Ethernet

Ethernet based services

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Ethernet Switches

- Layer 2 forwarding – MAC address based
- Learns MAC addresses
- Store-and-forward operation
  - No collision
  - High speed *backplane*
- Many interfaces
  - Different interface speeds
  - Different media

Switches

- Standard refers them as bridges
  - They divide the broadcast domains
- Types
  - Unmanaged
    - SOHO use, low level aggregation
    - No support for STP nor VLAN
  - Managed
    - VLAN and STP support
    - management interface
  - Enterprise switches
    - L2/L3

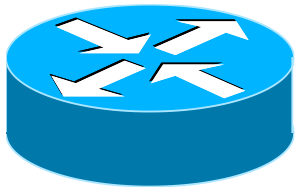
P-to-P mode

- On links between bridges CSMA-CD not needed
  - Separate RX/TX paths at phy
  - No collision
  - Full duplex
  - Higher achievable BW
- Can be used
  - Between bridges
  - Between bridge-PC
- HUB and shared media can not use it

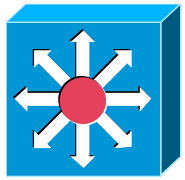
Ethernet local network design

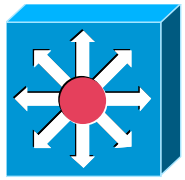
- Hierachically

Router



Multiservice switch



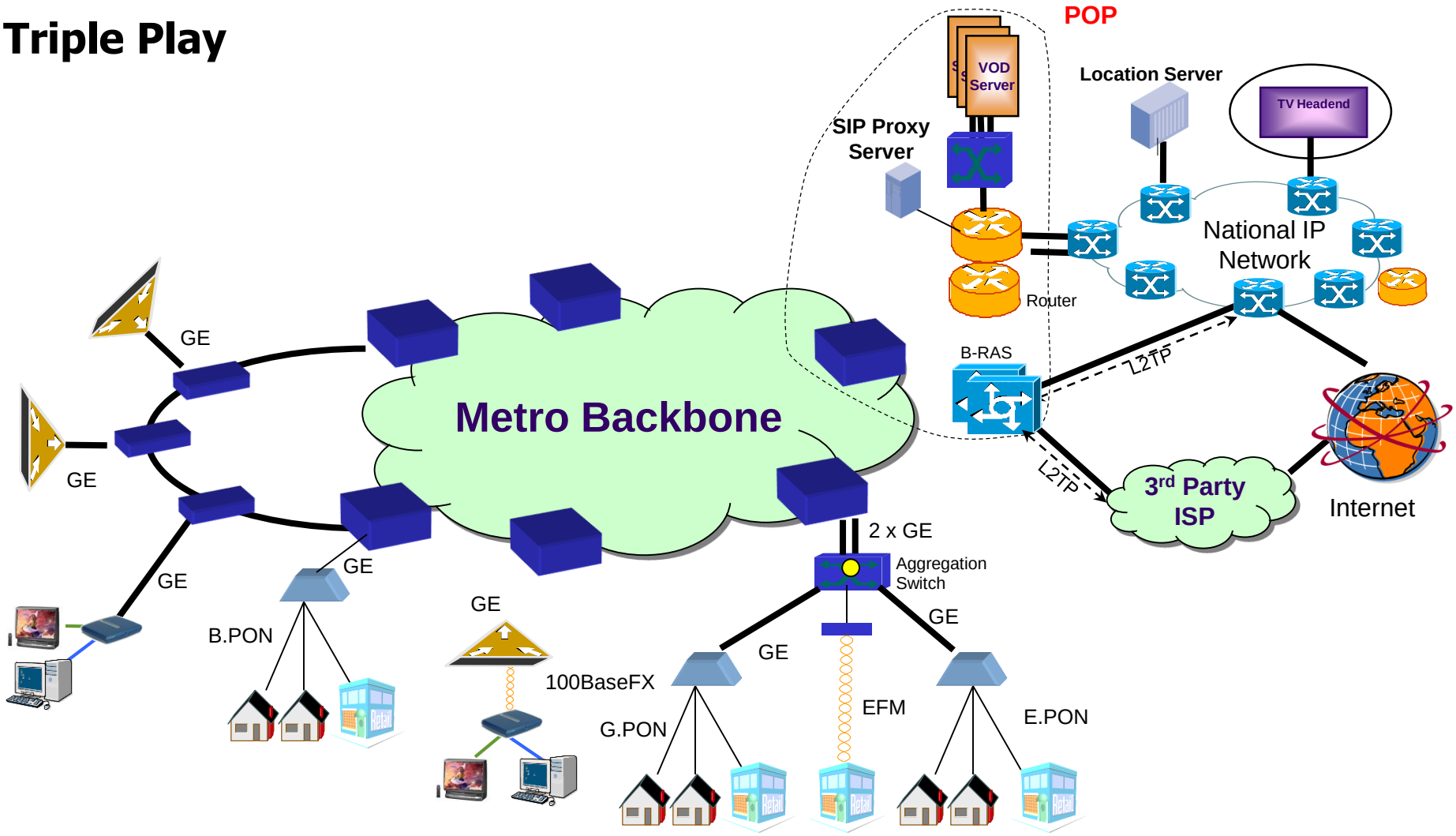


SWITCH, Bridge

HUB

Metro Ethernet

Triple Play

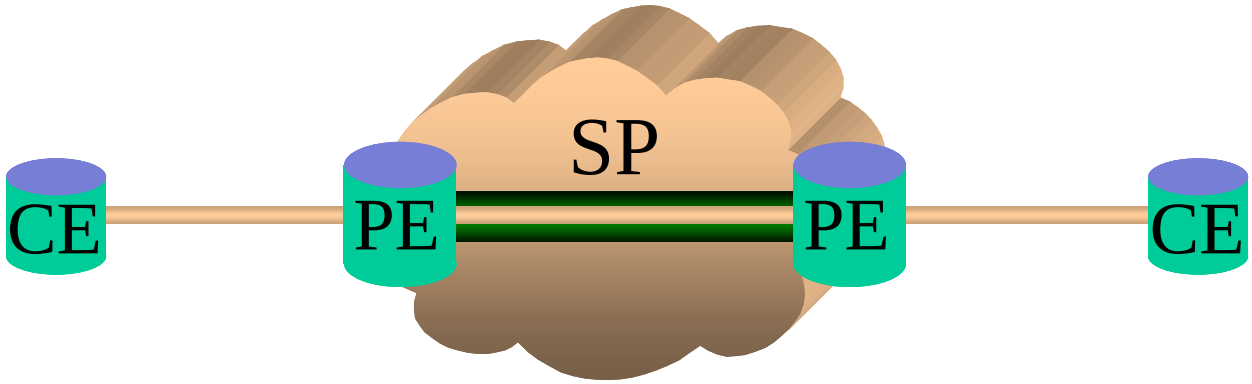


VPN services

- Layer 3 VPN
  - IP level connectivity
- Layer 2 VPN
  - Ethernet level connectivity
- Implementation can be at L1, L2, L3!

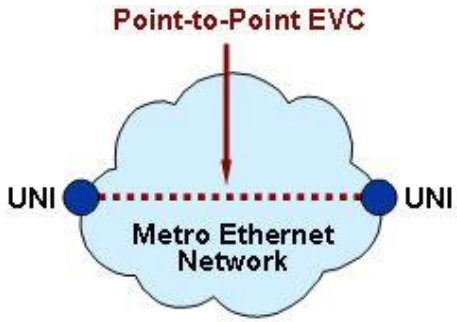
L3 VPN

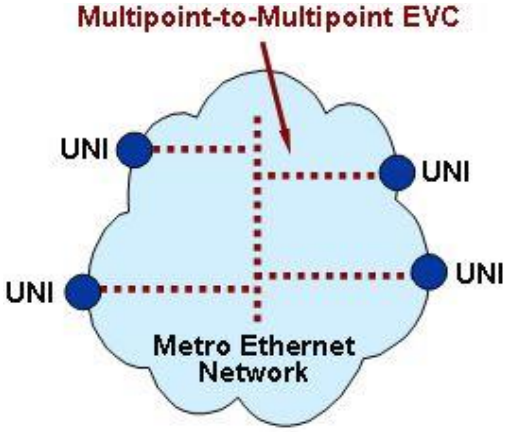
- Or IP VPN
- IP addressing used for connectivity
- The network is seen as a ROUTER



Ethernet VPN services

- ***E-Line*** (MEF) [ITU: Ethernet Virtual Private Line ***EVPL***, IETF: Virtual Private Wire Service, ***VPWS***]
  - Leased line
  - Point-to-point
- ***E-LAN*** (MEF) [ITU: Ethernet Virtual Private LAN ***EVPLAN***, IETF: Virtual Private LAN Service, ***VPLS***]
  - Virtual LAN service
  - Multipoint-to-multipoint
- **UNI**-connection point
  - Virtual connection - EVC

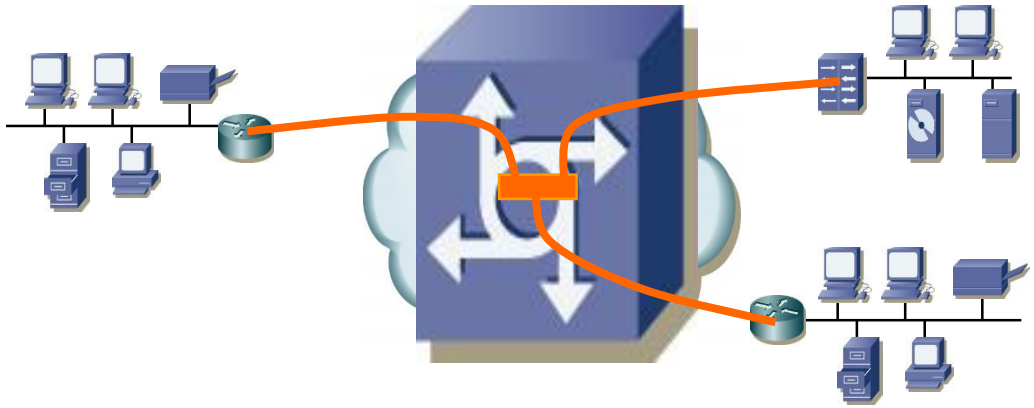




Source: MEF

What is a "LAN-like Ethernet service"? Definition of L2 VPN

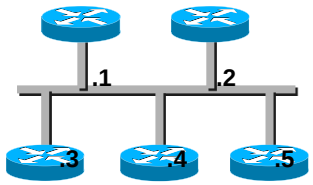
- L2 VPN: connection of multiple sites in a single bridged domain over a SP network
- Customer perspective:
  - all sites appear to be connected to a single Ethernet-Switch/Segment
  - no L2 protocol conversion between LAN/WAN
  - no knowledge required on WAN technologies (e.g. FR)
  - complete control and freedom of routing (IP, IPX, AppleT, DecN, etc.)
  - simple to add new sites: no reconfiguration at existing ones
- SP perspective:
  - logical separation of the existing network resources in order to provide L2 connectivity

