



**Cisco Expo
2007**

Carrier Ethernet



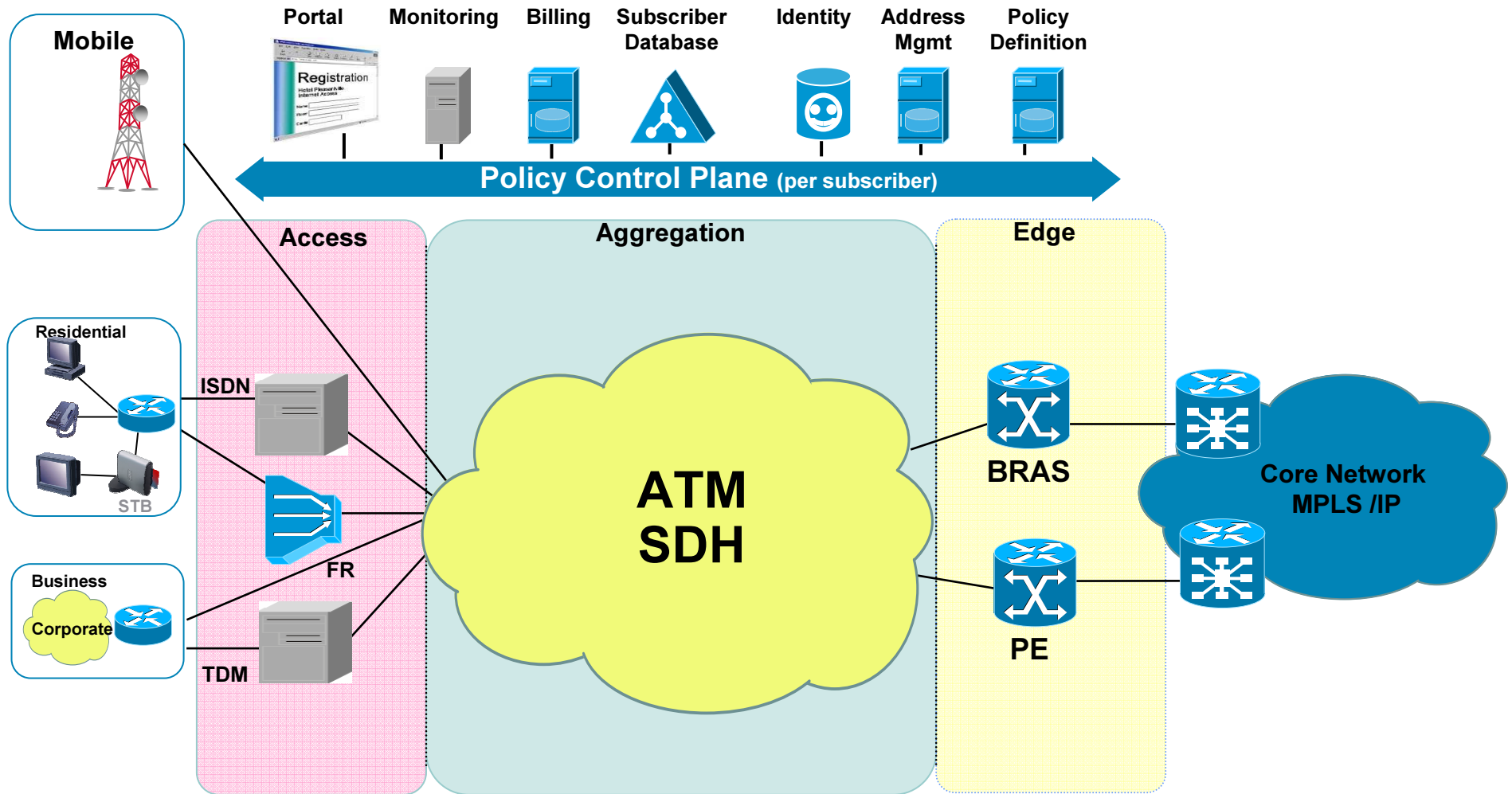
Josef Ungerman
Consulting Systems Engineer

