



## Carrier Ethernet Design



**Mar 2007**

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# Agenda

## Carrier Ethernet and IP NGN Architectures

- what network architecture is the best for me?
- where should I put my services edge?

## Carrier Ethernet Hardware Usage

- ES20 – what does it bring to me?
- Where to put it in my network?

## L2 Access Redundancy

- How to connect my access domain to 7600?
- Rings, stars, REP, MST, Flexlink – I'm lost.

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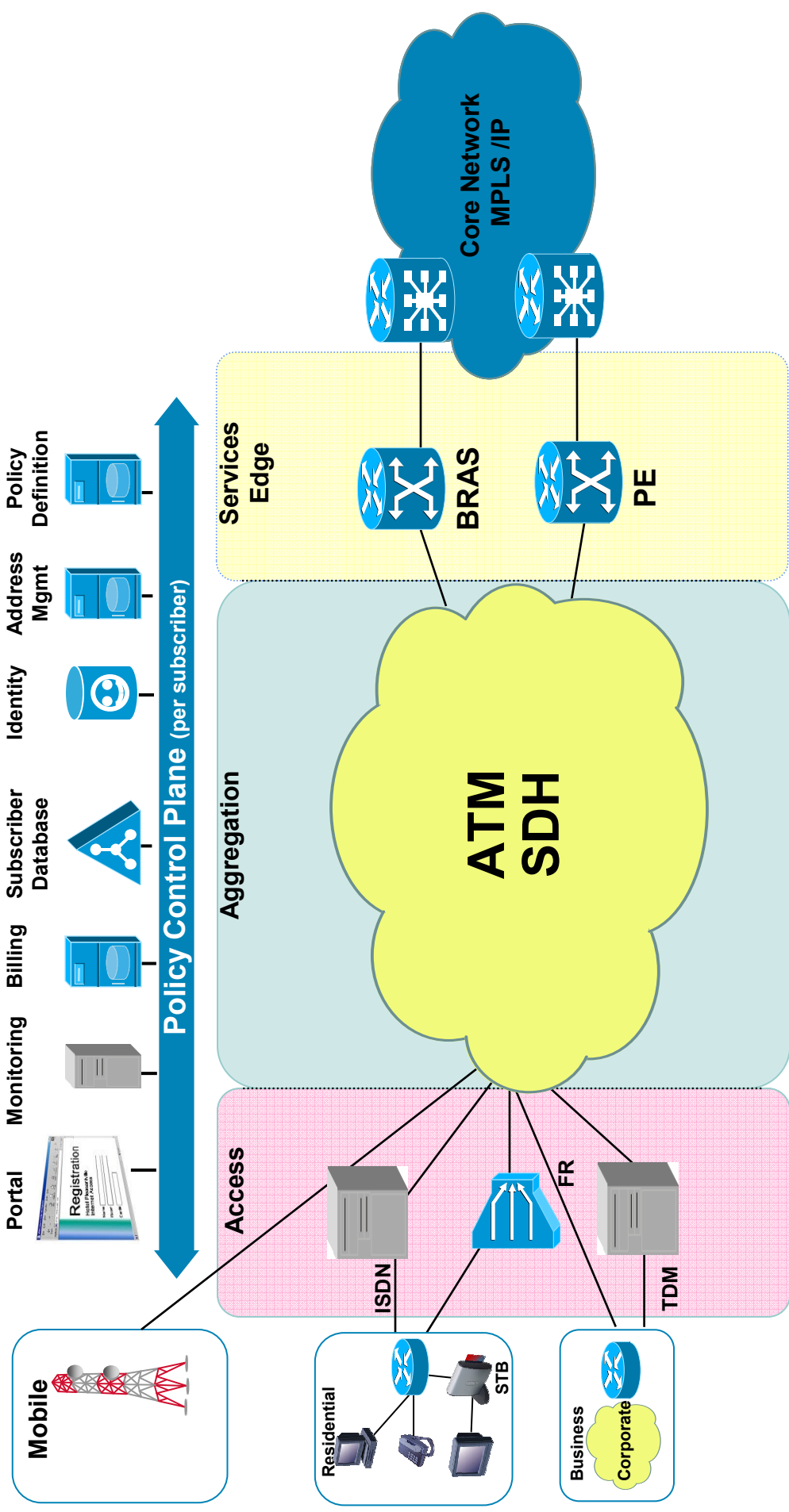
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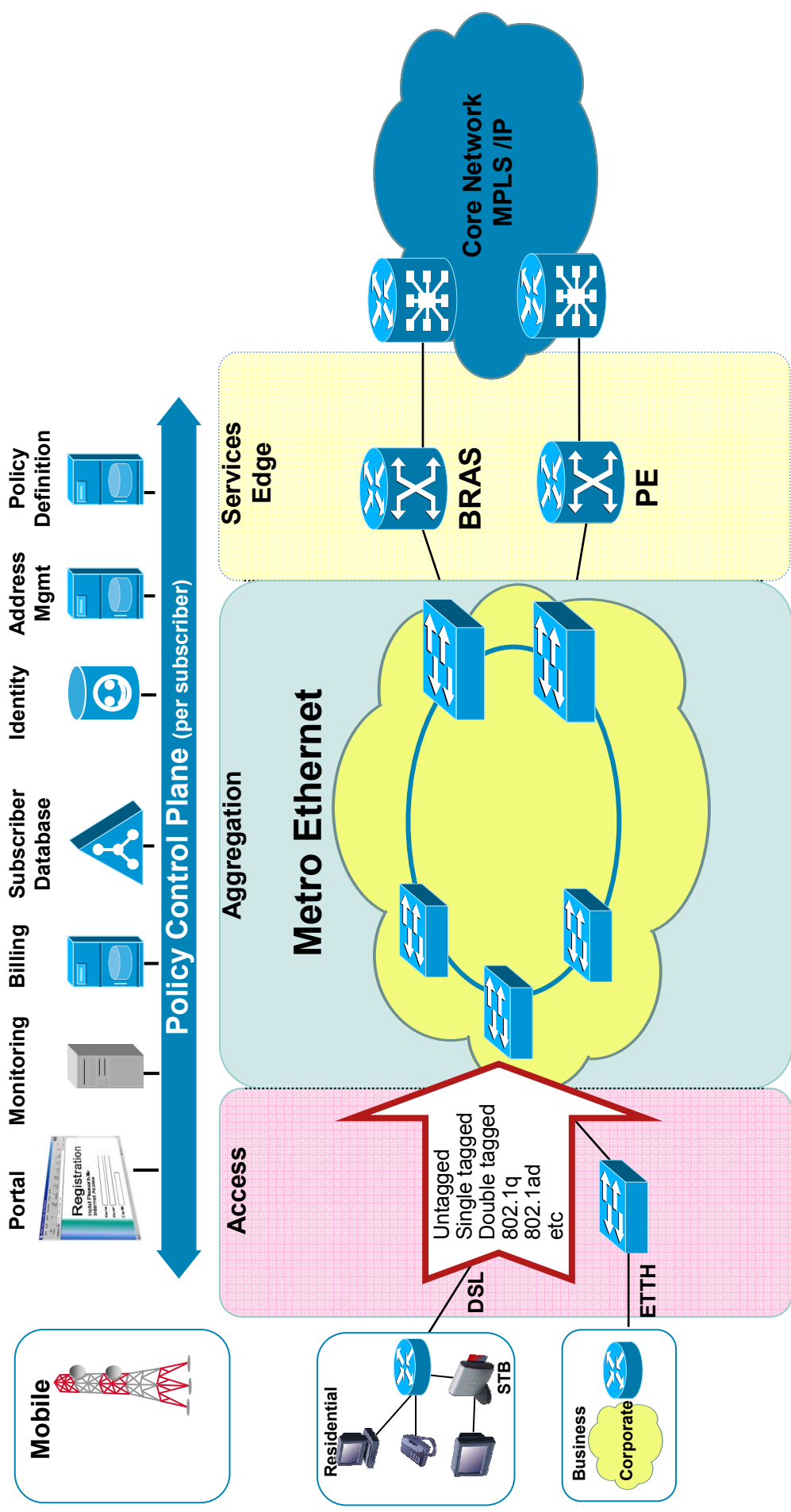
## L2 Access Redundancy

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# Where is it going from: Aggregation 2000



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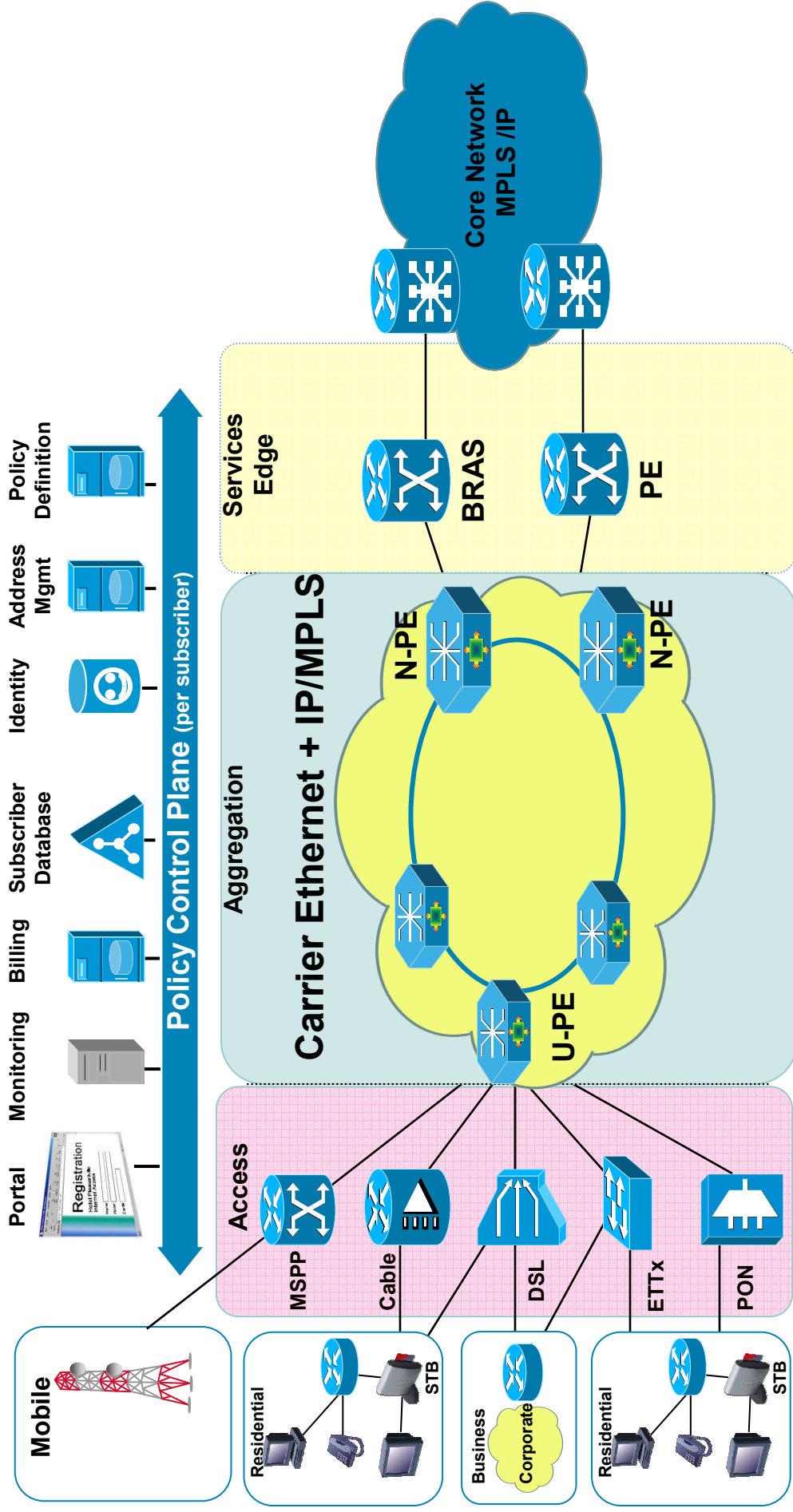


# What is Carrier Ethernet?

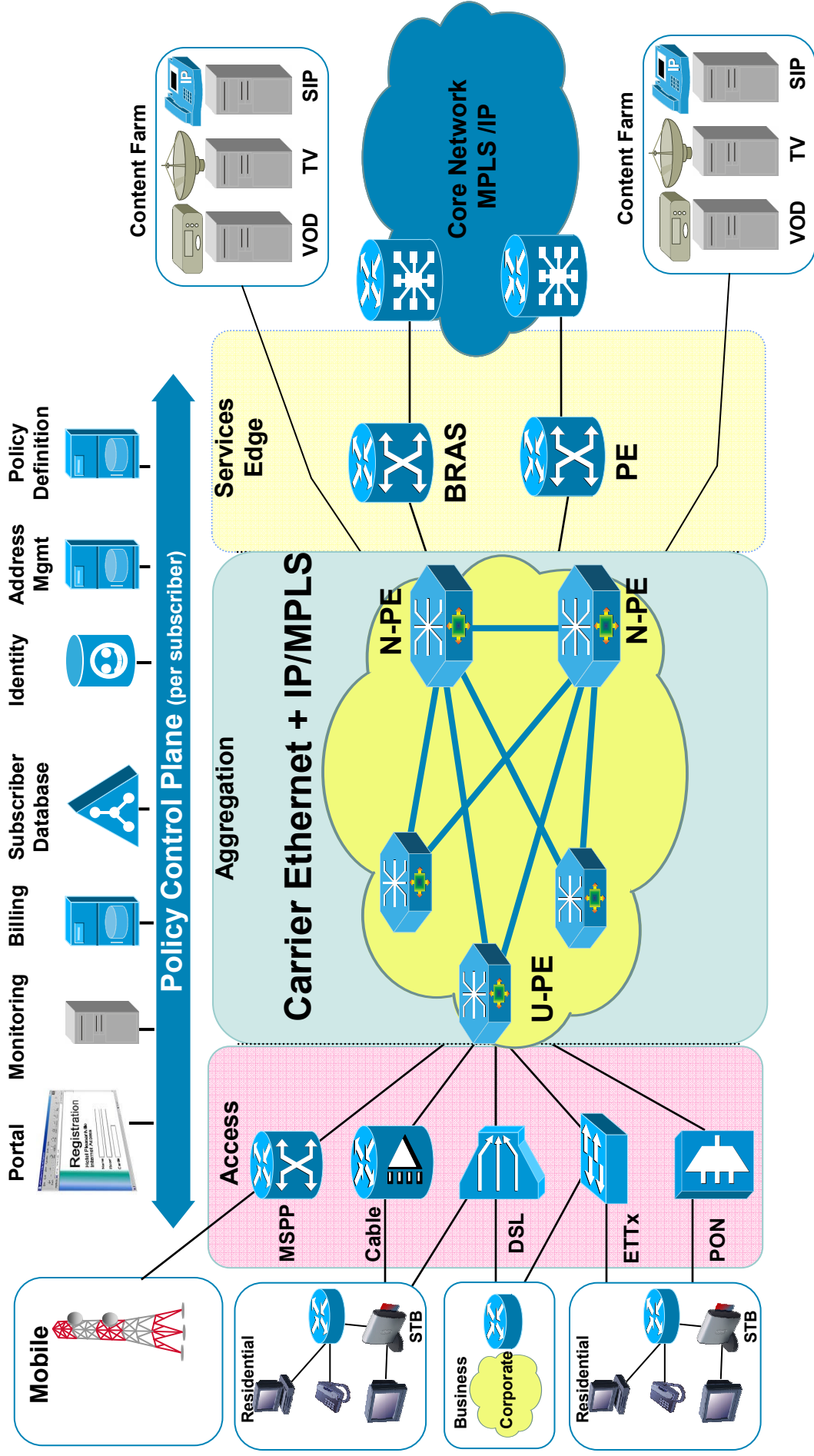
## *Making LAN Ethernet suitable for replacing ATM/SDH*

- Scalability
  - Going beyond 4K VLAN's and keep the flexibility
- Reliability
  - Going beyond Spanning Tree (50ms/FRR, fault detection, 1+1)
- Dynamic signaling
  - DLDP-set pseudowires (PVC vs. SVC)
- Service Management
  - OAM to Provision, Monitor, Diagnose and Resolve Issues
- Standardized Services
  - Standard EVC, E-Line, E-LAN (MEF)
  - de-facto standard Residential Quad-Play (incl. IPTV, Mobile)
  - de-facto standard Business IP VPN (inc. H-QoS)