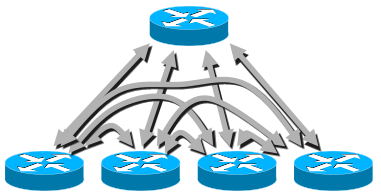


P2P versus MP Connectivity

- P2P
  - customer edge (CE) end point or node are able to communicate to a single other CE nodes.
- P2MP (a.k.a. hub-and-spoke)
  - end customer designates one CE node to be the hub that multiplexes multiple point-to-point services over a single User-Network Interface (UNI) to reach multiple "spoke" CE nodes. This means that each spoke can reach any other spoke only by communicating through the hub.
- MP
  - CE end point or node is able to communicate directly and independently to all other CE nodes.

- Three generations of Ethernet
  - FE: CSMA/CD*
  - GE: CSMA/CD + Full-Duplex
  - 10GE: Full-duplex Only
- MP by nature
  - CSMA/CD:
    - Carrier Sense Multiple Access with Collision Detection
  - Full-Duplex (on P2P links)
    - L2 and L3 communication = MP
- L2/L3 protocols
  - assumes MP connectivity by default on Ethernet interfaces





Ethernet based transport in provider networks

The Ethernet way

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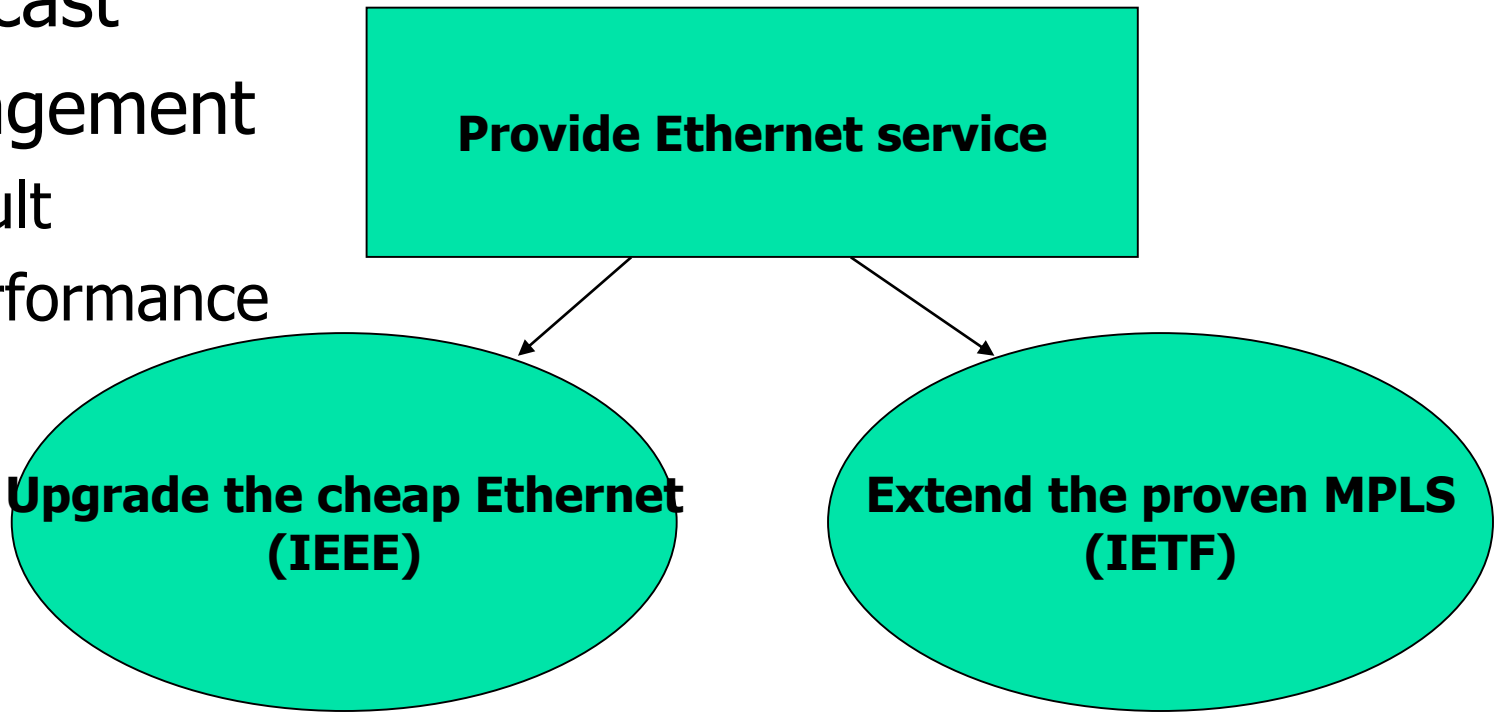
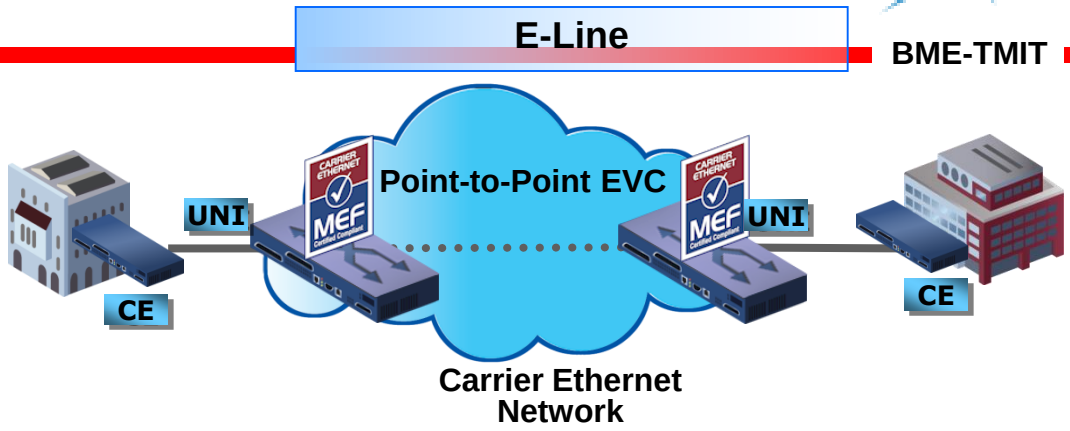
Challenges

- Carrier grade requirements
  - Scalability
  - Service Quality
  - Multicast
  - Management
    - Fault
    - performance

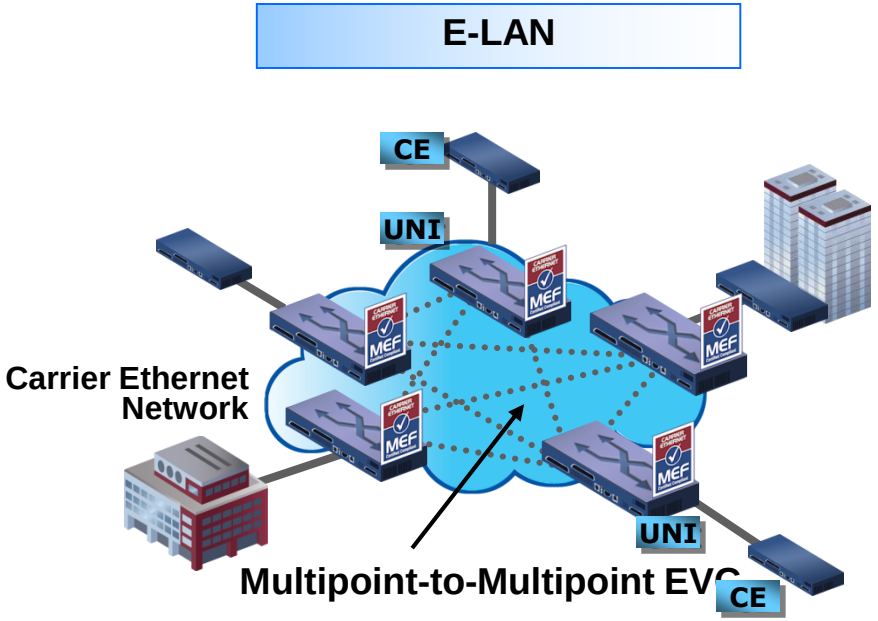


Carrier Ethernet: service types

- E-Line service:
  - Ethernet Private Line
  - Virtual Private Line
  - Ethernet Internet Access



- E-LAN Service:
  - Multipoint L2 VPN
  - Transzparent LAN
  - Needed for IPTV multicast etc

