Optical Ethernet Architecture Evolution

The Logical Provider Edge

Mark I Williams

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Agenda

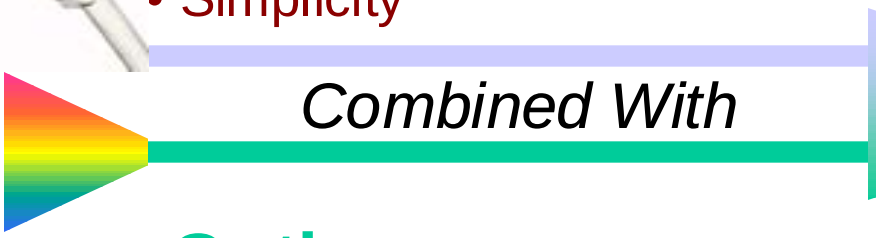
- OE Introduction and Drivers
- VPLS – The technology behind the Service
- Decoupled VPLS – Providing Scalable and Affordable VPLS Services
- Summary

What is Optical Ethernet?

Ethernet

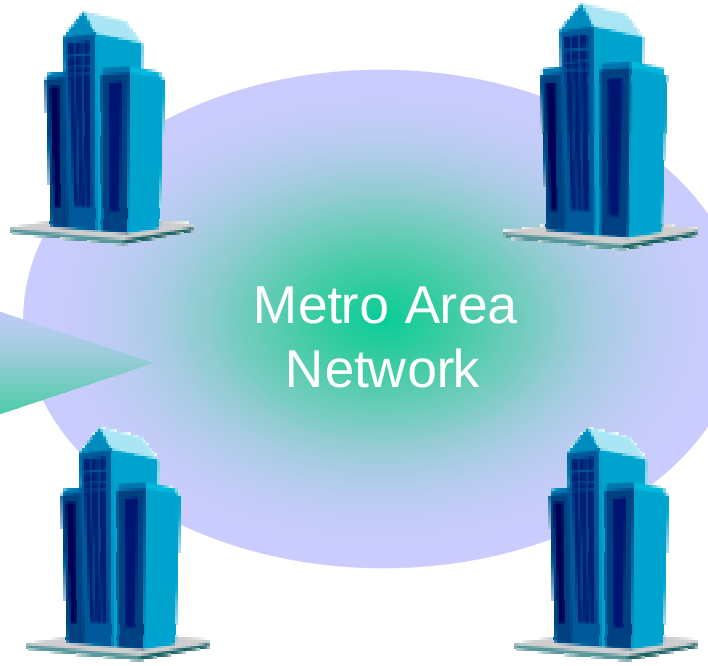
- Ubiquity
- Flexibility
- Simplicity

Combined With



Optics

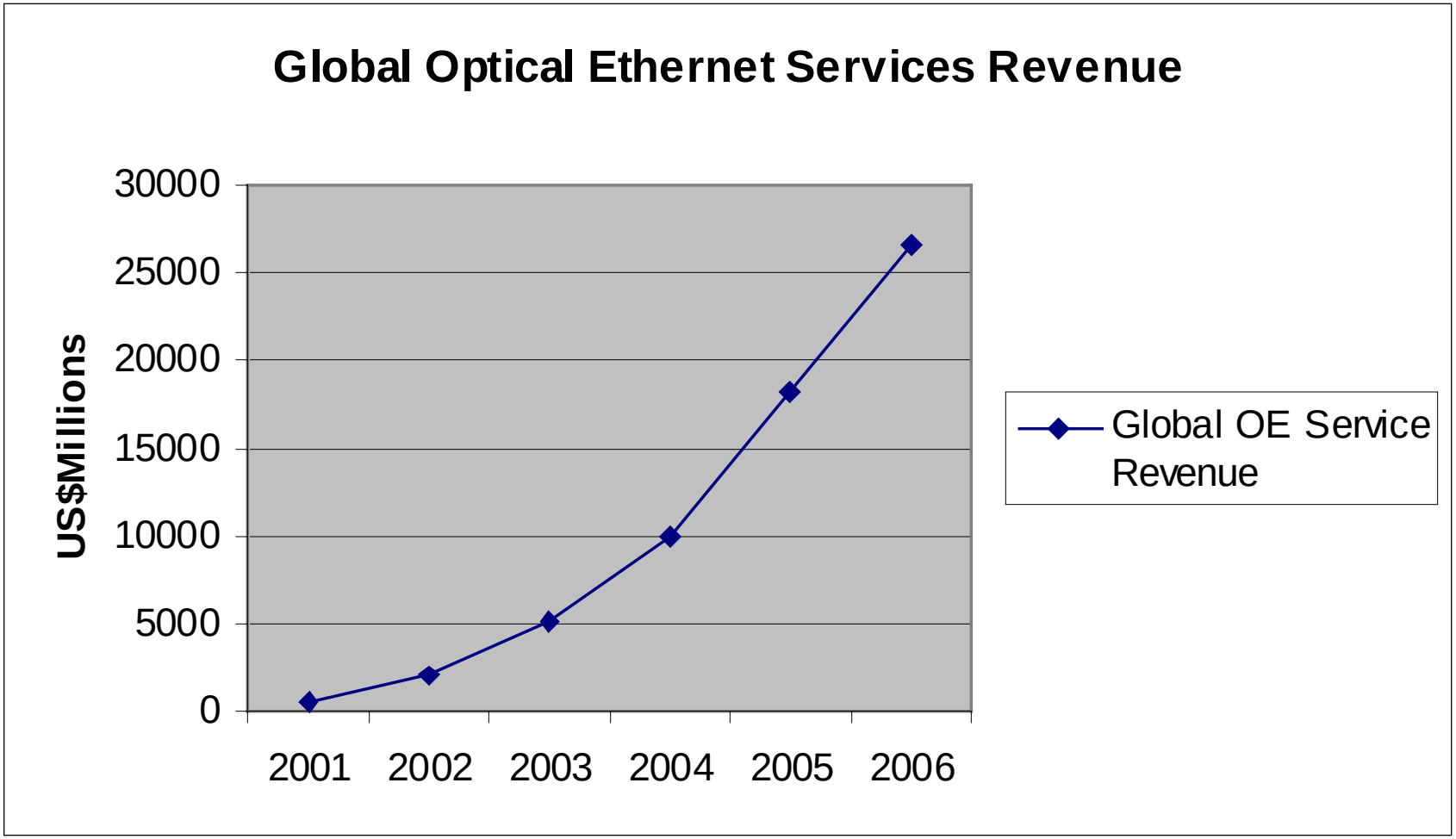
- Reach
- Scale
- Reliability



Fast • Simple • Reliable

Extend the boundaries of the LAN to encompass the MAN & WAN

Global Optical Ethernet Service Revenue



Source: IDC 2003

Success is in the Plug

Network-Based Services

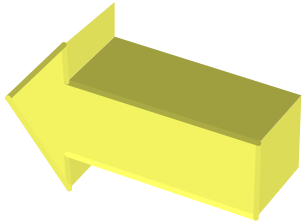
Services customers will buy

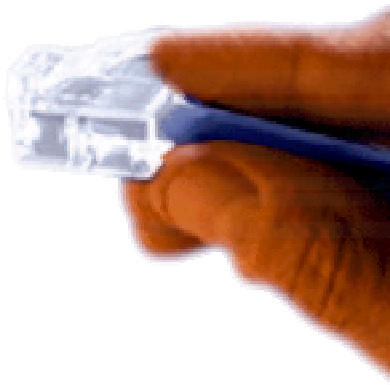
Connectivity
Applications
Content & Entertainment
Telephony
Outsourced services

