



Hybrid Bridging & VLAN Cross Connect Provider Ethernet Networks

Nurit Sprecher

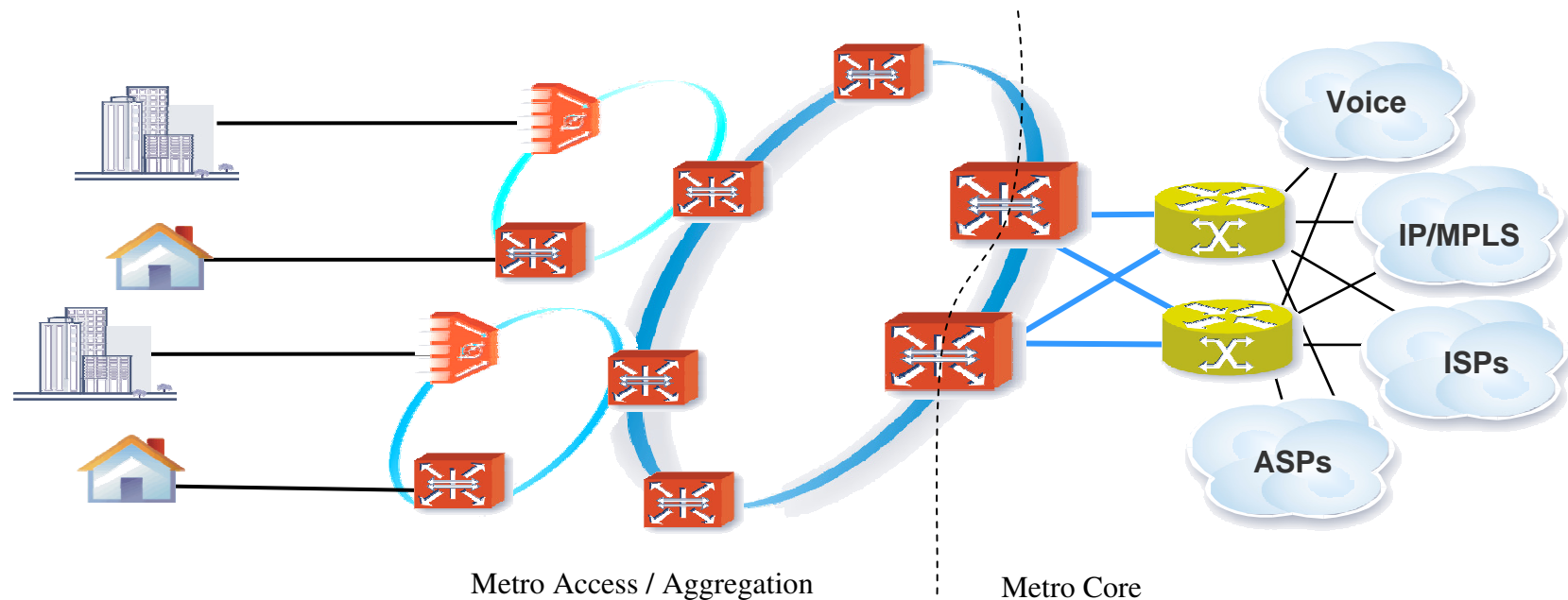
March 2006

SIEMENS

Communications

Provider Ethernet in Metropolitan Networks

- Ethernet, which is currently deployed in Metropolitan Access/Aggregation Networks, is expected to be extended to Metropolitan Core environments in the near future.
- Carrier-grade Ethernet is designated for a significant number of services.



New Infrastructure → New Network Challenges

**New Provider Ethernet
Infrastructure**



**Tough Challenges for Ethernet
Networks**

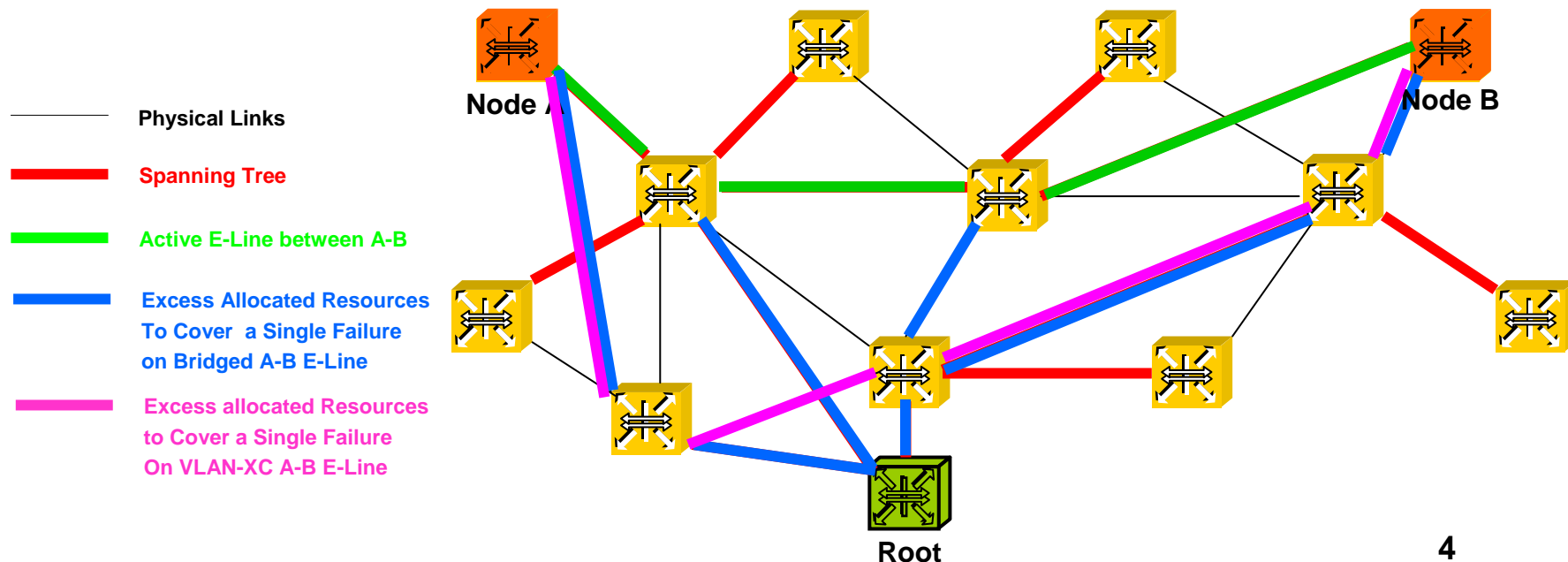
- Strict customer SLAs in terms of:
 - End-to-end guaranteed bandwidth with controlled jitter and delay
 - Service recovery in 50 ms
- Scalability to hundreds of thousand of subscribers with diversity of services in a single Ethernet domain
 - Business and residential services over a single network
 - Wholesale and retail services over a single network
- Secured networks and services
- Simple networks to minimize CAPEX and OPEX

Network Challenges: End-to-End Guaranteed Bandwidth

Assertion: “End-to-end guaranteed BW services can be supplied over Ethernet Bridged networks. Everything is predictable...”

But...