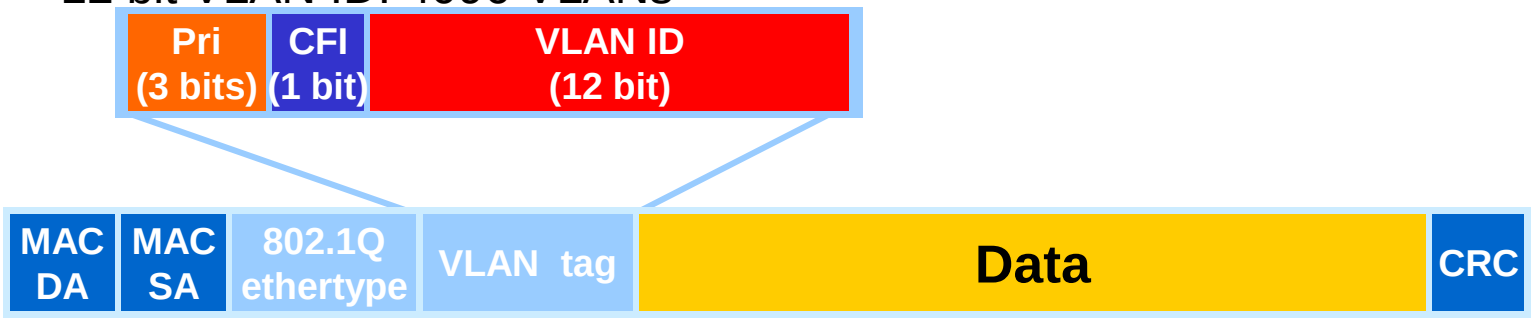


MEF által hitelesített Carrier Ethernet termékek

UNI: User Network Interface, CE: Customer Equipment

IEEE 802.1Q - VLAN

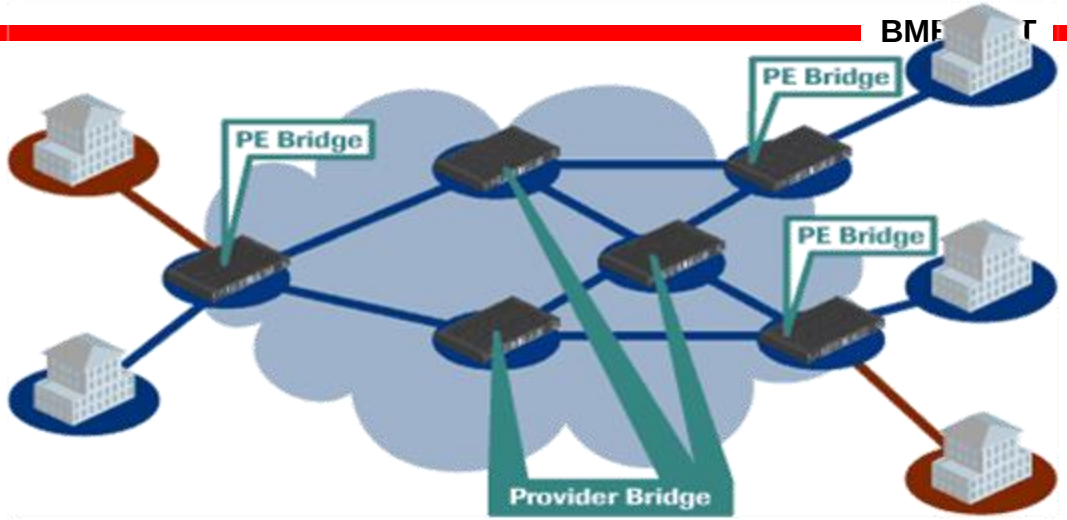
- VLAN tag
  - QoS: priority
  - 12 bit VLAN ID: 4096 VLANs



- Usage
  - User identification
  - Service identification
- The 4096 limit is there– Too few for a provider!
- The most wide spread UNI
  - Also we must be prepared to transfer VLAN tagged packets

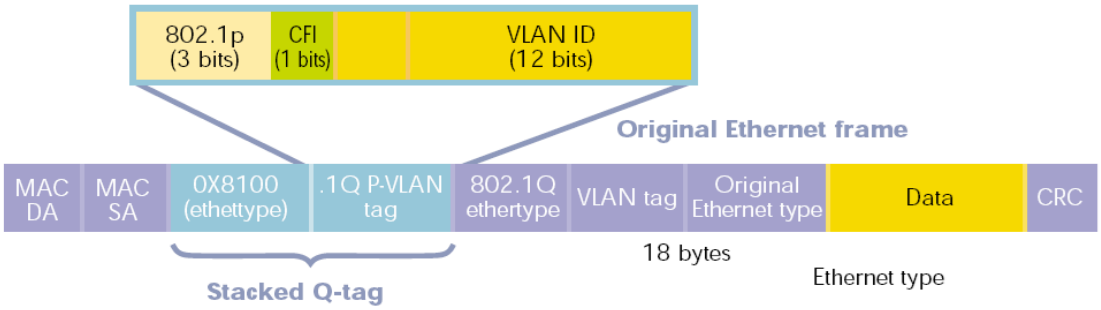
Provider Bridges (IEEE 802.1ad)

- Also known as Q-in-Q
- Widely used

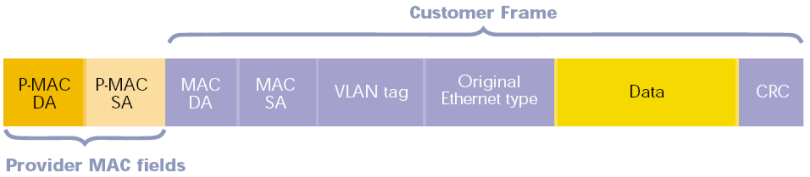


- 4K services (12-bits)
- Unique service ID
  - (S-VID)
- Forwarding is the same, L2 learning bridge with STP, filtering for the outer VLAN (S-VID)

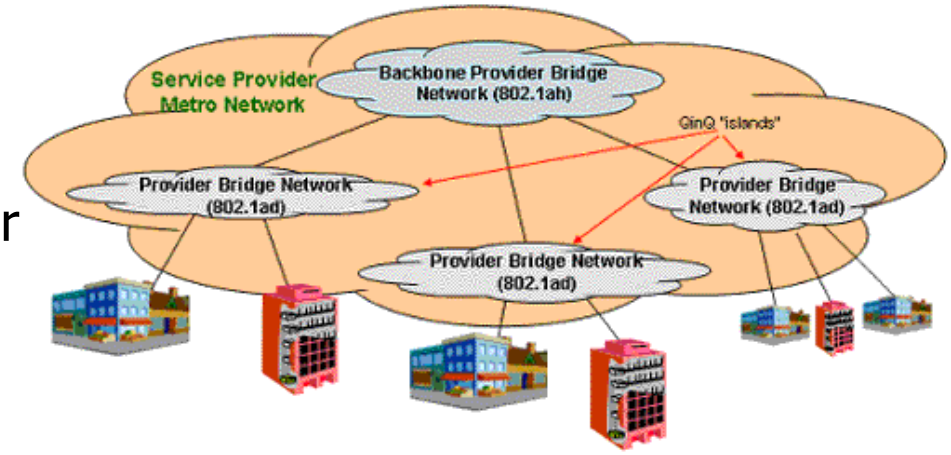
- Scalability
  - 4K service



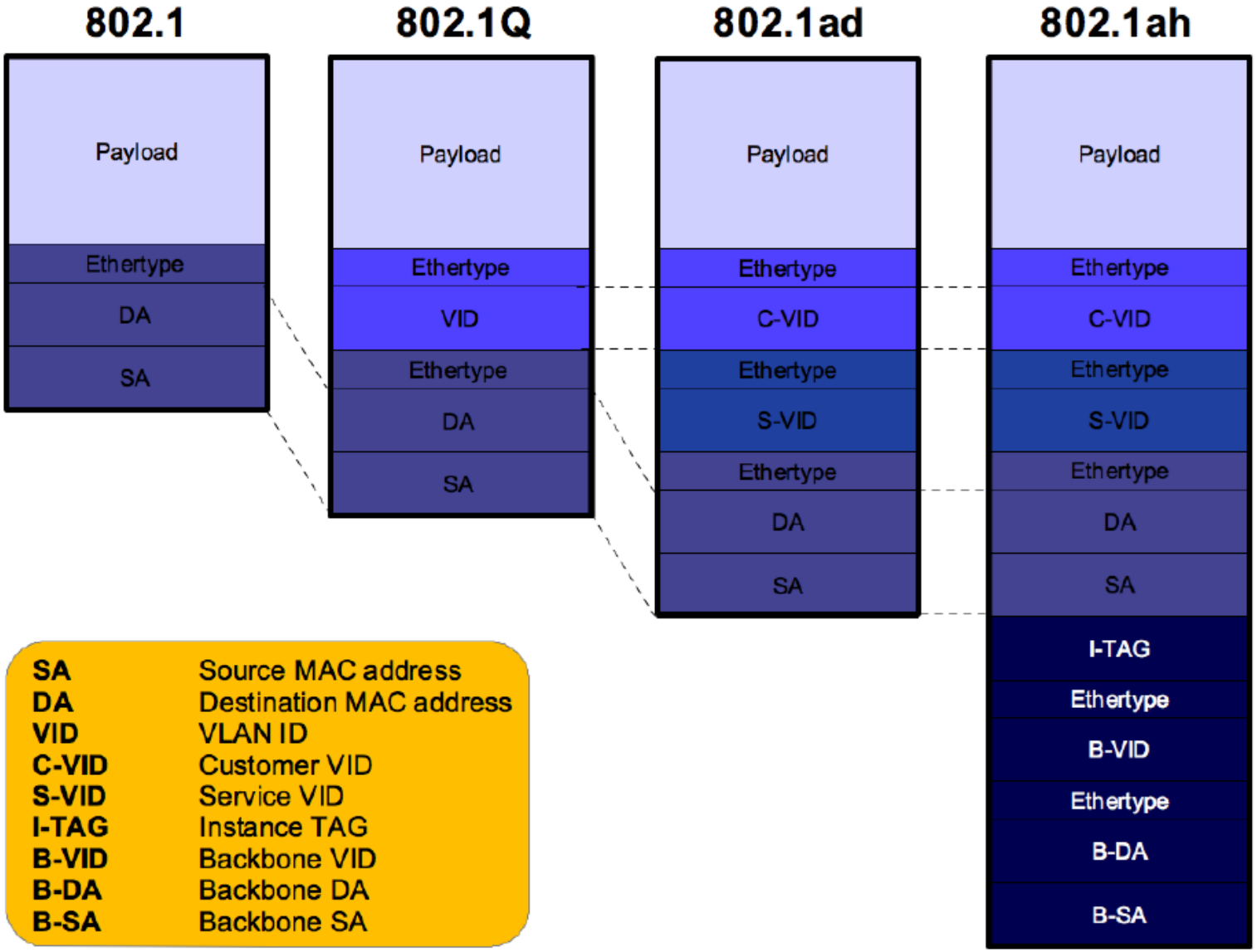
Provider Backbone Bridges



- 4K connected LAN
- Unique per service ID
  - (LAN = I-SID)
- Forwarding is the same, L2 learning bridge with STP, filtering for the outer VLAN (B-VID)
- Service management is simple
- Scalability
  - Massive sservice scalability (24-bit)
  - Only learn MAC of the Provider bridges
  - Mapping of C-MAC to VIDs