# Carrier Ethernet – Centralized Design

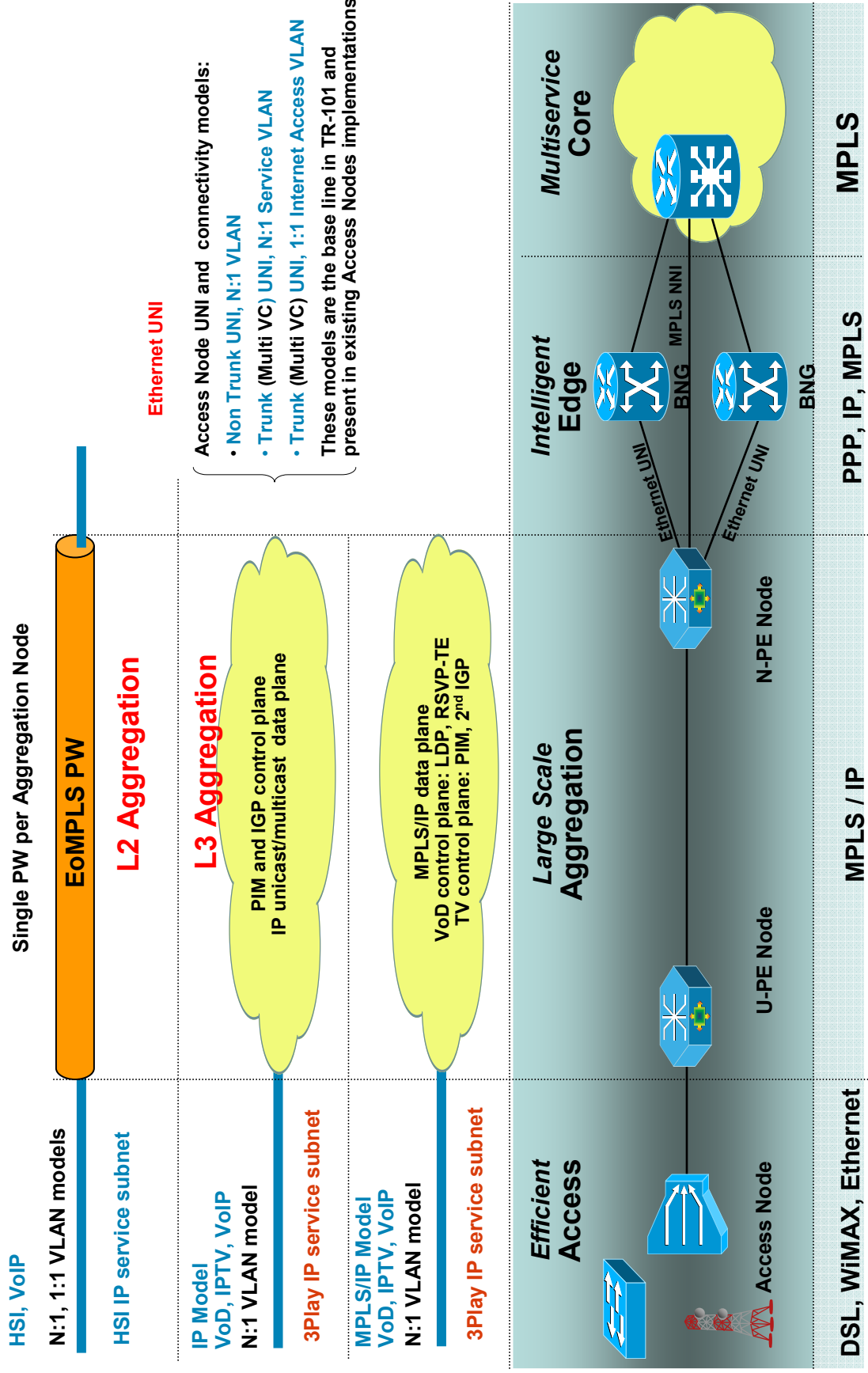


# Carrier Ethernet – Centralized Design

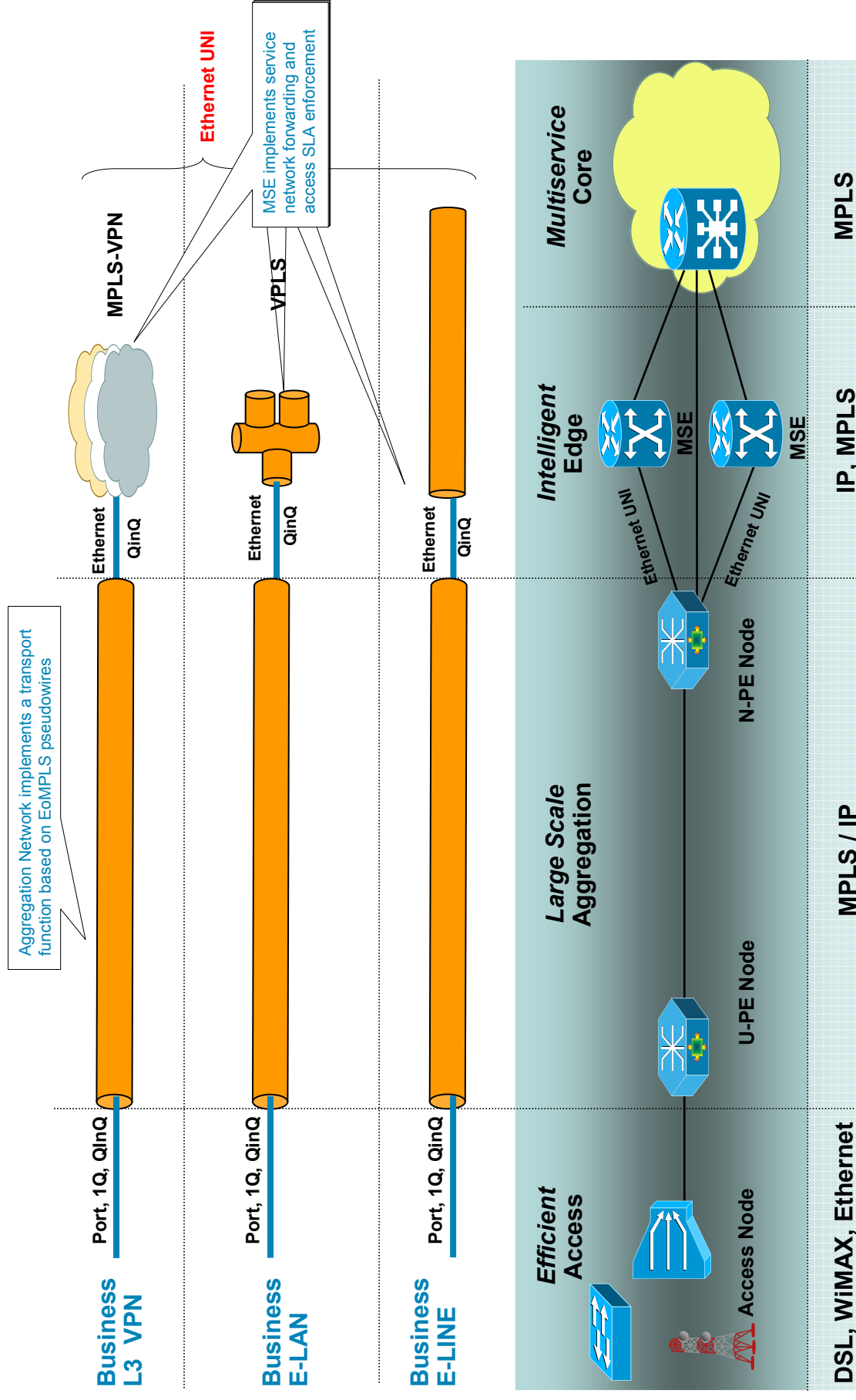




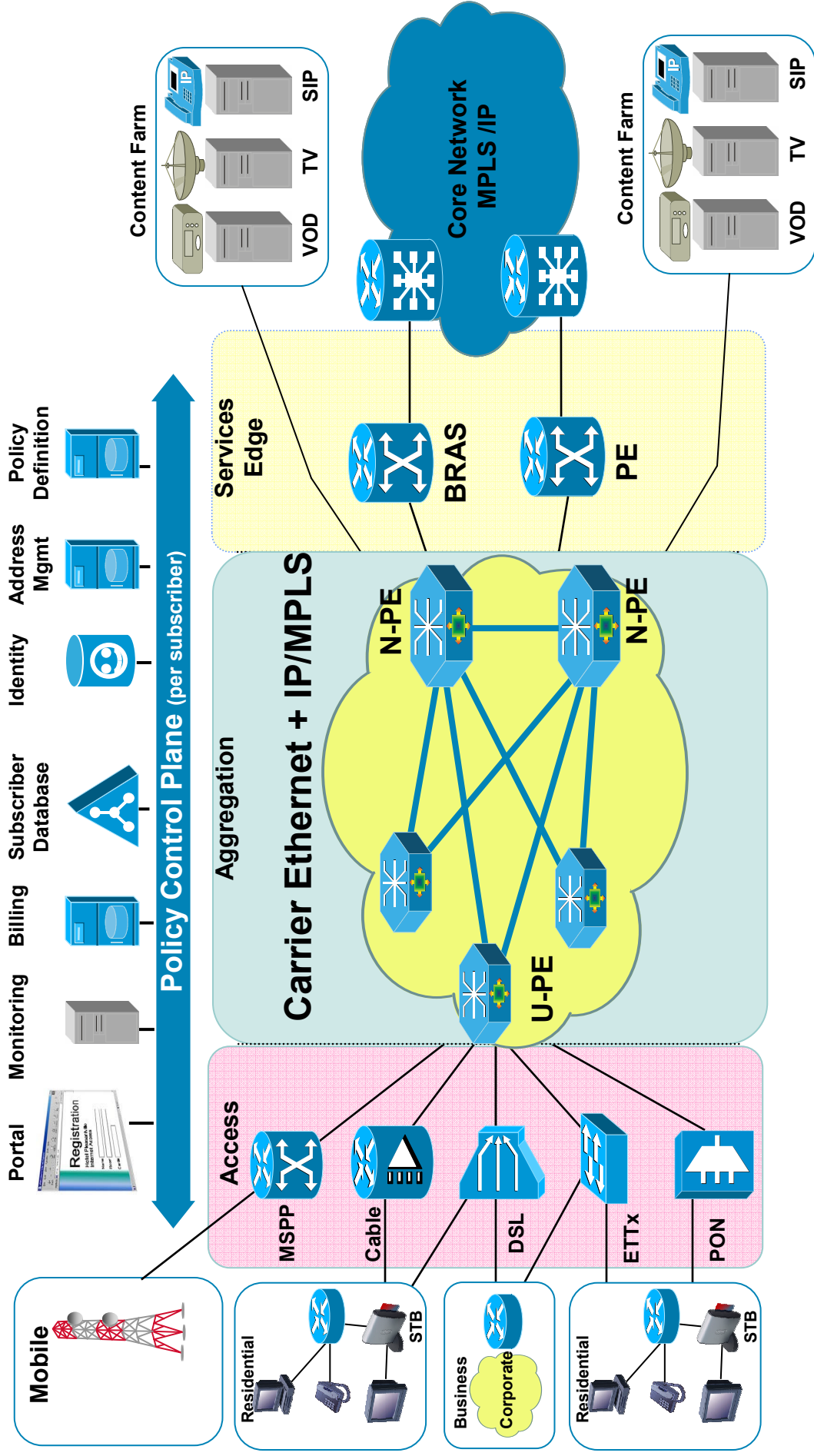
# Residential Services Architecture



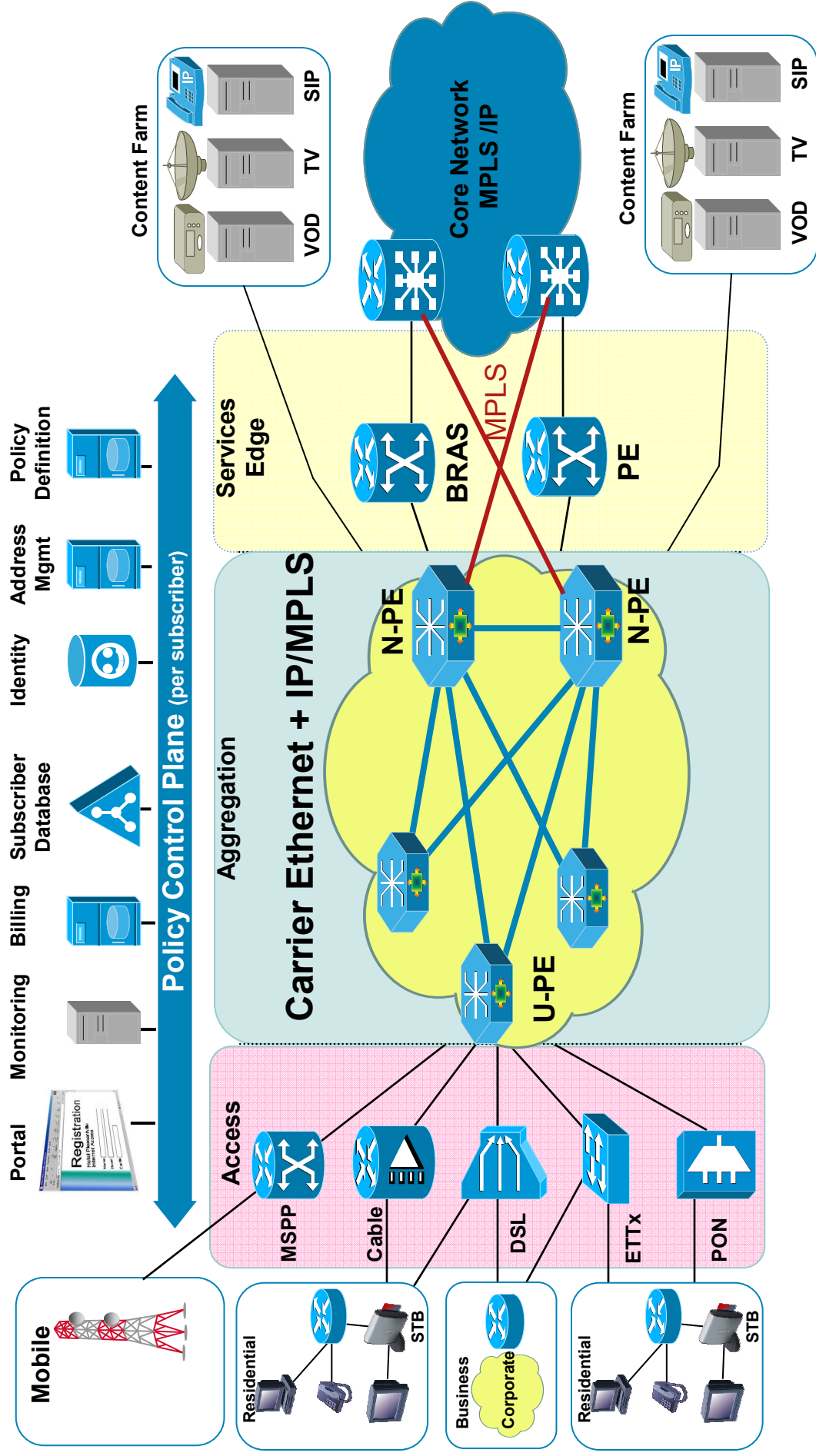
# Business Services Architecture



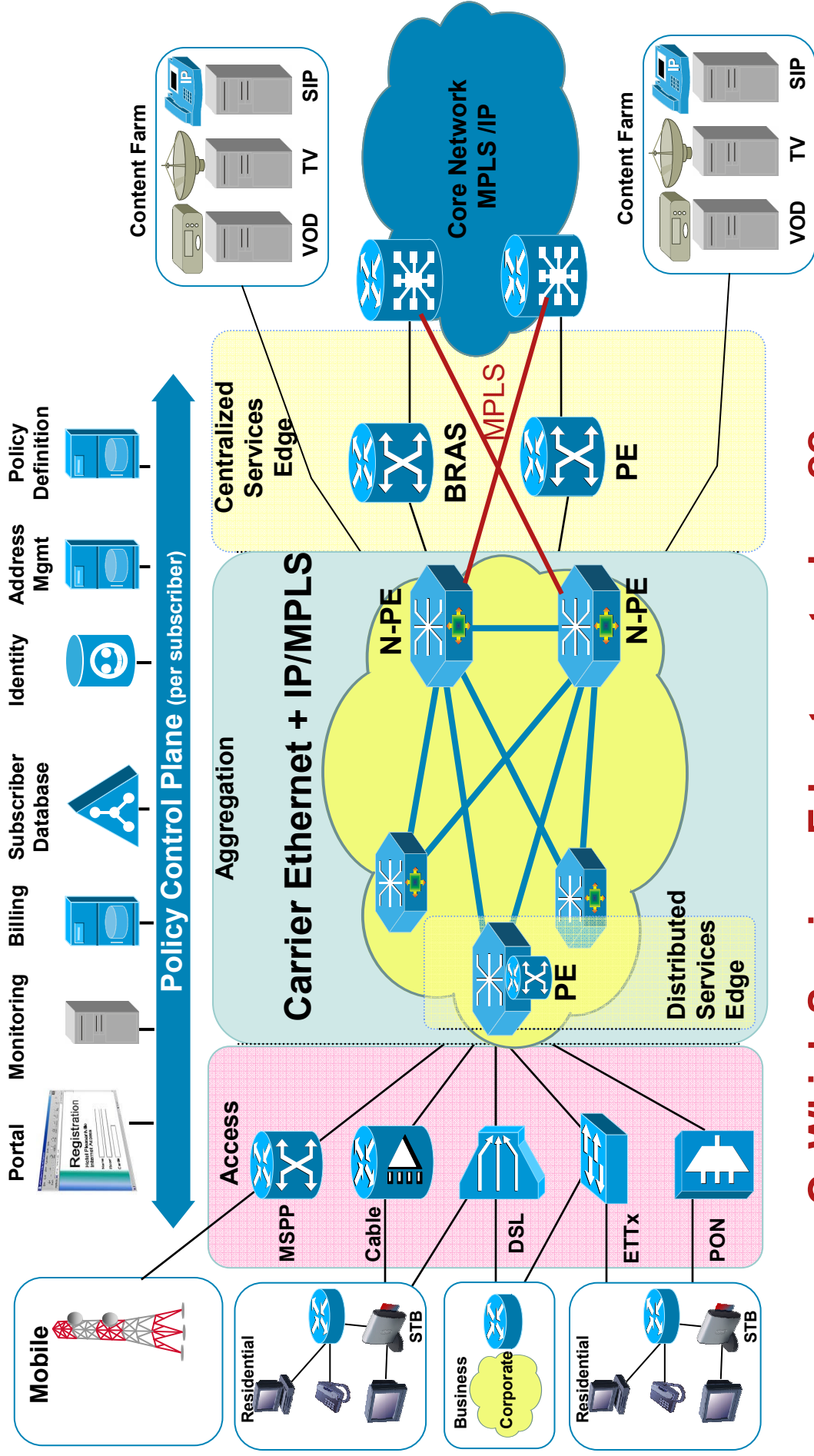
# Carrier Ethernet – Centralized Design



# Carrier Ethernet – MPLS NNI

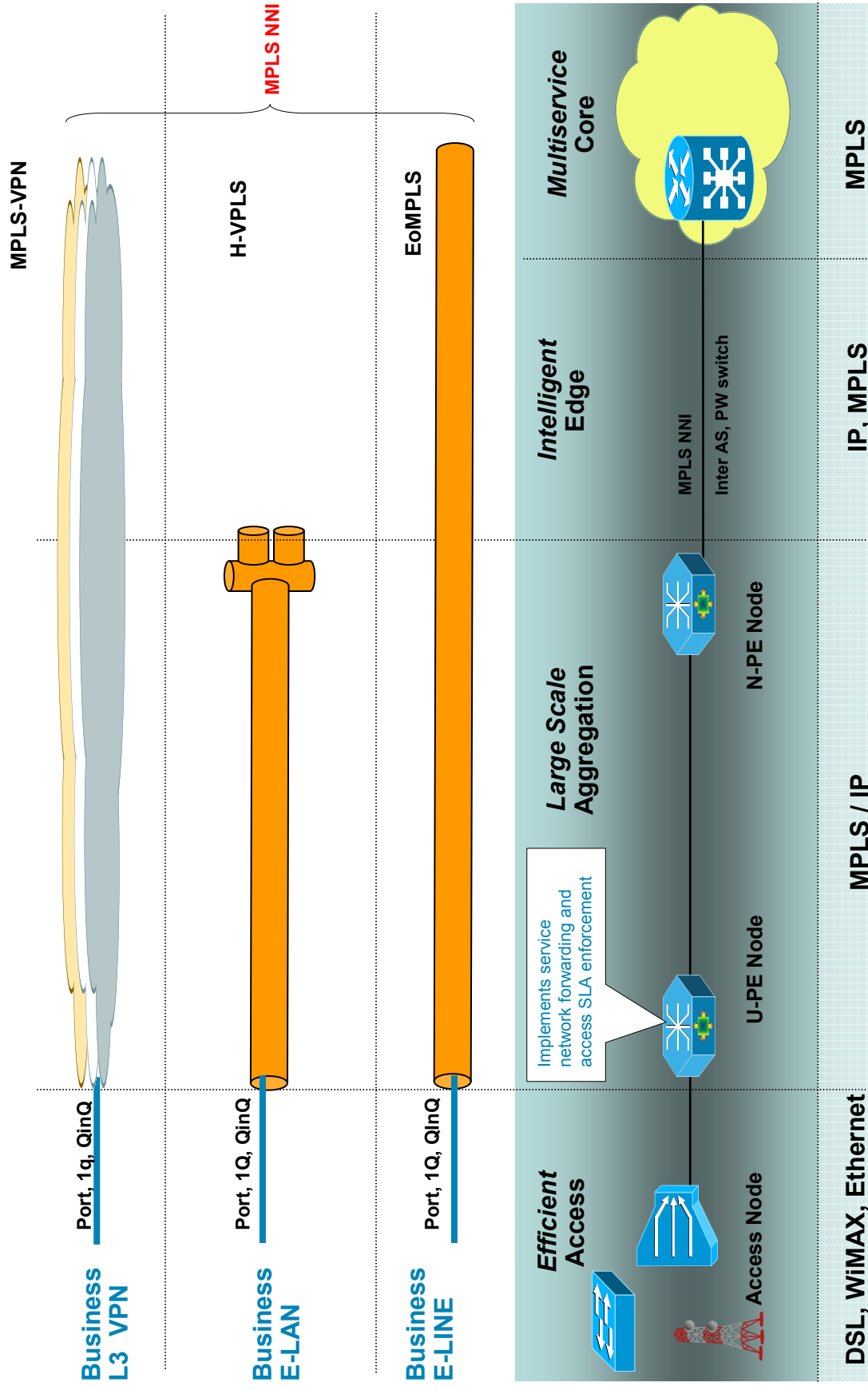


# Carrier Ethernet – New Service Edges



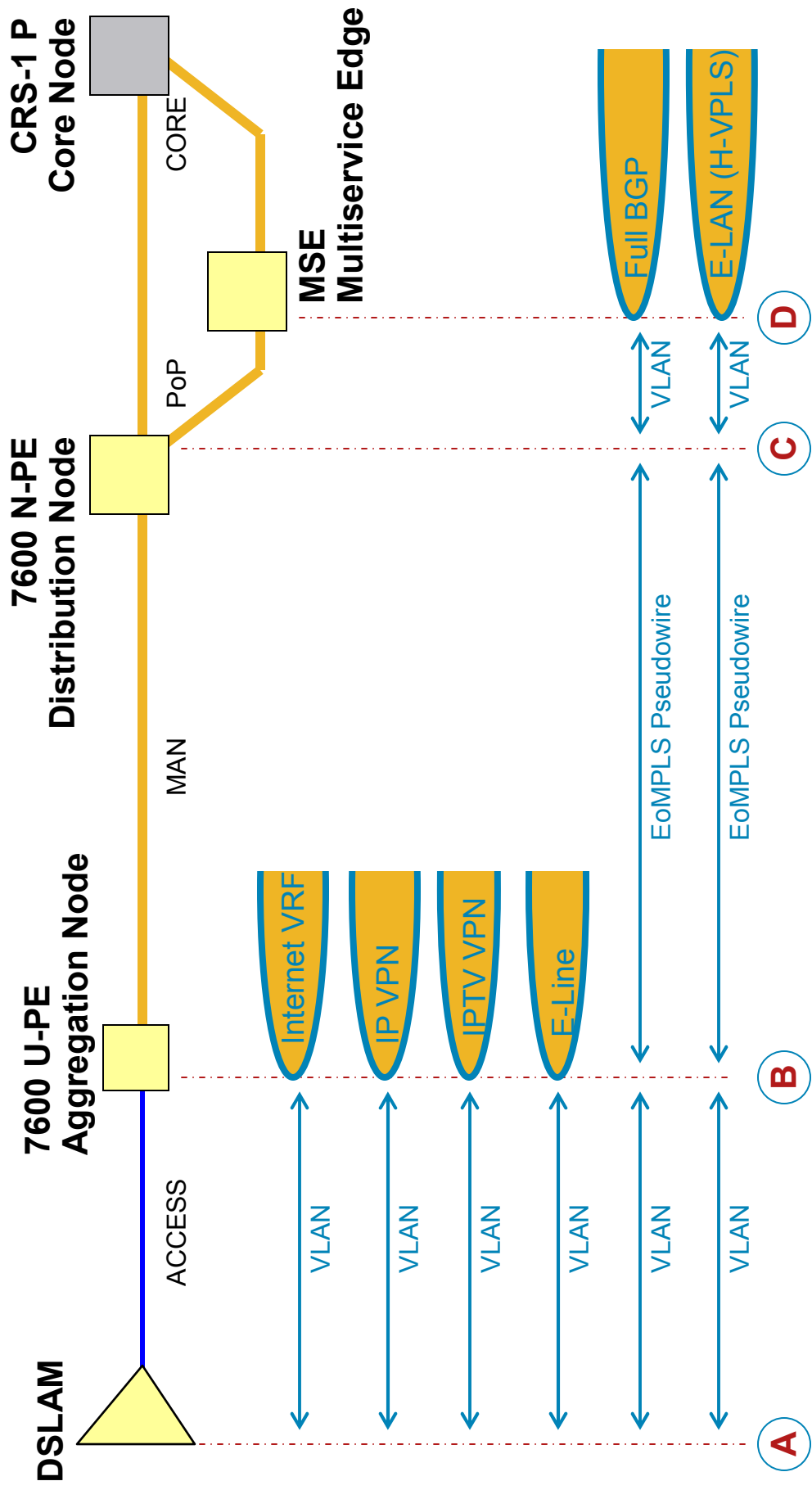
**Q: Which Services Edge to put where??**