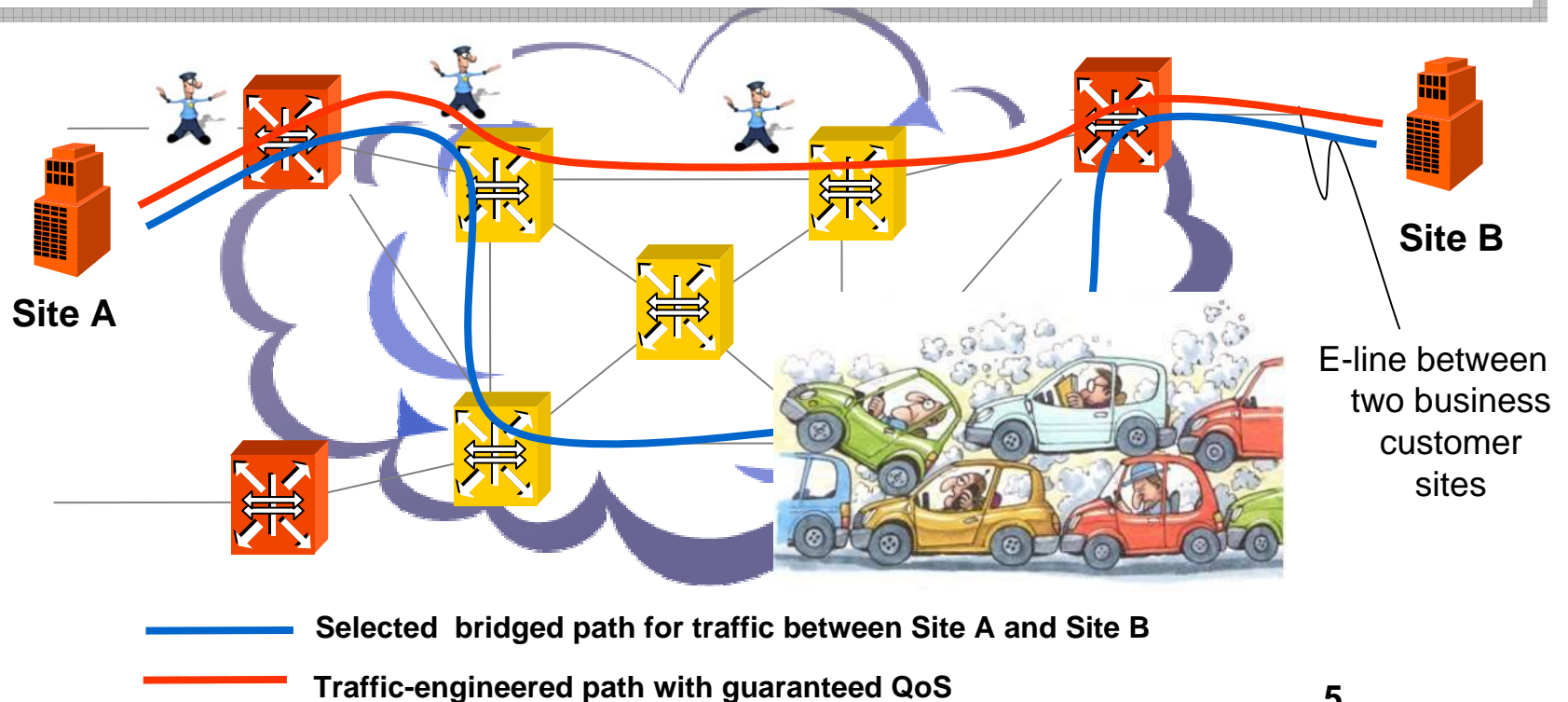
- **The allocation process is very complicated** (requires the simulation of MSTP and of all types of resource failures along the calculated paths, etc.).
- **A large number of excess resources must be allocated** (about 3-4 times the required BW!) to cover each failure along the calculated path.



Network Challenges: End-to-End Guaranteed Bandwidth (Cont.)

VLAN Cross Connect is a connection oriented technique which explicitly enables Traffic Engineering (to maintain efficient utilization of the network).

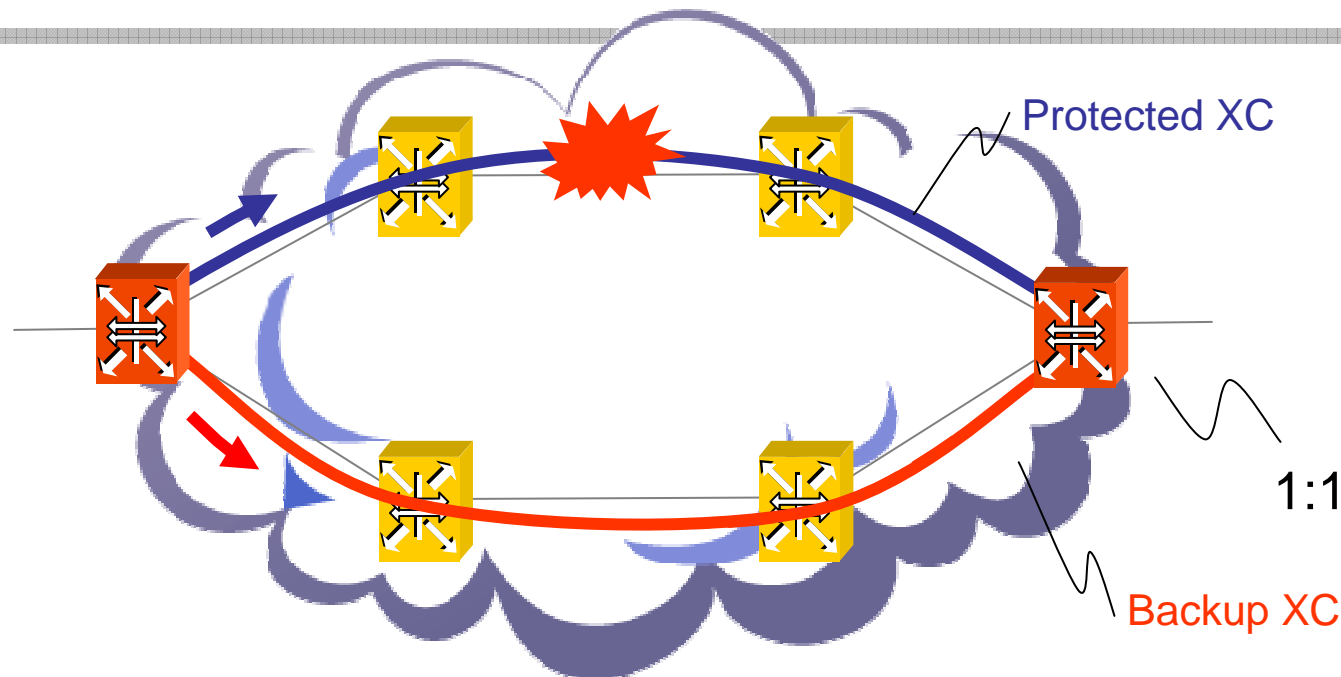
- Bandwidth can easily be handled by admission control and allocated for end-to-end connections.
- Bandwidth can easily be handled by admission control and allocated for end-to-end pre-provisioned (preferably disjoint) backup paths. The backup resources can be used for lower priority traffic when there is no failure.



Network Challenges: Service Resiliency

VLAN Cross Connect provides 50 ms full network recovery to maintain time-bounded services, even when thousands of services are simultaneously affected by a failure:

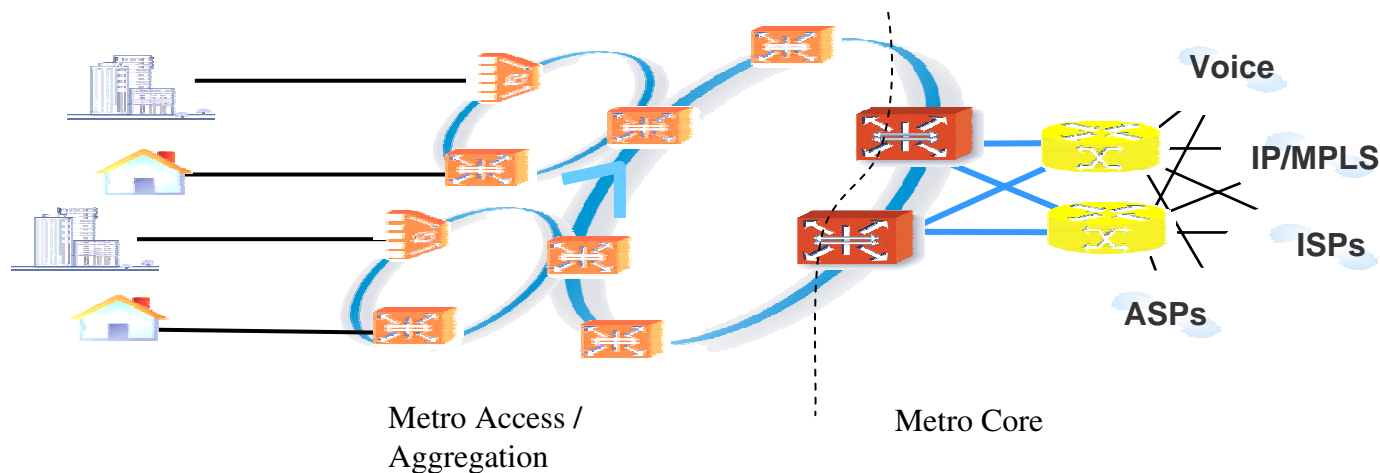
- 1:1 global protection with extra traffic, including pre-provisioned end-to-end backup paths
- Fast error detection using IEEE 802.1ag OAM messages
- 50 ms switchover following failure
- Revertive or non-revertive modes when the failure is eliminated



Network Challenges: MAC Scalability

A typical network delivers residential services to hundreds of thousands subscribers. In Ethernet bridged networks this results in:

- A requirement for a huge FDB (number of subscribers * number of services)
- Network flooding during convergence time
- Slow recovery time due to long network convergence time
- In ring topologies aggregation nodes might have to learn the topologies behind access rings that are not directly connected to them.