Comparison – headers added



PB/PBB facts

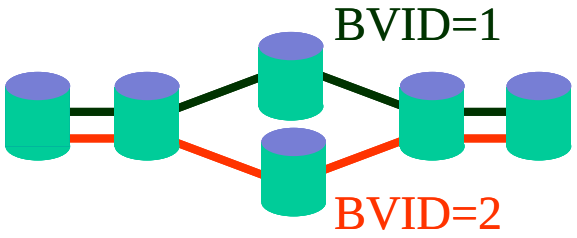
- Scalability solved ☑
- Cheap Ethernet switching remains ☑

- Still no support for Traffic Engineering ☒
- Protection/restoration based on STP ☒
- Management is more complex ☒
  - Different layers of VLANs
  - No adequate management

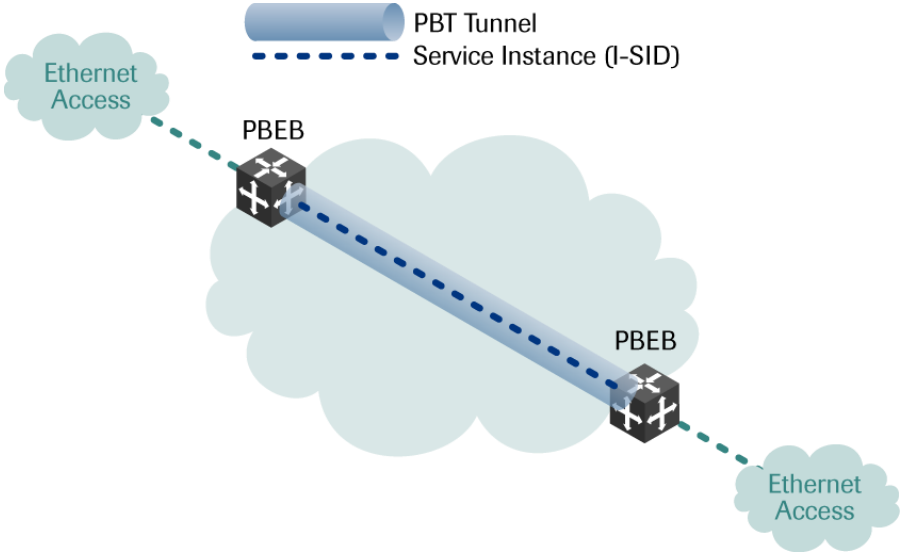
- Still not good in the core…

PBT

- Goal
  - Keep the Ethernet forwarding
  - Change the control plane (no STP and learning)
  - Set up paths ”manually“
    = Traffic Engineering - Ethernet

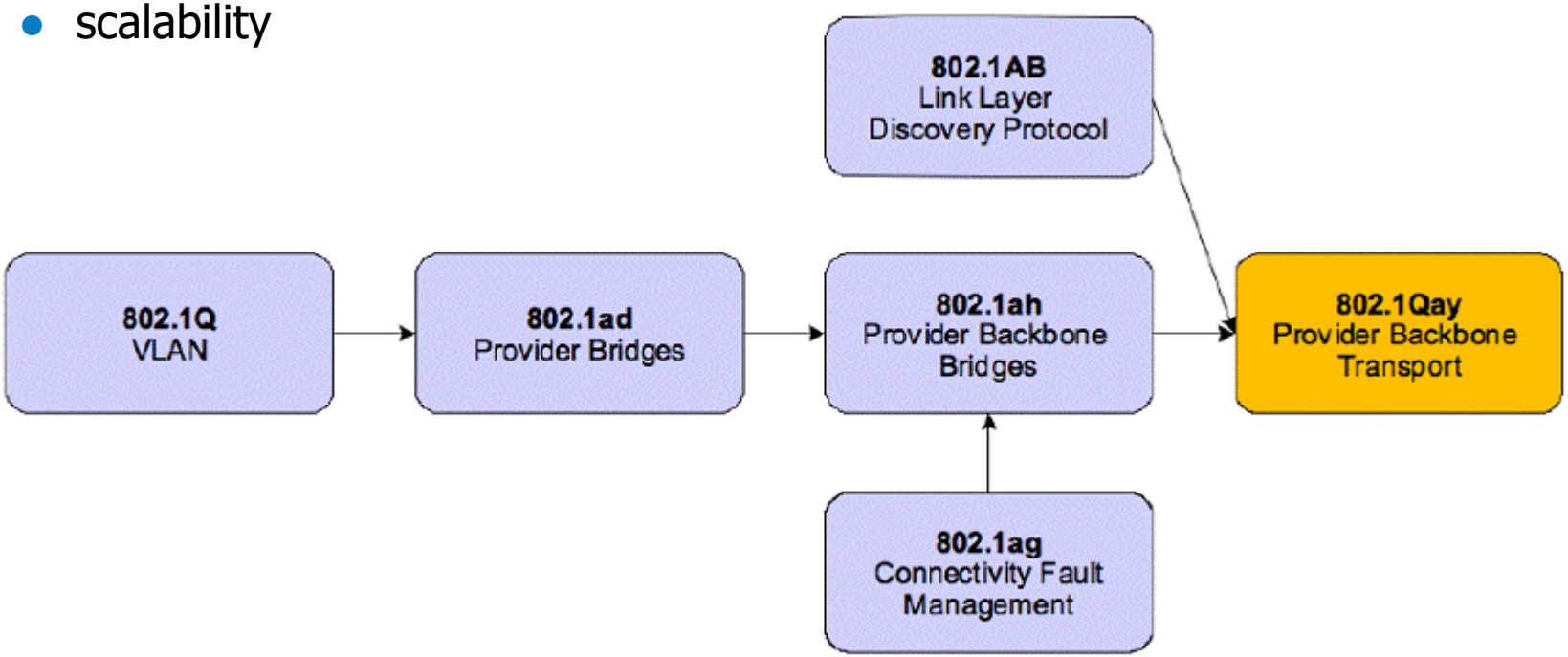


- What we get:
  - Point-point tunnel
  - Traffic Engineering
  - Protection



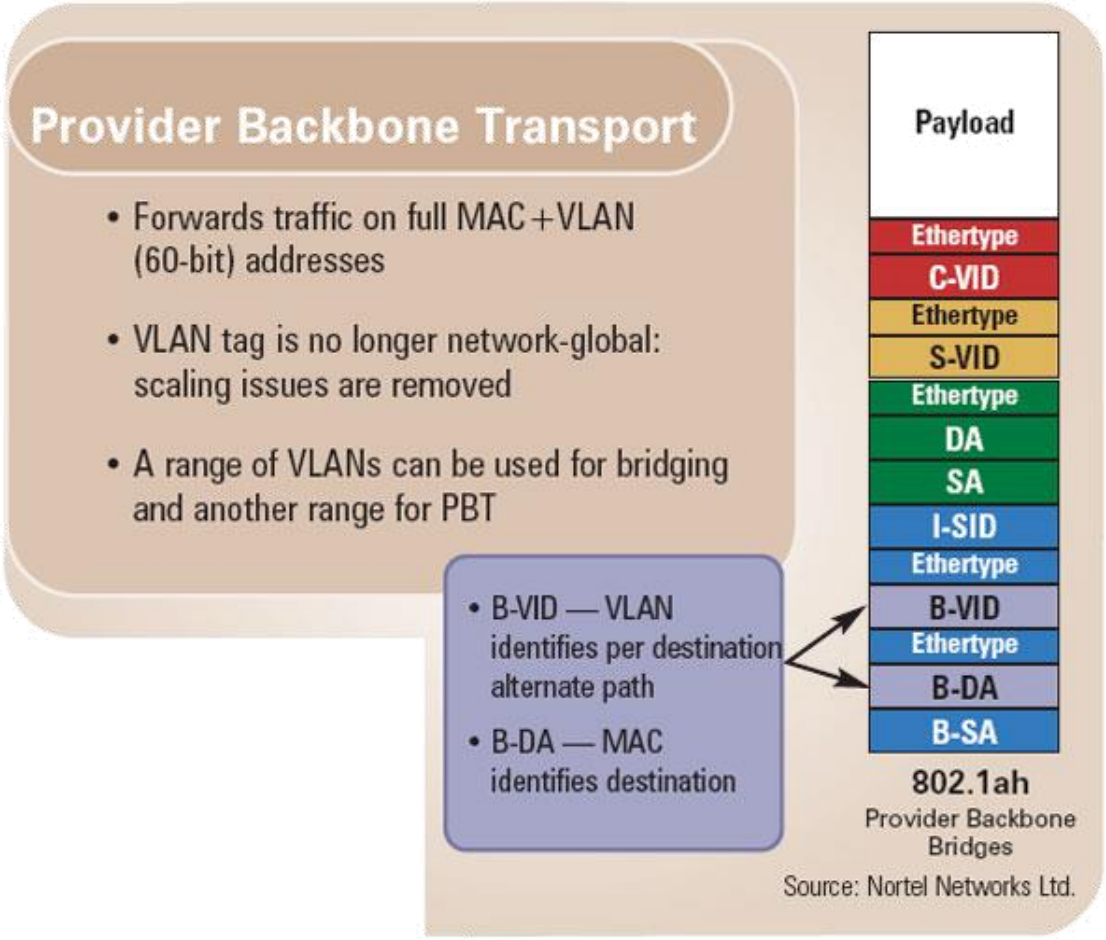
PBT

- Provider Backbone Transport – IEEE 802.1Qay
  - Nortel started
  - based on PBB
- Uses the existing technologies
  - Deterministic QoS for service is the target
  - scalability