**Enable Your Network
Empower Your Business**

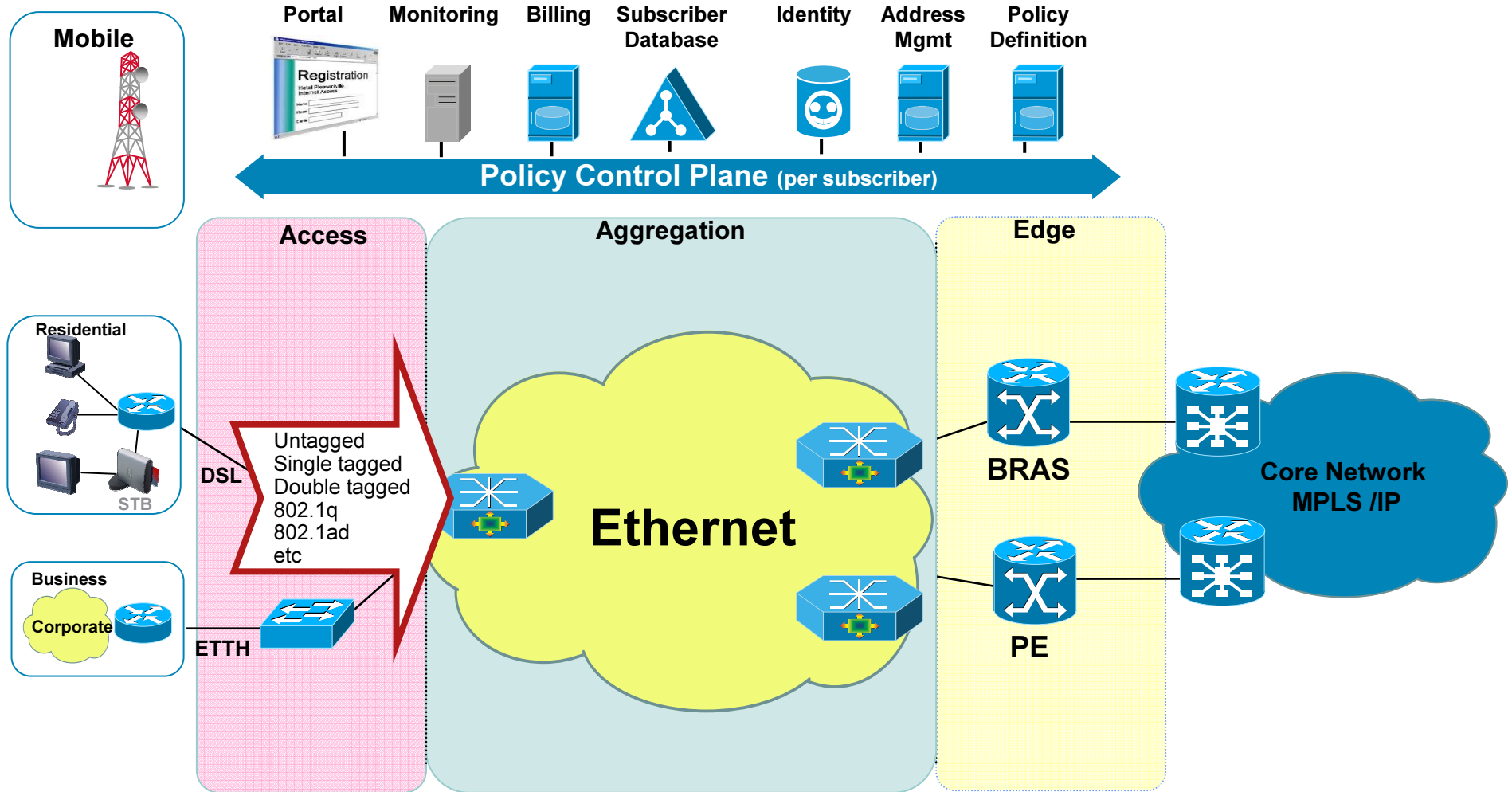
Agenda

- Carrier Ethernet Architecture
- Specific Hardware and Software
- Triple-Play and Business Services
- Network and Service Management
- Redundancy, QoS, Security
- System Testing
- Conclusion