VLAN Cross Connect is MAC agnostic. Hence, the MAC scalability issue is inherently eliminated.

Network Challenges: VLAN Scalability

- In Enterprise networks, 4K VLANs are traditionally used to create virtual LANs.
- In provider networks, VLAN deployment is extended to handle new requirements:
 - **User isolation** is required to prevent traffic leaking and unauthorized communication between users.
 - **User identification** is required for policing, billing and fault isolation purposes.
 - **Service separation** is required for traffic engineering purposes.
- Extending the use of VLANs creates VLAN scalability issues.

Network Challenges: VLAN Scalability (Cont.)

Example of VLAN scalability problems:

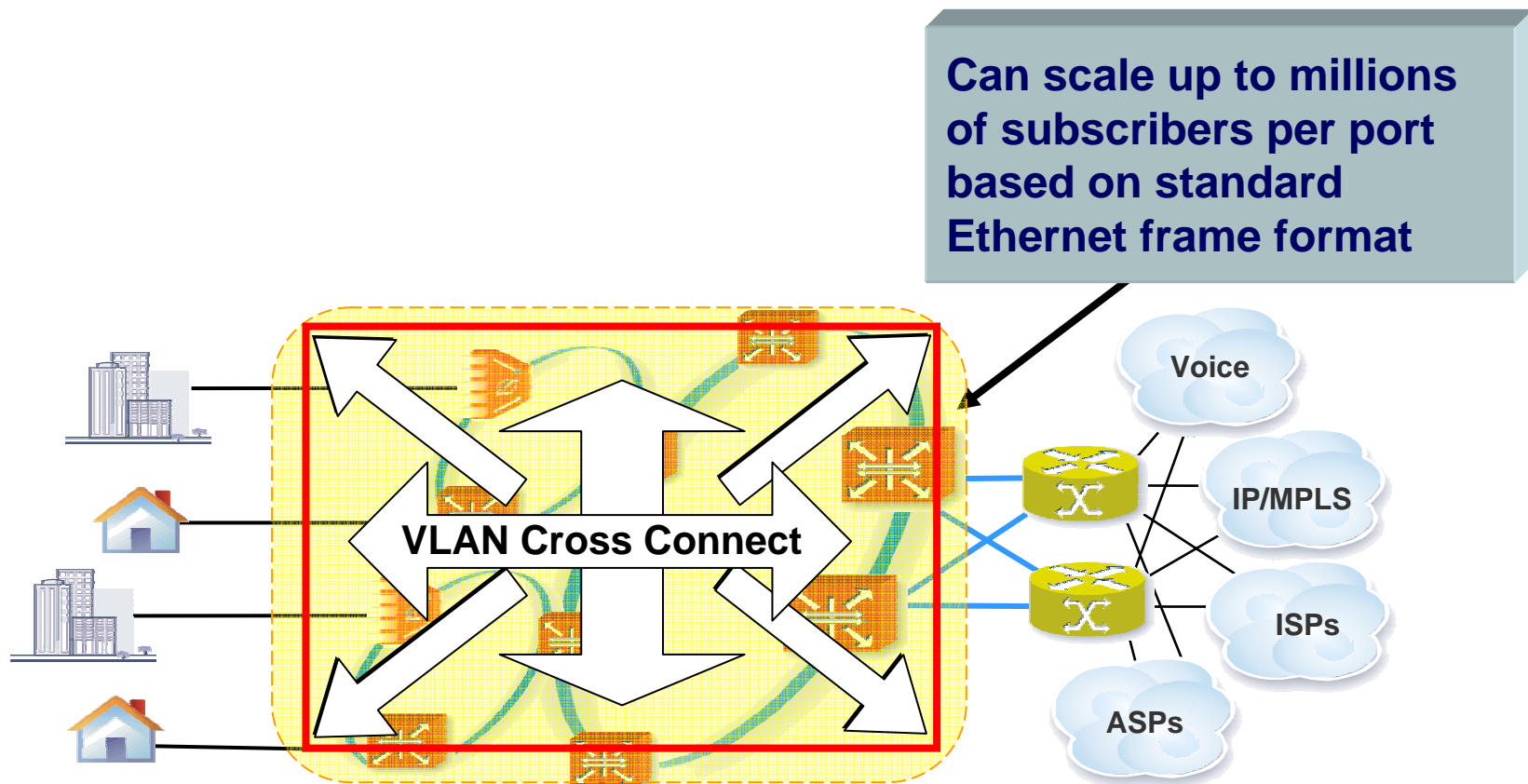
In residential services, with hundred of thousands of subscribers, Q-in-Q should be supported:

- In a typical aggregation network, the outer VLAN is used to identify the DSLAM (and optionally the specific service), while the inner VLAN is used to identify the DSLAM port (i.e. the subscriber).
- In VDSL, the number of DSLAMs in an aggregation domain can easily reach thousands:
 - 4K VLANs are not sufficient, especially when more than one service is provided.
 - The number of VLANs left for multipoint services (E-LAN services) is small.

Network Challenges: VLAN Scalability (Cont.)

VLAN Cross Connect eliminates the VLAN scalability issues:

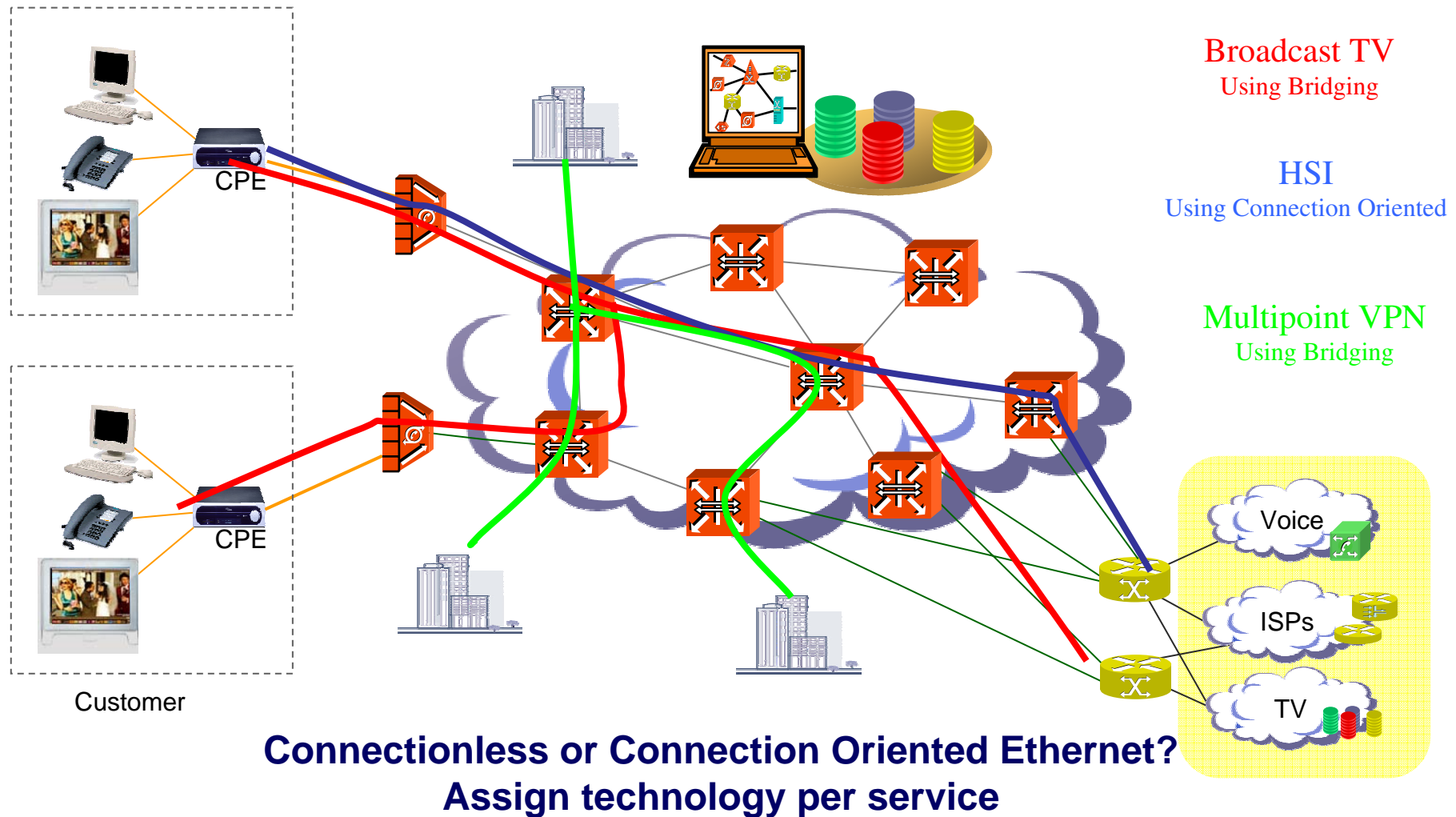
- In a VLAN Cross Connect, the VLANs have local port scope.
- Users are inherently identified and isolated by the end-to-end connection.