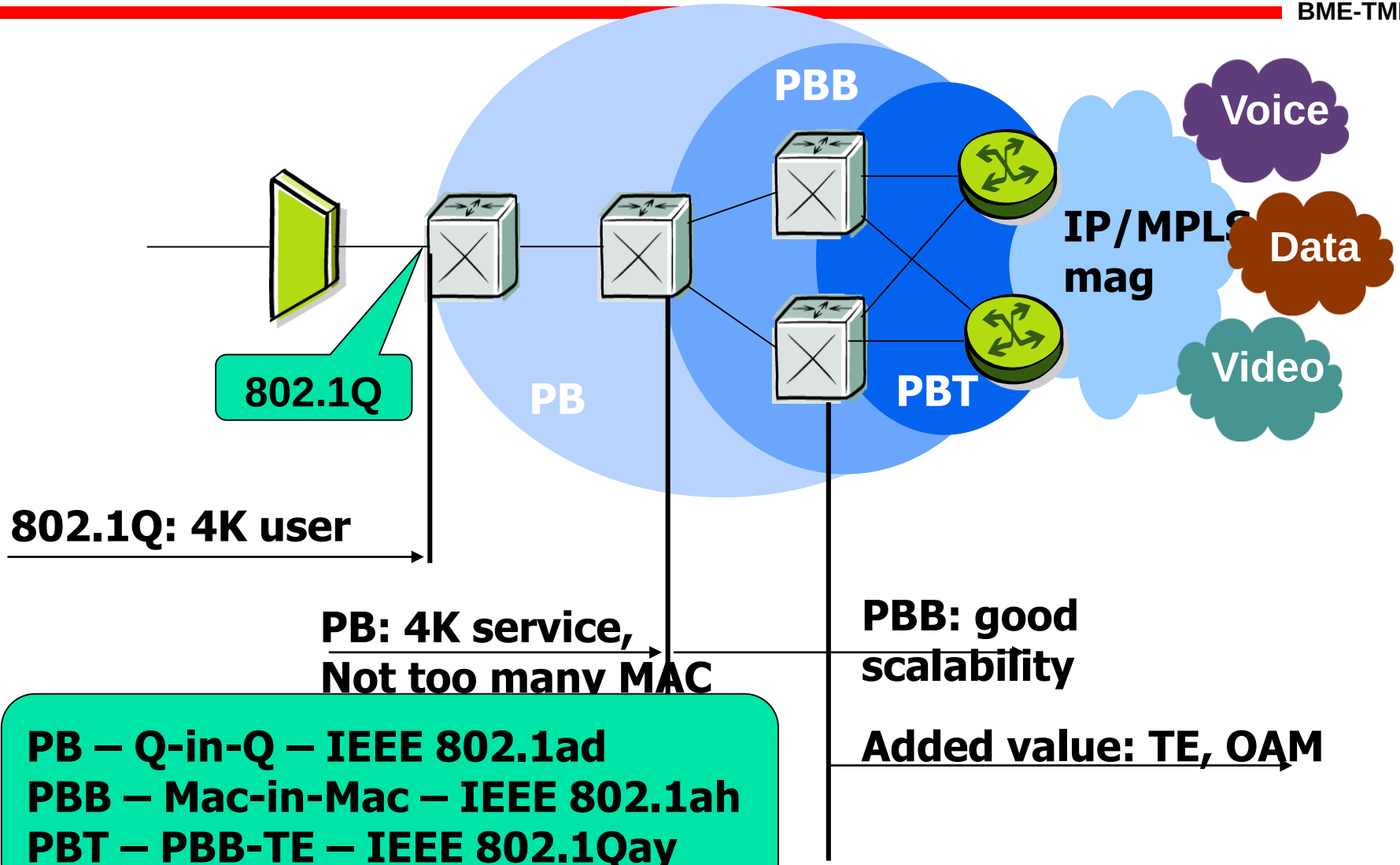


PBT - operation

- Data plane
  - Static forwarding tables
  - Addressing
    - 60 bit MAC + VLAN based
- Totally different control plane
  - Manual
  - MPLS based



Ethernet Transport technology use



Ethernet based transport in provider networks

The other way – IP/MPLS

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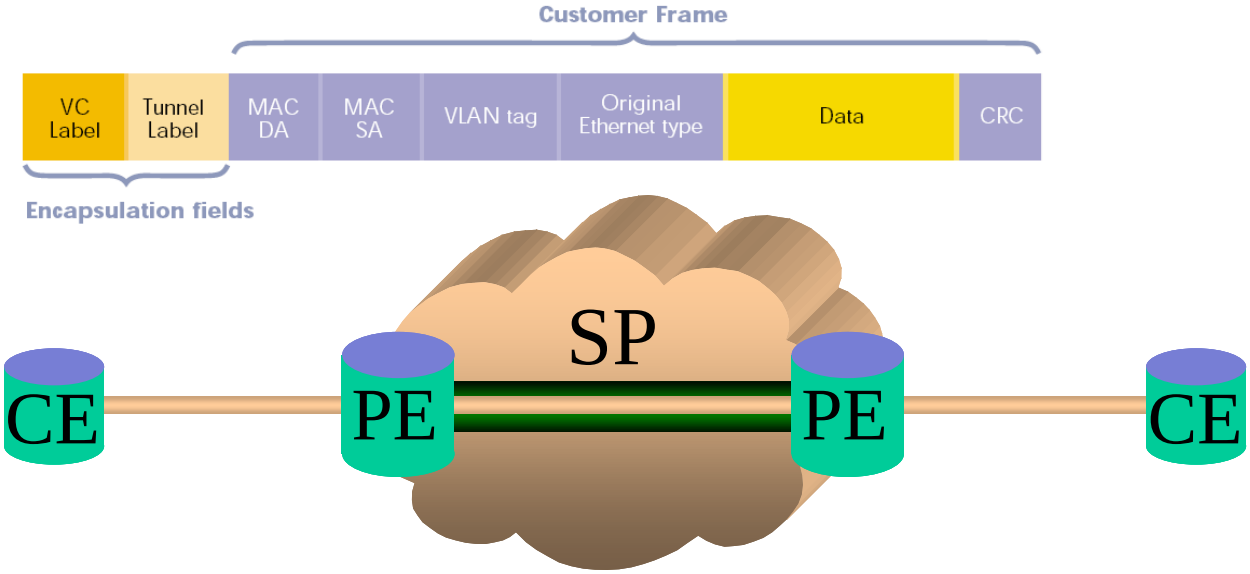
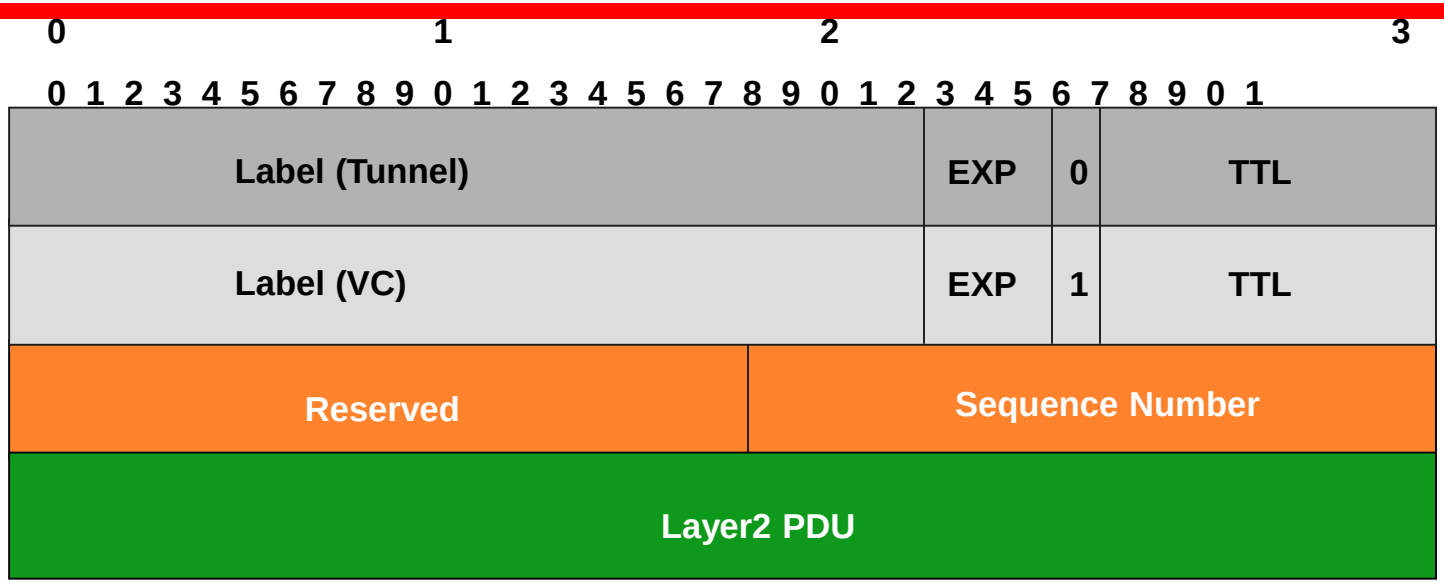
MPLS Pseudowire - WPWS

- Ethernet p2p service
  - IETF pwe3 study group, the draft name Martini –encapsulation
  - MPLS label is encapsulated, multiple virtual connections within an UNI (VC)
  - Forwarding based on tunnel label