# Aggregation Network Service Edge Business Ethernet Services Architecture



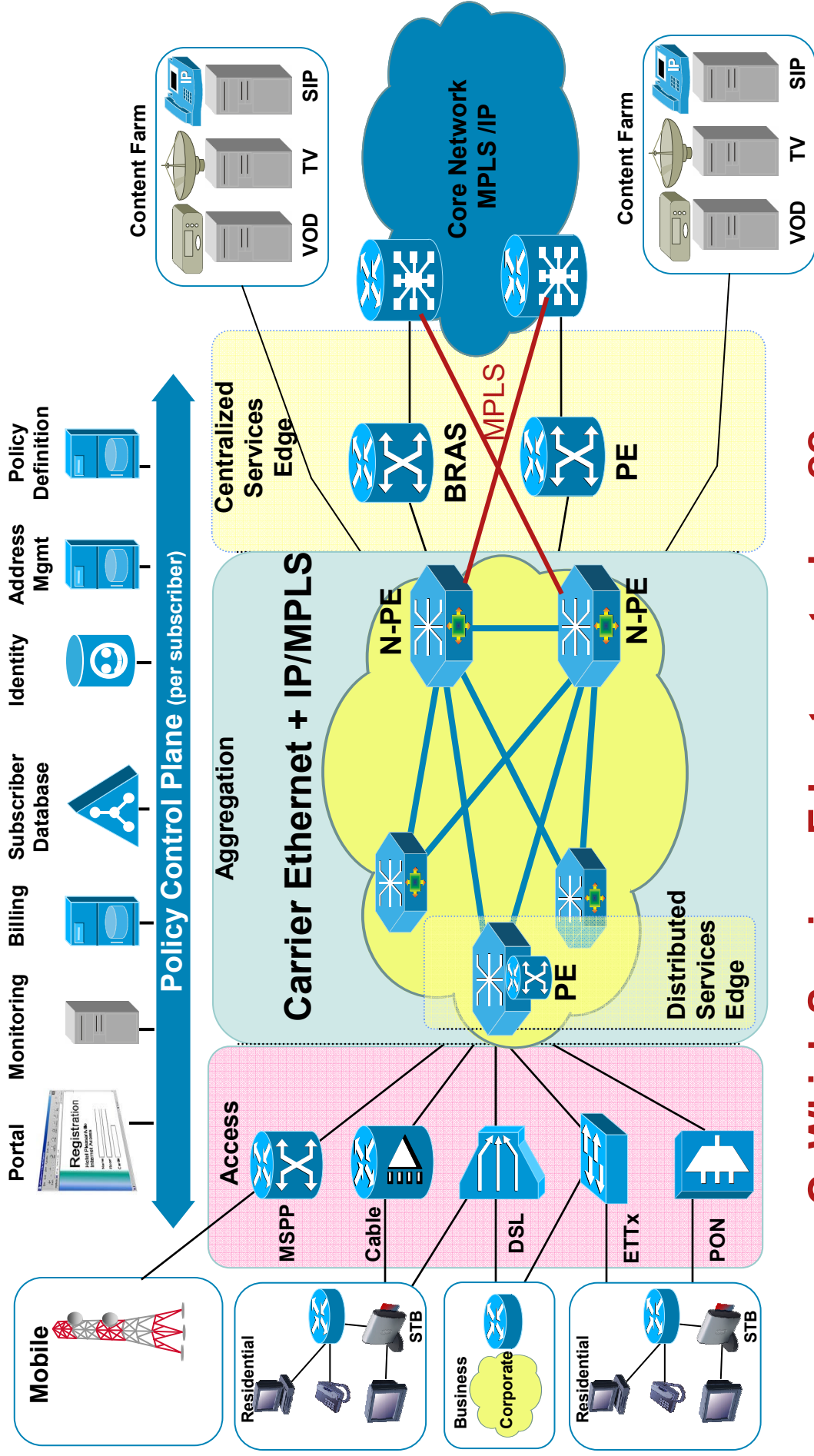
# Flexible Service Edge Placement

*according to penetration, complexity, growth....*



## PROVISIONING POINTS

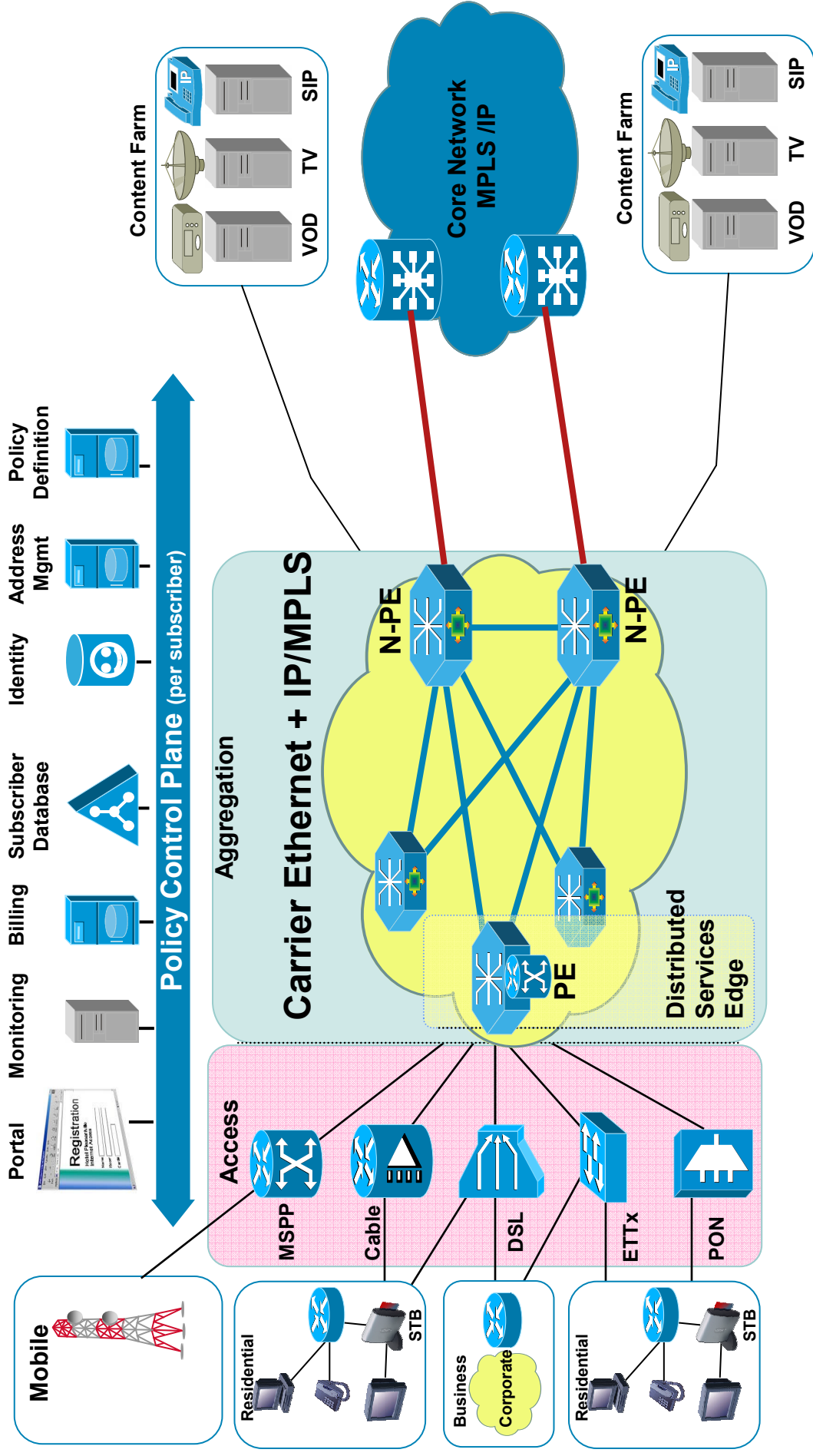
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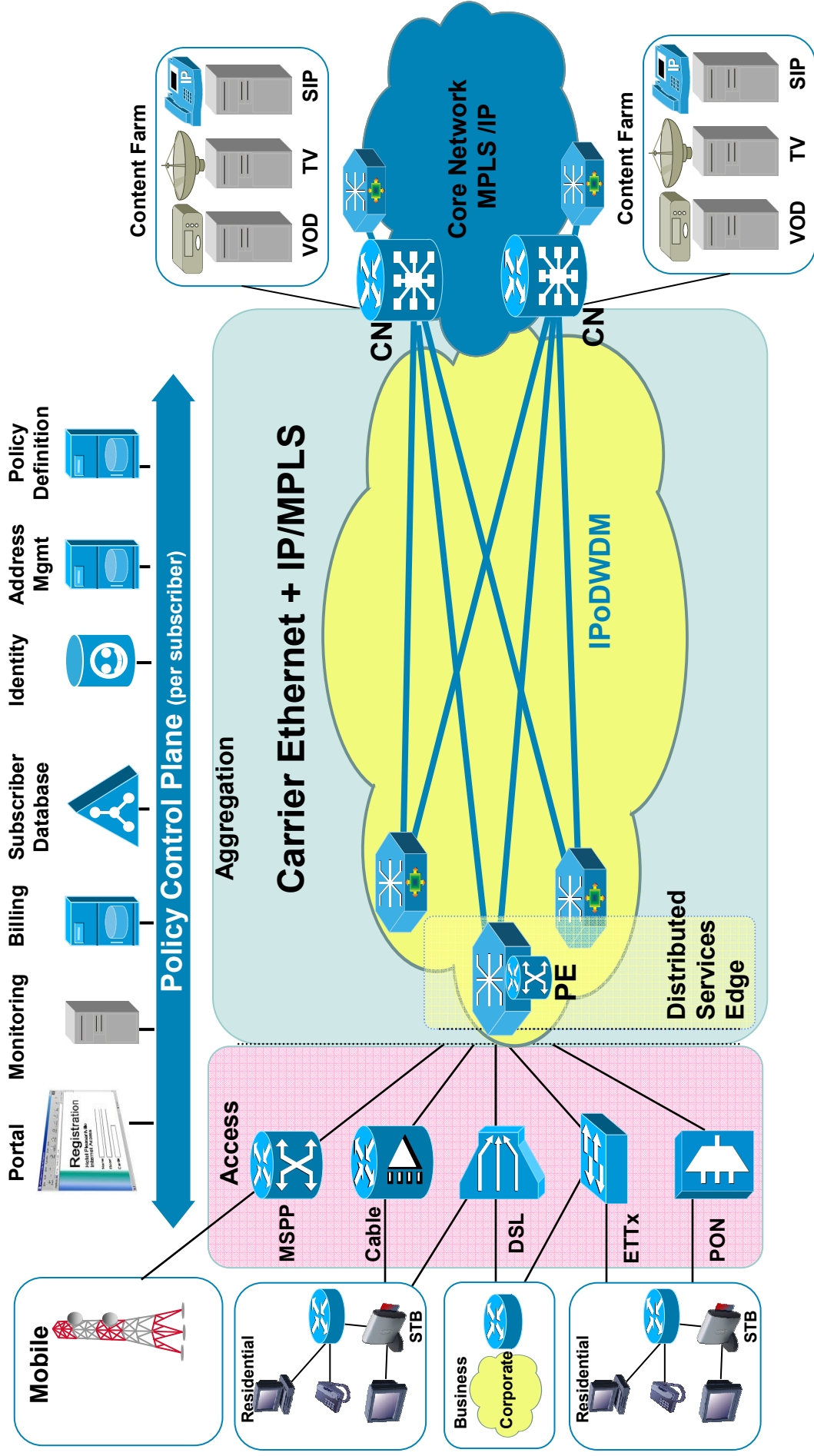


# Carrier Ethernet – Distributed Design

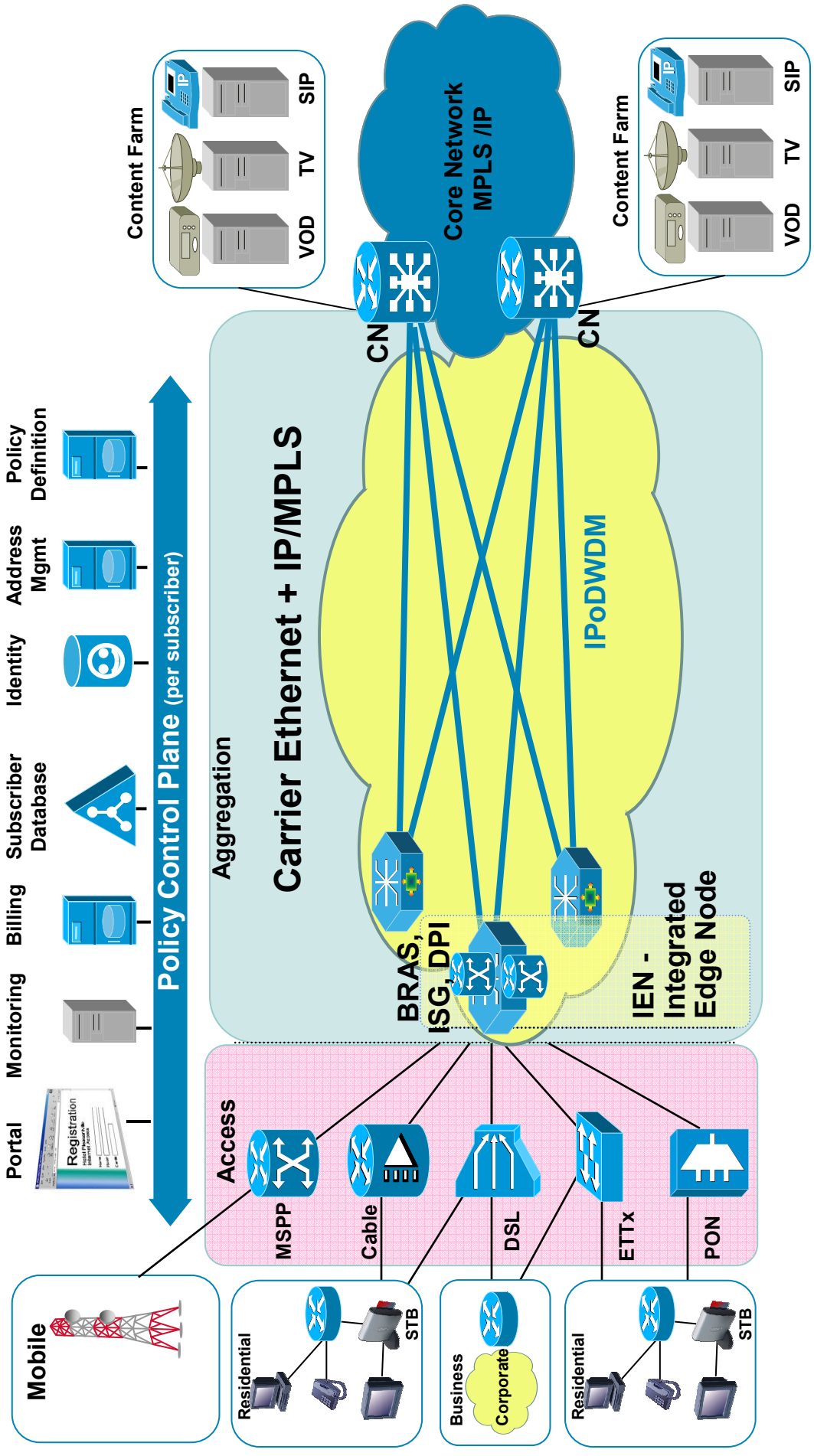


**The old Centralized Edge does not have to be in every PoP!**

# Carrier Ethernet – Integrated Design



# Programmable Carrier Ethernet vision



# Agenda

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# Carrier Ethernet and Cisco 7600



# Cisco Carrier Ethernet Portfolio



2007

FROST & SULLIVAN

North American Carrier  
Ethernet Equipment Market  
Leadership of the Year Award

## IP/MPLS and Ethernet



CRS-1



12000 / XR 12000



Cisco  
7600



Cisco  
10000



Cisco  
72xx/73xx



ME 3750



ME 3400



ME 4924



ME 6524



Catalyst  
4500

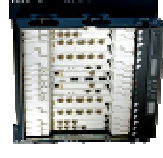


Catalyst  
6500



ASR 1000

## Ethernet/SONET/SDH Ethernet/ DWDM



ONS  
15454



ONS  
15600



ONS  
153xx

### Cisco Carrier Ethernet Solutions Deliver :

- Architectural Flexibility – Network Convergence
- Service Richness – Complete Solutions
- MEF9 and MEF 14 Certified
- Portfolio Breadth – End to End Manageability (Ethernet OAM)



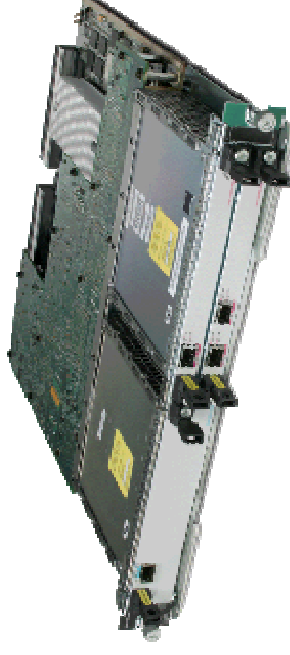
# Hardware: 7600 Ethernet Service Modules

## What does it bring?

- Up to 32k EVCs per system (16k per card)
- Up to 32K Pseudowires (16k per card)
- Multipoint VPLS & H-VPLS
- Ethernet and MPLS OAM interworking
- Flexible VLAN translation
- Hierarchical QOS (16K, resp. 32K queues)

## Pricing?

- X6724 LAN card = \$625 per GE port (GPL)  
basic L2/L3 features set
- ES20-GE card = \$2000 per GE port (GPL)  
for Triple-Play and L2 VPN services
- ES20-ADVIP-LIC = \$4000 per GE port (GPL)  
in-service upgrade to L3 VPN services



**SIP-400 – 4x SPA**



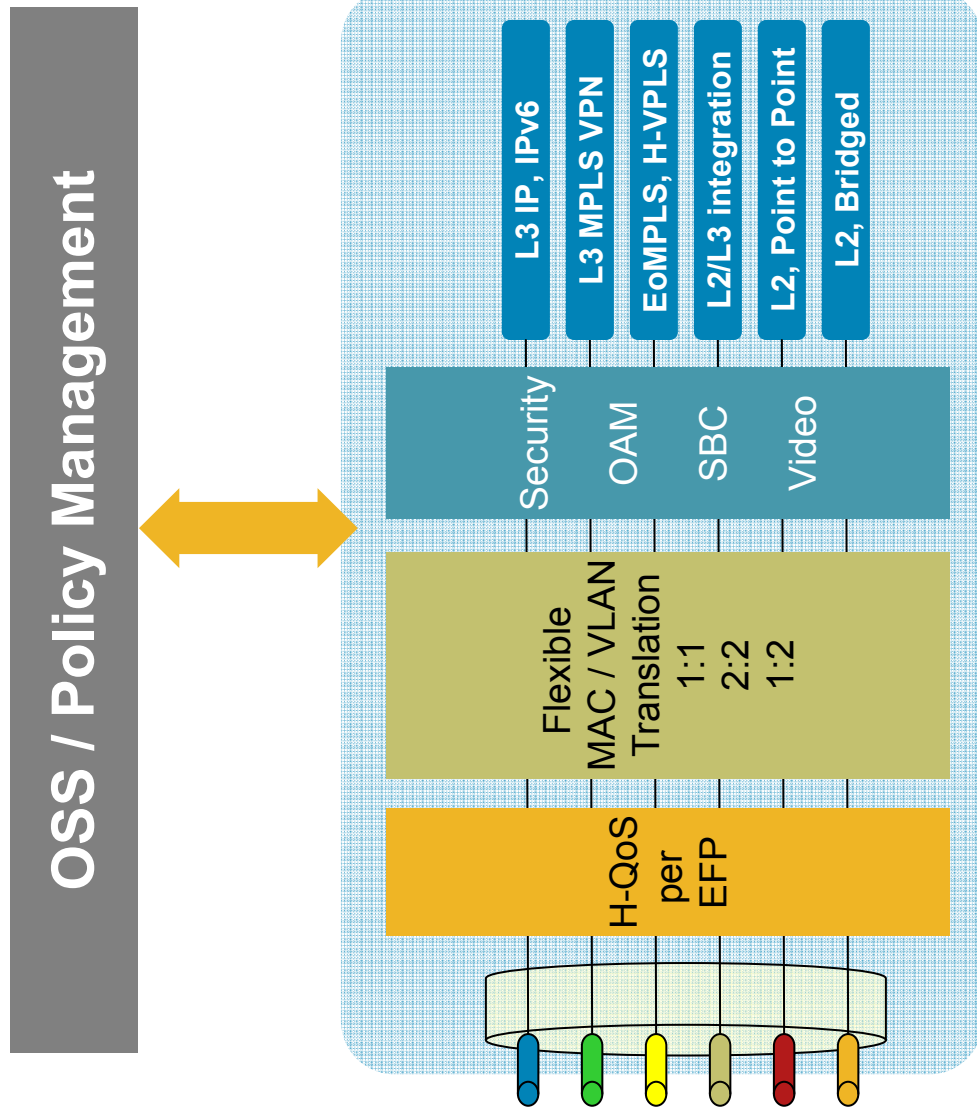
**ES20 – 2-port 10GE**



**ES20 – 20-port GE**

# Software: IOS EVC infrastructure

- **The Flexible Ethernet UNI defines a unique, virtual L2 or L3 service instance per customer**
  - A service instance can be a MAC address, VLAN, Q-in-Q VLAN, L2 VPLS pseudowire, IP address, or L3 MPLS VPN
- **For each service instance, Flexible UNI offers:**
  - Unique ID with service separation via VLAN or MAC translation
  - H-QoS with shaping per VC
  - IP+MAC spoofing prevention
  - Ethernet and MPLS OAM
- **Each service instance can in turn be flexibly mapped to:**
  - L2: Pseudowires, H-VPLS
  - L3: IP, IPv6, MPLS VPN