Network Challenges: Secured Networks and Services

- Carrier grade Ethernet requires secured networks and secured services:
 - MAC attacks and MAC spoofing should be eliminated.
 - Spanning Tree attacks should be eliminated.
 - Traffic leaking should be eliminated.
 - Unauthorized communication should be eliminated.
- Mechanisms are available in bridging networks to reduce the number of security issues, but some of them are complicated (like private VLAN, MAC limitations, etc.).
- **In a VLAN Cross Connect, security issues are inherently eliminated** for the following reasons:
 - It is MAC agnostic, hence, MAC attacks and MAC spoofing are inherently eliminated.
 - It does not employ Spanning Trees.
 - Traffic flows are transmitted via a pre-provisioned, end-to-end connection and there is no flooding since:
 - Traffic leaking is eliminated.
 - Communication between unauthorized users is eliminated.

Connectionless or Connection Oriented Ethernet ?



Hybrid Bridging and Connection Oriented Methods

- Bridging is appropriate for the following services:
 - **IPTV**
 - Requires tens of channels (DA MACs) and a few TV servers (SA MACs)
 - **Business multipoint VPN (E-LAN)**
 - Provided for large enterprises
 - Small enterprises use point-to-point VPNs (optionally using the hub-and-spoke topology)
 - **Network management**
 - Requires a small number of MAC addresses (i.e. number of network elements) and only one VLAN
- **VLAN Cross Connect is appropriate for business-critical services with an associated SLA, and for services that consume a large number of MAC addresses and VLANs:**
 - **Residential services**
 - High speed Internet service
 - Voice services
 - Video-on-demand
 - **Business services**
 - Point-to-point VPN (E-LINE)
 - Multipoint VPN (hub-and-spoke based E-LAN)
 - Voice services
 - **Wholesale services**

Enlightenments

- The provider network introduces challenges for Ethernet.
- There is a real need for the connection oriented method in provider Ethernet networks.
- The connection oriented method should be implemented in conjunction with connectionless bridging with the aim of providing the optimum method per service.

Connection Oriented Methods in Provider Ethernet

Assertion: “Why VLAN Cross Connect and not MPLS? Deploy MPLS already from the access area.”

But...

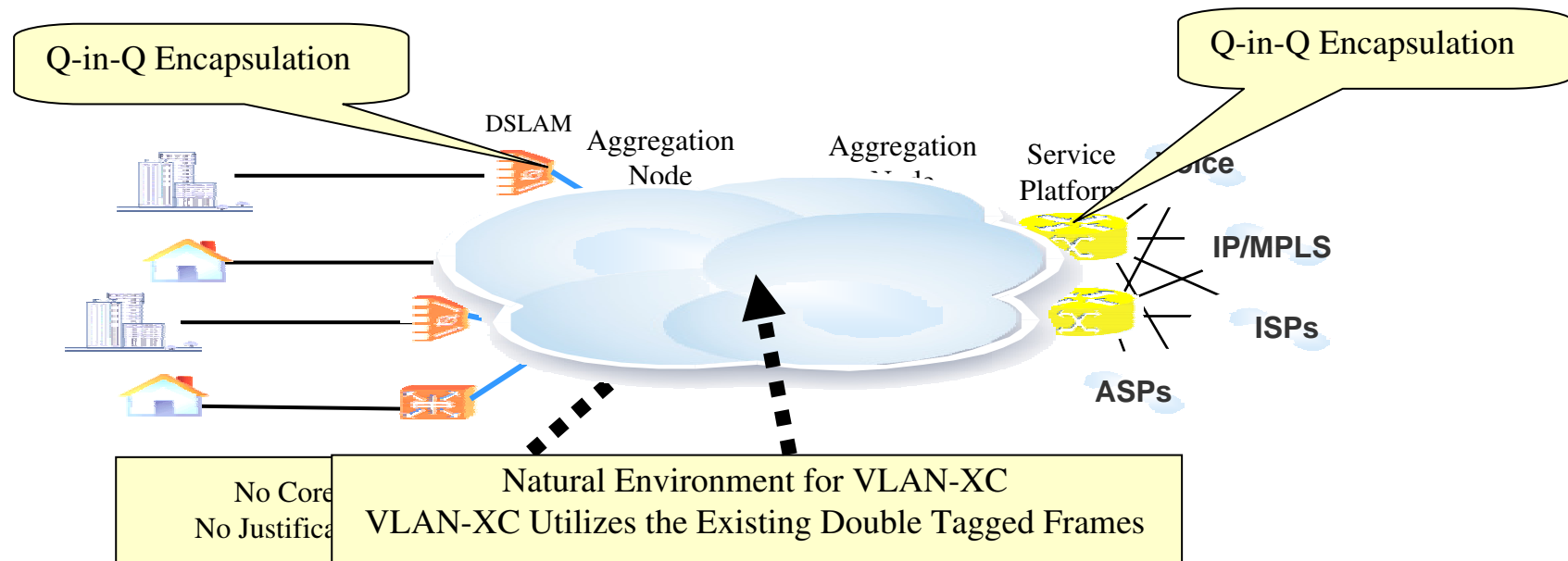
- **VLAN Cross Connect enables Ethernet to provide a transport layer for multiple services.** MPLS does this at higher layers and may therefore involve additional cost in comparison to Ethernet hardware.
- **Multipoint services are inherently supported in Hybrid Ethernet Bridging and VLAN Cross Connect networks.** In MPLS networks, additional complicated mechanisms are required, such as VPLS, etc.
- MPLS involves a comprehensive stack of protocols and operational expenses, especially at the edge nodes:
 1. The number of hierarchies in aggregation networks is typically small.
 2. The number of edge nodes is much greater than the number of core nodes.
- **Hybrid Ethernet Bridging and VLAN Cross Connect reduce CAPEX and OPEX and keep the network simple.**

Connection Oriented Methods in Provider Ethernet (Cont.)

Assertion: “Why VLAN Cross Connect and not PBT? Deploy PBT already from the access area.”

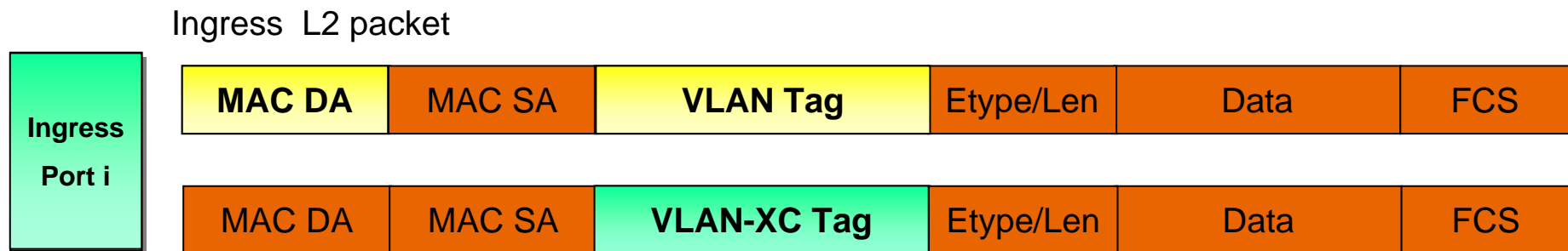
But...