Aggregation 2000



Aggregation 2005

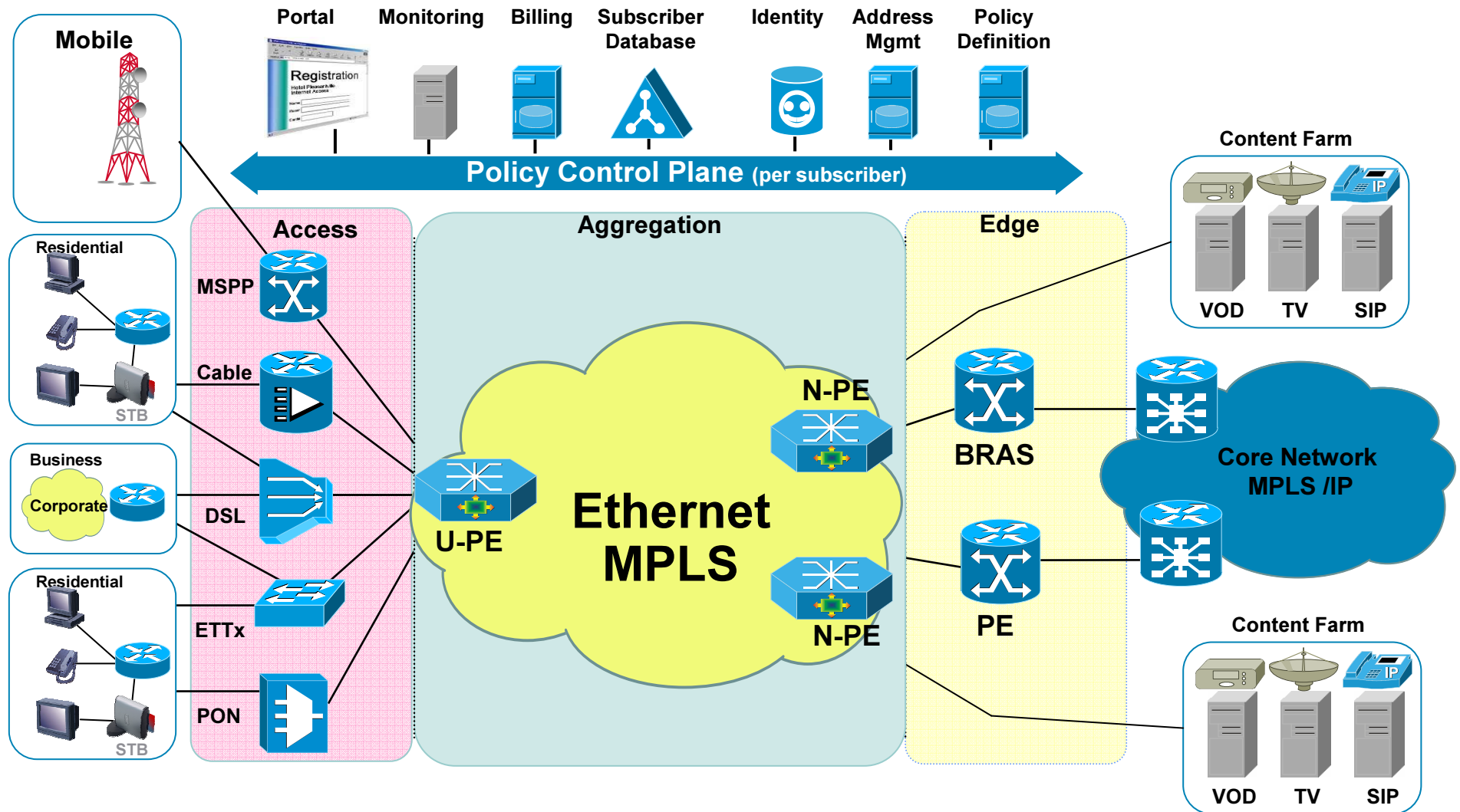


What is Carrier Ethernet?