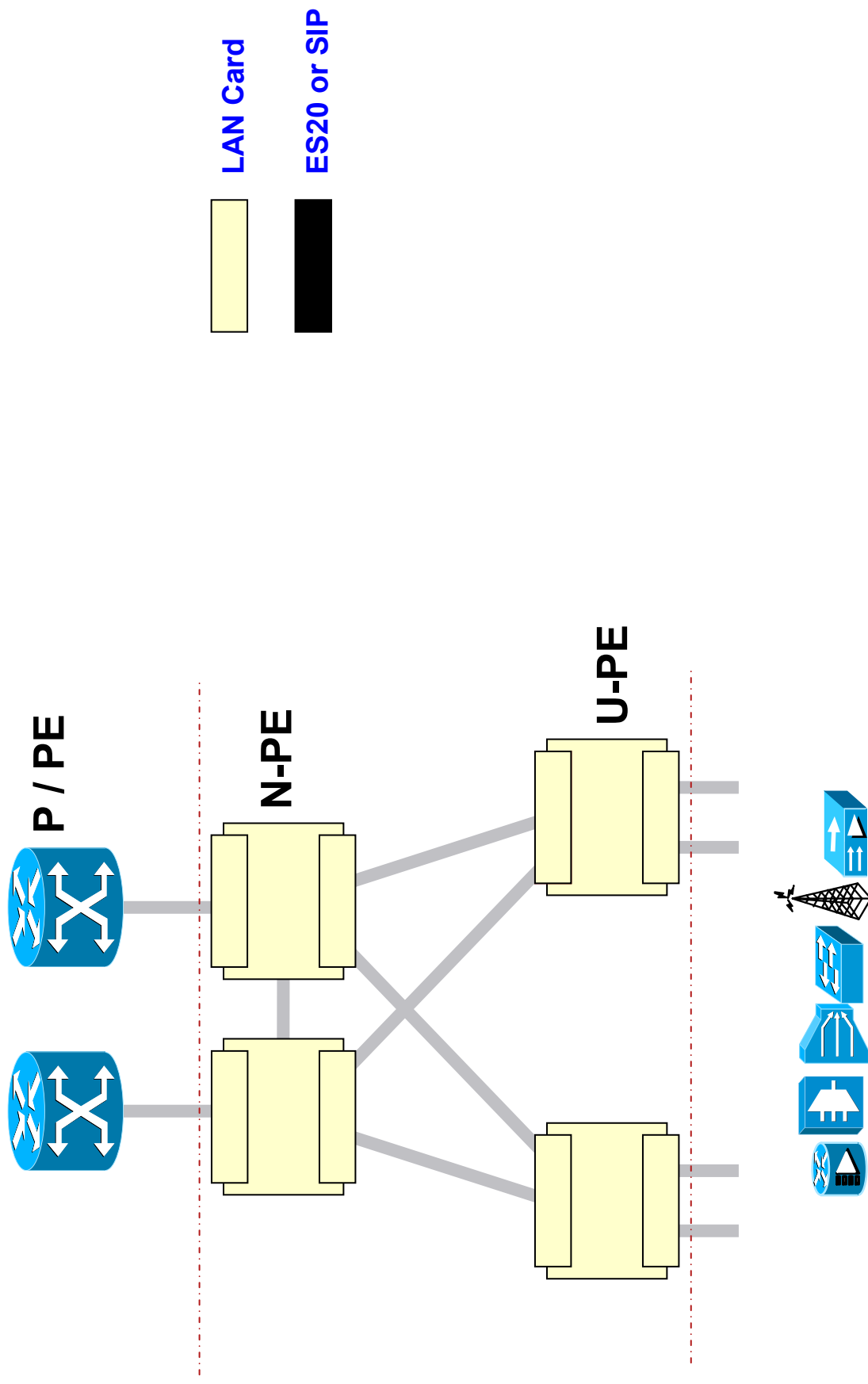




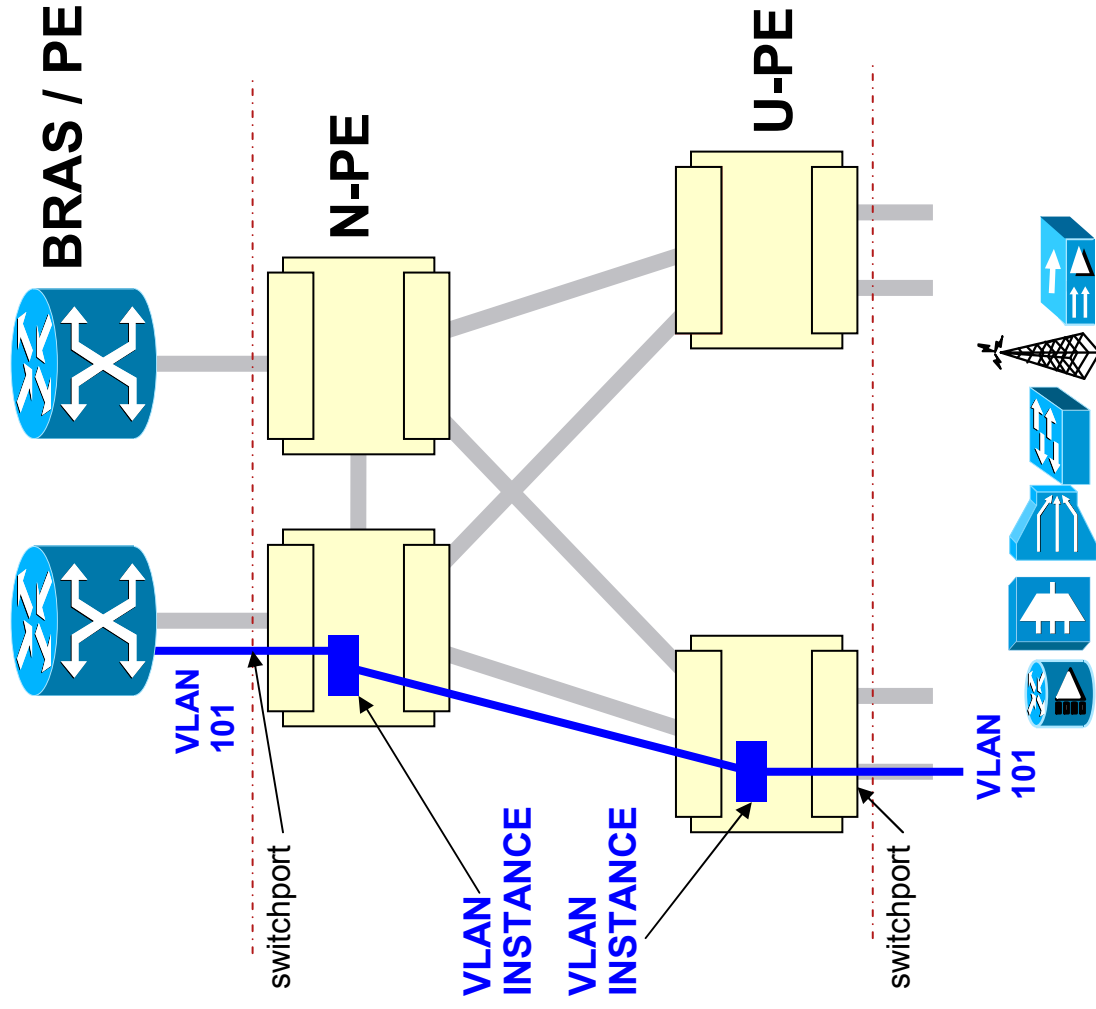
# ES card placement L2 designs



# Base Design: Carrier Ethernet Network

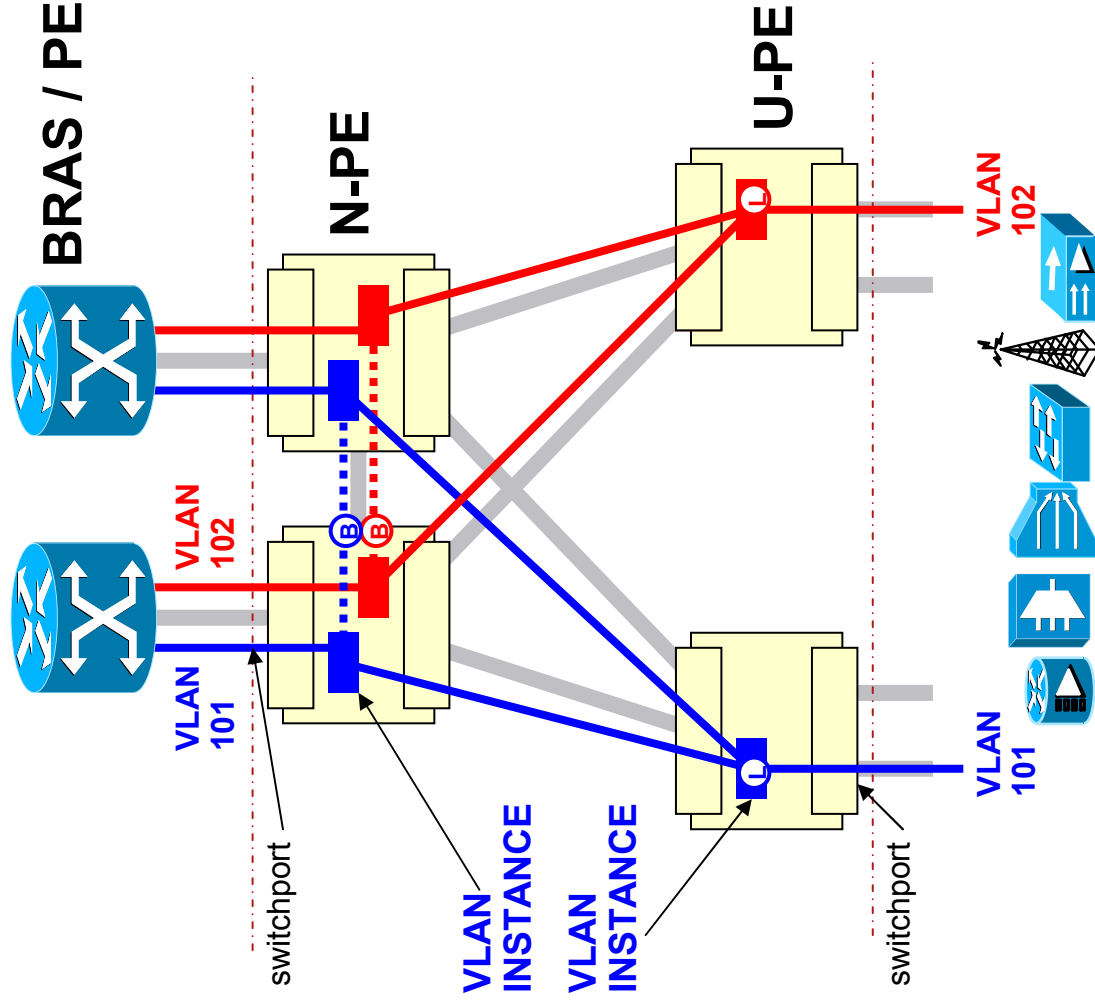


# Base Design 1: RSTP-based Aggregation





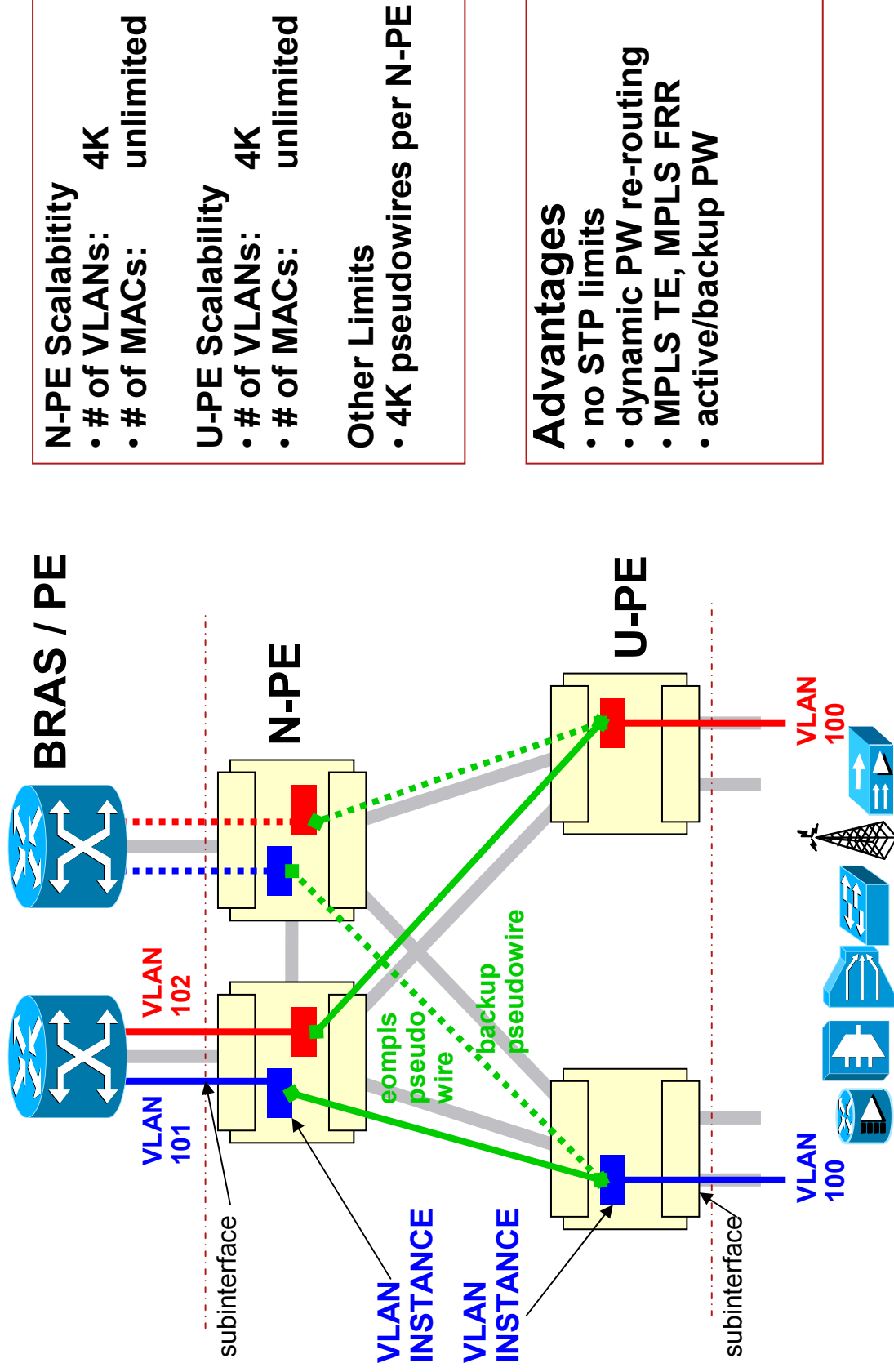
# Base Design 1: RSTP-based Aggregation



- N-PE Scalability**
- # of VLANs: 4K
  - # of MACs: unlimited
- U-PE Scalability**
- # of VLANs: 4K
  - # of MACs: 32K/56K/80K
- Other Limits**
- PVST VLANs per card: 1800
  - MST VLANs per card: 6000

- Advantages**
- simple, inexpensive
  - active-active
  - learning can be turned off (manual or auto/cGVRP)
- Can be any Cisco switch**
- Catalyst 6500, 4500, ME....

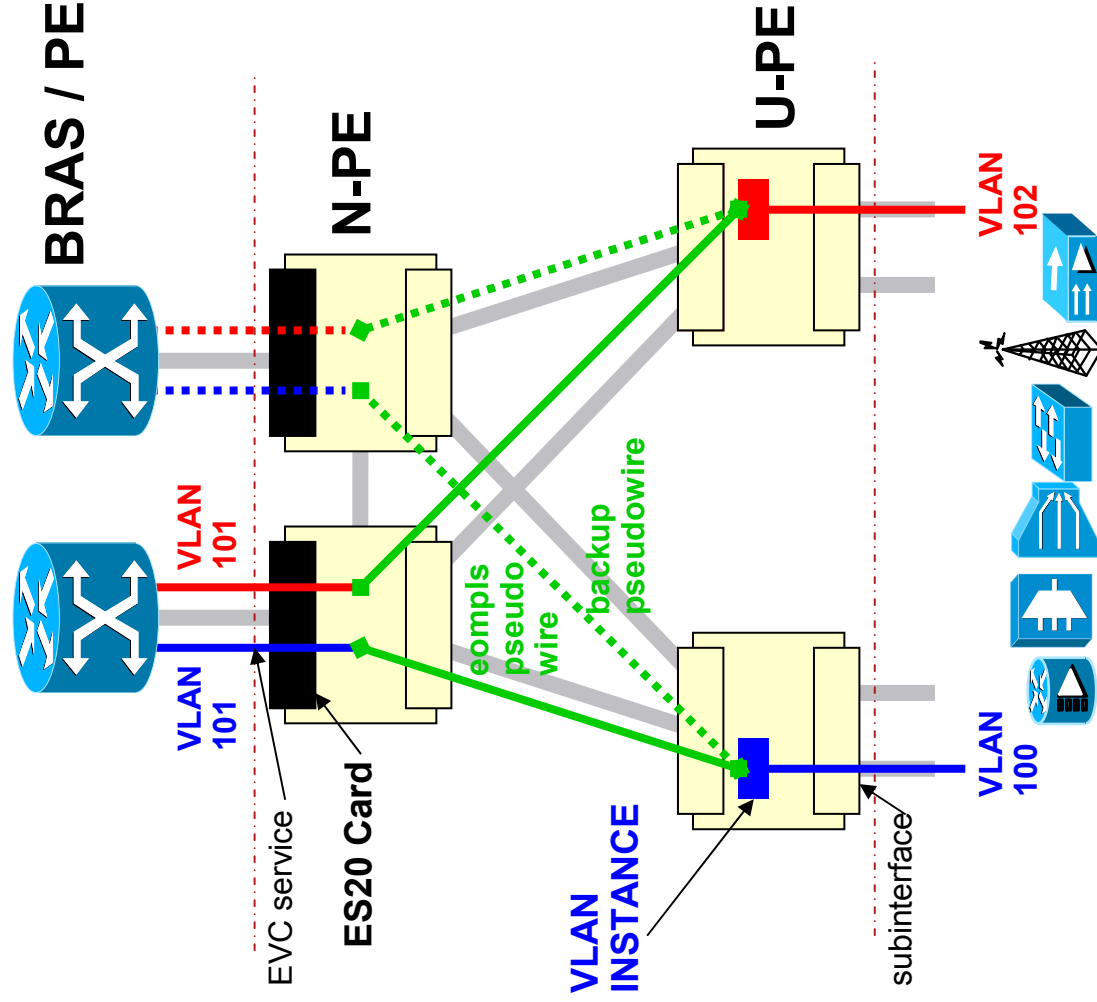
# Base Design 2: MPLS-based Aggregation



- N-PE Scalability**
- # of VLANs: 4K
  - # of MACs: unlimited
- U-PE Scalability**
- # of VLANs: 4K
  - # of MACs: unlimited
- Other Limits**
- 4K pseudowires per N-PE

- Advantages**
- no STP limits
  - dynamic PW re-routing
  - MPLS TE, MPLS FRR
  - active/backup PW

# Puzzle #1: Edge-facing



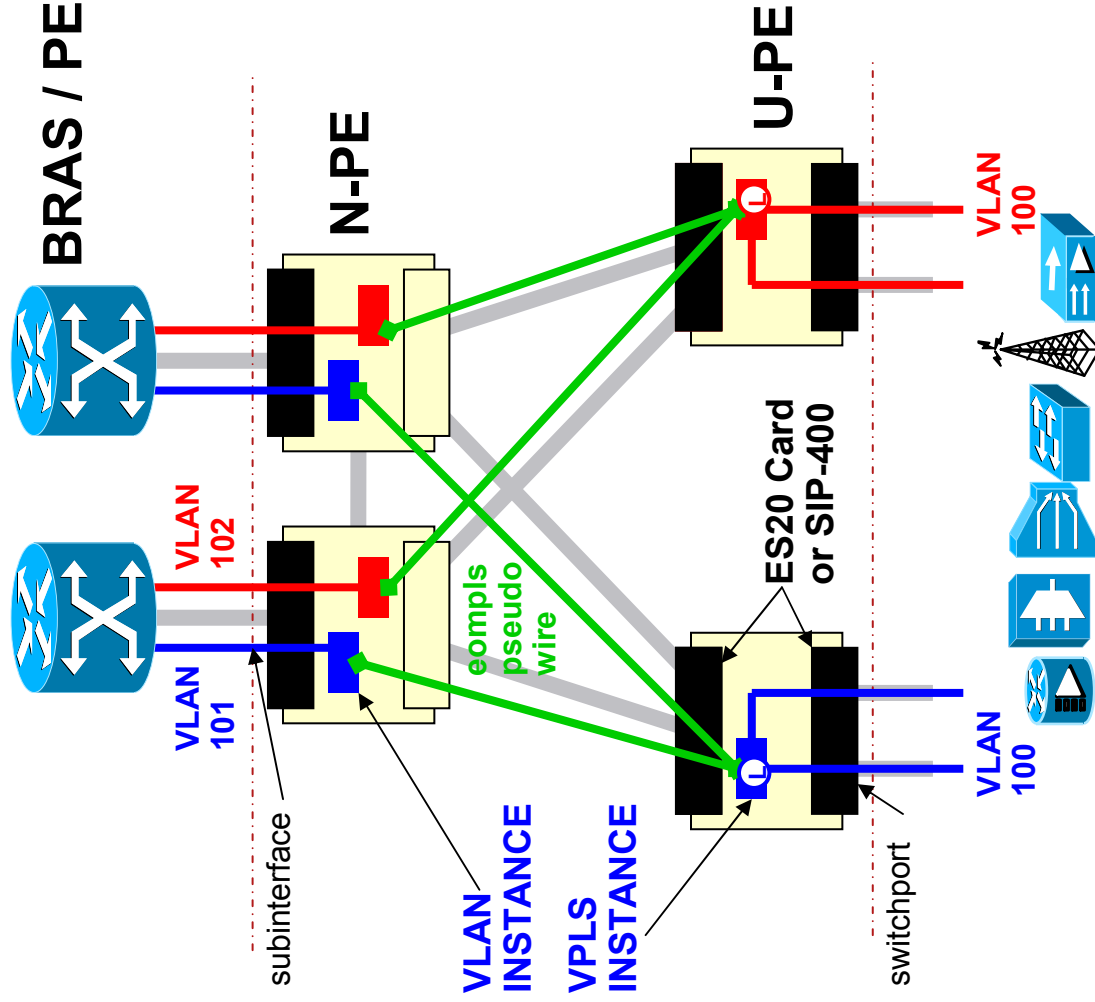
<b>N-PE Scalability</b>	<b>32K</b>
• # of VLANs:	unlimited
• # of MACs:	unlimited
<b>U-PE Scalability</b>	<b>32K</b>
• # of VLANs:	unlimited
• # of MACs:	unlimited

- Advantages at N-PE**
- PW Scalability (no global VLAN instance is consumed)
  - EVC and Flexible QinQ
  - Per-Port VLAN significance
  - Flexible VLAN translations
  - Flexible QinQ CoS mapping





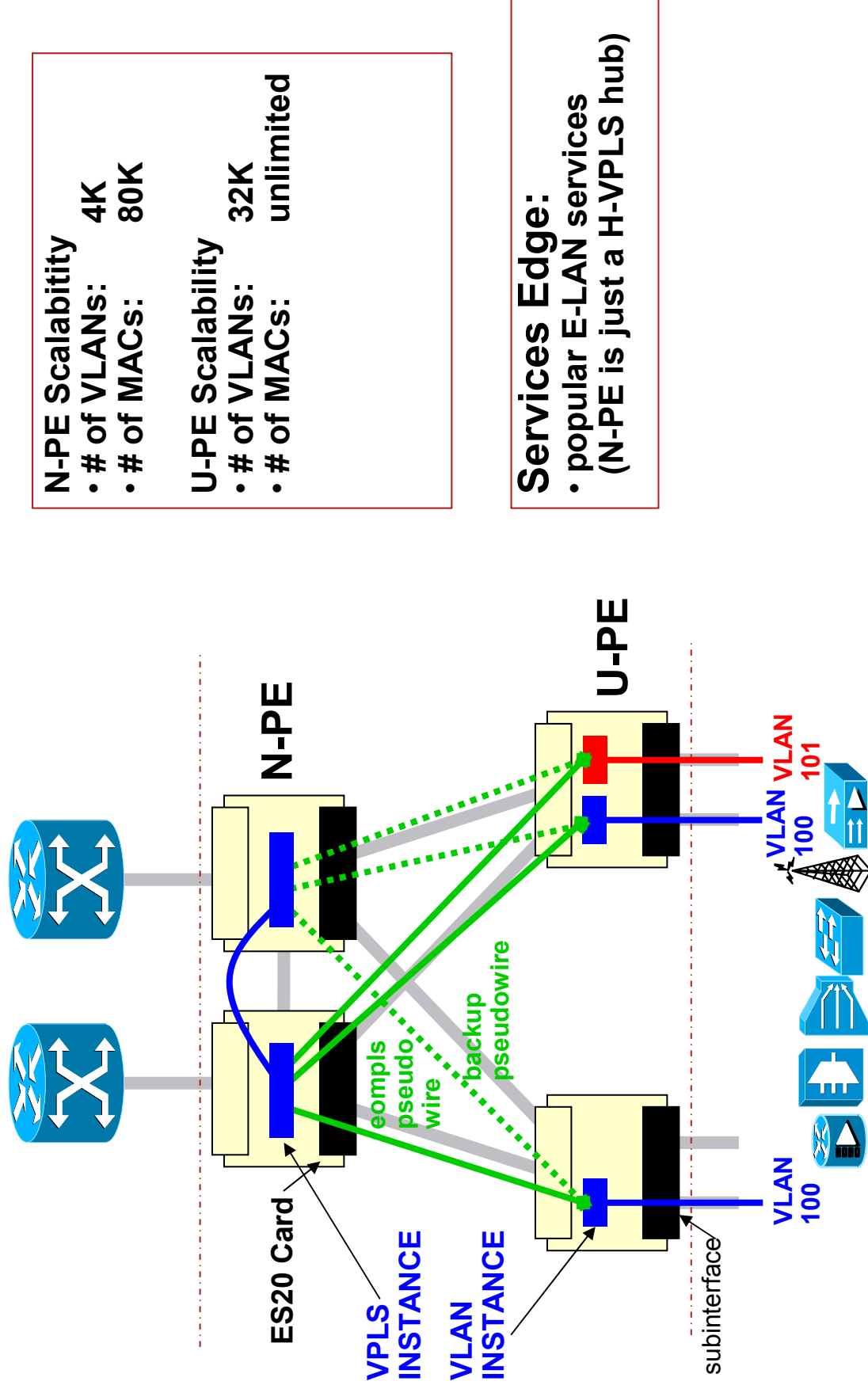
# Puzzle #3: U-PE uplink



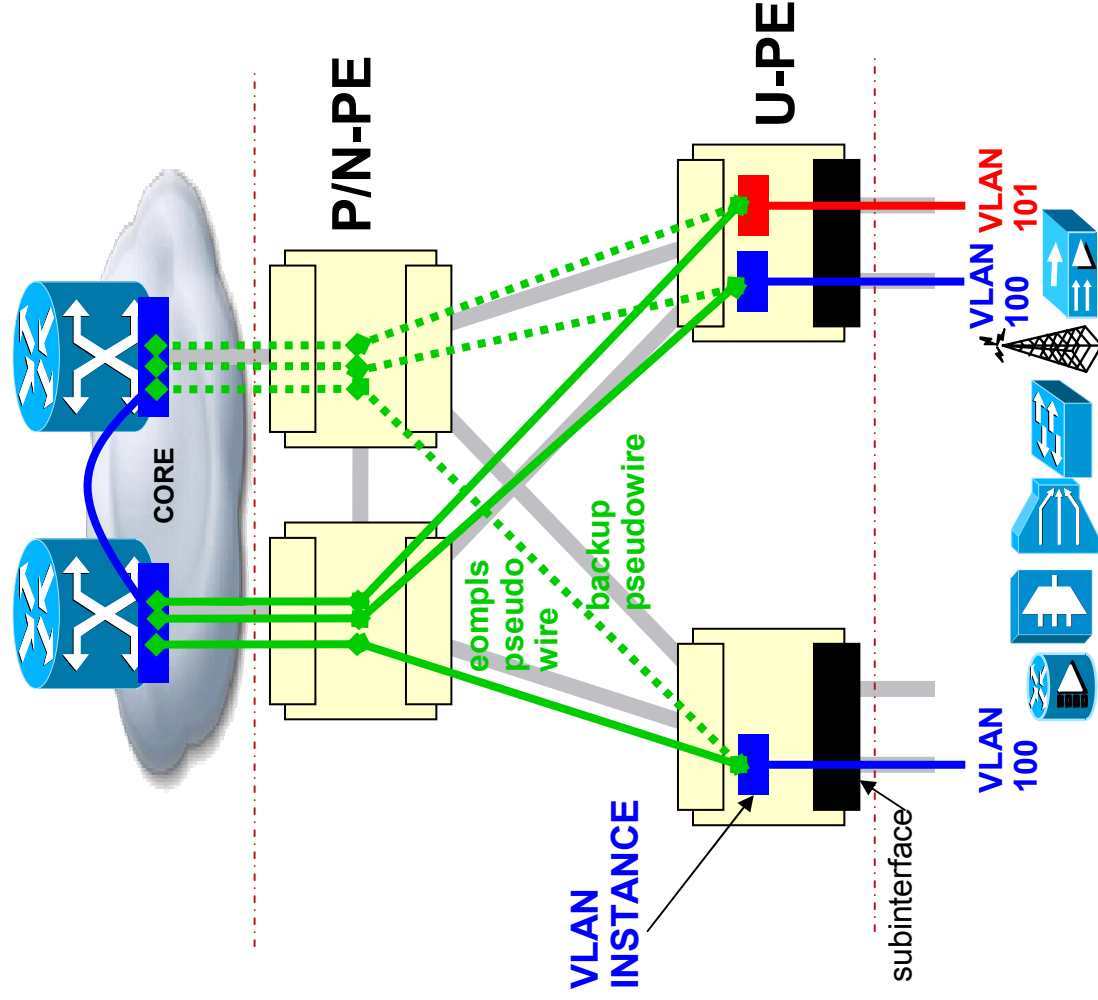
- |                         |            |
|-------------------------|------------|
| <b>N-PE Scalability</b> | <b>32K</b> |
| • # of VLANs:           | unlimited  |
| • # of MACs:            |            |
| <b>U-PE Scalability</b> | <b>32K</b> |
| • # of VLANs:           | 80K/unitd. |
| • # of MACs:            |            |
| <b>Other Limits</b>     |            |
| • 4K VPLS instances     |            |