PBT is not an appropriate solution for Metro Access and Aggregation networks. **VLAN Cross Connect is naturally appropriate for these kinds of networks.**



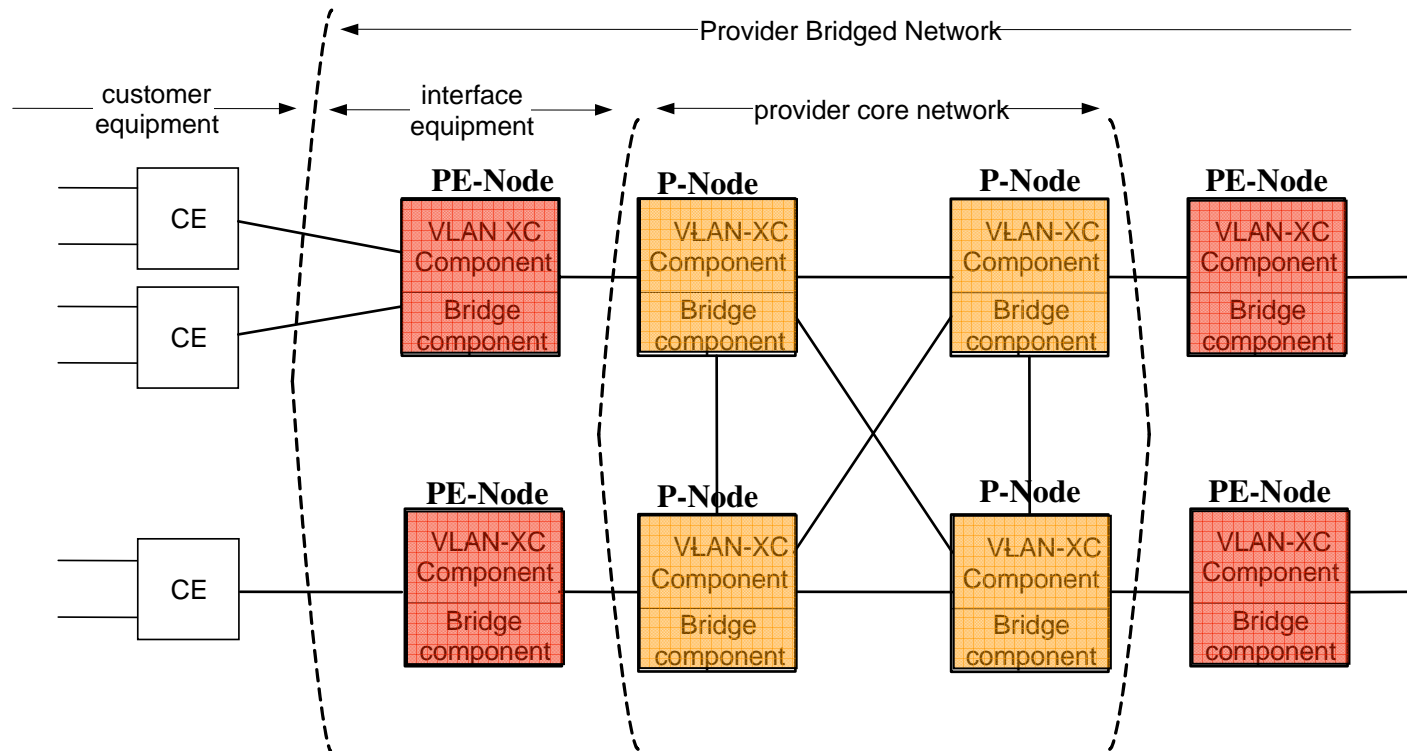
VLAN Cross Connect Concept

- **Standard VLAN Bridging:** Switching based on MAC addresses and VLANs
- **VLAN Cross Connect:** Cross Connect according to the **ingress port** and the **VLAN-XC Tag**, **regardless of the MAC addresses**



- VLAN Cross Connect **co-exists** with standard VLAN bridging, even on the same port
- VLAN Cross Connect **eliminates** MAC learning and flooding per VLAN
- VLAN Cross Connect **enables** up to 16M connections per port

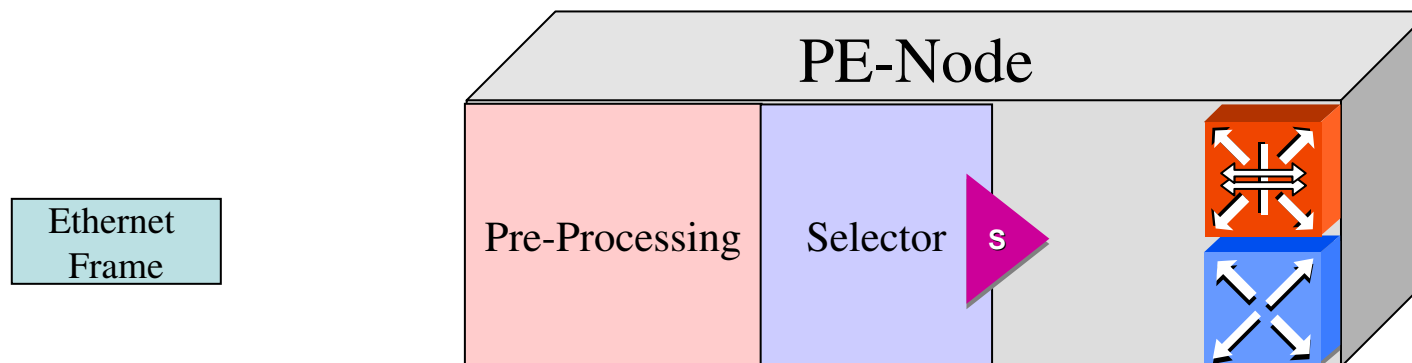
Hybrid Bridging & VLAN Cross Connect Network Topology



- Provider Edge Nodes (PE-Nodes) reside at the boundary of the provider network and consist of two components: a VLAN-XC component and a Bridge Component. The VLAN-XC component creates/terminates VLAN-XC connections.
- Provider Internal Nodes (P-Nodes) reside within the provider network and consist of two components: a VLAN-XC component and a Bridge component. The VLAN Cross Connect performs VLAN Cross Connect switching.

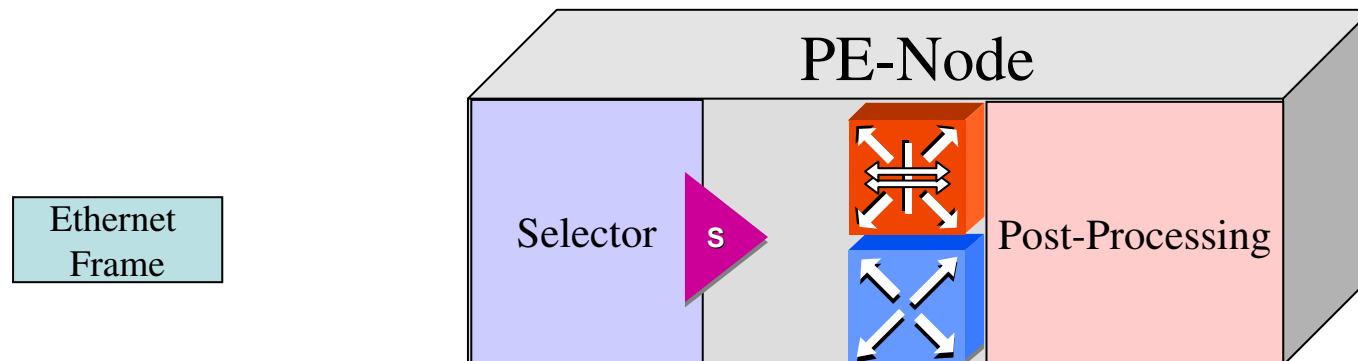
Provider Edge Nodes

- The Provider Edge node handles traffic entering via the CE-PE interface and from the provider network. Traffic from the CE-PE interface is handled as follows:
 - The incoming frame is pre-processed at the PE-Node (e.g. VID translation, VID insertion, stripping, etc).
 - The frame is presented either to the bridge component or to the VLAN-XC component according to a selection criterion :
 - The bridge component performs normal bridging operations (e.g. learning, forwarding, etc.)
 - The VLAN-XC component (1) maps the incoming frame to a particular end-to-end VXC connection (according to different criteria, for example, VID, the 1.Q priority, the standard 5-tuple, etc.), (2) adds an Ethernet VLAN-XC tag to the frame and forwards it via the appropriate outgoing interface towards the provider network.



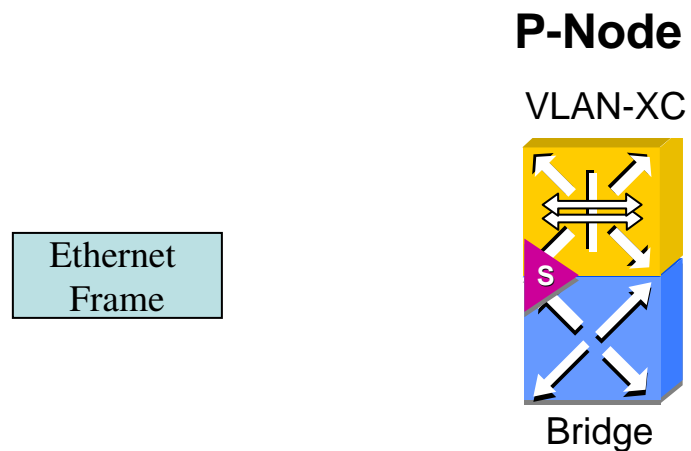
Provider Edge Nodes (Cont.)

