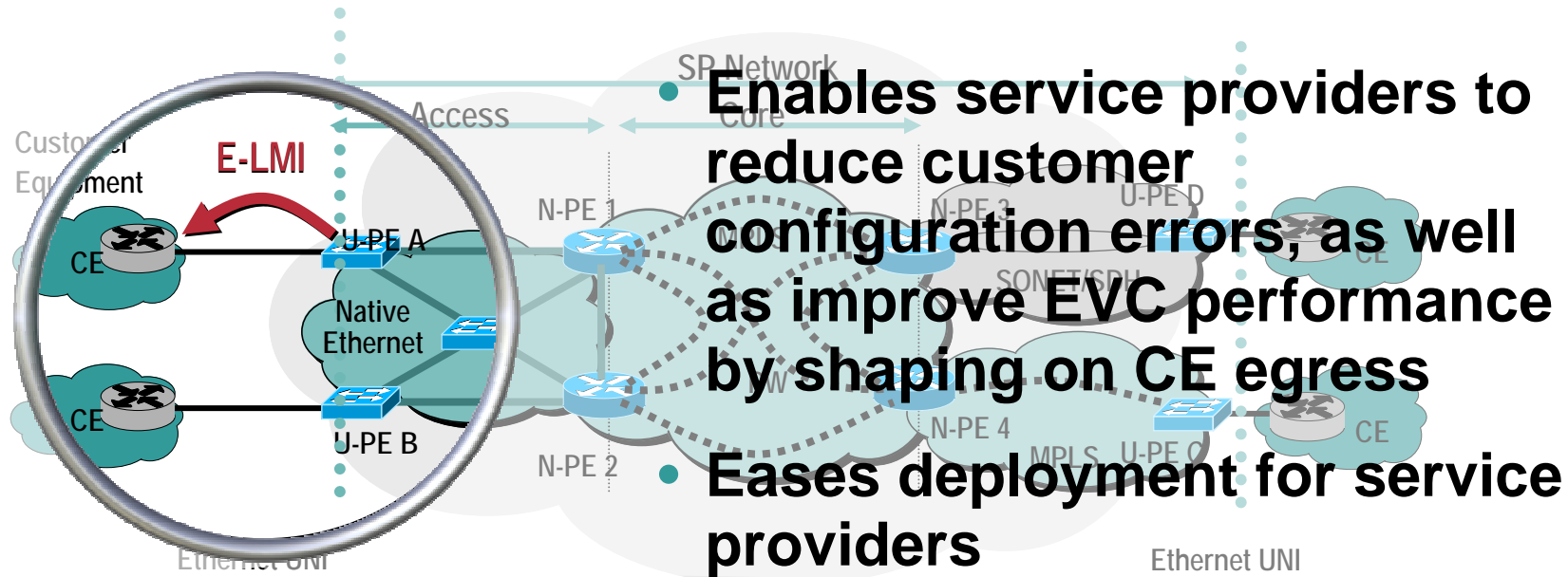
# Alarm Indication Signal



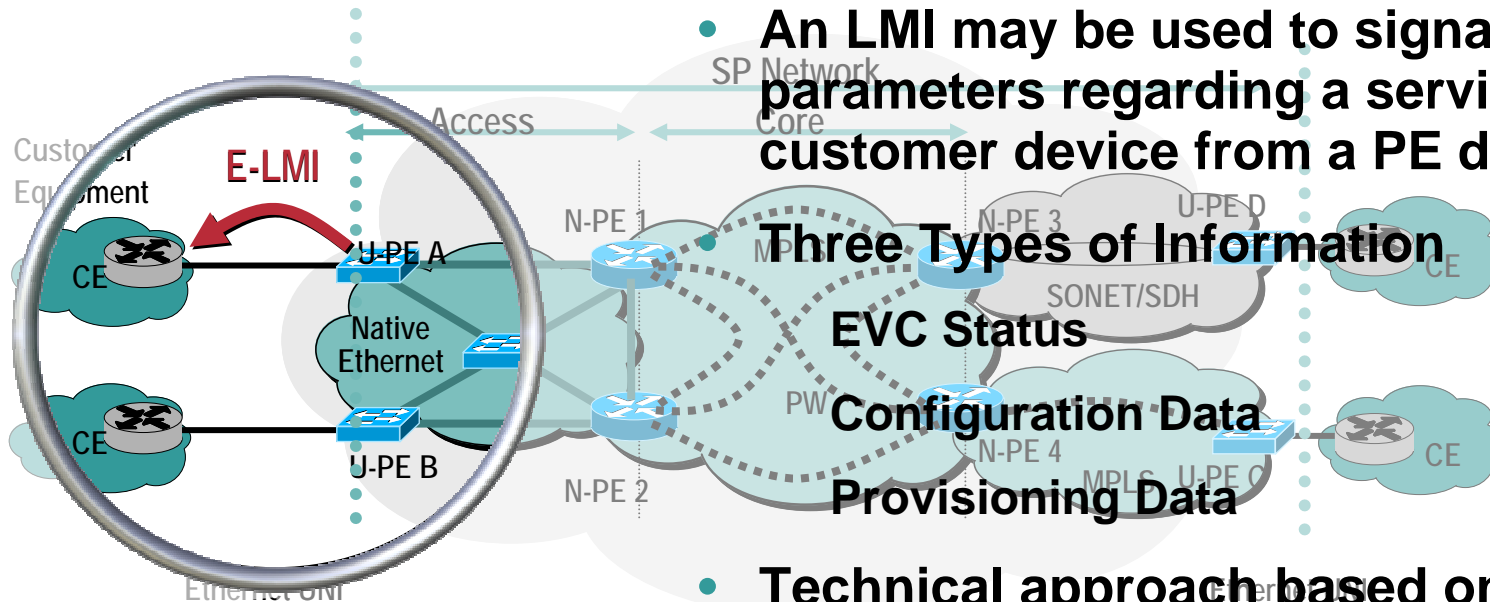
# Ethernet TOOLS

## - E-LMI





# Ethernet LMI



- An LMI may be used to signal various parameters regarding a service to a customer device from a PE device