- Advantages at U-PE**
- Local Switching with Learning
  - Concurrent STP and MPLS
  - Active-Active Pseudowires

# Puzzle #4: N-PE downlink



# Puzzle #4a: remote H-VPLS hub



**N-PE Scalability**

- # of VLANs: unlimited
- # of MACs: unlimited

**U-PE Scalability**

- # of VLANs: 32K
- # of MACs: unlimited

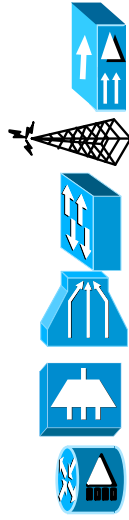
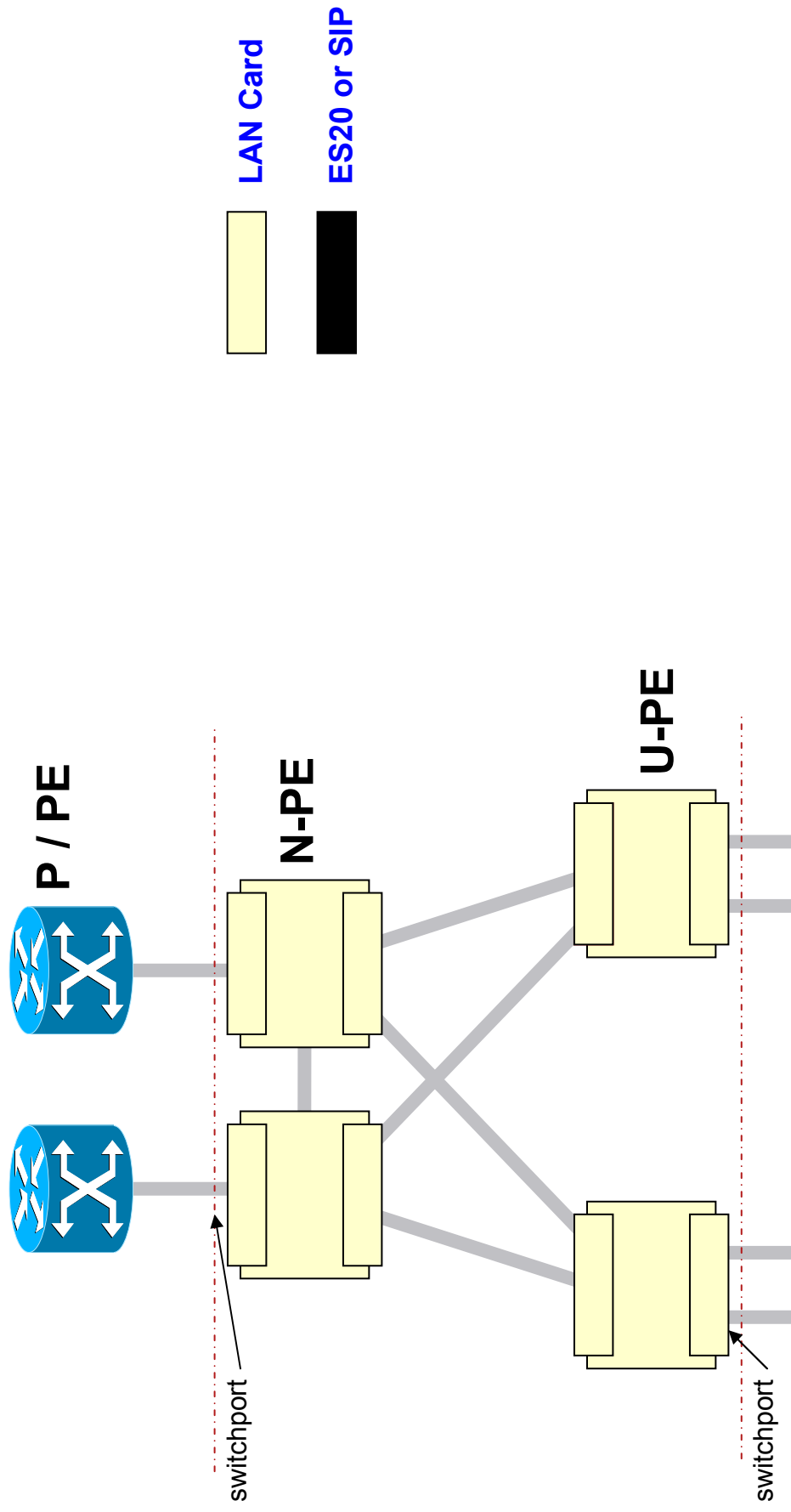
**Services Edge:**

- sporadic E-LAN services (N-PE is just a P)

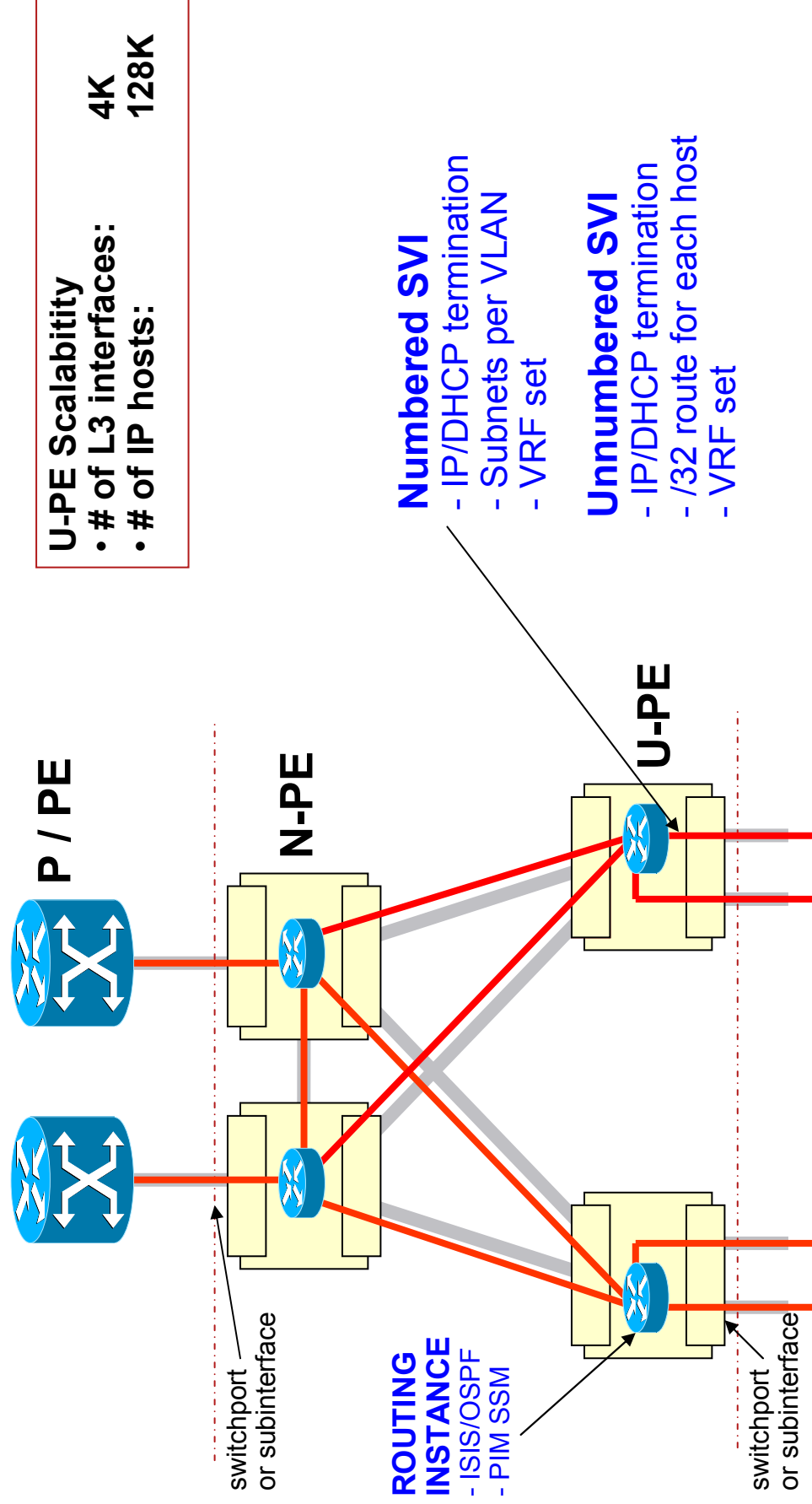
# ES card placement L3 designs



# Base Design: Carrier Ethernet



# Base Design: L3 Aggregation for IPTV



**U-PE Scalability**

- # of L3 interfaces: 4K
- # of IP hosts: 128K

**ROUTING INSTANCE**

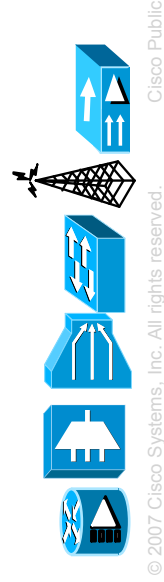
- ISIS/OSPF
- PIM SSM

**Numbered SVI**

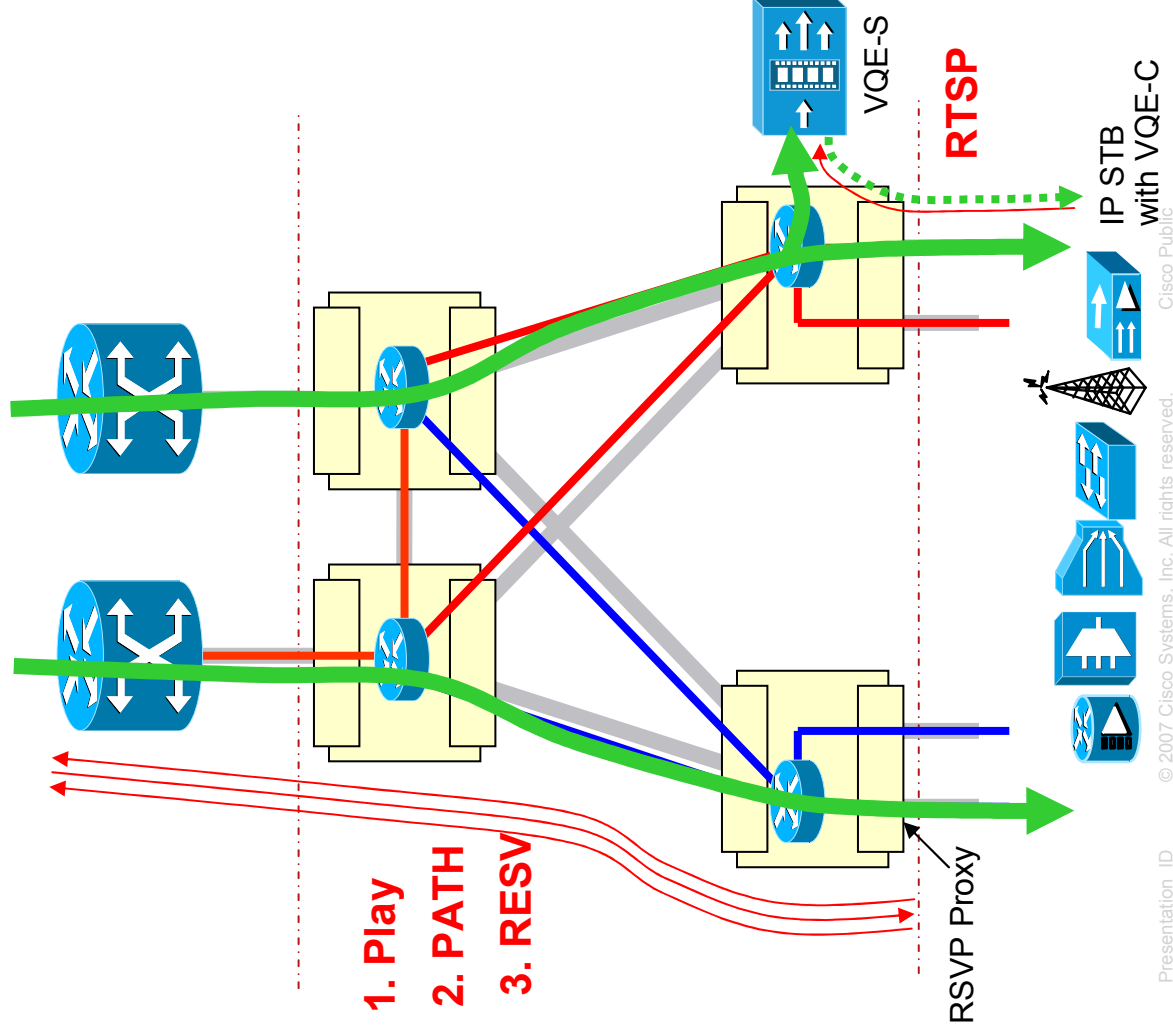
- IP/DHCP termination
- Subnets per VLAN
- VRF set

**Unnumbered SVI**

- IP/DHCP termination
- /32 route for each host
- VRF set



# Base Design: IPTV intelligence



## 1. RSVP CAC

### Video Call Admission Control

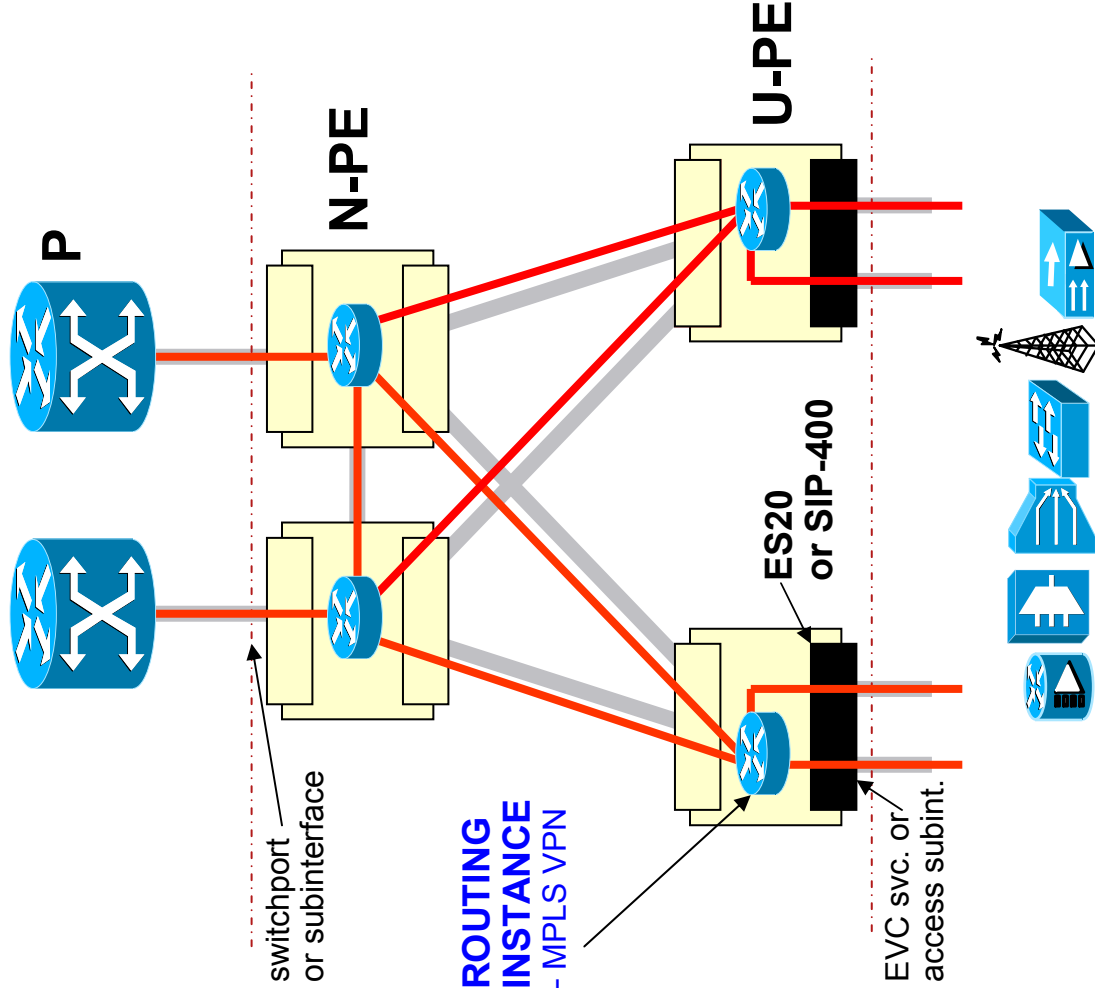
- no need for policy server layer
- scalability, topology independence
- fast re-convergence

## 2. VQE Technology

### Video Quality of Experience

- Look-aside stream RTP monitoring
- Last-mile error correction
- Fast channel zapping

# Puzzle #1: Customer-facing



**U-PE Scalability**

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- # of IP hosts: 128K

**Services Edge:**

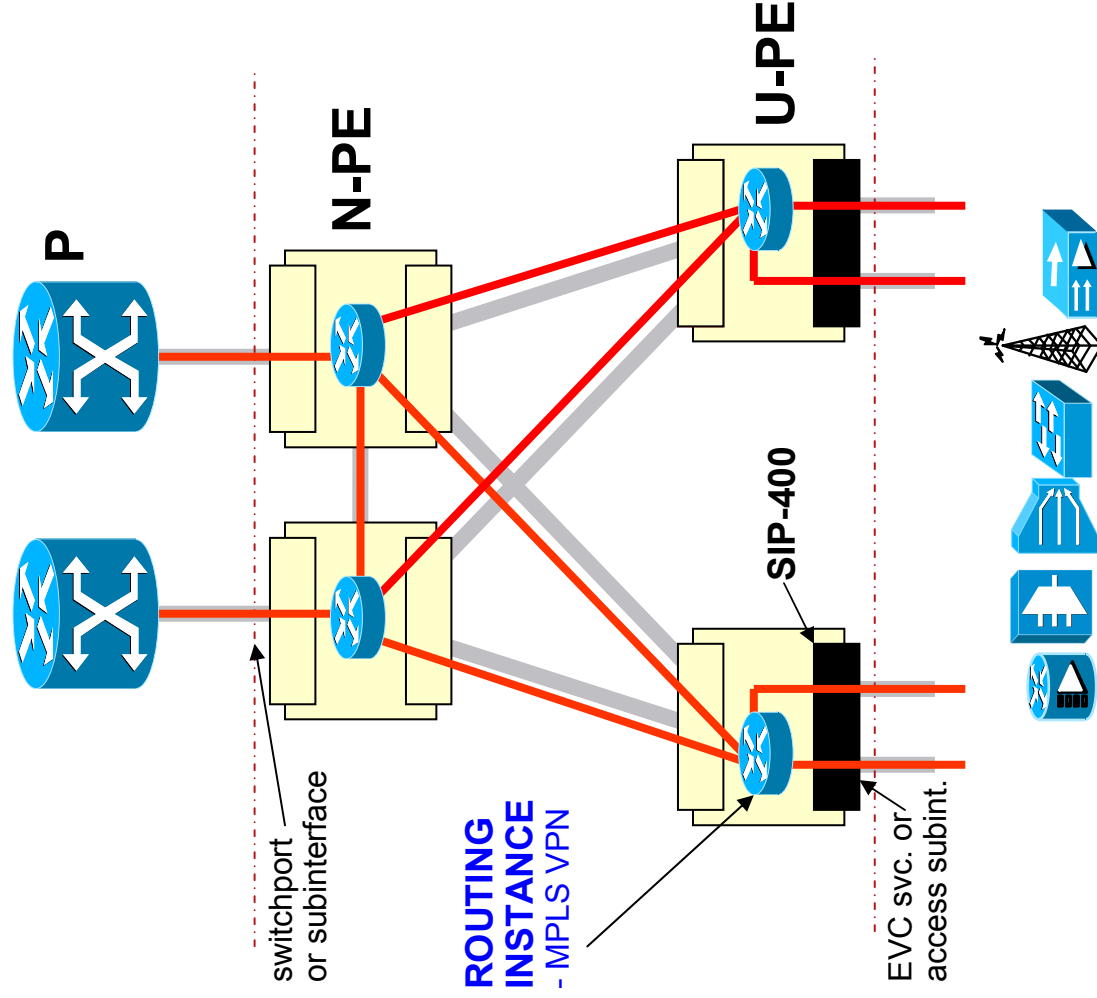
- Business VPNs
- also required for IPTV with QinQ!