Ethernet Connection

Interfaces readily used today

Network switches & routers
Computers & Peripherals
i-appliances





Simplicity at the edge

OE Enterprise Value Propositions

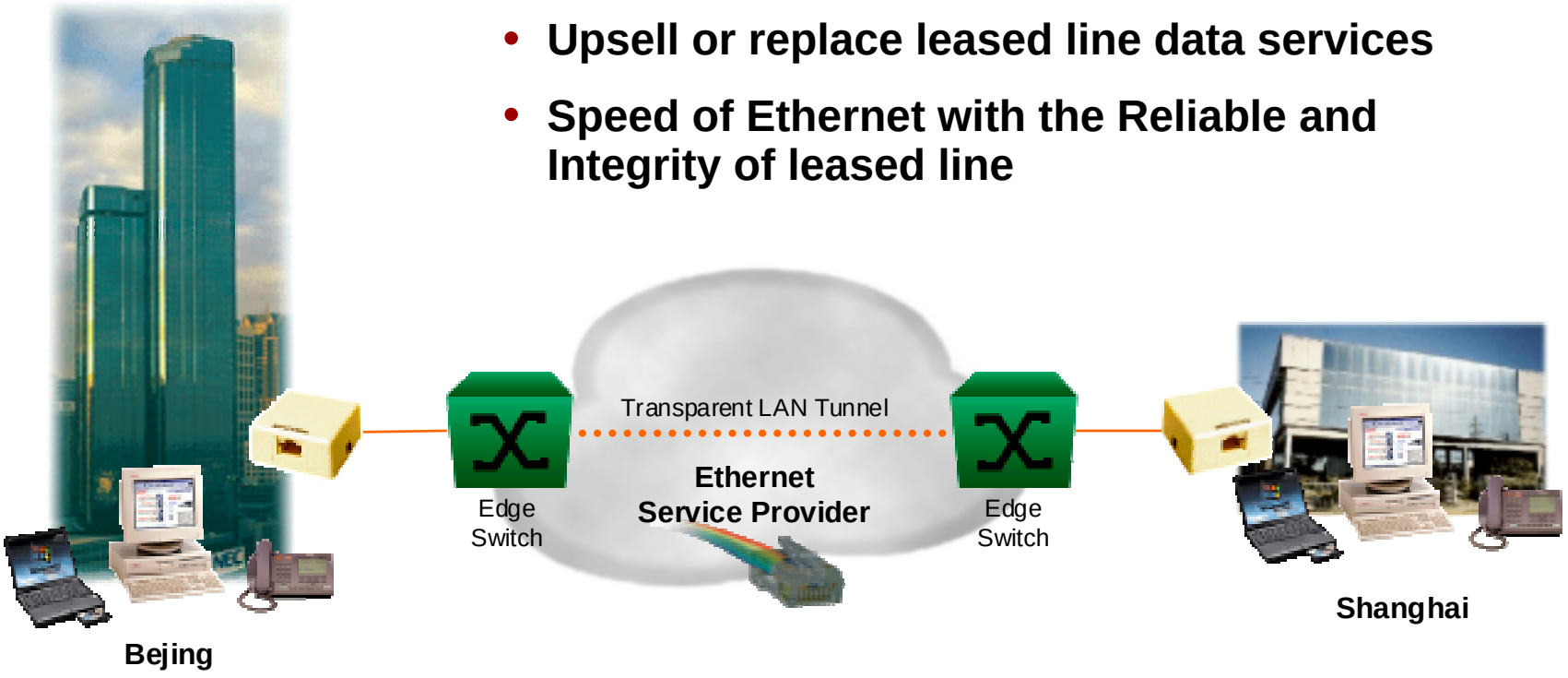
- Reduce IT cost and risk by simplifying the Network
  - Reduced dependence on IP routing & complexity
- Increase the available bandwidth over the network to 'LAN' levels
  - Enable high data volume applications such as multimedia streaming to be deployed across a wide area
  - Extend the reach of the Campus network across wide area
- Improve the reliability of the network
  - Carrier-grade OE enables critical applications like Disaster Recovery and Data Centre connectivity

OE Carrier Value Propositions

- Improve Enterprise customer business via OE services
  - Deliver the Enterprise Value Propositions in previous chart
- Increase revenue by delivering new services
  - Layer 2 VPNs, Multi-media streaming…
- Reduce the Capex and Opex of delivering carrier services
  - OE infrastructure in conjunction with traditional IP & MPLS infrastructure

Carrier OE Service
Transparent LAN Service

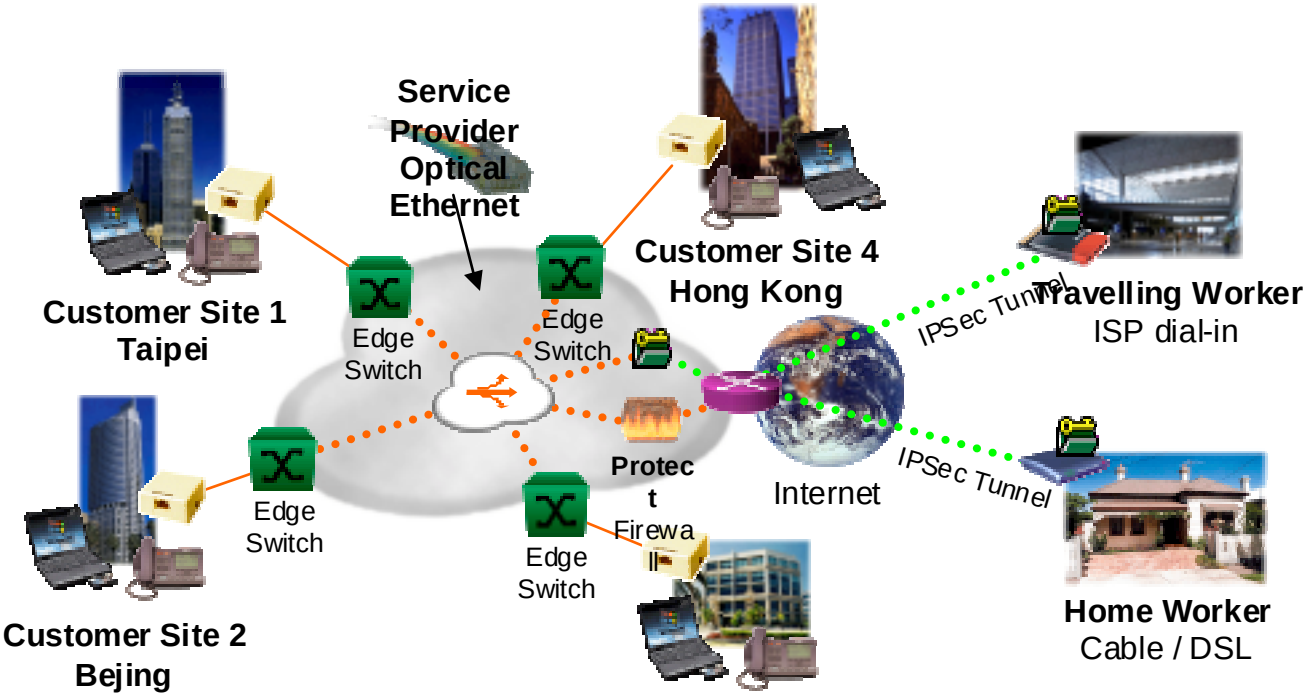
- **Extending LANs into the Metro and beyond**
- **Upsell or replace leased line data services**
- **Speed of Ethernet with the Reliable and Integrity of leased line**



Targeted at Business Users !

Carrier OE Service
Managed LAN Service

- **Multi-point LAN and network topology**
- **Combine both L2 and L3 VPN service offerings**



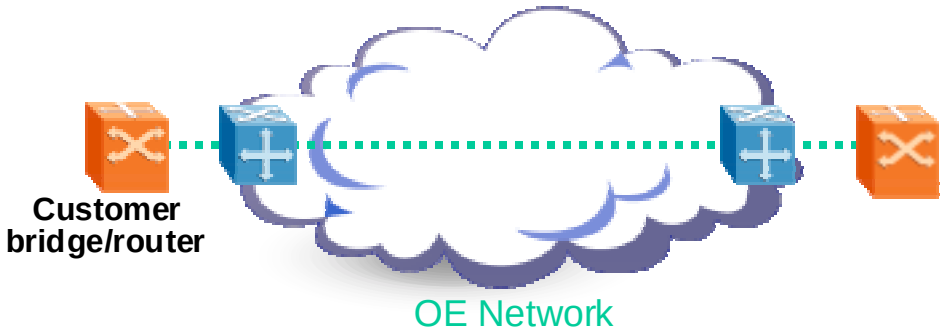
Enable Enterprise Outsourcing

VPLS – The Technology Behind the Service

OE Virtual Private LAN Service (VPLS) Types

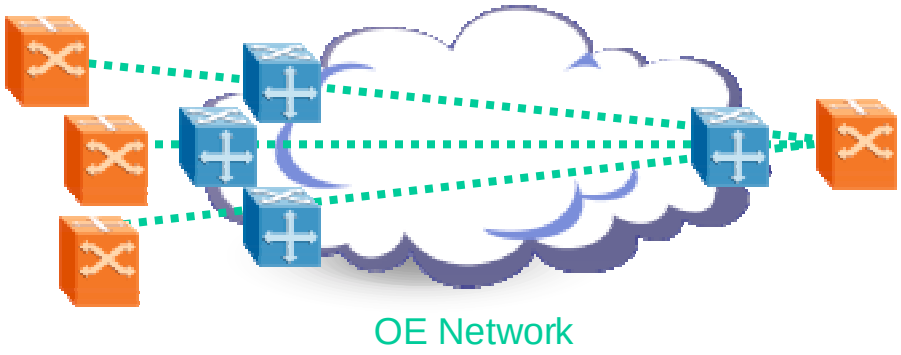
Ethernet Point-to-Point

- '*Wholesale*' connectivity (POP-to-POP, data centre interconnect, virtual colo)
- *Alternative* for leased lines