## Three Types of Information

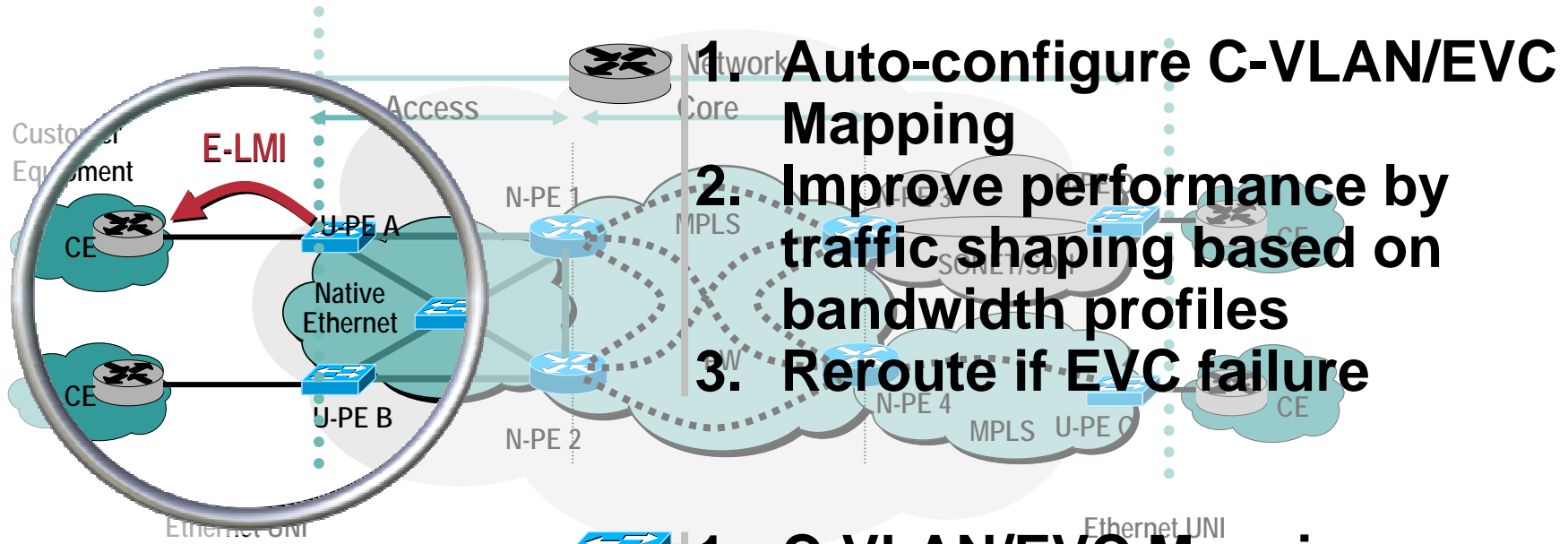
EVC Status

Configuration Data

Provisioning Data

- Technical approach based on Frame Relay LMI
- Part of MEF UNI Type 2 (beyond standard Ethernet)
- Can leverage to develop E-NNI (similar protocol, but symmetric)

# Ethernet LMI



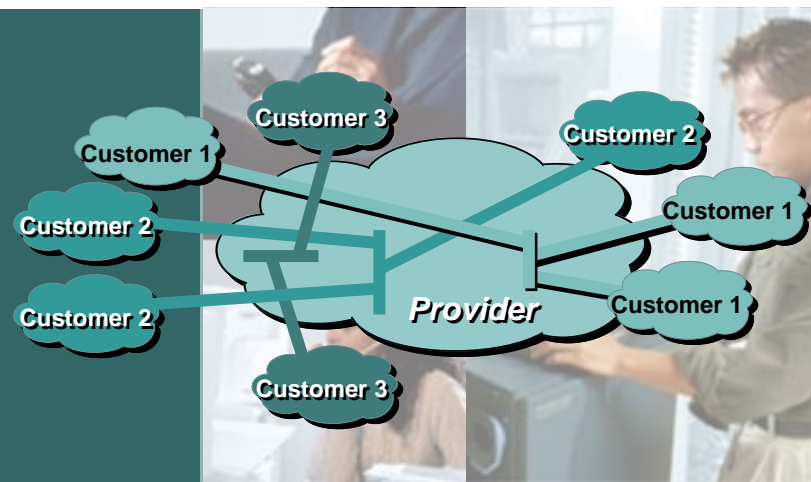
- UNI-based attributes*
- EVC based attributes*



- 1. C-VLAN/EVC Mapping**
- 2. Bandwidth profiles:  
Per Port, Per EVC, Per CoS**
- 3. EVC status**