- Traffic from the provider network is handled as follows:
 - The frame is presented either to the Bridge component or to the VLAN-XC component according to a selection criterion :
 - The Bridge component performs normal bridging operations (e.g. learning, forwarding, etc.), determines the outgoing interface and presents the frame to the post-operation process.
 - The VLAN-XC component terminates the VLAN-XC connection by removing the VLAN-XC Tag from the frame, determines the outgoing interface and presents the frame to the post-operation process.
 - Post-operations may include, for example, VID translation, VID insertion/ stripping, etc.
 - The frame is then forwarded to the appropriate CE-PE interface.



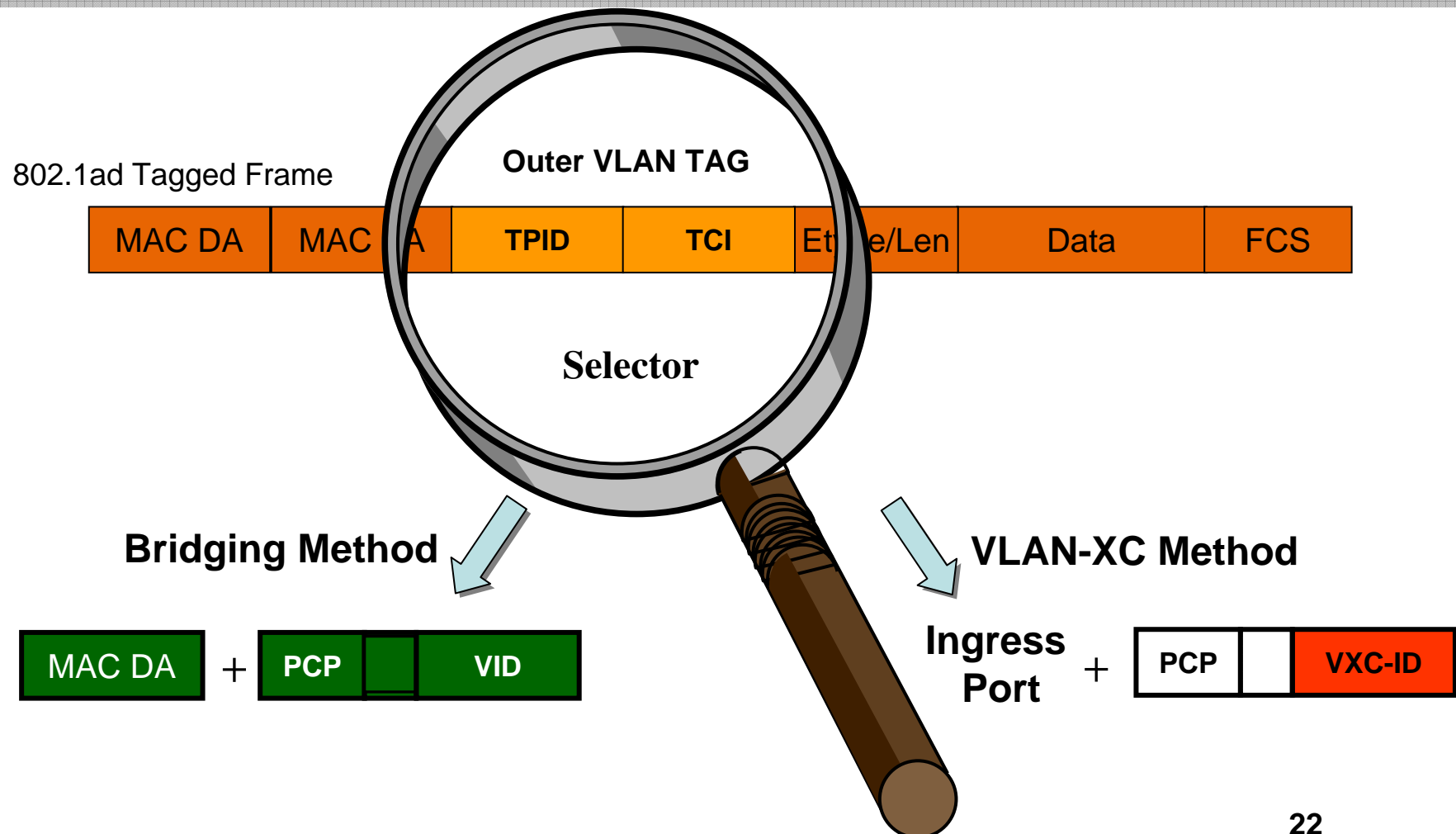
Provider Internal Node

- The Provider Internal Node resides within the provider network and has no direct interfaces towards customer networks.
- The incoming frame is presented either to the bridge component or to the VLAN-XC component according to a selection criterion:
 - The bridge component performs normal bridging operations (e.g. learning, forwarding, etc.).
 - The VLAN-XC component switches the frame according to the ingress port and the VLAN-XC Tag, and forwards it towards its destination via the appropriate outgoing interface.



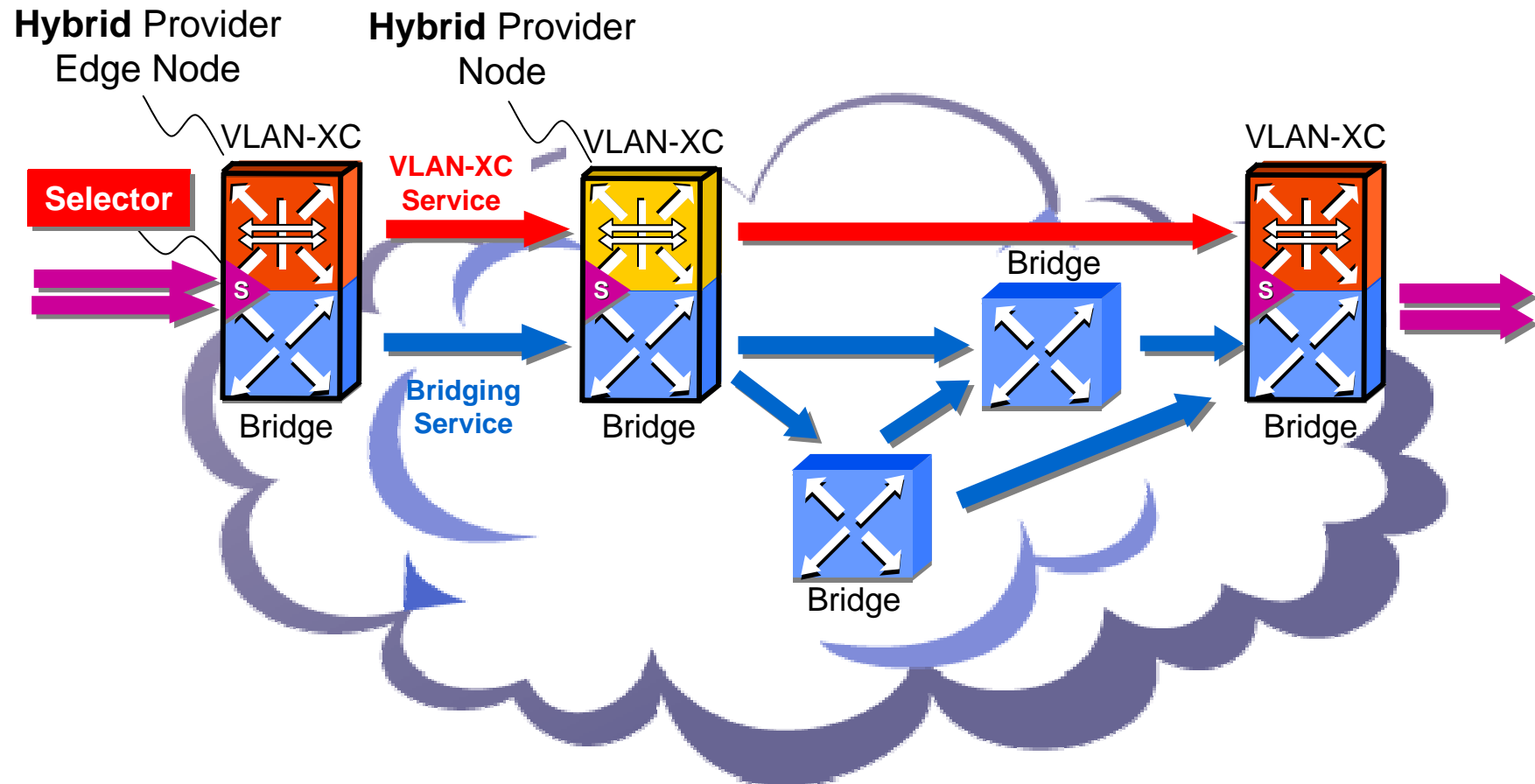
Bridging / VLAN Cross Connect Selector

The outer VLAN Tag acts as the method selector (TBD whether VID space, new TPID).