**Advantages at U-PE**

- Per-VLAN HQoS
- IP over QinQ (tag push/pop)
- QinQ inner/outer CoS setting
- Scalable E-Line/E-LAN
- SIP400 is better for L3 VPN



# Puzzle #2: Distributed BRAS and ISG



**U-PE Scalability**

- # of L3 interfaces: 32K
- # of PPPoE or IP sessions: 32K (per SIP: 8K VLANs, 8K sessions)

**Services Edge:**

- integrated residential BRAS
- integrated AAA or SCE

**Advantages at U-PE**

- AAA
- PPPoE sessions
- IP/DHCP sessions
- Change of Authorization
- L4 redirect
- SCE integration bus

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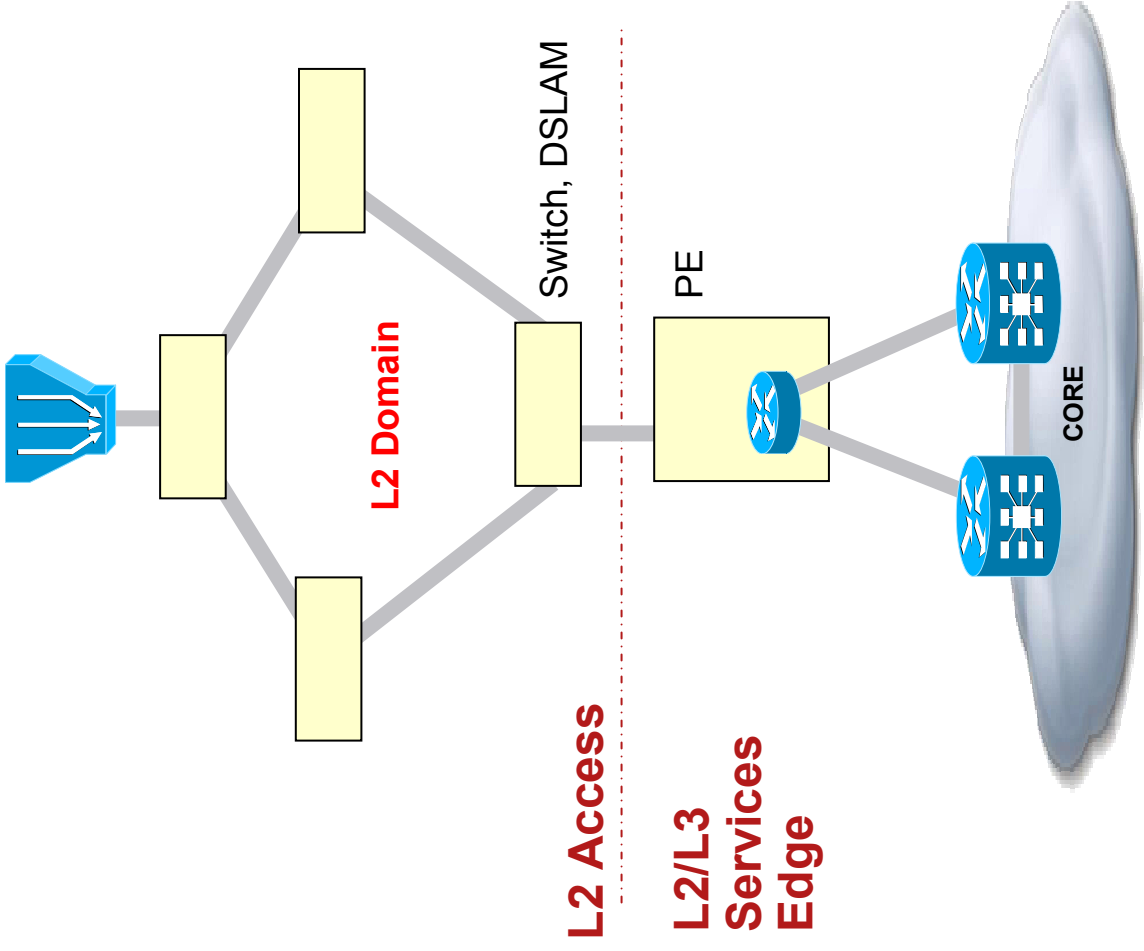
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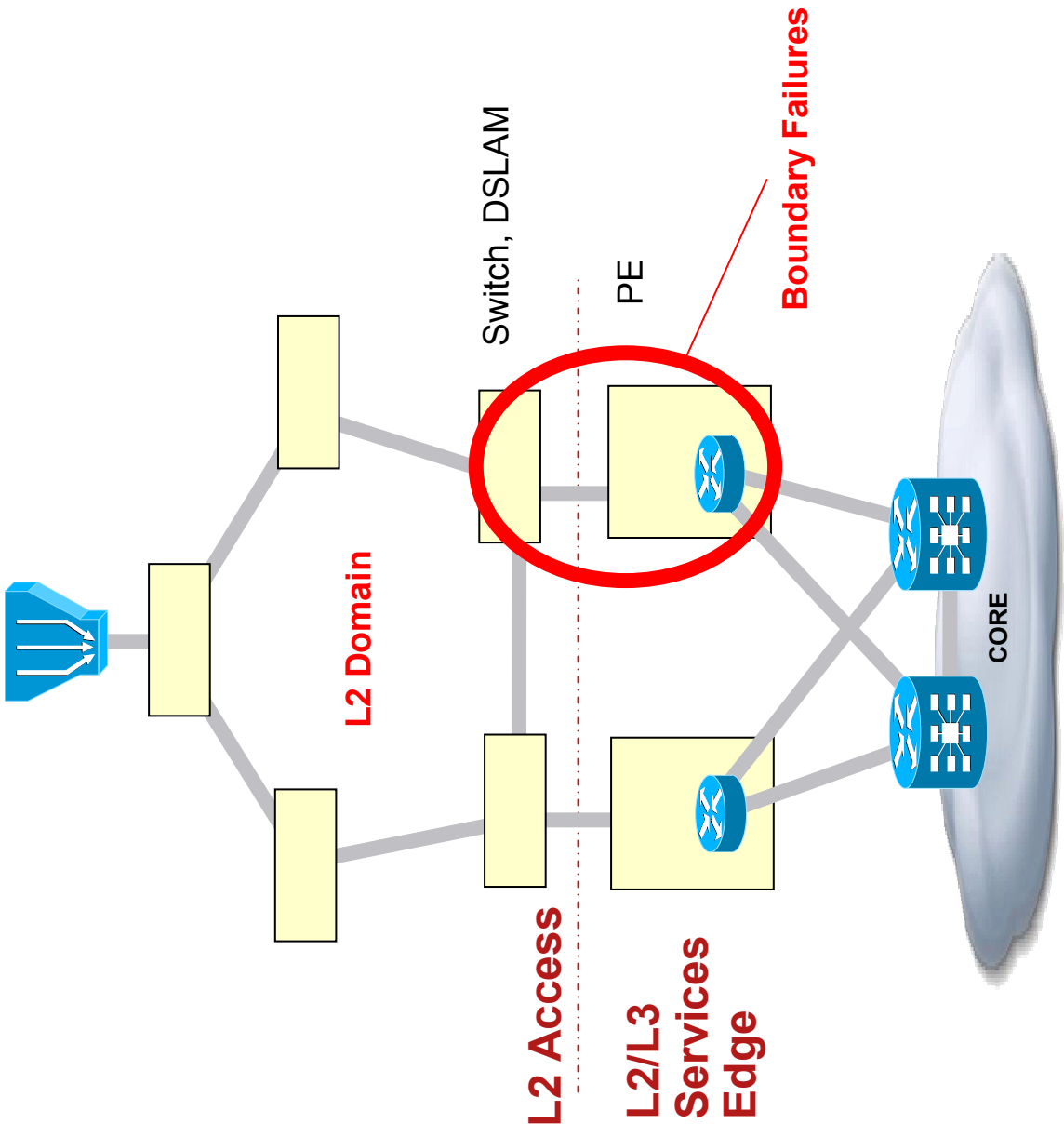
## L2 Access Redundancy

- How to connect my access domain to 7600?
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# Access – no Redundancy



# Access Redundancy



## L3 Service Redundancy

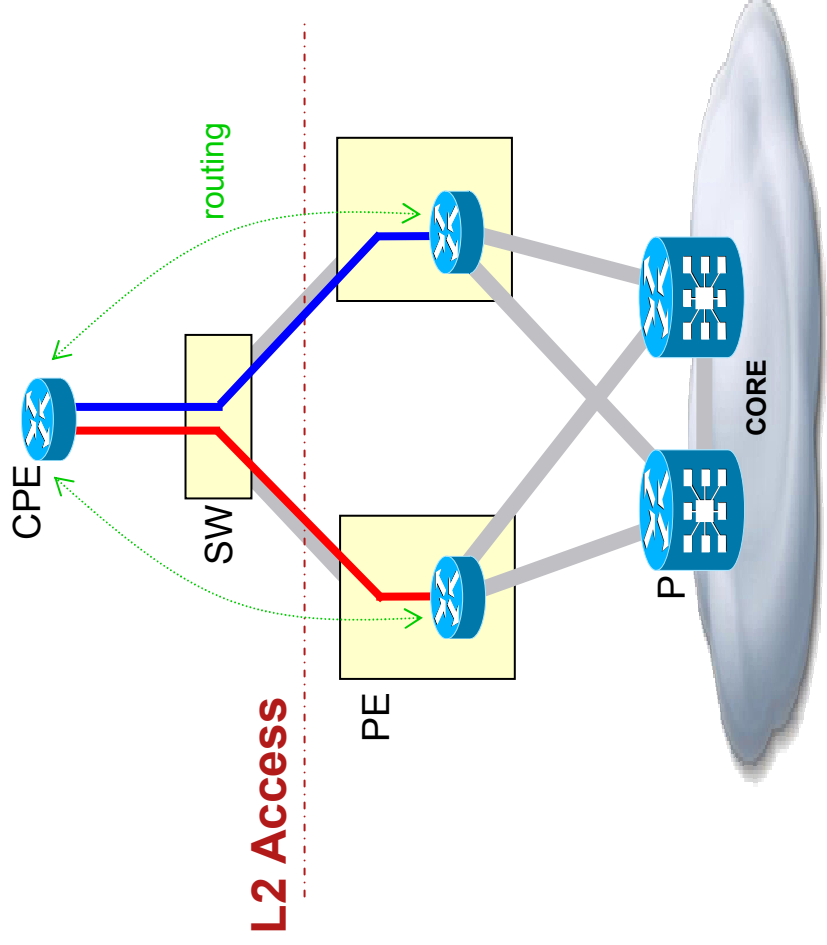


# Redundancy Design – L3 services edge

## CPE dual-homing/backup

- business VPN, Internet
- simple, well-known by customers
- routing protocol (BGP)
- reliable static route (BFD)

**NO PROBLEM ;)**

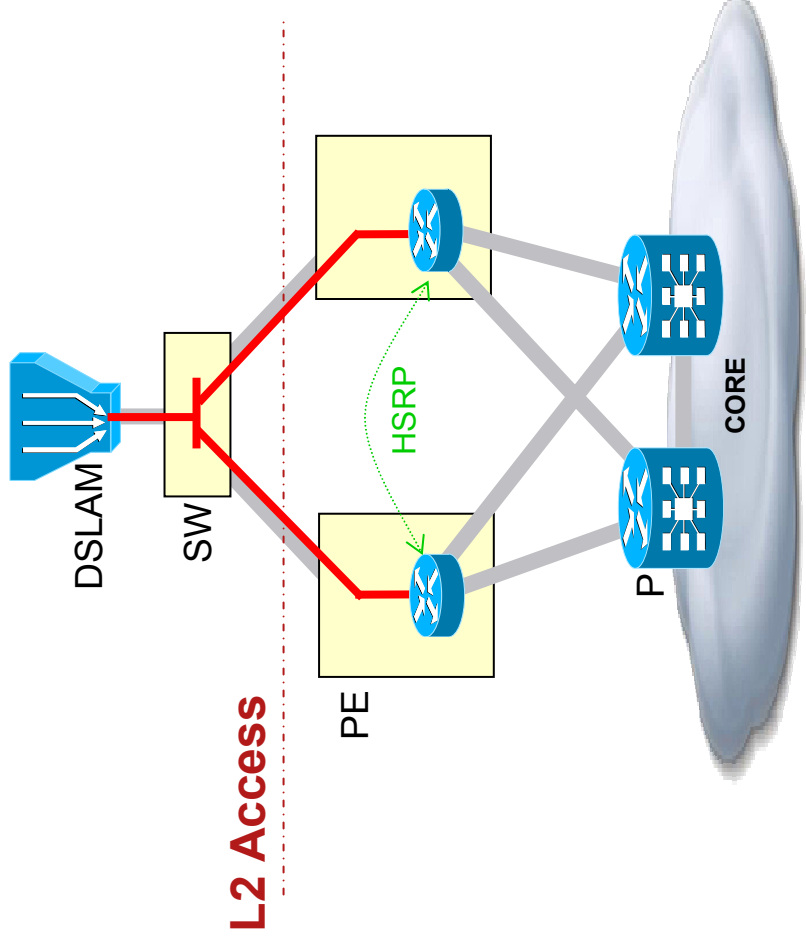


# Redundancy Design – L3 services edge

## Dual-homed Switch or DSLAM

- IPTV STB, PPPoE/DHCP clients
- loop-free L3 termination
- no need for Flexlink, REP, MST
- only 1 port per L3 interface!

**NO PROBLEM ;)**

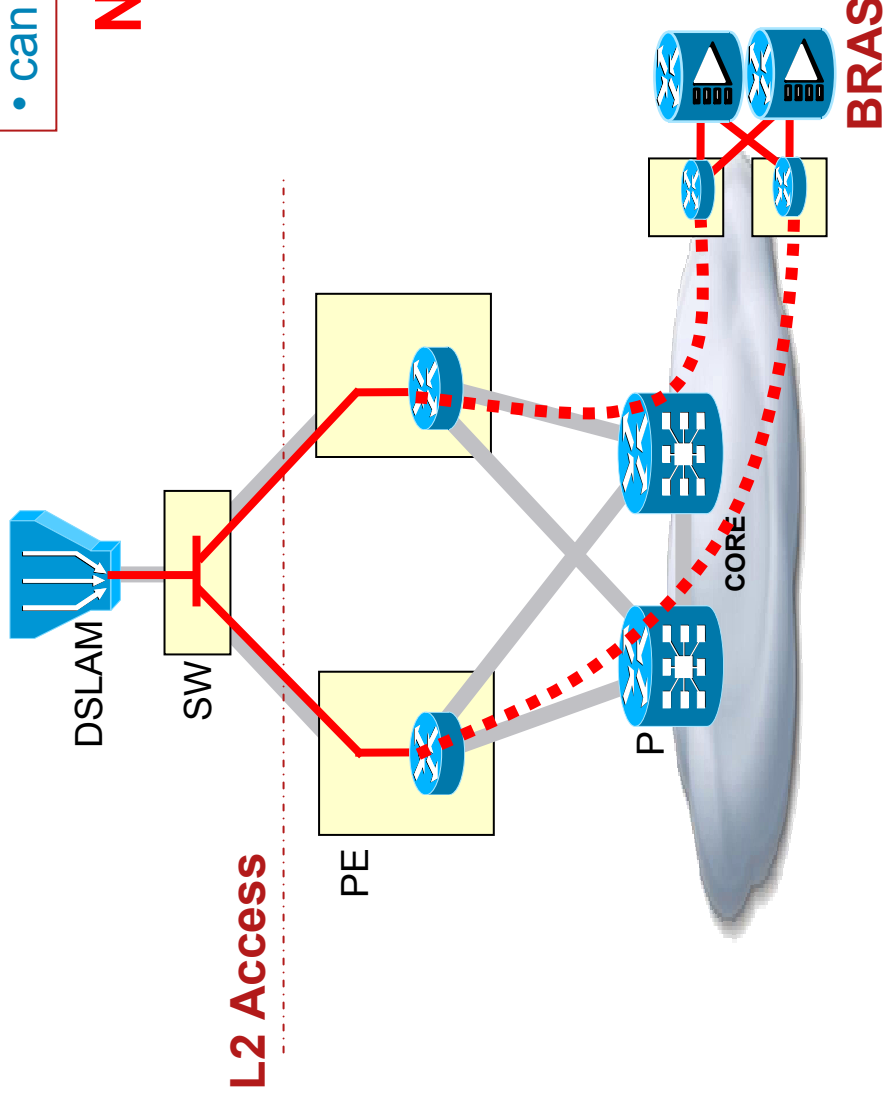


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- only 1 port per L3 interface!
- can be extended using PW

**NO PROBLEM ;)**



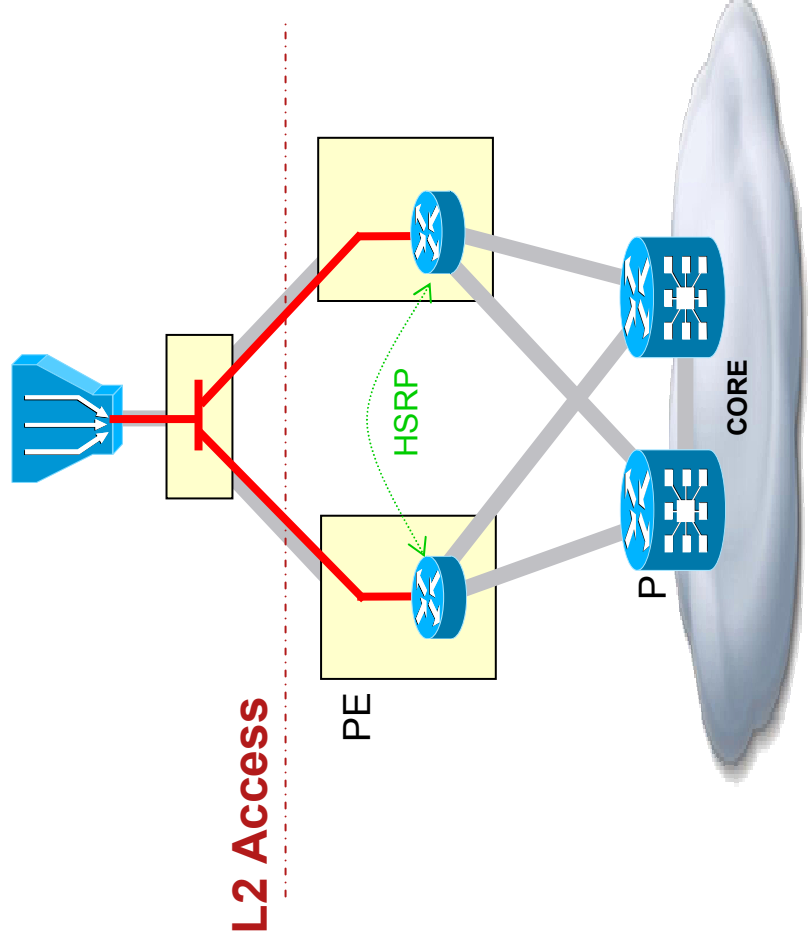


# Redundancy Design – L3 services edge

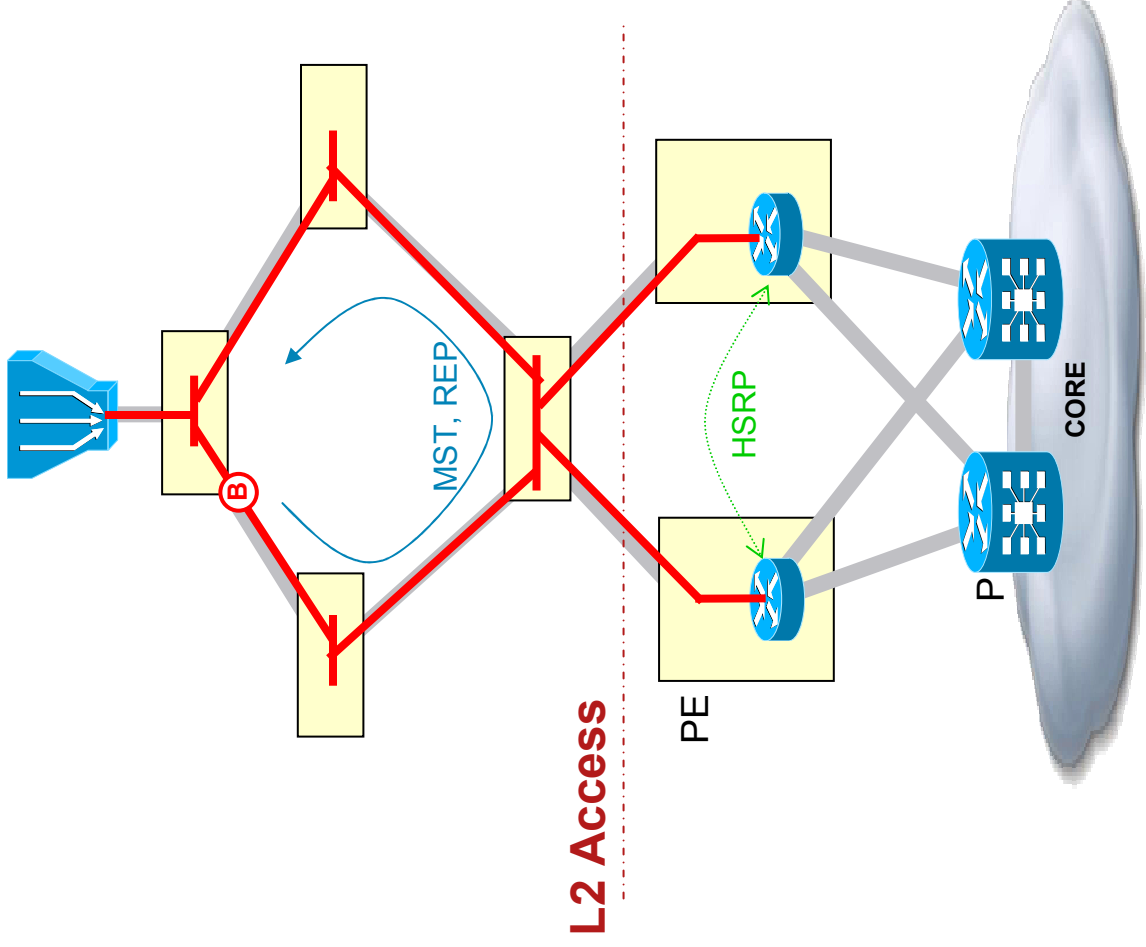
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**NO PROBLEM ;)**