# Ethernet in WAN

## Summary



# Ethernet in WAN summary

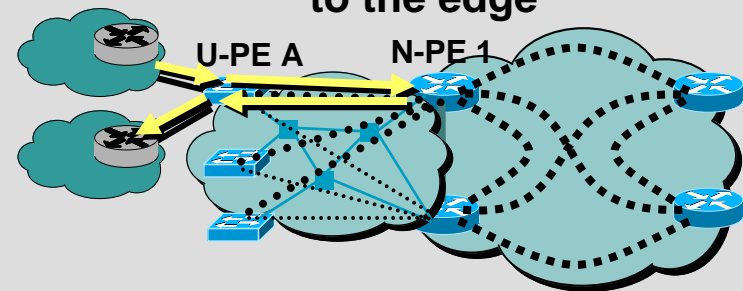
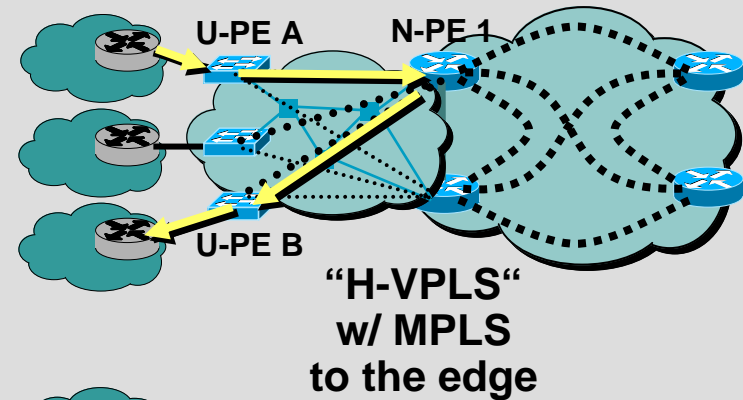
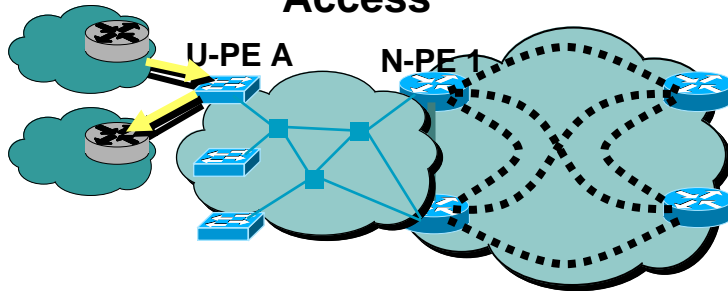
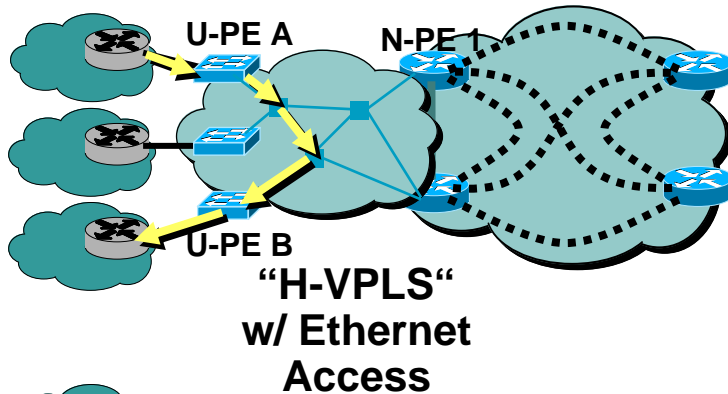
- **Not just about emulated Ethernet over IP/MPLS**
- **Other points are as mush important**
  - **Auto-discovery**
  - **AOM's**
  - **Signaling (E-LMI)**
  - **QoS**
  - **Scalability (MAC, VSI, PWE3)**
  - **Integration with existing (xDSL, FR/ATM Interworking)**

# CISCO SYSTEMS



# Comparing H-VPLS: Local Switching

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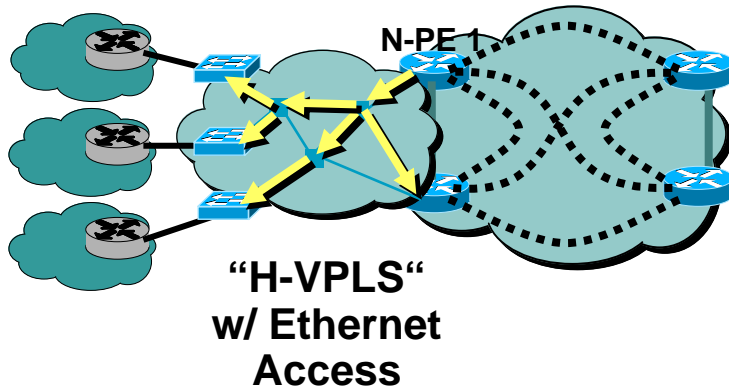


- Local Switching within the access domain: Optimal traffic flow, PE not involved
- Remember: Metro 80/20 rule: 80% of the traffic stays local...