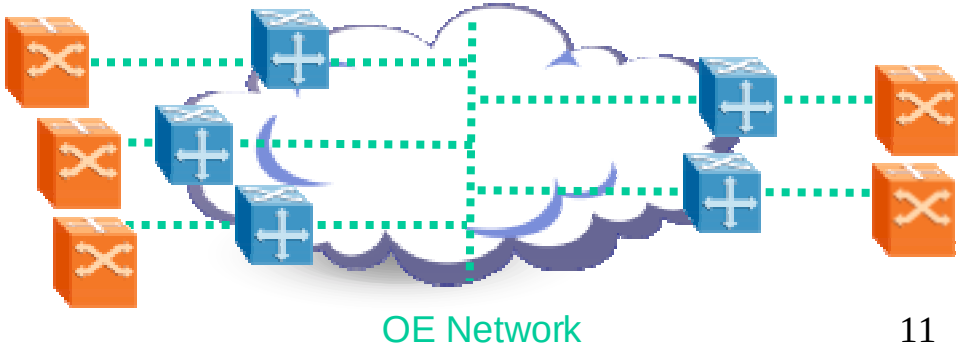
Ethernet Point-to-Multi-Point

- '*Retail*'/"*Wholesale*" OE services
- Switching based on 802.1Q VLAN tag
- *Alternative for FR, ATM, …*

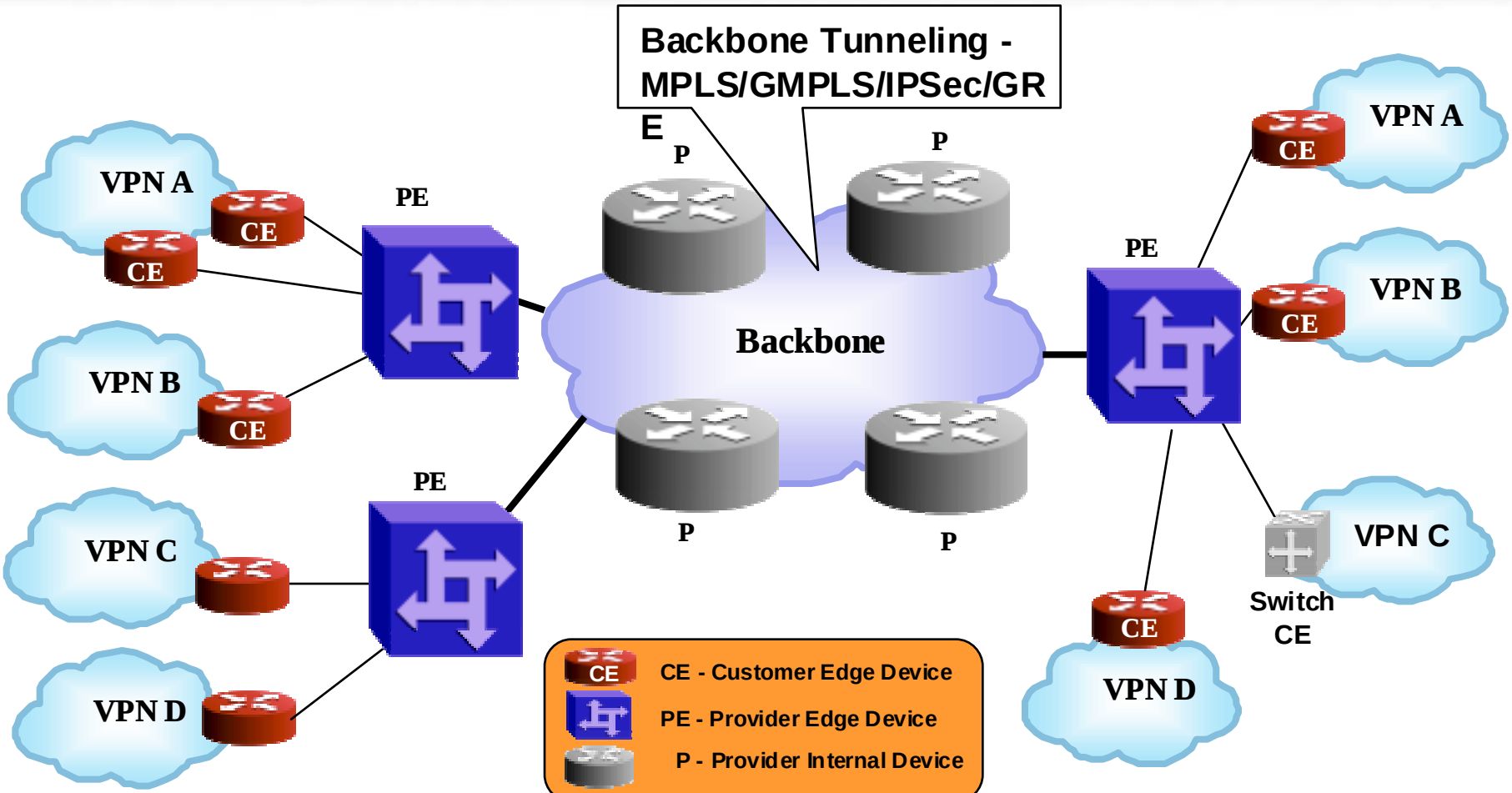


Ethernet Any to Any

- '*Retail*' OE services to enterprise
- Ethernet LAN extension over the metro/WAN
- Alternative for IP VPN



Network Reference Model for PPVPN



"Provider Provisioned VPNs": VPNs for which the Service Provider (SP) participates in management and provisioning of the VPN.

Decoupled VPLS

Providing Scalable and Affordable VPLS Services

VPLS Architectures

Edge-to-edge MPLS

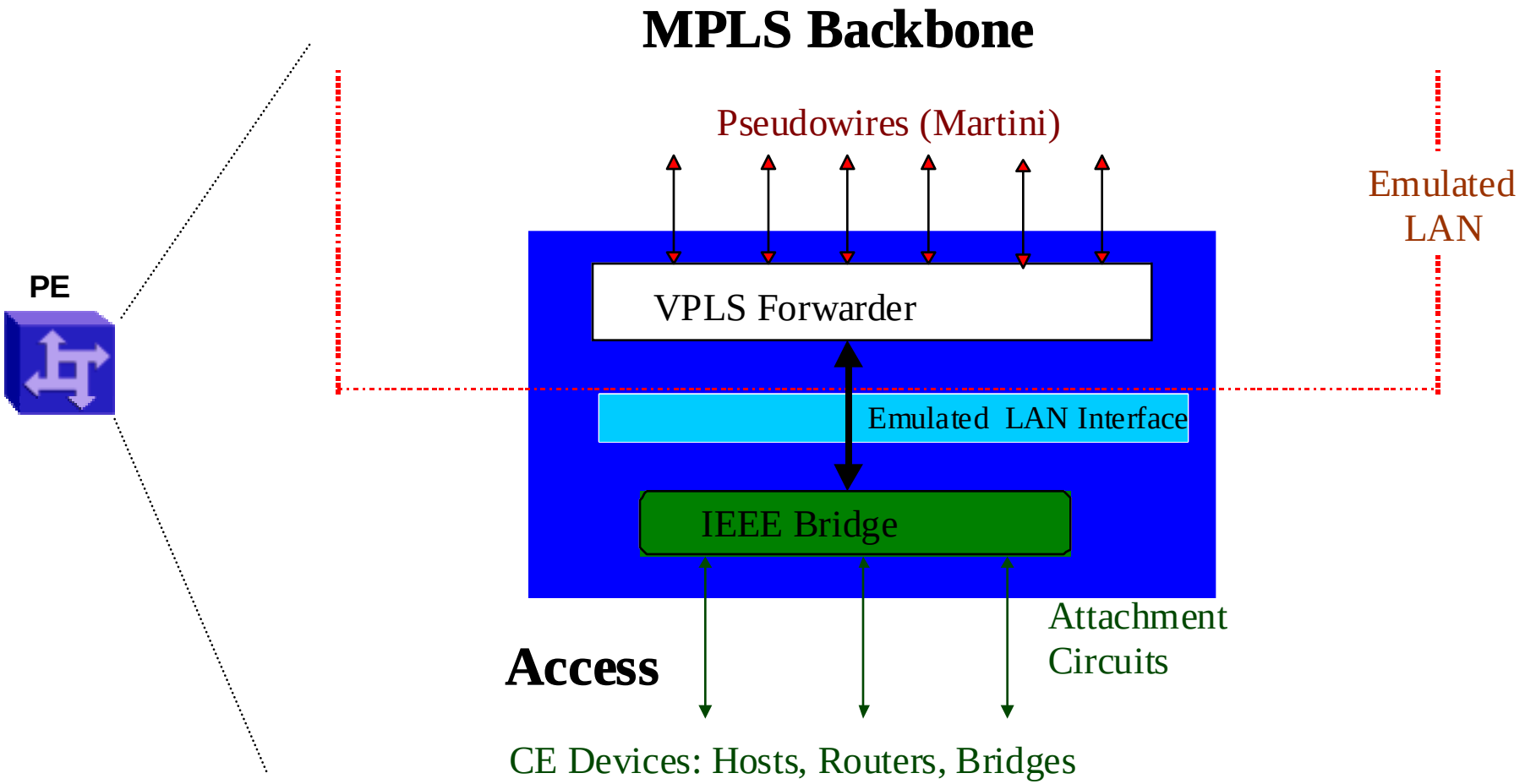
- **MPLS is deployed all the way between Service Provider Edges**