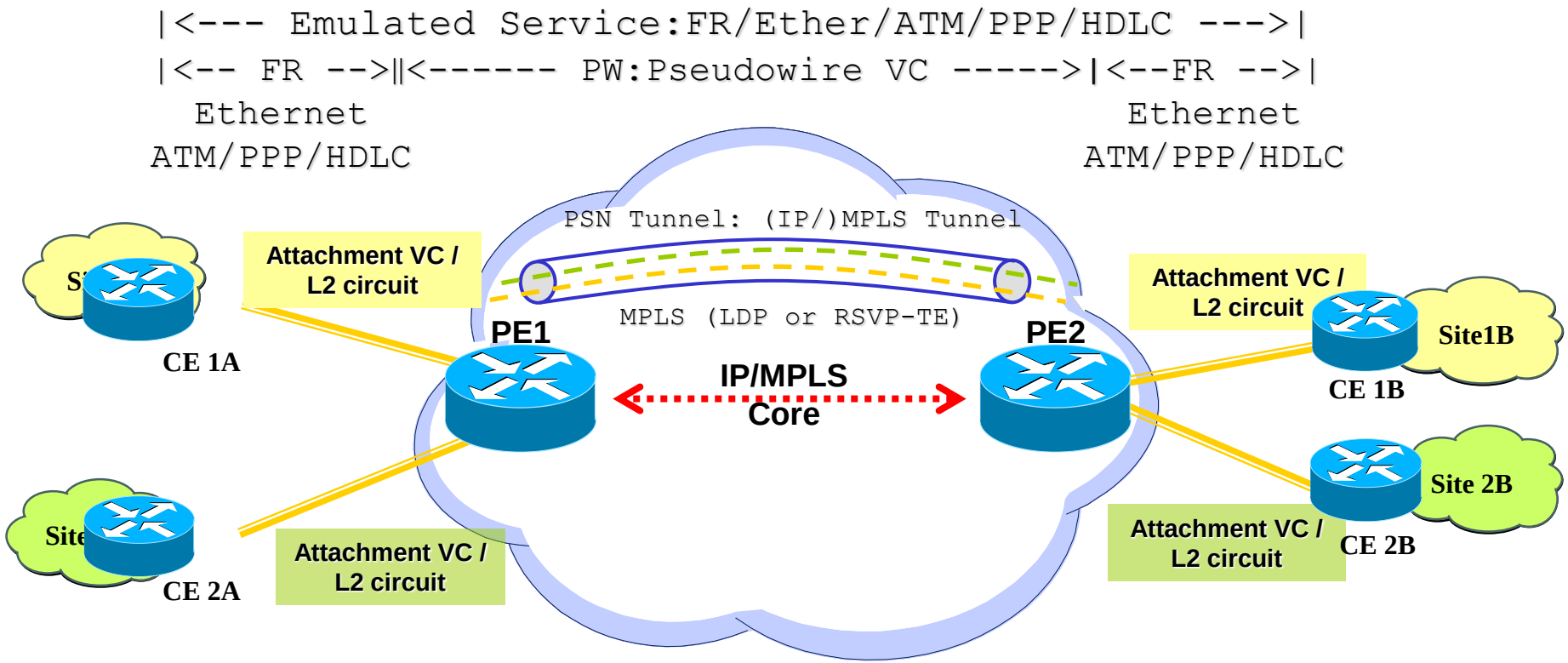
- The solution inherits all MPLS solutions
  - Traffic Engineering, protection, OAM

Data Plane : EoMPLS packet



- Tunnel label :
  - LSP label to get the packet from ingress PE to egress PE (IGP label or RSVP (TE) label)
- VC Label :
  - demultiplexing label identifying an emulated VC
  - Identifies outgoing interface/vlan
- Control Word : extra information regarding the VC
- VC Label TTL = 2

Pseudo-Wire reference model



ES → Emulated Services: FR/Ether/ATM/PPP/HDLC

Attachment VC (AVC): FR DLCI/Ethernet VLAN/ATM PVC/PPP/HDLC

PW → Pseudo-Wire: Emulated VC (EVC): MPLS LSP

PSN → Packet Switched Network (Tunnel): MPLS LSP or RSVP-TE

Comment on VPWS: MTU

- EoMPLS does not support fragmentation
  - MTU > layer2 VLAN frame
- No e2e detection
  - MTU in core should be bigger
- MTU values
  - a PE-CE should match
  - MTU set them correctly

MTU Calculations for EoMPLS:

Max Frame Size = Link Header + labels + Transported L2 Header + Payload

Transported Ethernet Header:

AToM removes (1) Preamble (2) SFD (3) FCS

Ethernet II Encapsulation → 18 Bytes

Ethernet SNAP → 26 Bytes

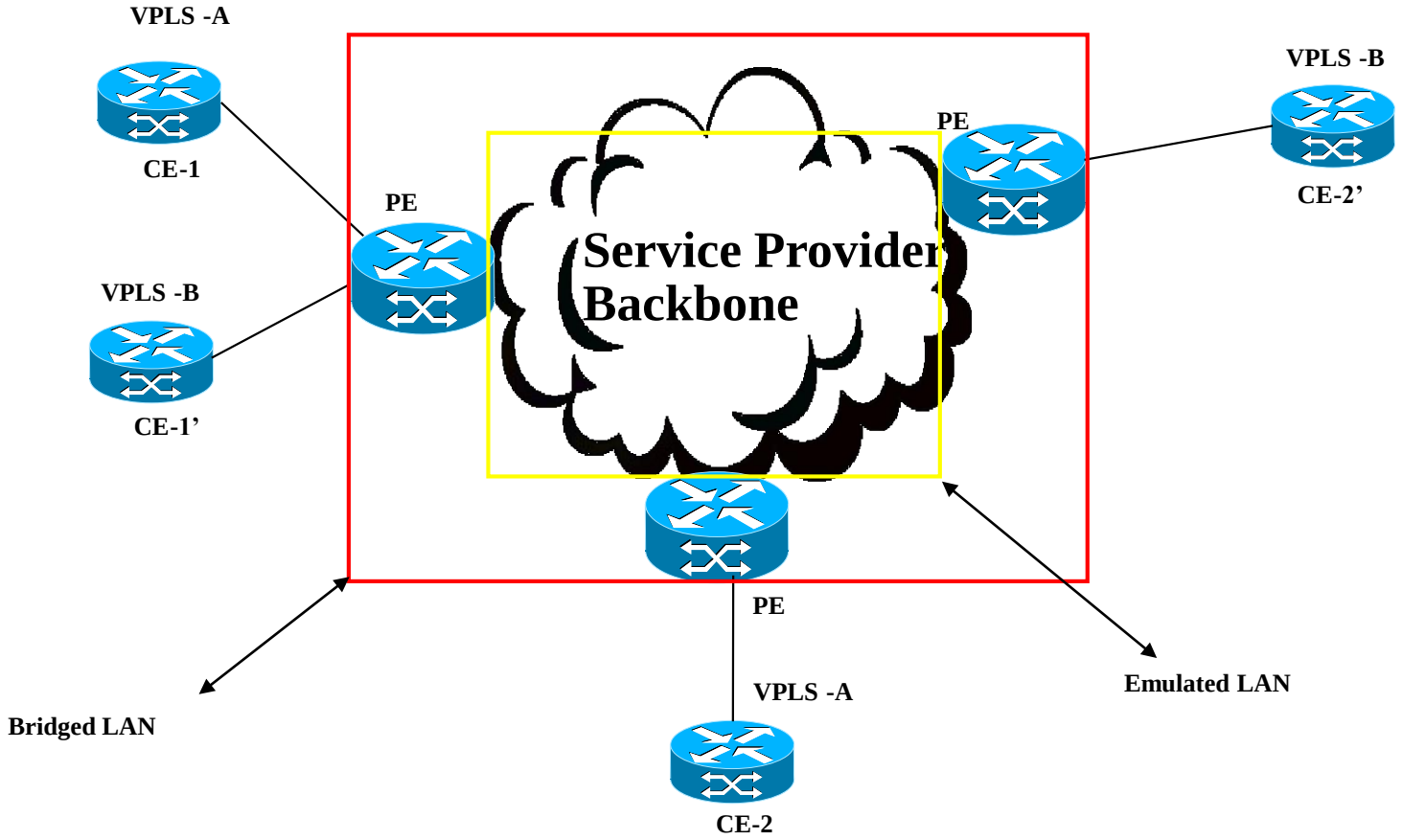
Dot1q tag(s) → 4 Bytes per tag

Labels : usually 2 labels

Example : Ethernet II + dot1q tag + 2 labels + Ethernet II + 2 dot1q tags (QinQ) + Payload

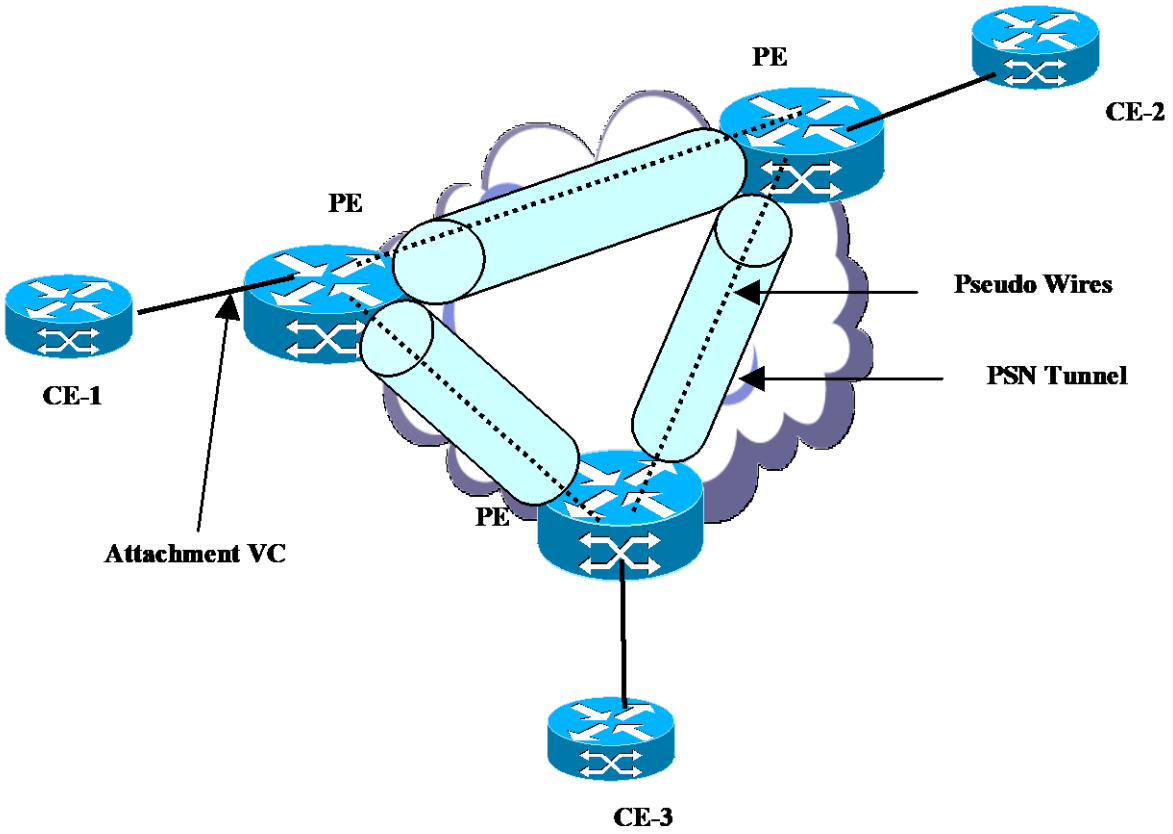
18B 4B 8B 18B 8B 1500B

VPLS



Customer Edges (CE): Client side device, tyically Ethernet
Provider Edges (PE): VPLS inteligence, start/end
Core: just forwarding