# Redundancy Design – L3 services edge



## Dual-homed L2 Domain

- still the same situation
- loop-free L3 termination

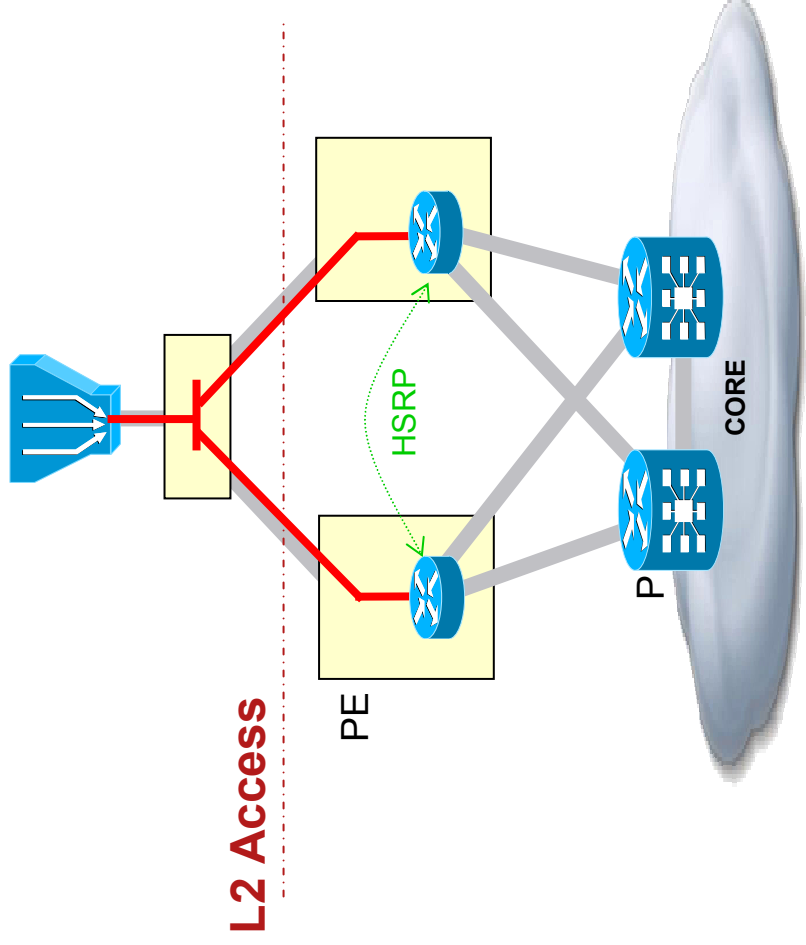
**NO PROBLEM ;)**

# Redundancy Design – L3 services edge

## Dual-homed L2 Domain

- still the same situation
- loop-free L3 termination

**NO PROBLEM ;)**

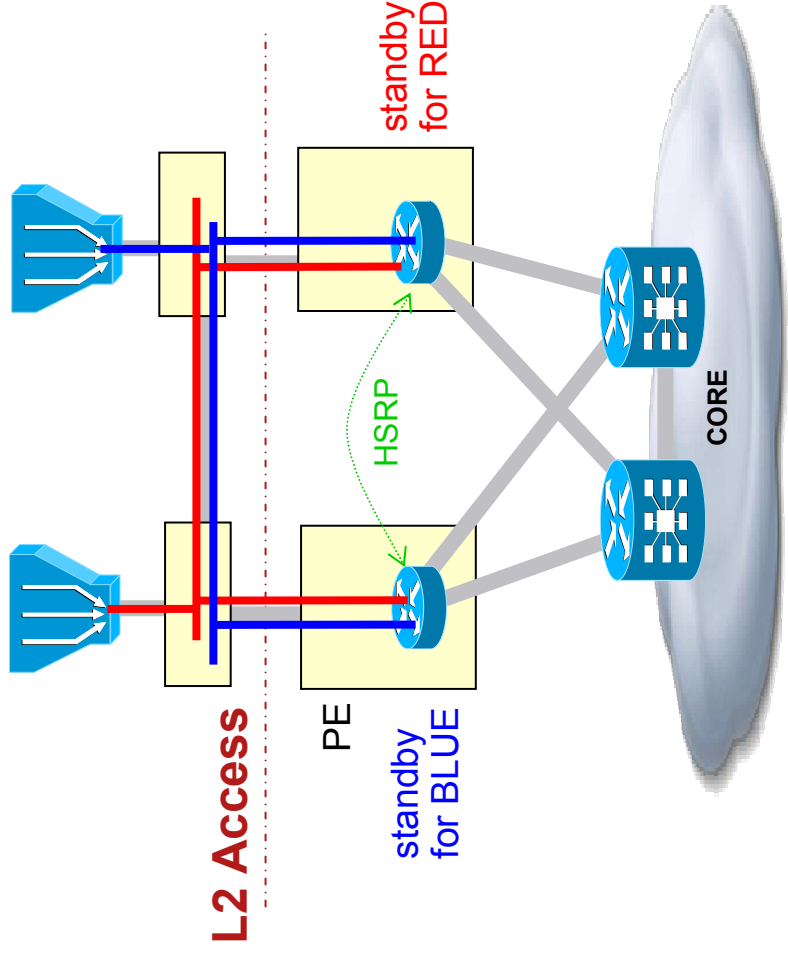


# Redundancy Design – L3 services edge

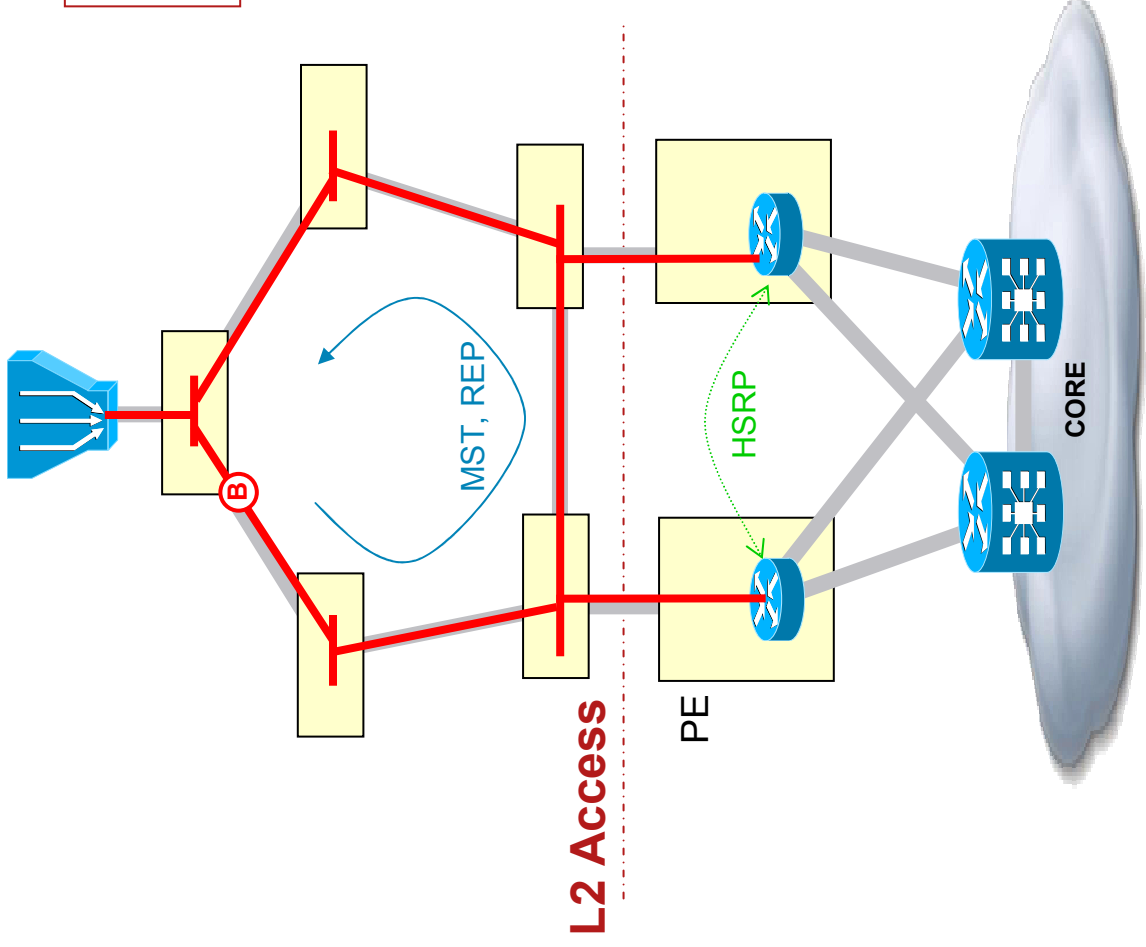
## Two-side, dual-homed L2 Domain

- still the same situation
- loop-free L3 termination

**NO PROBLEM ;)**



# Redundancy Design – L3 services edge

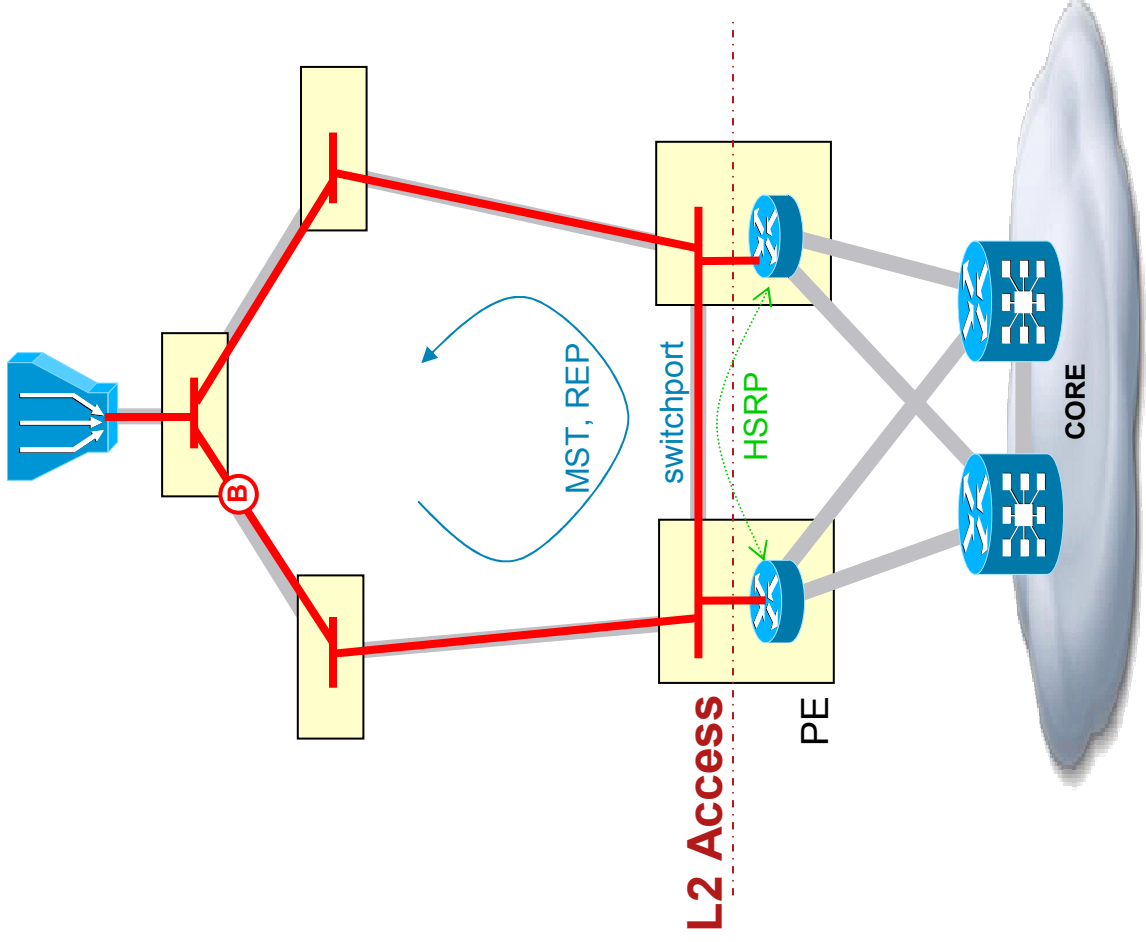


**Two-side, dual-homed L2 Domain**

- still the same situation
- loop-free L3 termination

**NO PROBLEM ;)**

# Redundancy Design – L3 services edge

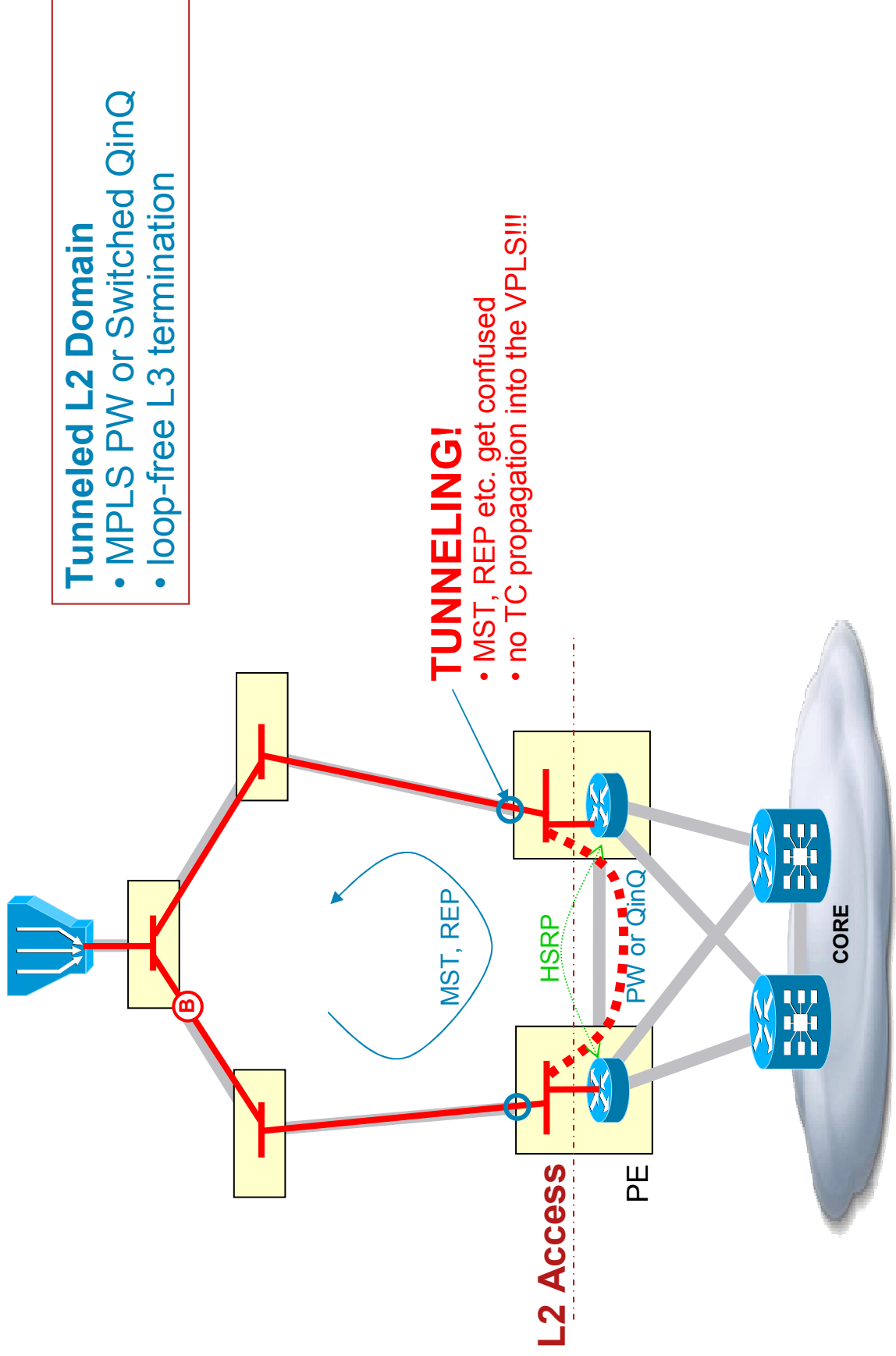


**L2 link is moved between PE's**

- still the same situation
- loop-free L3 termination

**NO PROBLEM ;)**

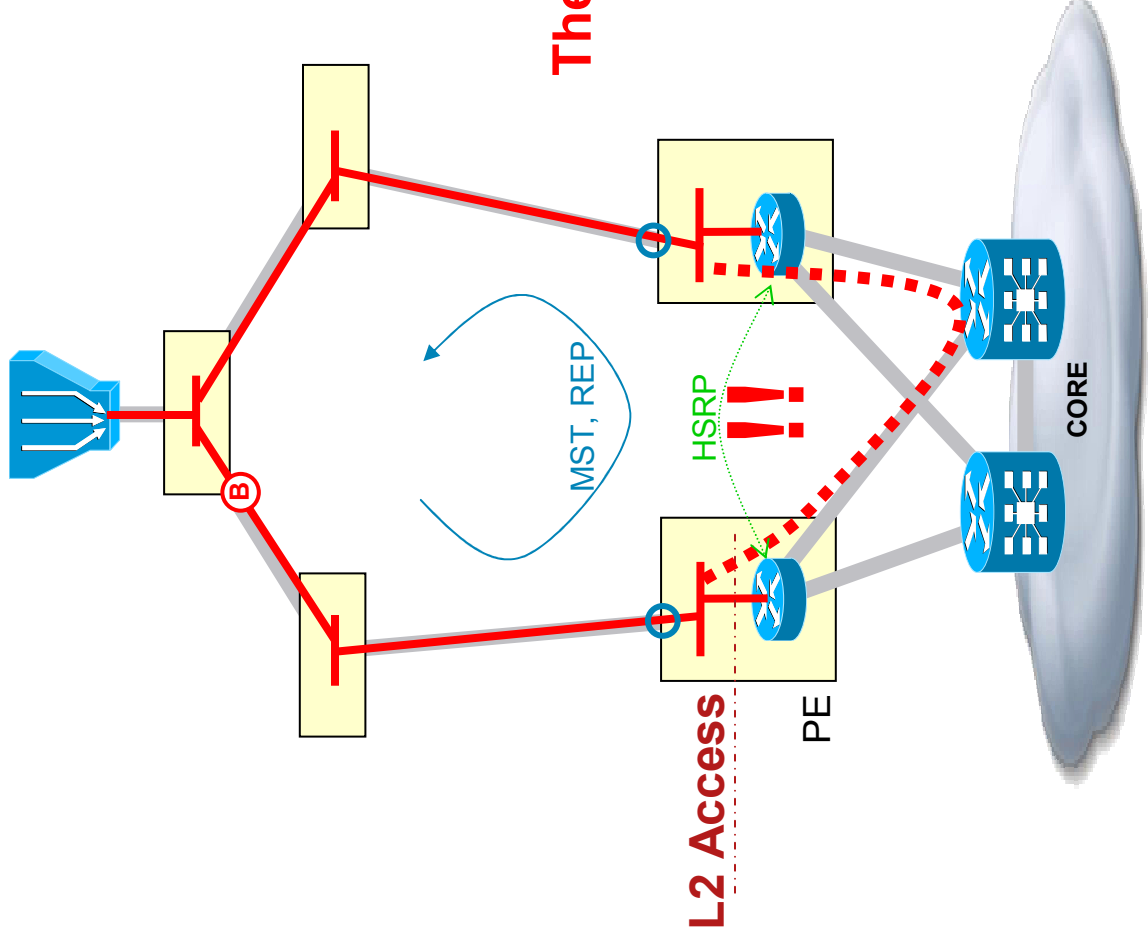
# Redundancy Design – L3 services edge



## Tunneled L2 Domain

- MPLS PW or Switched QinQ
- loop-free L3 termination

# Redundancy Design – L3 services edge

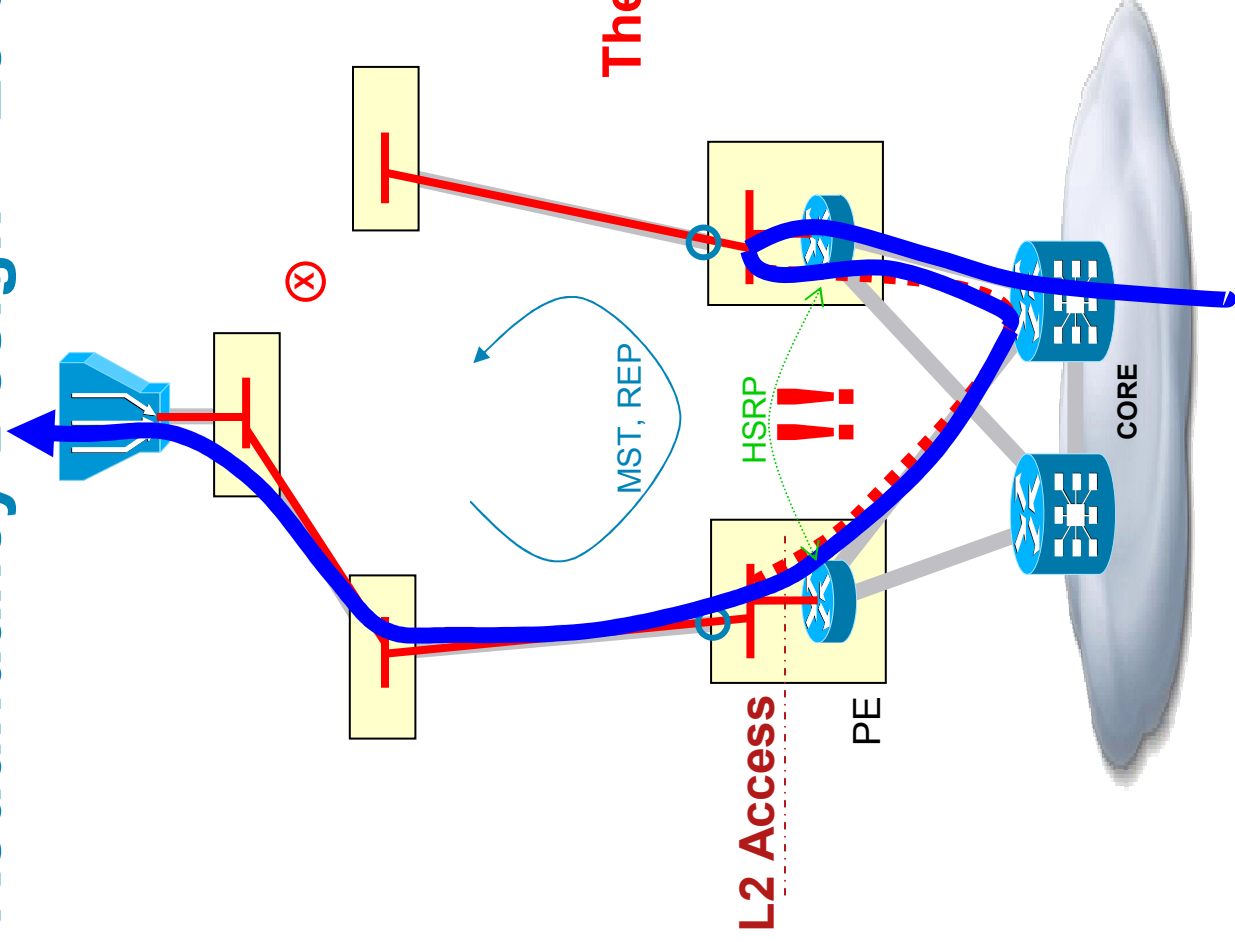


Do not remove PE-PE direct link  
• it is needed

The PE-PE link is removed.