Decoupled Models

- **PE-Edge in the buildings –Transport Network (EoX, Others)- (MPLS Enabled) PE-Core – MPLS Backbone**
- **802.1Q at Edge & Aggregation Network with MPLS core: i.e. decoupled model with a "dumb Edge"**

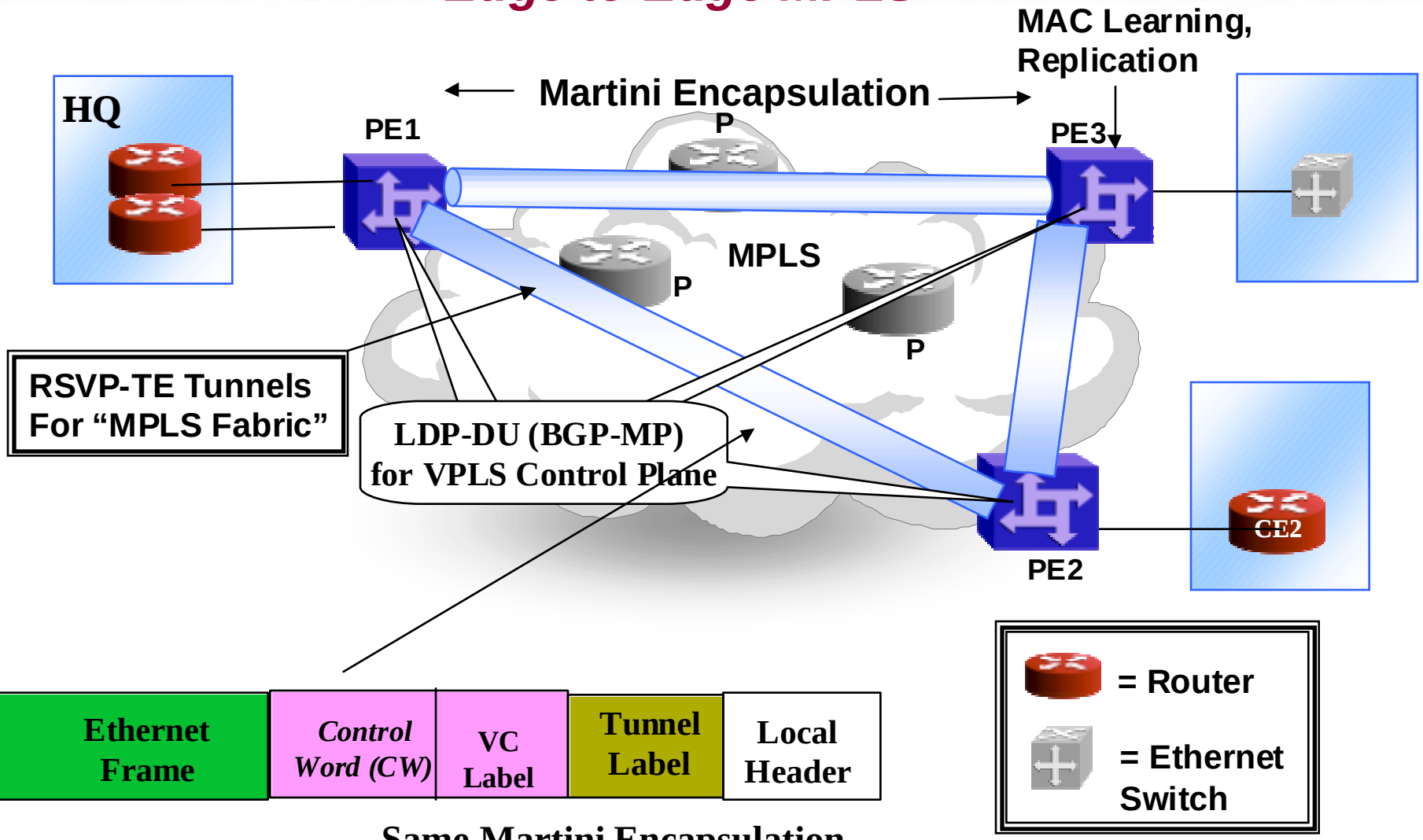
VPLS Architecture

Partial Bridge – MPLS edge-edge



VPLS Architecture

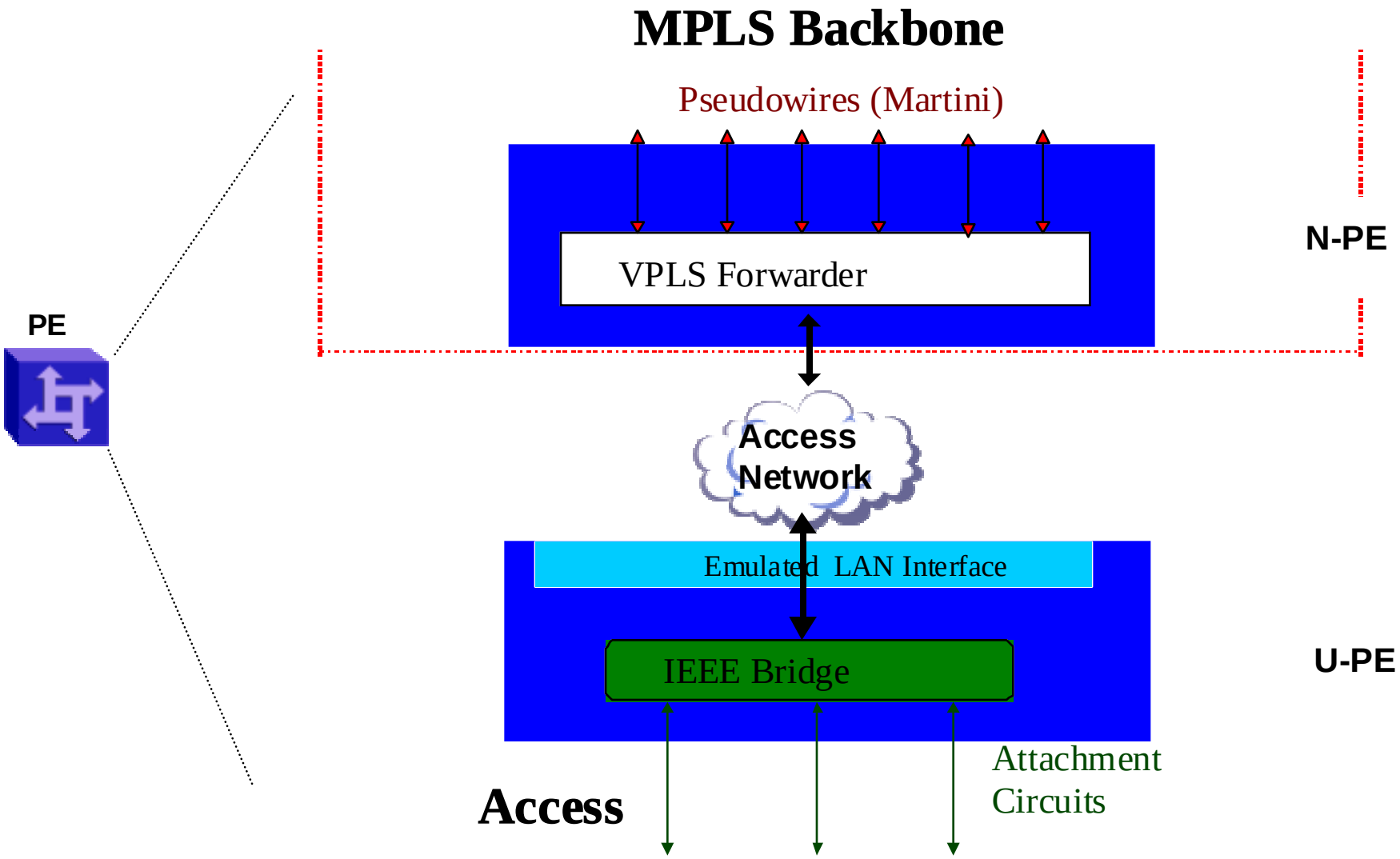
Edge to Edge MPLS



Same Martini Encapsulation

Decoupled VPLS Architecture

Decoupled Partial Bridge



Why Use A Decoupled Model?