VPLS example



Full Mesh
PEs are acting like a bridge towards the CE nodes

VPLS Operation

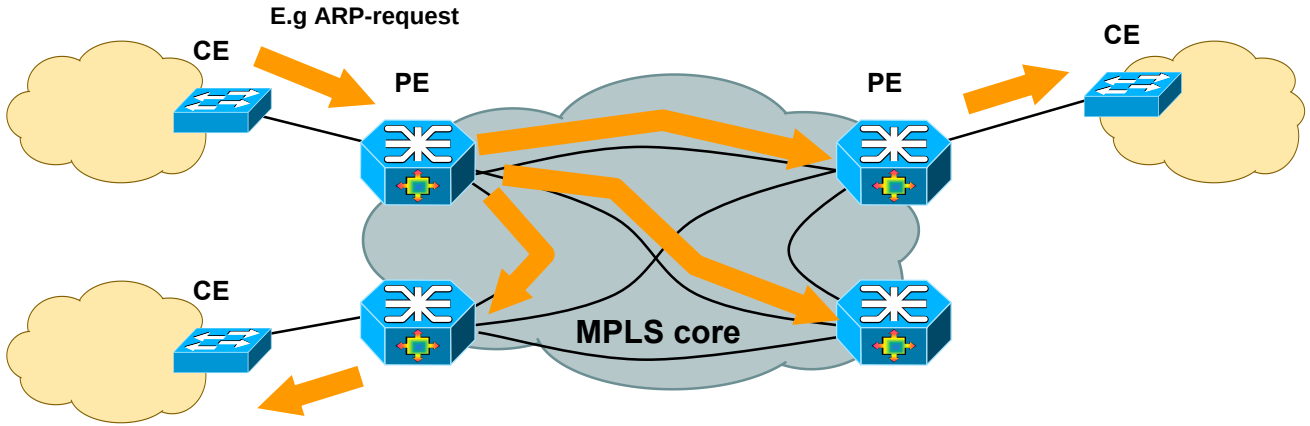
- VPLS instance : Service–identifier (Svc-id)
- Full mesh tunnels
  - Targeted LDP messages
- Forwarding: learning bridge
  - Flooding
  - Split-horizon – never send to the receiving interface

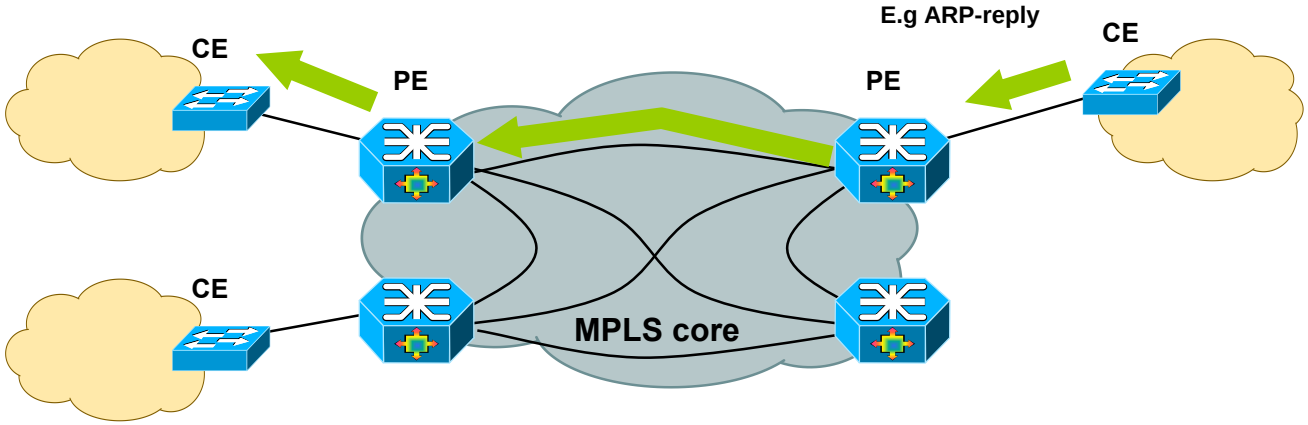
Why not VPLS End-to-End?

- VPLS scalability
  - eg. 5 PE - 20 LSP, 40 PE: 1,536.
  - High bandwidth waste because of broadcasts
- VPLS – new requirements
  - Protection, OAM, mapping

Number of PE in VLAN	Number of LSPs	Number of Retransmissions/ Broadcast
5	20	4
10	90	9
20	380	19
40	1 560	39

VPLS – Flooding & forwarding



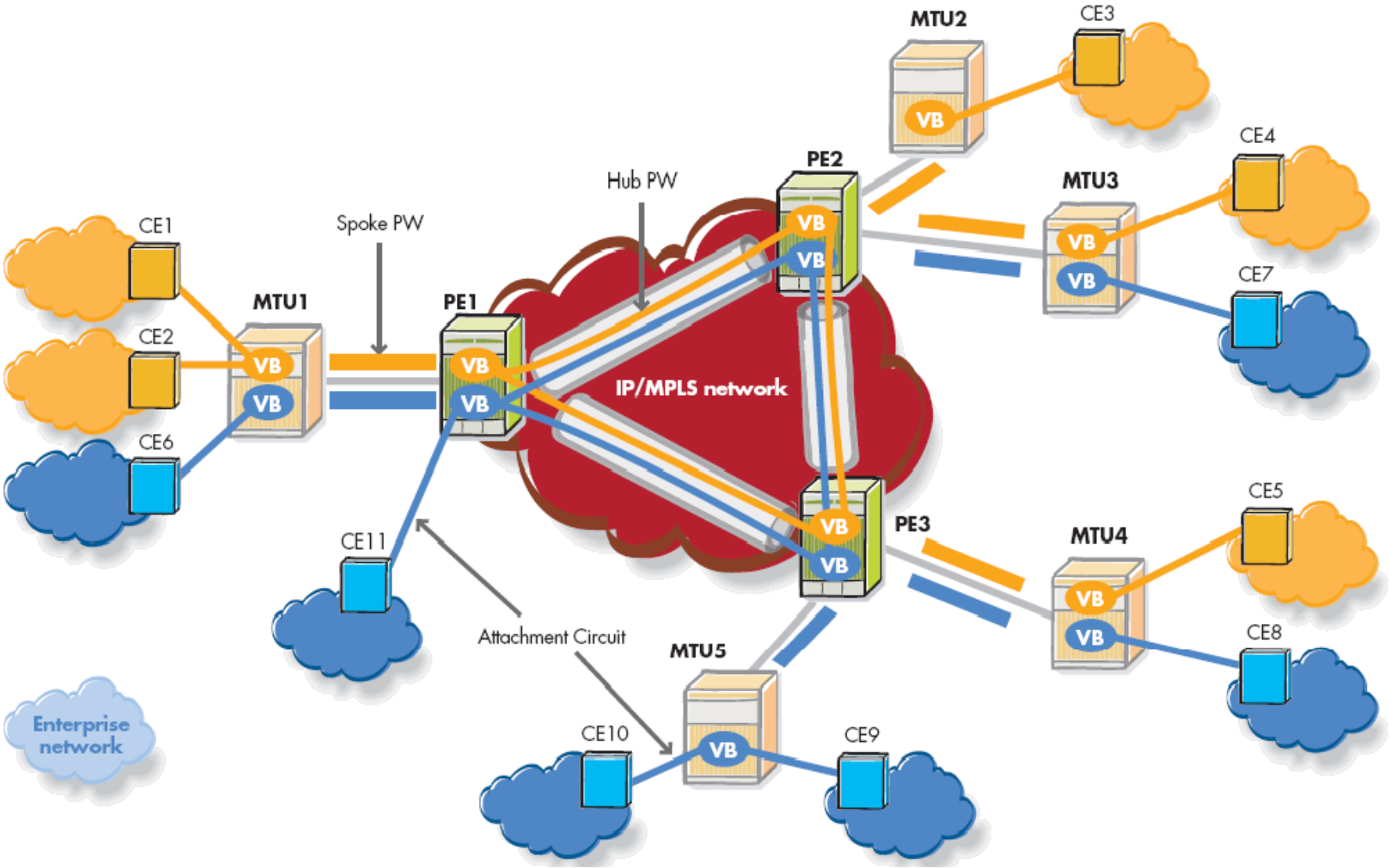


- Flooding (Broadcast, Multicast, Unknown Unicast)
- Dynamic learning of MAC addresses on PHY and VCs
- Forwarding
  - Physical Port
  - Virtual Circuit