# Redundancy Design – L3 services edge

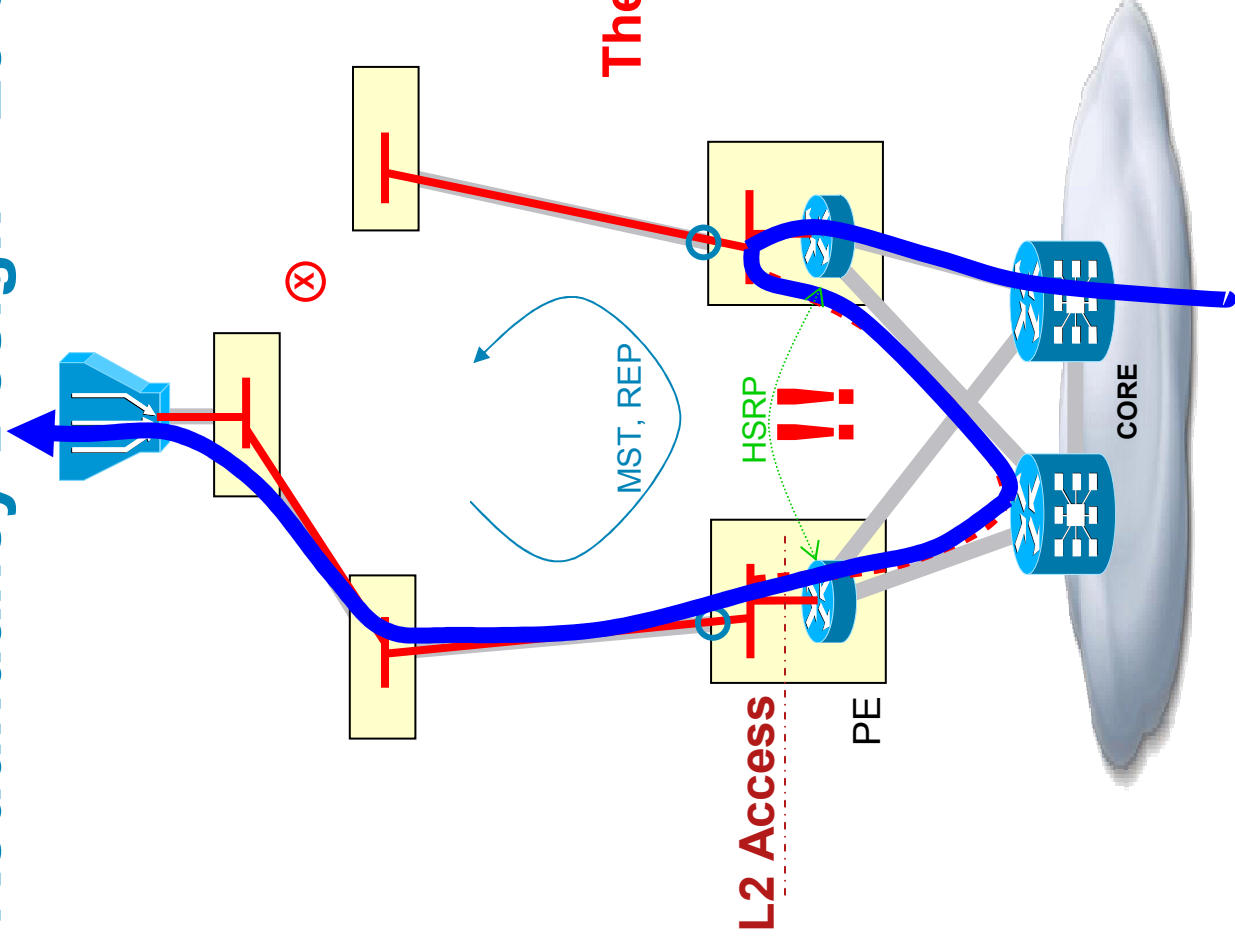


**Do not remove PE-PE direct link**

- it is needed
- in some cases it carries data

**The PE-PE link is removed.**

# Redundancy Design – L3 services edge

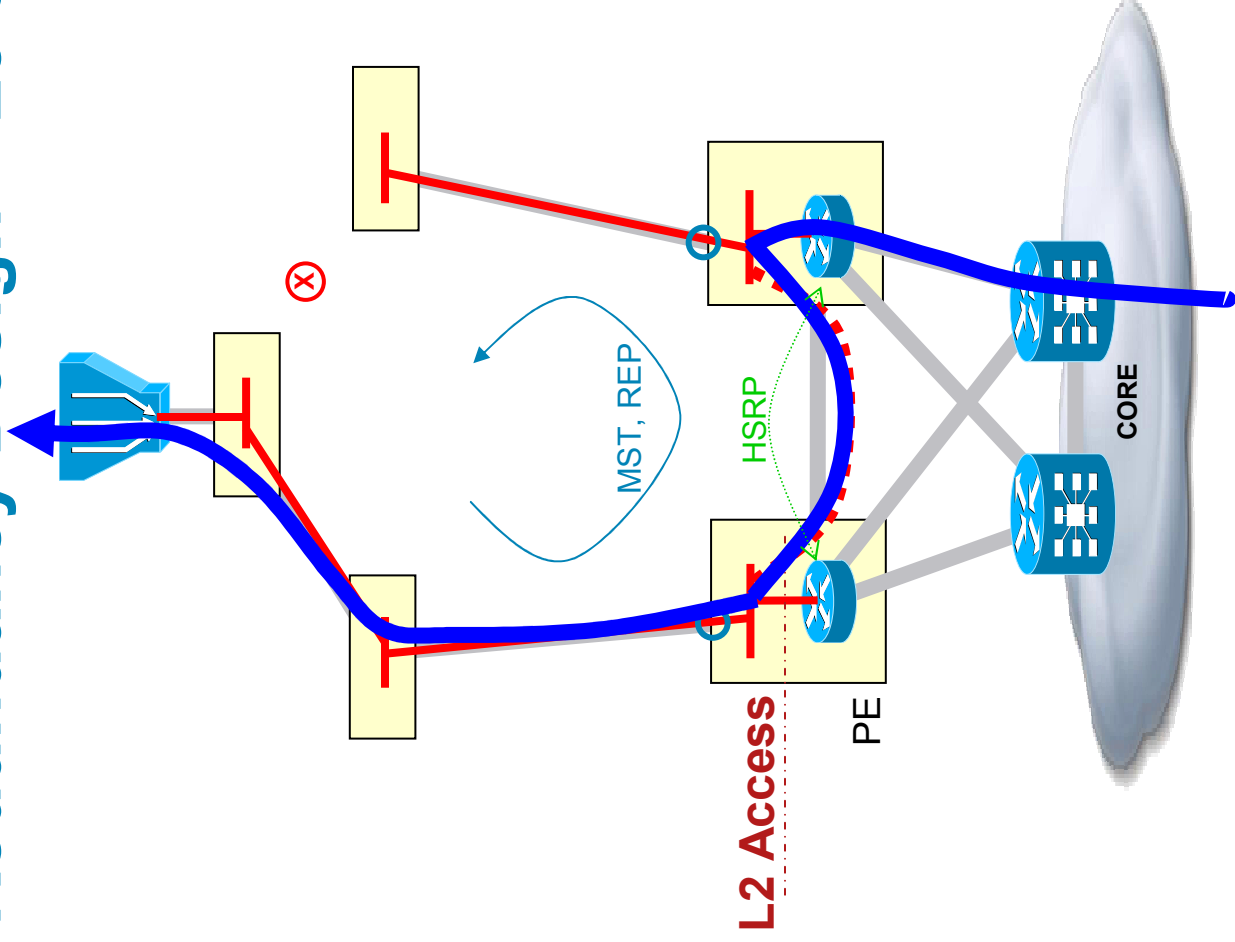


**Do not remove PE-PE direct link**

- it is needed
- in some cases it carries data
- if you can't have it, plan ahead!

**The PE-PE link is removed.**

# Redundancy Design – L3 services edge



**Do not remove PE-PE direct link**

- it is needed
- in some cases it carries data
- if you can't have it, plan ahead!

# L2 Service Redundancy

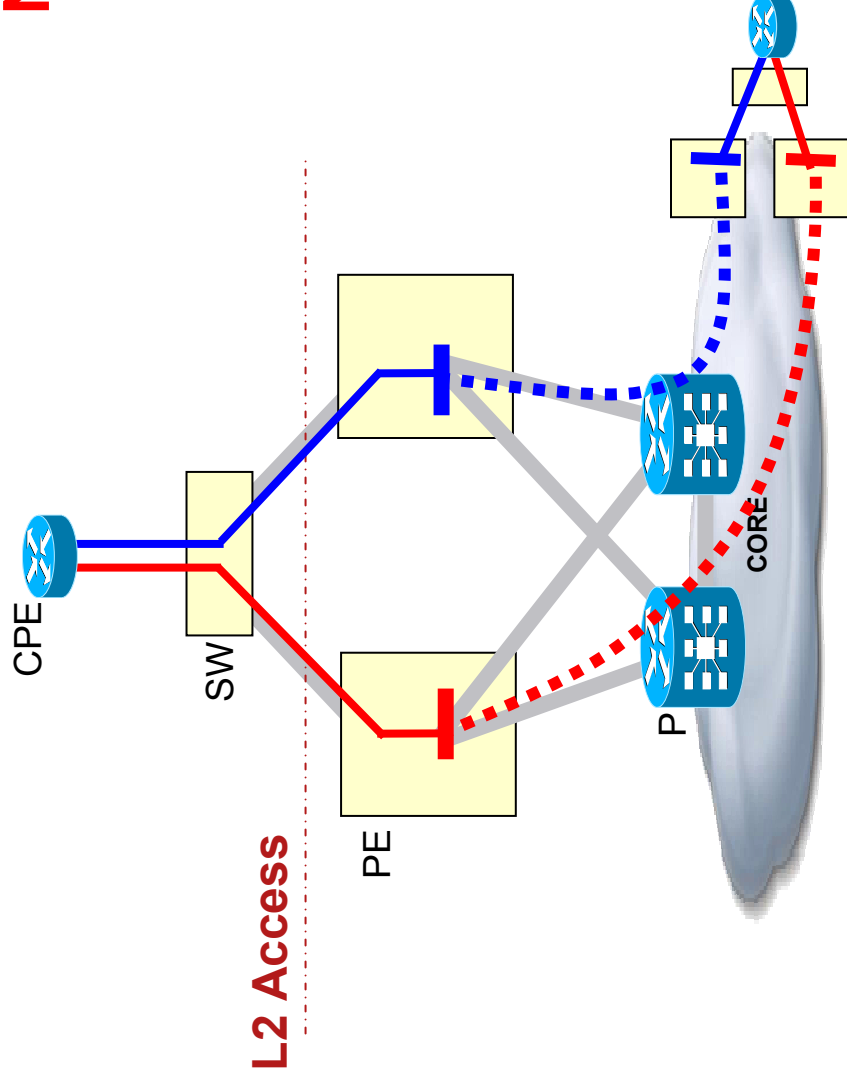


# Redundancy Design – L2 services edge

## Dual-homed CPE

- simple, well-known by customers
- Routed CPE runs routing
- Switched CPE runs STP

**NO PROBLEM ;)**

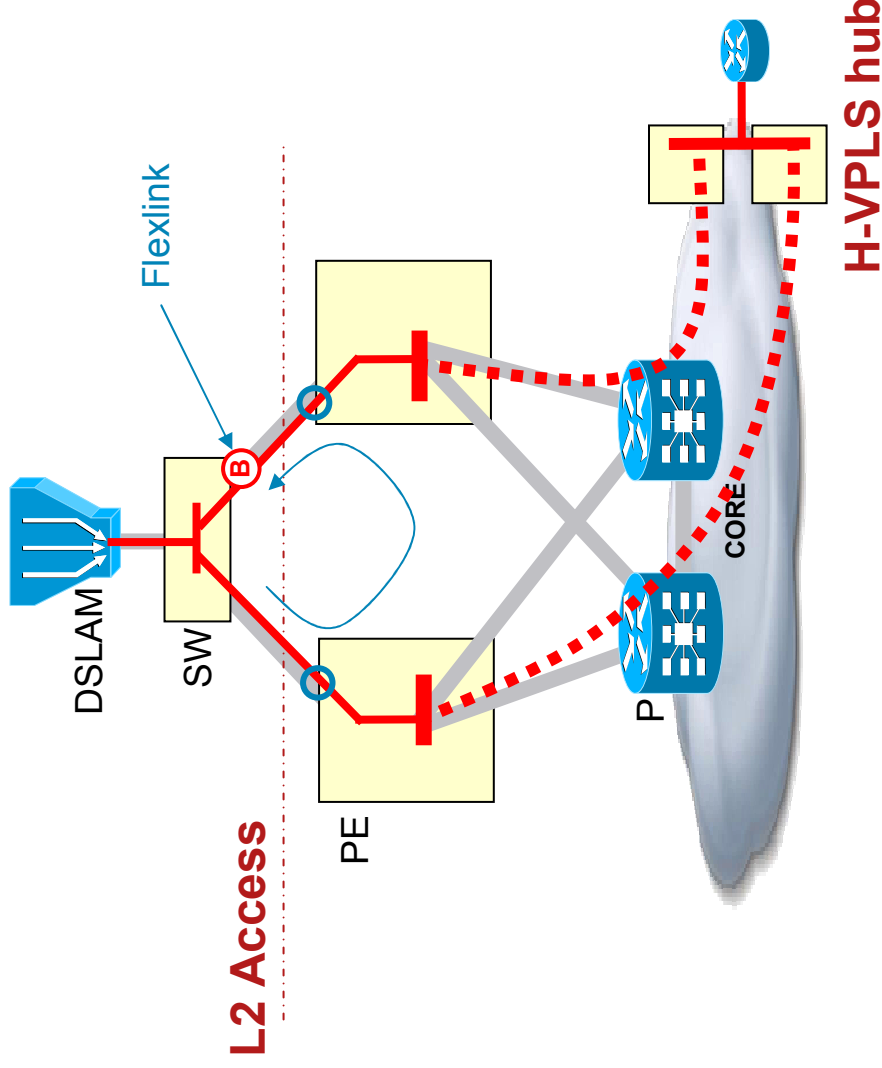


# Redundancy Design – L2 services edge

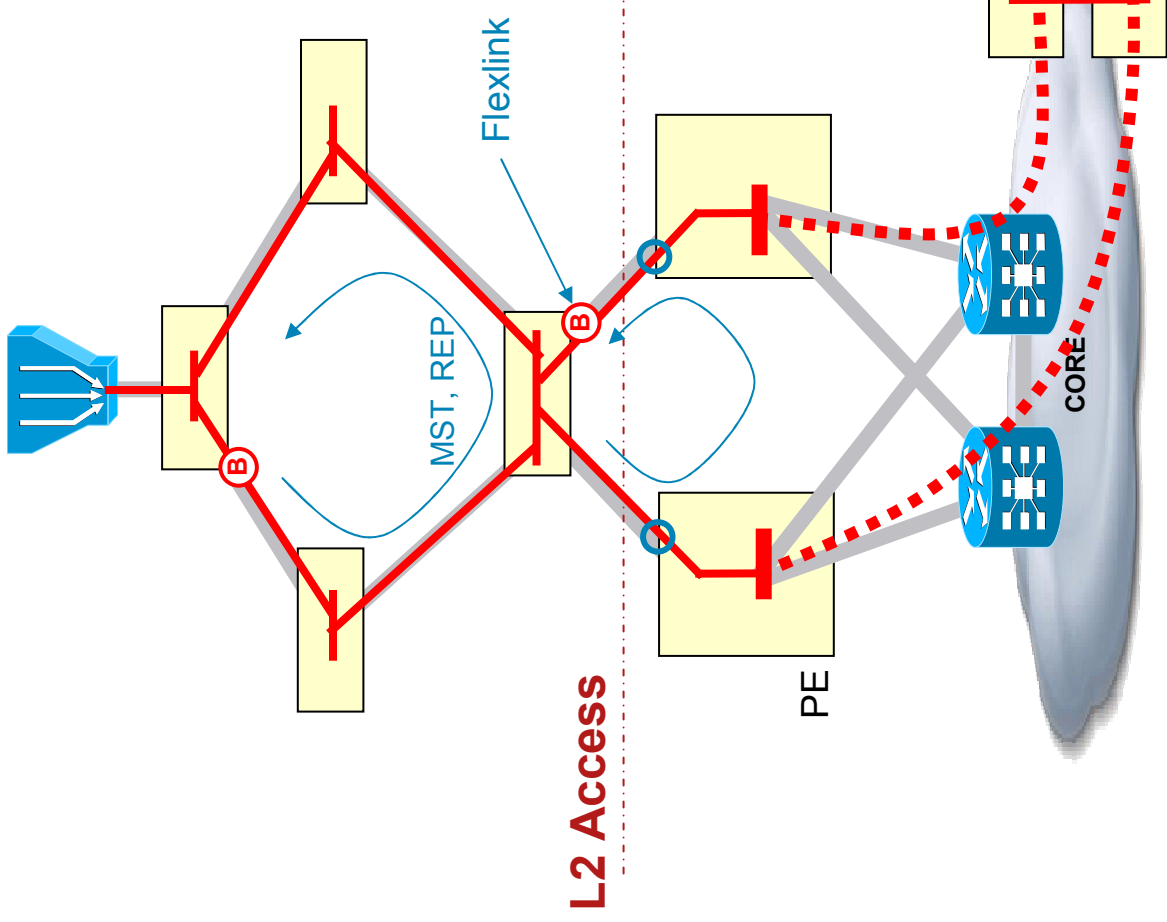
## Dual-homed Switch

- E-Line/LAN with PE redundancy
- Flexlink (if direct fibers exist)

**NO PROBLEM ;)**



# Redundancy Design – L2 services edge

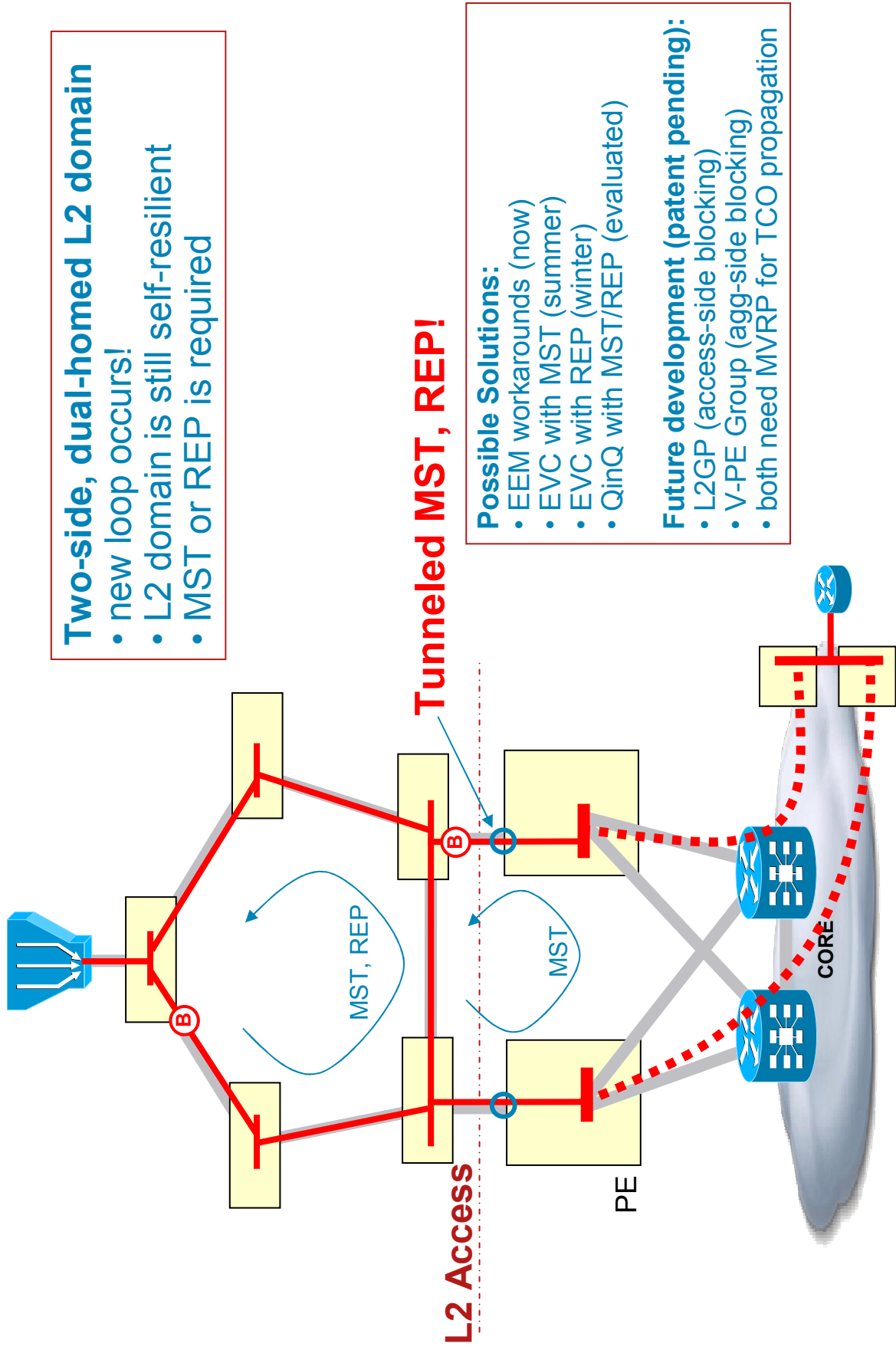


## Dual-homed L2 Domain

- still the same situation
- Flexlink (if direct fibers exist)

**NO PROBLEM ;)**

# Redundancy Design – L2 services edge



**Two-side, dual-homed L2 domain**

- new loop occurs!
- L2 domain is still self-resilient
- MST or REP is required

**Possible Solutions:**

- EEM workarounds (now)
- EVC with MST (summer)
- EVC with REP (winter)
- QinQ with MST/REP (evaluated)

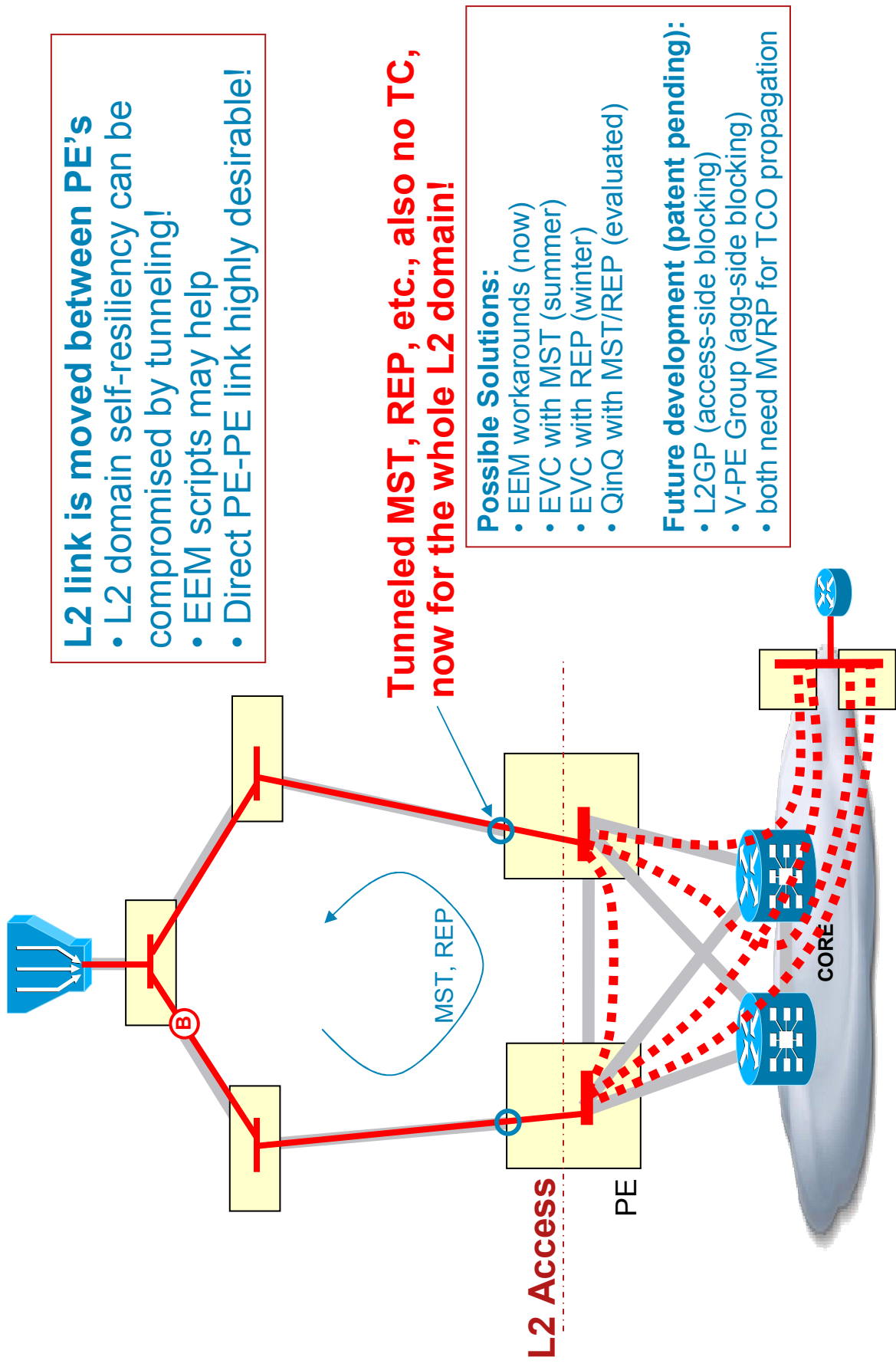
**Future development (patent pending):**

- L2GP (access-side blocking)
- V-PE Group (agg-side blocking)
- both need MVRP for TCO propagation

**H-VPLS hub**



# Redundancy Design – L2 services edge



# Conclusion



# Conclusion

## Carrier Ethernet Technology

- Bringing Ethernet at ATM level from operational point of view
- Uses MPLS, uses both L2 and L3 elements
- Cisco 7600 + IOS 12.2SR = the reference platform

## 1. Which architecture?

- plan your service edges
- jump on the architecture evolution train

## 2. Do I need ES cards?

- yes, if you know what to do with them
- let's optimize the design for your network

## 3. Is L2 access redundancy going to blow off my head?

- no, focus on the most important services
- avoid complex L2 topologies