ECONOMICS

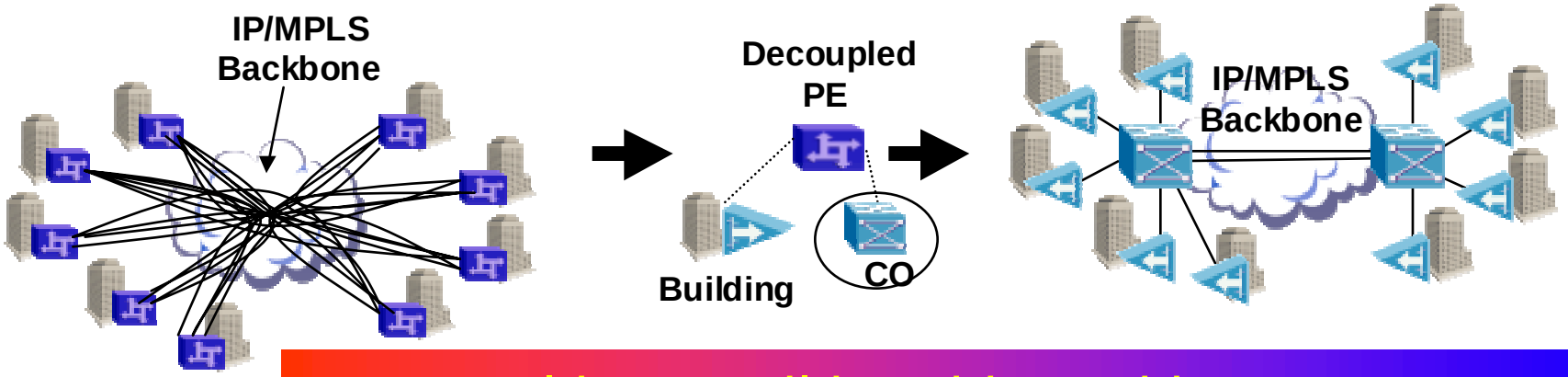
- **MPLS down to the SP Edge Increases cost**
  - Expensive PE in Buildings: (10,000s vs 100s)$ * 1000s of PEs
  - Complex Protocol Stack in the “Building” PE
    - MPLS → Complexity → Cost
  - Bandwidth Loss - Multicast Replication in buildings
    - too close to the source → too many copies in the network

Over 50% of the cost is In-Building Equipment
Simplicity here is an absolute must!

Why Use a Decoupled Model?

MPLS SCALING

- PPVPN Model requires a full-mesh of MPLS tunnels between PEs.
- MPLS Edge-Edge requires 1 PE per building
- Decoupled Model Requires 1 PE per 100s of buildings.
- Example: China-Wide Network, 100,000 buildings.
  - MPLS edge-edge: 100,000*99,999 LSPs = 10 billion LSPs.
  - Decoupled VPLS: 1,000*999 LSPs = 1 Million LSPs



You Could Not Build a China-Wide VPLS Network without using a Decoupled VPLS Model

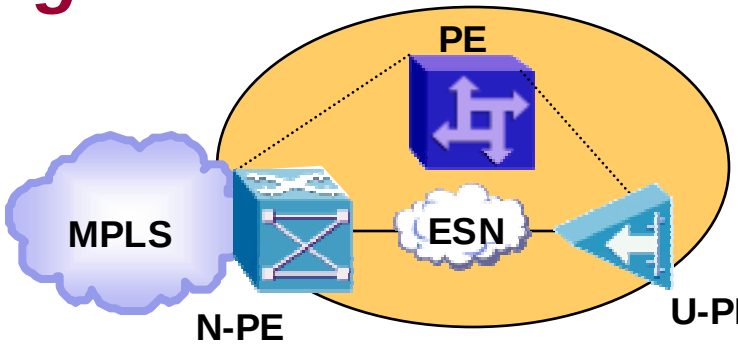
VPLS Decoupled Models

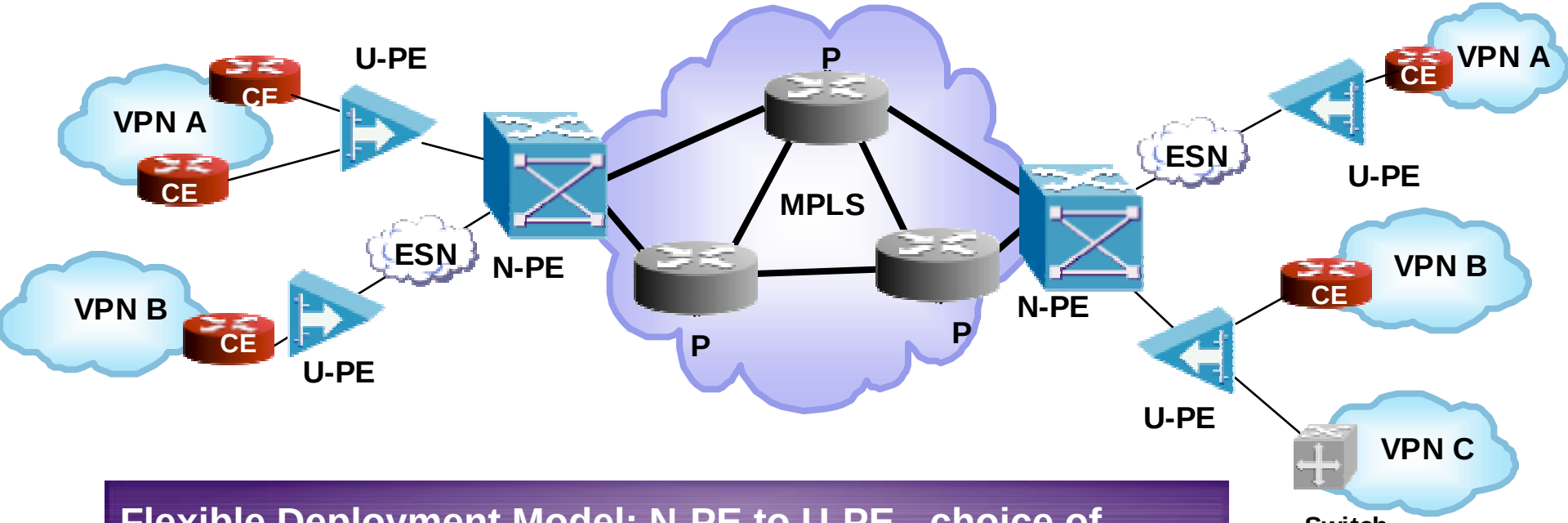
Building Blocks

ESN — Ethernet Switched Network

N-PE - Provider Edge Device

U-PE - PE Edge Device



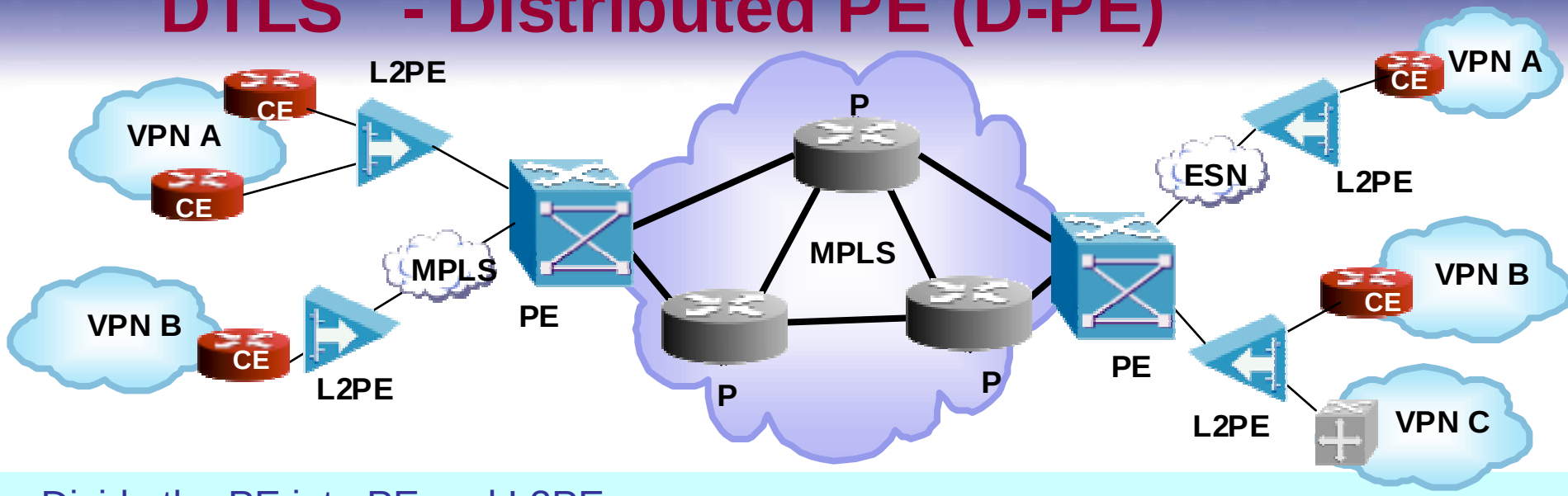


Flexible Deployment Model: N-PE to U-PE - choice of Direct Link or different Ethernet Switched Networks