Hybrid Bridging & VLAN Cross Connect Network

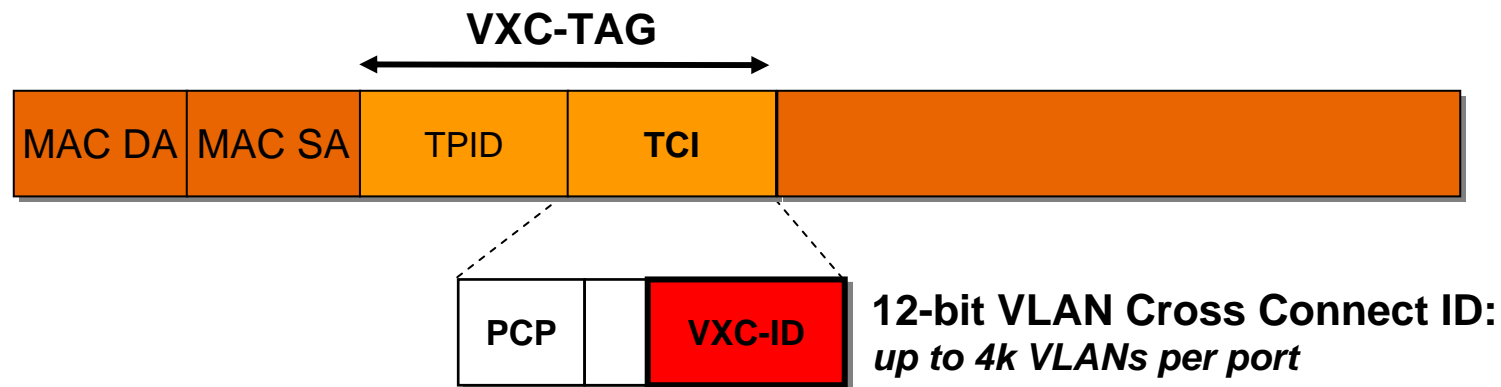
VLAN Cross Connect and Bridging services coexist in the same provider network.



VLAN Cross Connect Frame Semantic

- VLAN Cross Connect identifier has local port scope
- Frame format as defined in IEEE 802.1ad
- VLAN Cross Connect tagged frame allows up to 4K VLANs per port

VLAN Cross Connect tagged frame



VLAN Cross Connect with 4K VLANs per Port

Assertion: “4K point-to-point services are already supported by the 802.1ad.”

But...

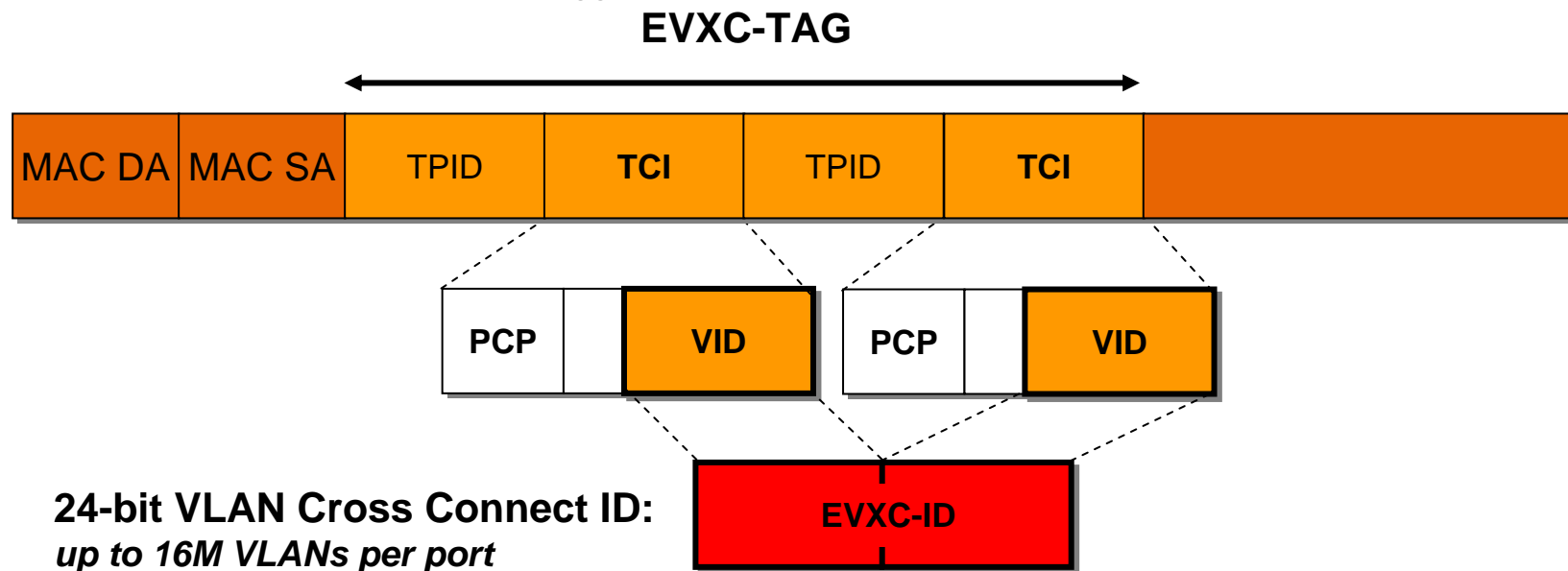
- They are limited to 4K VLANs per switch.
- In certain applications, even 4K VLANs per port are insufficient.

VLAN Cross Connect Frame Semantic (cont.)

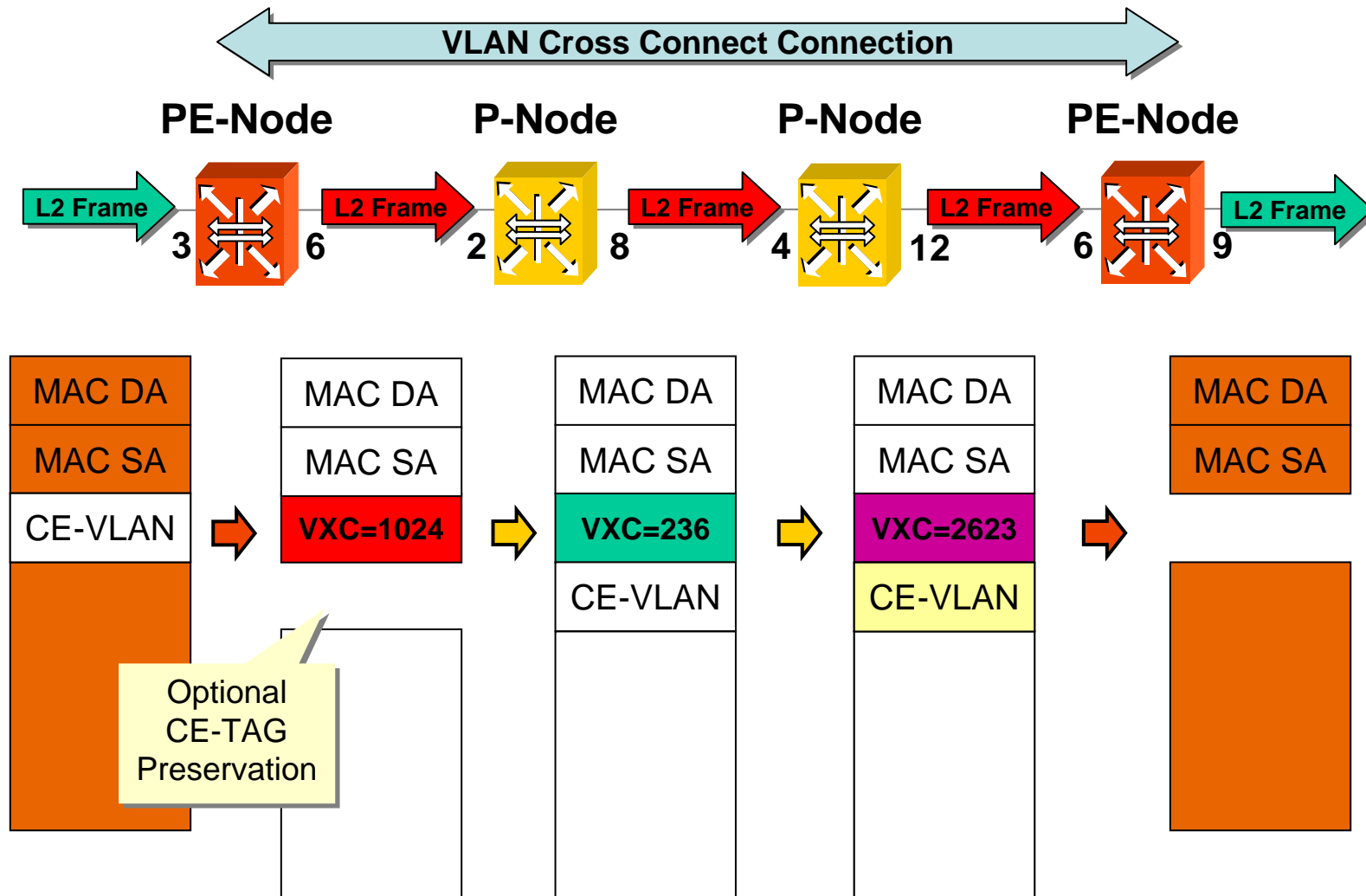
Extended VLAN Cross Connect frame with a 24-bit VLAN Cross Connect ID:

- Frame format as defined in IEEE 802.1ad. A new TAG definition may be considered.
- VLAN Cross Connect tagged frame allows up to 16M VLANs per port

Extended VLAN Cross Connect tagged frame

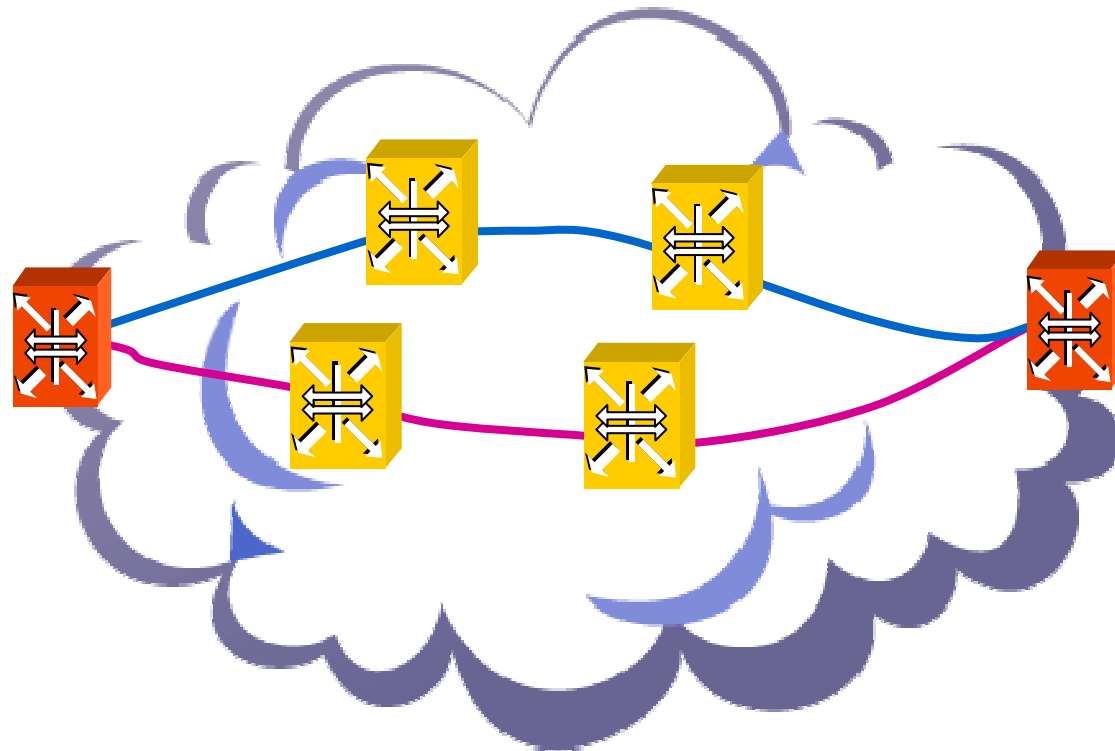


VLAN Cross Connect Example (with CE-VLAN Preservation)



Scalability

- End-to-end connections can be used to deliver services or a trunk of services (i.e. tunnels). The following combinations may be considered:
 - Services with 12-bit identifiers
 - Services with 24-bit identifiers



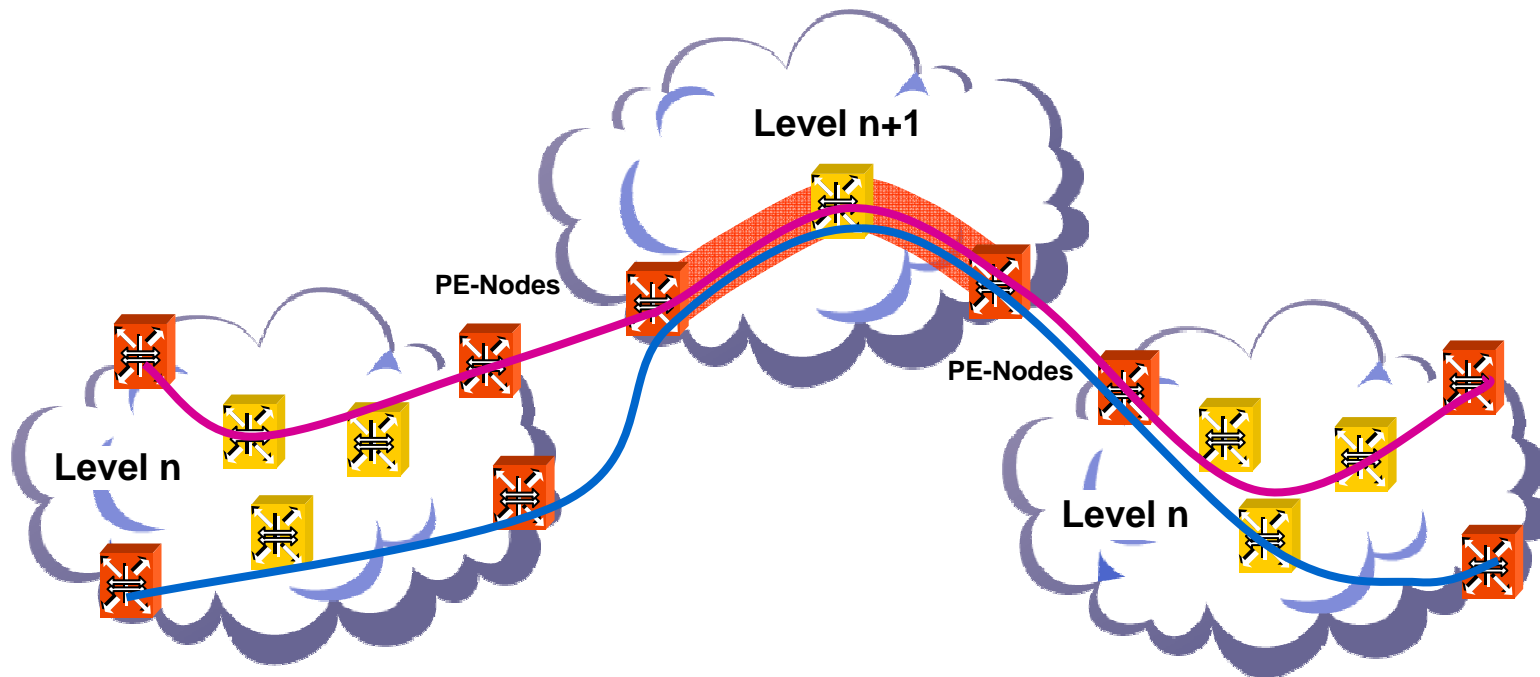
Scalability (Cont.)

- An end-to-end connection can be used as a service transport or as a tunnel. Many combinations may be considered:
 - Services with 12 or 24-bit identifiers
 - Tunnels with a 12-bit identifier. Services with the tunnel may have a 12-bit or 24-bit identifier (using the VLAN stacking capability).



Scalability (Cont.)

- End-to-end services between two level n domains can be delivered via level n+1 tunnels.



Conclusion

- **We propose that the IEEE 802.1 start working on the VLAN Cross Connect method to extend the Provider Bridging method in response to the challenges facing Provider Ethernet.**
- **We propose to start a new project on Connection Oriented Ethernet based on the VLAN Cross Connect method.**



Thank You!

Nurit.Sprecher@seabridgenetworks.com

SIEMENS

Communications