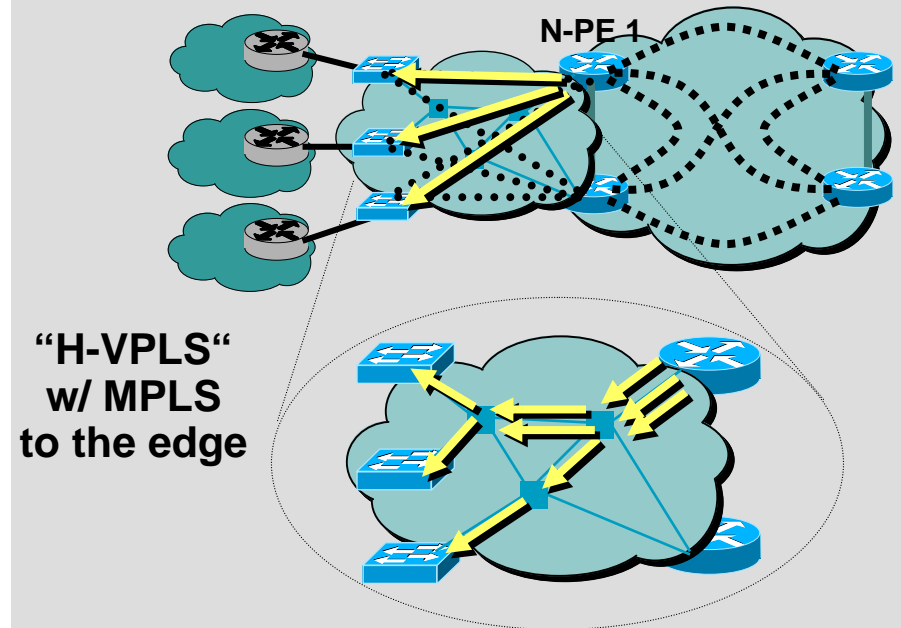
- Traffic always first passed from U-PE to N-PE

# Comparing H-VPLS: Multicast Distribution

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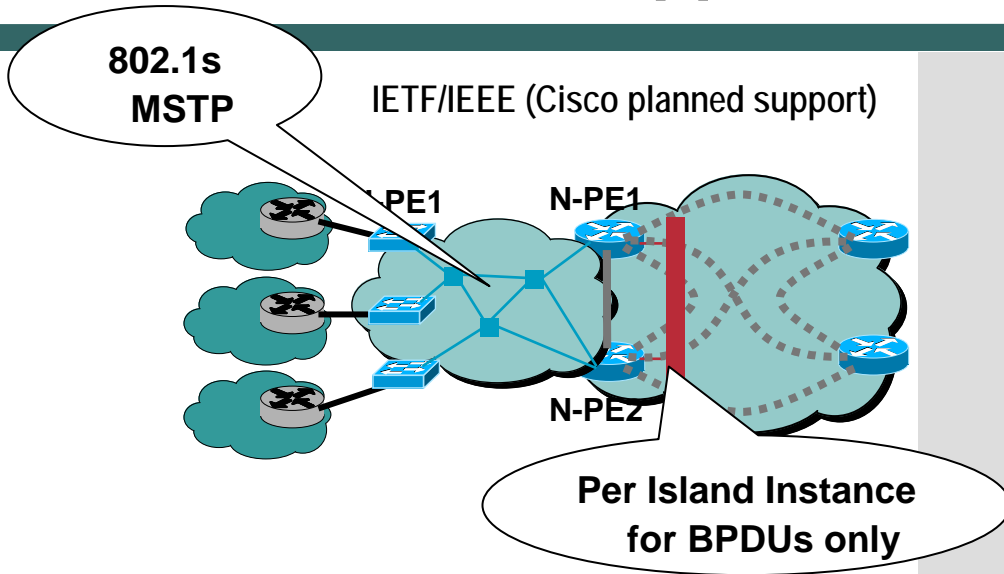


- **Efficient Broadcast/ Multicast distribution – native Ethernet. Distributed replication**



- **All Multicast/Broadcast traffic replicated only by the N-PE and sent to all attachment PW in the access: Significant load on the N-PE (which also does replication towards the core)**

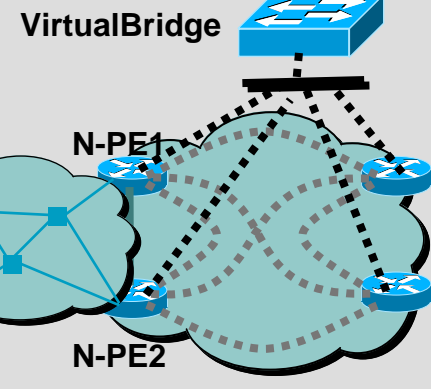
# Redundant Access of STP-Islands to the Core: The IETF/IEEE approach



- Standard 802.1s
- Per Access Island “BPDU Instance”
- Constrained topology

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Other solutions



- Emulates Virtual Core Bridge to avoid Loops
- Non-Standard Implementation
- Results in non-optimal traffic flows and topological constraints the standard solution does not show