4 Examples of Decoupled VPLS Today

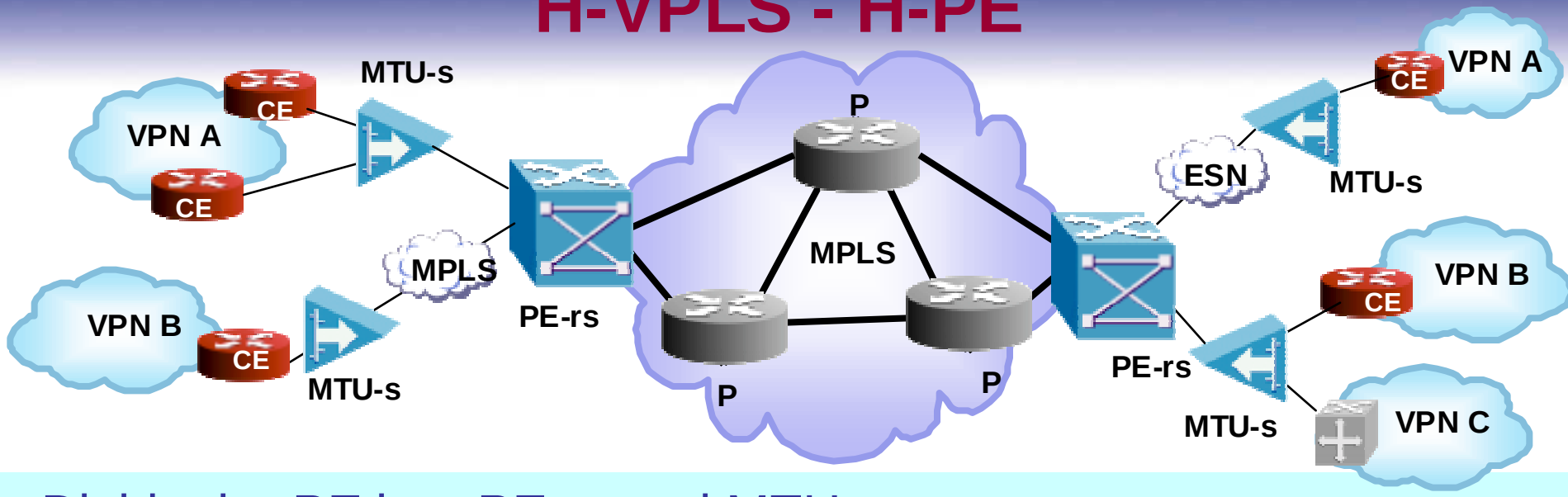
- DTLS – Decoupled TLS
  - draft-kompella-ppvpn-dtls-02.txt
- HVPLS – Heirarchical VPLS
  - draft-lasserre-vkompella-ppvpn-vpls-04.txt
- Logical PE
  - draft-ouldbrahim-l2vpn-lpe-02.txt
- GVPLS – Generic VPLS solution
  - draft-radoaca-ppvpn-gvpls-02.txt

DTLS - Distributed PE (D-PE)



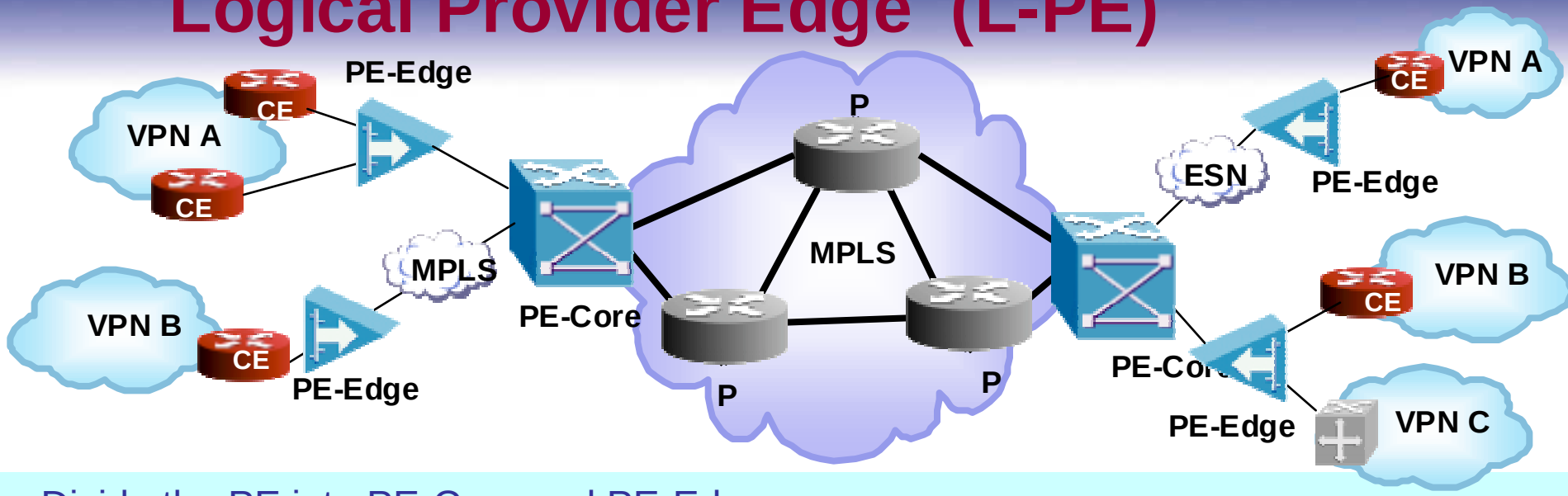
- Divide the PE into PE and L2PE
  - PE runs MPLS-TE across the core MPLS network
  - PE knows about VPLS instances, but not about MAC addresses.
  - Recommended that all provisioning be done on PE, distributed to L2PE by protocol.
  - L2PE is mostly a L2 device only. (L3 simple and used by control plane only.
  - L2PE acts as L2 bridge and sends encapsulated packets across pseudowire to PE.
  - Encapsulation can be MPLS or stacked VLANs
- Core transport uses Martini Encapsulation or any other tunnel (GRE, IPSec, etc)
- PE uses BGP for membership discovery across core.
- Broadcast/Multicast replication at source L2PE

H-VPLS - H-PE



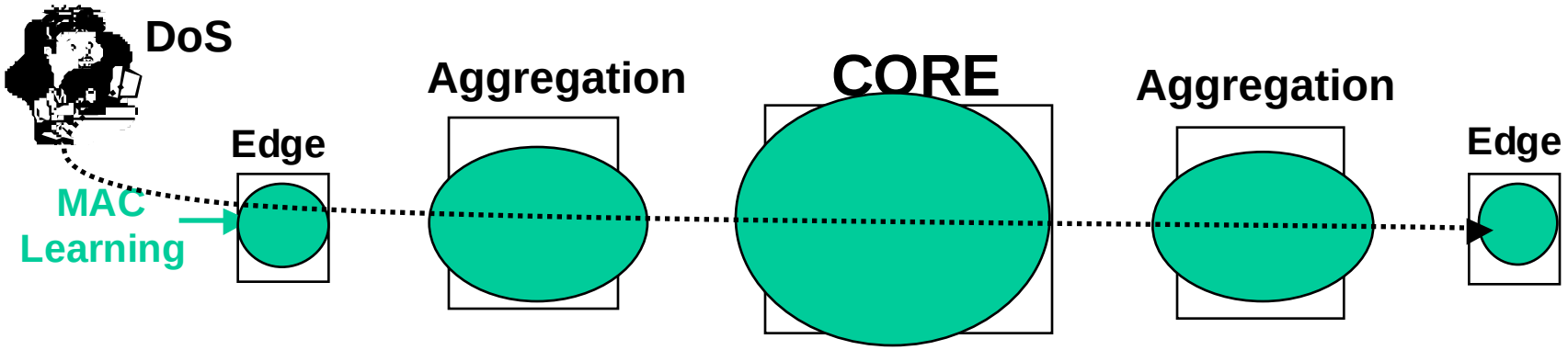
- Divide the PE into PE-rs and MTU-s
  - PE runs MPLS-TE across the core MPLS network
  - PE-rs learns MAC addresses and contains virtual bridging function.
  - MTU-s aggregates VPLS ports onto a single PW per VPLS to PE-rs
  - Encapsulation can be MPLS or stacked VLANs
- Core transport uses Martini Encapsulation, GRE, IPsec, etc.
- PE uses LDP for membership discovery across core.
- Broadcast/Multicast replication at source and dest PE-rs and dest MTU-s

Logical Provider Edge (L-PE)