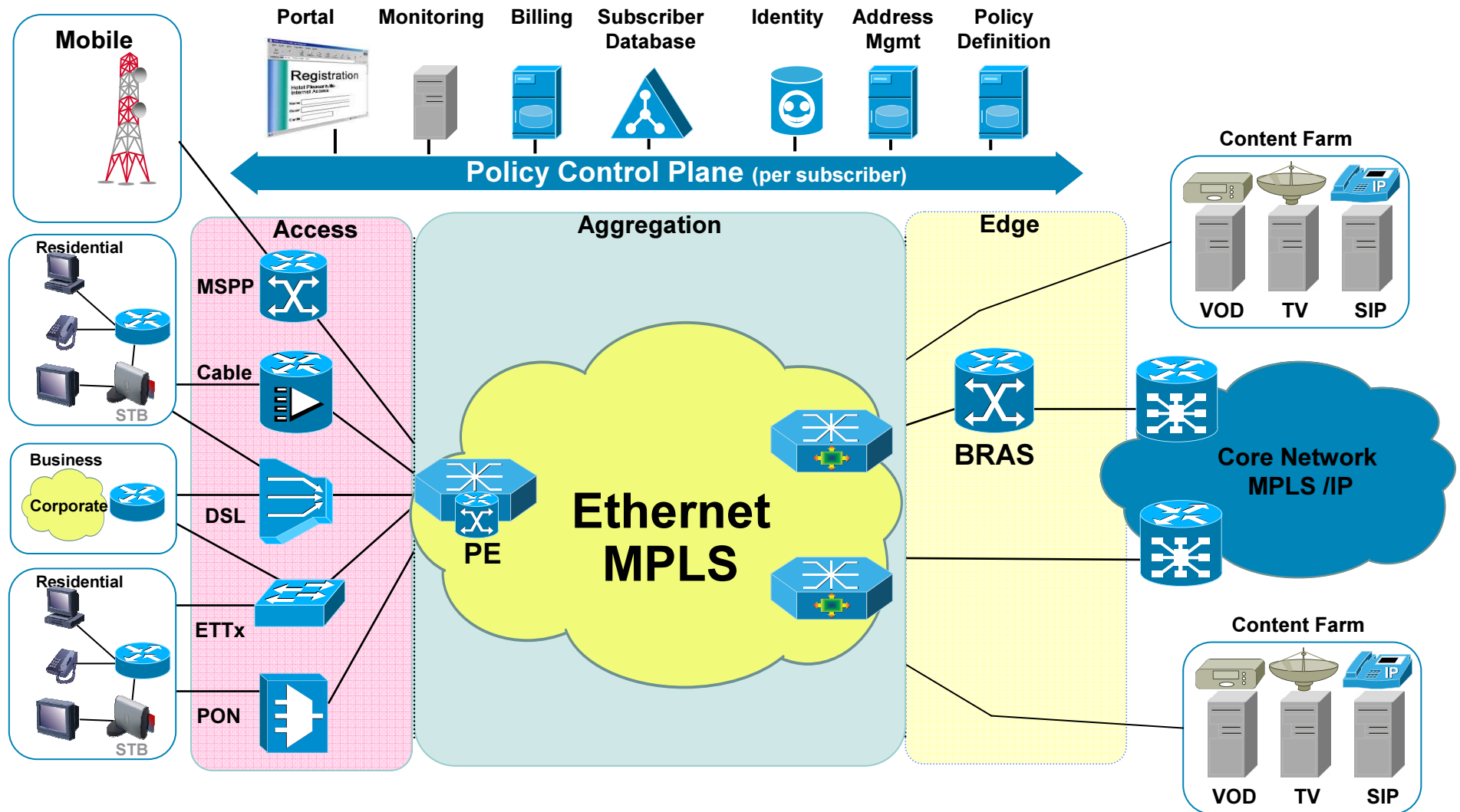
Making LAN Ethernet suitable for replacing ATM/TDM

- **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)