VPLS scalability- hierarchical

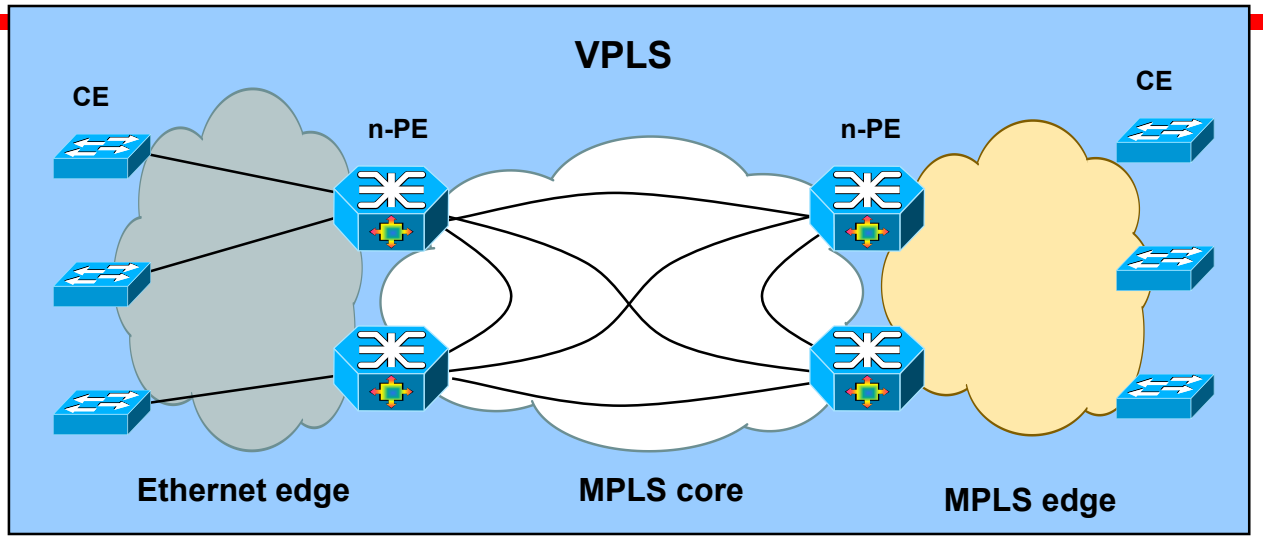
- MTU - Multi-Tenant Unit: owned by multiple users, bridge
- VPLS can be extended to the MTUs
  - MAC/VLAN scalability increased
  - More complex MTU
- Hierarchical VPLS
  - „HUB” pseudowire (hub PW) between PEs
  - „spoke” PW between MTU-PE
    - Spoke PW can be QiQ, MPLS, …

Hierarchical VPLS

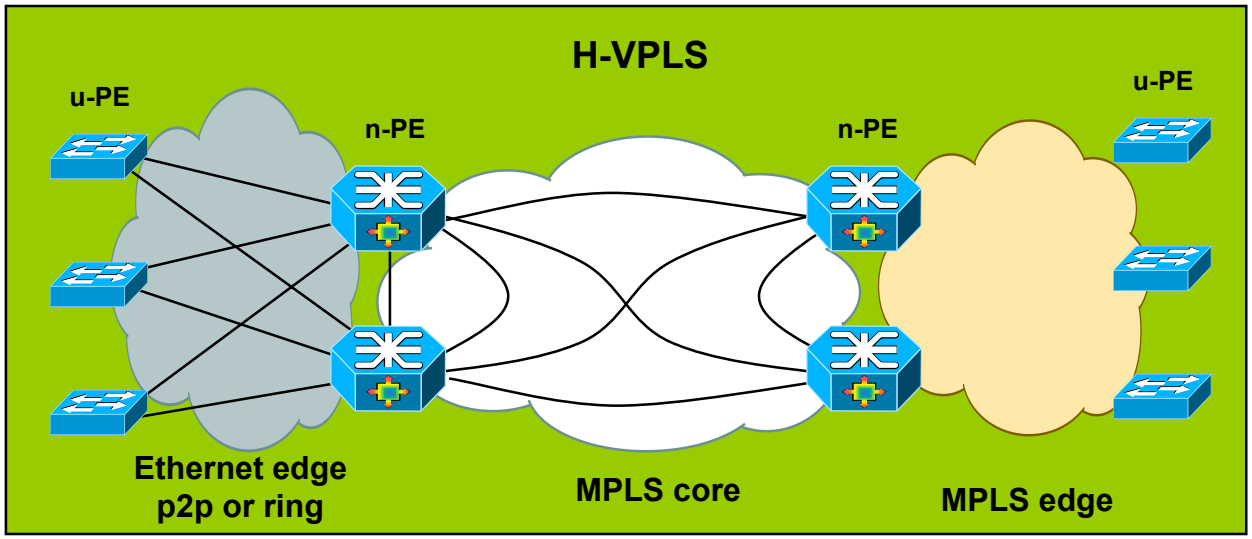


VPLS – Architectures

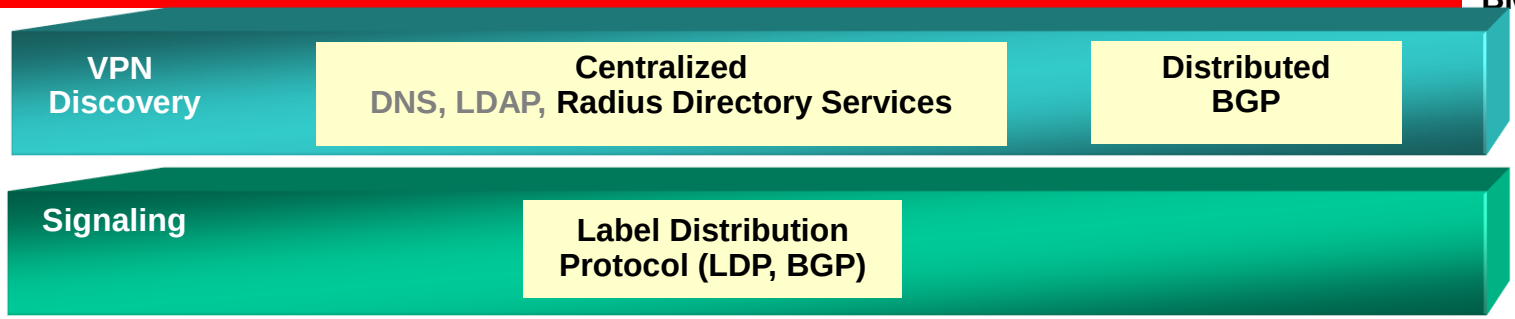
- VPLS
  - One big hierarchy
  - MPLS to the Edge



- H-VPLS
  - 2 level Hierarchy
  - MPLS or Ethernet Edge
  - MPLS core



VPLS signaling and auto-discovery



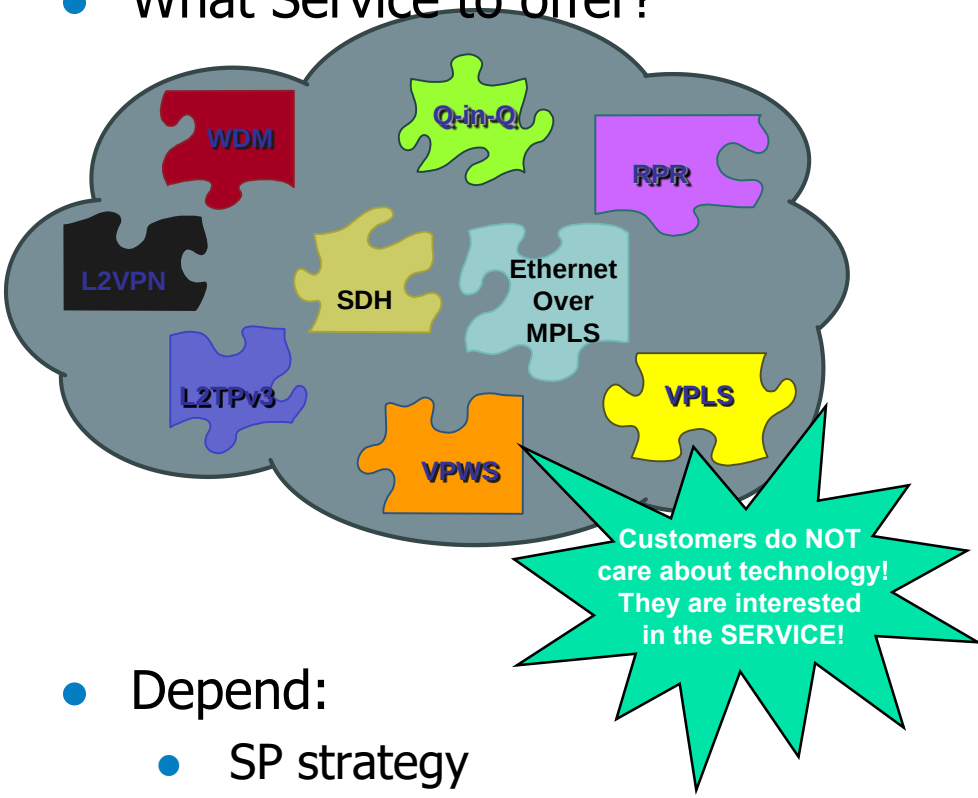
- VPLS requires full mesh of LSPs between PEs:
  - Manual procedures (static)
  - Provisioning systems(NMS/OSS)
  - Signalling protocols:
    - LDP ("Lasserre-V. Kompella" draft)
    - BGP ("Kompella" draft, Juniper)
    - other (Radius, DNS, stb.)

VPLS proposal	Auto-discovery	Signalling / label distribution
Draft Kompella VPLS	BGP	BGP
Draft Lasserre-Vkompella VPLS	None (several options possible)	LDP

Ethernet transport alternatives- Ethernet over anything

- Ethernet over legacy networks
  - ATM: rfc2684-B
  - FR: rfc2427-B
  - PPP: rfc2878
- Ethernet over Ethernet
  - QinQ, MACinMAC
- Ethernet over SDH
  - GFP, VCAT, LCAS
- Ethernet over IP/MPLS
  - L2TPv3
  - VPWS, VPLS
- Ethernet over WDM
- Ethernet over RPR

- Which technology to use?
- What Service to offer?



- Depend:
  - SP strategy
  - Service definition
  - Existing investments

Conclusions

- There are multiple possibilities to implement Ethernet services
- All provide basic Ethernet level connectivity
- Which one to choose – it depends on existing infrastructure
  - „Green field” : Ethernet, Provider Bridges/Backbone Bridges etc.
  - Existing IP/MPLS network – VPWS and VPLS
  - Existing SDH network – Ethernet over SDH
  - …

Thank You for your attention

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