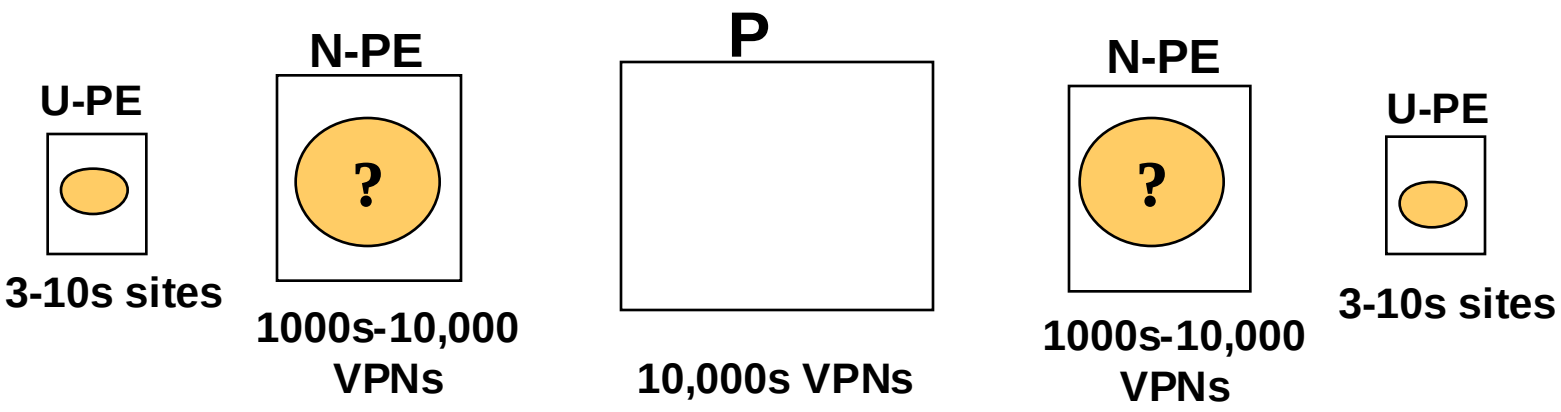


- Divide the PE into PE-Core and PE-Edge
  - PE-Core runs MPLS-TE across the core MPLS network
  - PE-Core knows about VPLS instances, but not about MAC addresses.
  - Recommended that all provisioning be done on PE-Edge, distributed to PE-Core by protocol.
  - PE-Edge is a L2 device only. (L3 used by control plane only)
  - PE-Edge acts as L2 access multiplexer and sends encapsulated packets across Ethernet to PE-Core
  - Encapsulation can be Mac-in-Mac or MPLS
- Core transport uses Martini Encapsulation or any other tunnel (GRE, IPSec, etc)
- PE-Core uses LDP for membership discovery across core.
- Broadcast/Multicast replication as close to destination as possible.

MAC Learning: H-PE

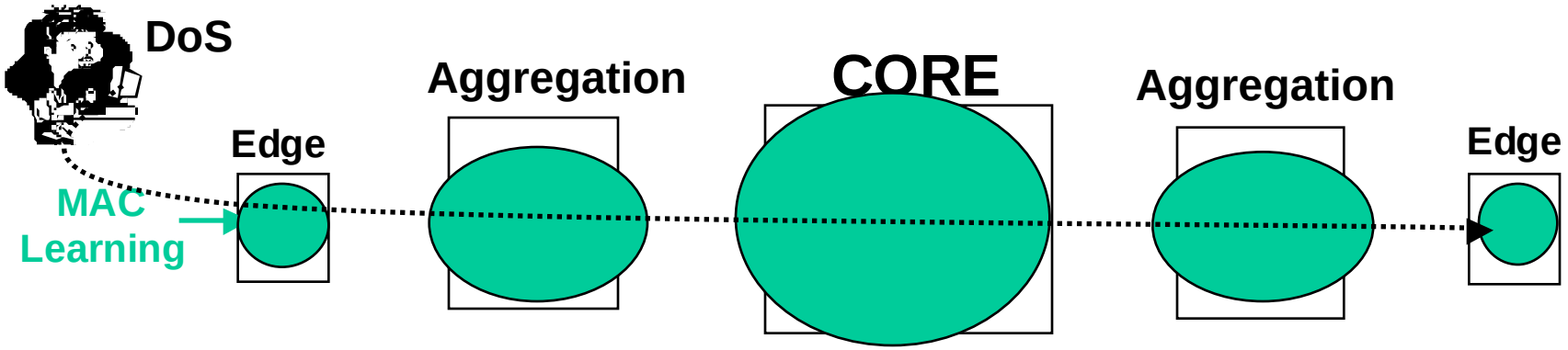


VLAN Stacking and Denial of Service Attacks, MAC Explosion



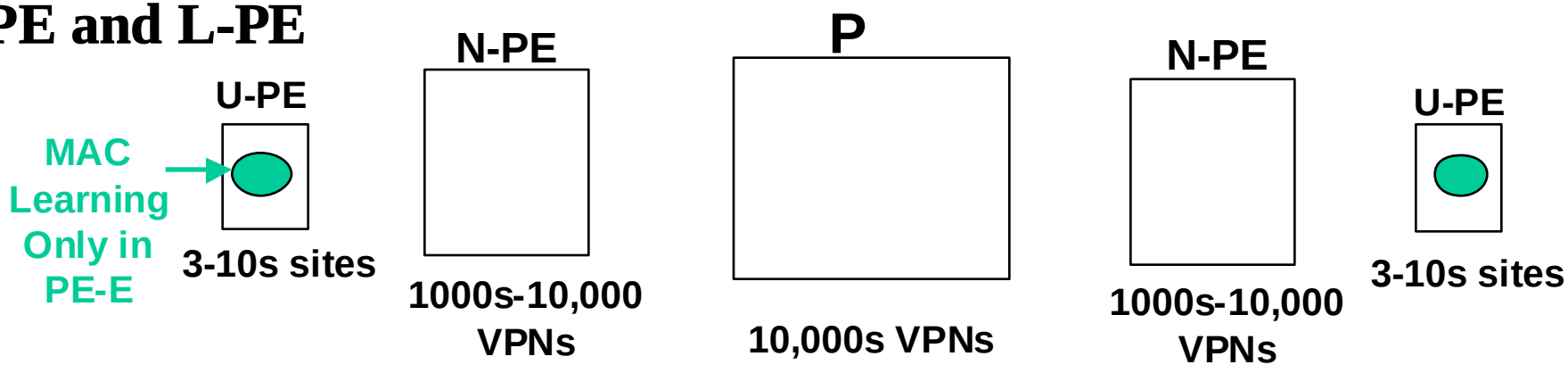
H-PE forces MAC Learning in the N-PE But still protects network core

MAC Learning: D-PE and LPE



VLAN Stacking

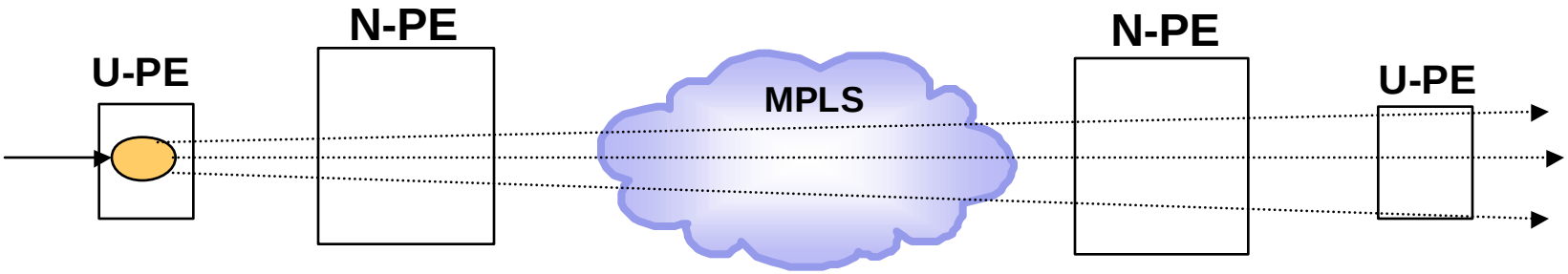
D-PE and L-PE



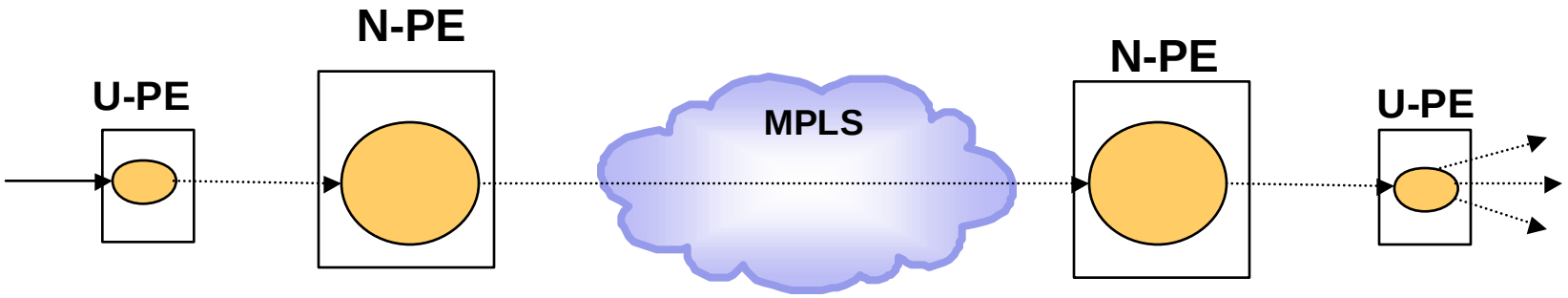
Distributes MAC Learning to U-PE - Contains the effects of DoS Attacks.