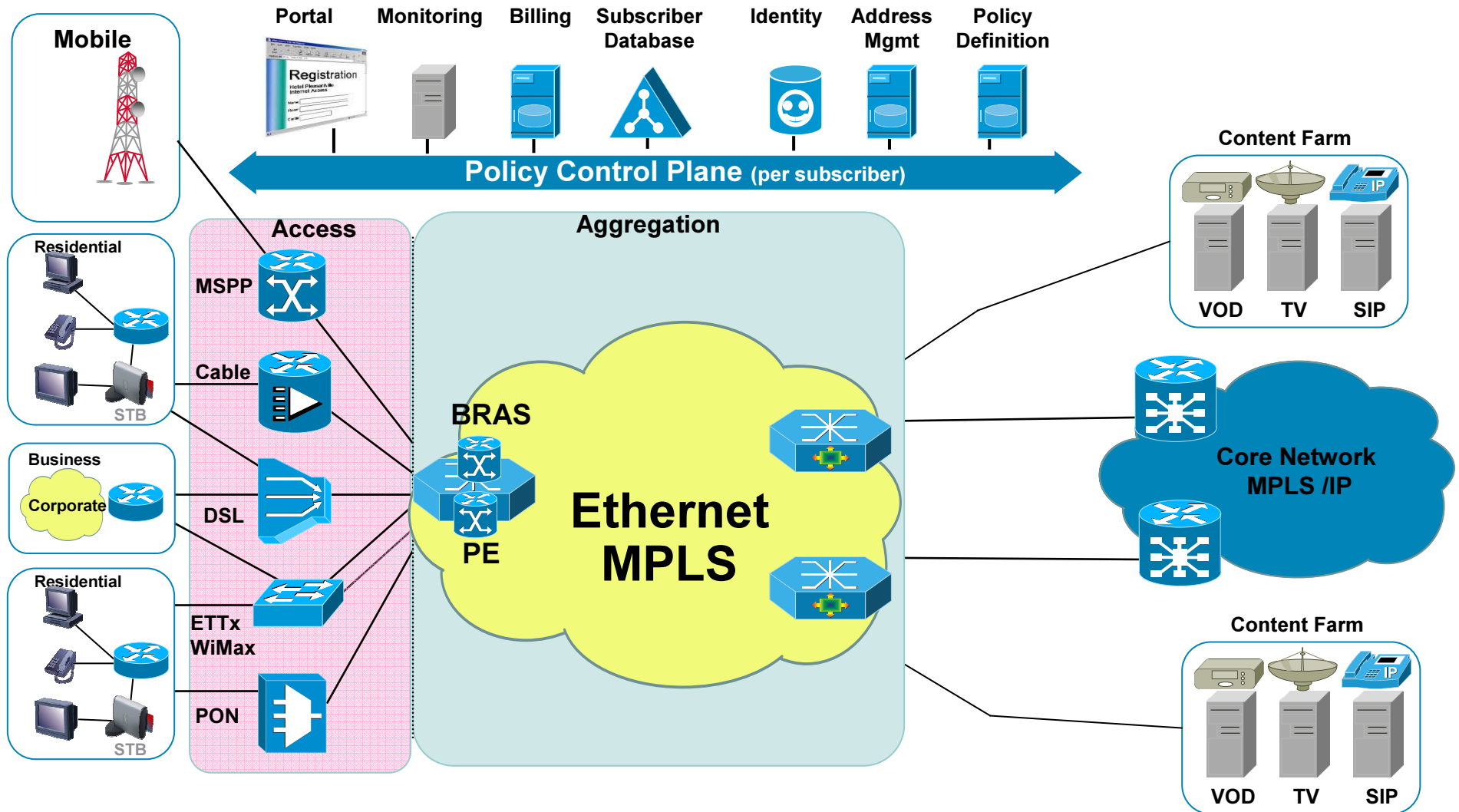
Carrier Eth 4.5 – Centralized Design



Carrier Eth 4.5 – Semi-Distributed Design



Carrier Eth 5.0 – Distributed Design





Carrier Ethernet Hardware



Cisco Carrier Ethernet Portfolio



IP/MPLS and Ethernet



CRS-1

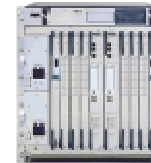


12000 / XR 12000

Cisco
7600



Cisco
10000



Cisco
72xx/73xx



ME 6524



Catalyst 3750
Metro



ME 4924



ME 3400



Integrated
Services Router



Catalyst
4500

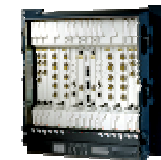


Catalyst
6500



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)