Technology Choices for Decoupled Models

Bcast/Mcast Replication



Multicast flow destined to 3 UNIs located on the same destination PE-E.
Wasted Bandwidth in the MPLS Backbone! (D-PE)



Replicate as close to the destination as possible.
Maximum Bandwidth Savings (H-PE and LPE)

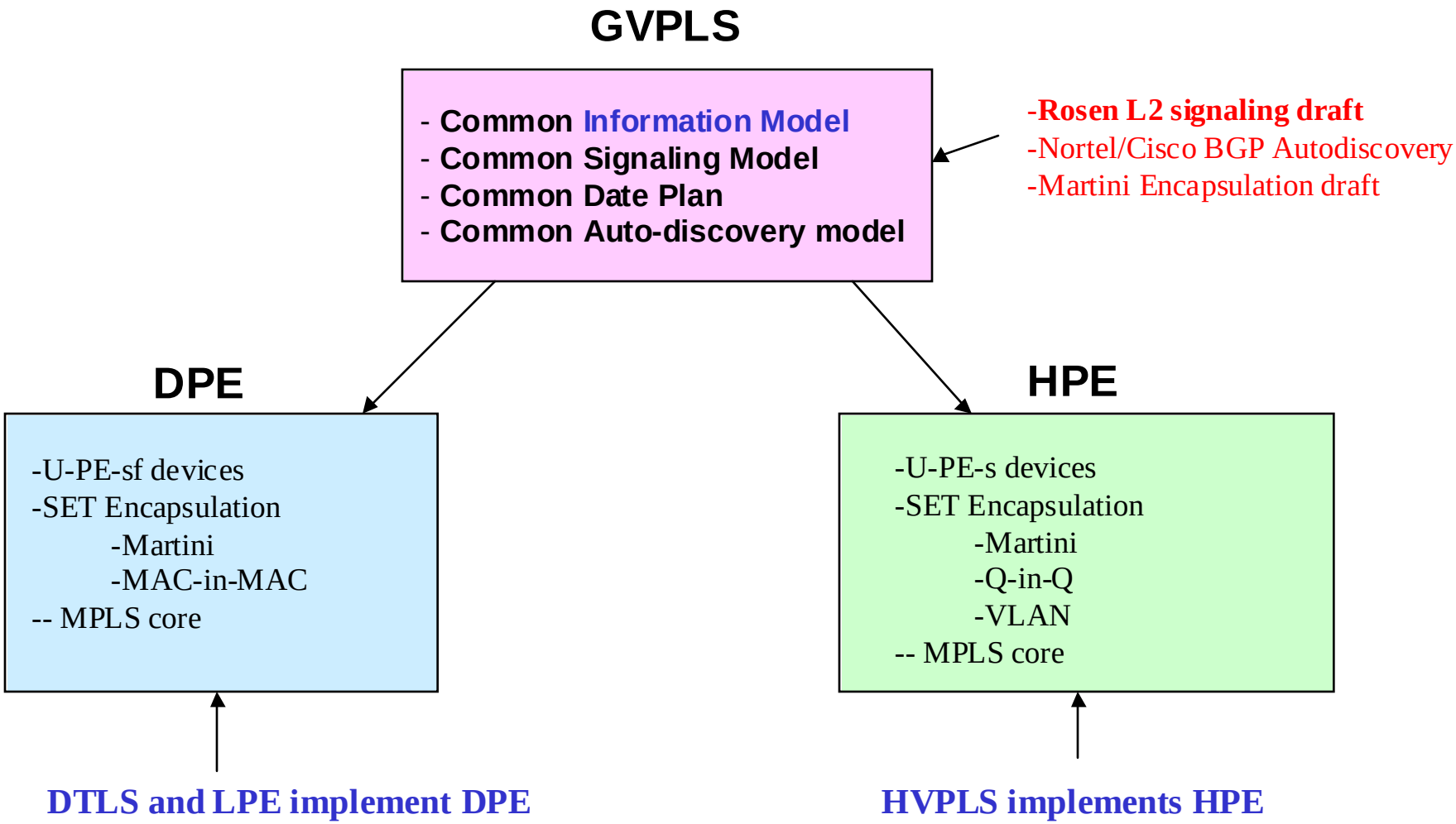
GVPLS Model

Objectives of GVPLS

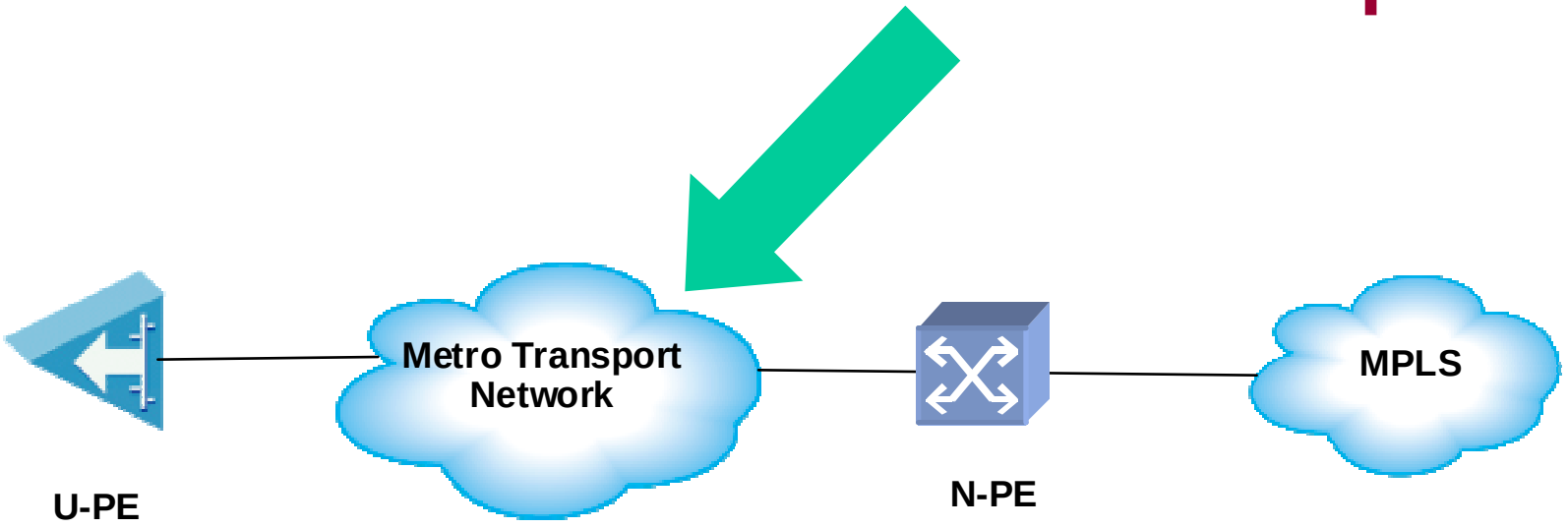
- Key goal is to support seamless integration of decoupled and all non-decoupled VPLS models
  - Same signaling mechanism
  - Same auto-discovery mechanism
  - Same provisioning model

- Allow integration of different access topologies – across Service Provider network:
  - Hierarchical PE
  - Distributed PE
  - With different technologies
    - SET (MAC-in-MAC), P2P, P2MP, Q-in-Q etc.

TOWARD a UNIFIED VPLS Solution

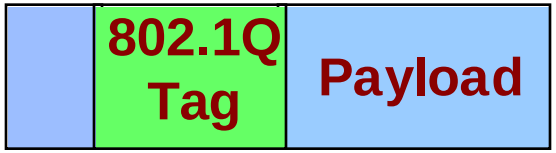


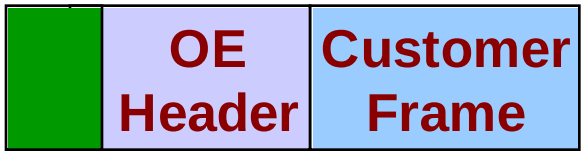
A Closer Look at the Metro Transport

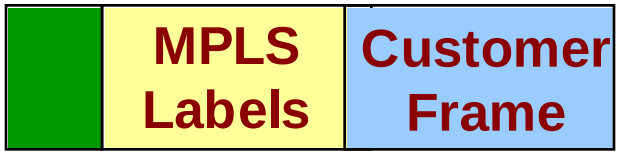


Metro L2 Transport Mechanisms

- Stacked VLANs (Q-in-Q)
  - VLAN stacking provides simple service delineation cost effectively
  - Limited scalability
  - Exposes Core Network to ALL Customer Addresses
- OE Header (MAC-In-MAC
  - Encapsulate entire frame into Service Provider Ethernet packet
  - Customer MAC addresses, VLAN and QoS transparently transported without affecting operator's network
- MPLS Labels (Pseudowires)
  - Leverage emerging connection-orientated standard for interoperability
  - Incorporate values of "fast, simple, reliable"







Comparing Metro Access Methods

	Q-In-Q	MAC-in-MAC	MPLS Pseudowires
Demarcation	Poor	Good	Good
Scalability	Poor	Good	Good
Can have Direct connect across Access net?	Yes	Yes	No
Media Agnostic?	No	No	Yes
Simple edge switch?	Yes	No	No

Each Method Has its Place

Summary

- Optical Ethernet and VPLS Services meet a significant Enterprise service requirement
- OE Service Revenue projected to grow at an annual rate of >120% from 2001 to 2006 (IDC)
- Asia Pacific will lead the investment with over 50% of revenues between now and 2007 (IDC)
- A Basic Technology behind these services is the L2 VPN based on MPLS core transport.
- The only way to affordably scale this infrastructure is by using a Decoupled VPLS technology.
- IETF is in advanced stages of drafting specifications for decoupled VPLS and multiple IETF-based implementations are in the market today.

www.MetroEthernetForum.org