Cisco 7600 – Carrier Ethernet Router



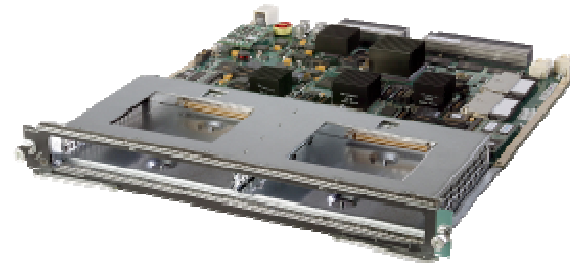
	Cisco 7603 Sup32	Cisco 7604 RSP720	Cisco 7606 RSP720	Cisco 7609 RSP720	Cisco 7613 RSP720
# of Slots	4-12	4-12	6-20	9-32	9-32
Height	4 RU	5 RU	7 RU	21 RU	18 RU
Throughput	15 Gbps	320 Gbps	480 Gbps	720 Gbps	720 Gbps
Performance	15 Mpps	100+ Mpps	200+ Mpps	400+ Mpps	400+ Mpps

Cisco 7600 – Carrier Ethernet Router



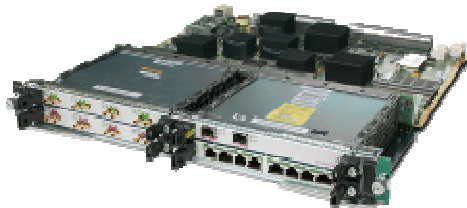
Engines

Supervisor 32
Supervisor 720
Route Switch Processor 720



Enhanced FlexWAN

7500 Parity and
PA Investment Protection



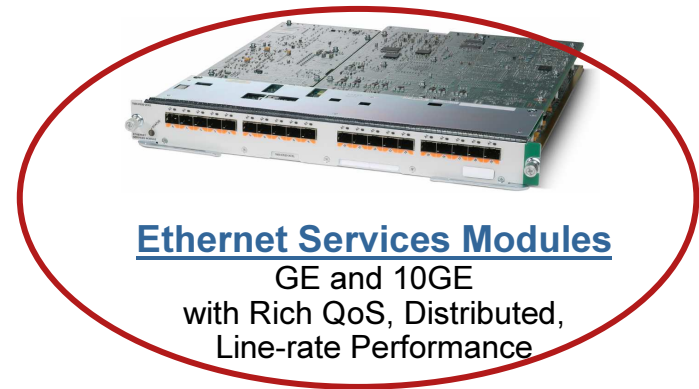
SPA Interface Processors

Modular Carrier Cards
for WAN and Metro
Shared Port Adapters



S Chassis

7613-S (future)
7609-S
7606-S
7604
7603-S



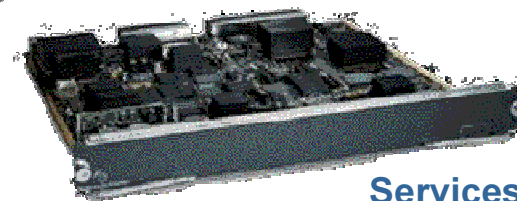
Ethernet Services Modules

GE and 10GE
with Rich QoS, Distributed,
Line-rate Performance



High-Density Ethernet Modules

High-Density GE and 10GE
with Distributed, Line-rate Performance



Services Modules

Distributed Security;
IPSEC, Firewall, IDS,
DoS Protection

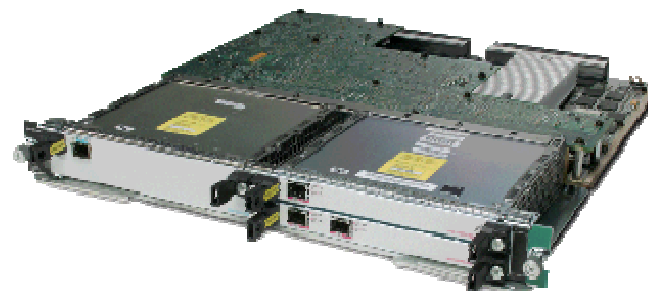
Hardware: Ethernet Service Modules

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



Carrier Ethernet Software



EVC (Ethernet Virtual Circuit) infrastructure

Convergence of Residential Quad Play + Business VPN

- **The Flexible Ethernet UNI defines a unique, virtual L2 or L3 service instance per customer**

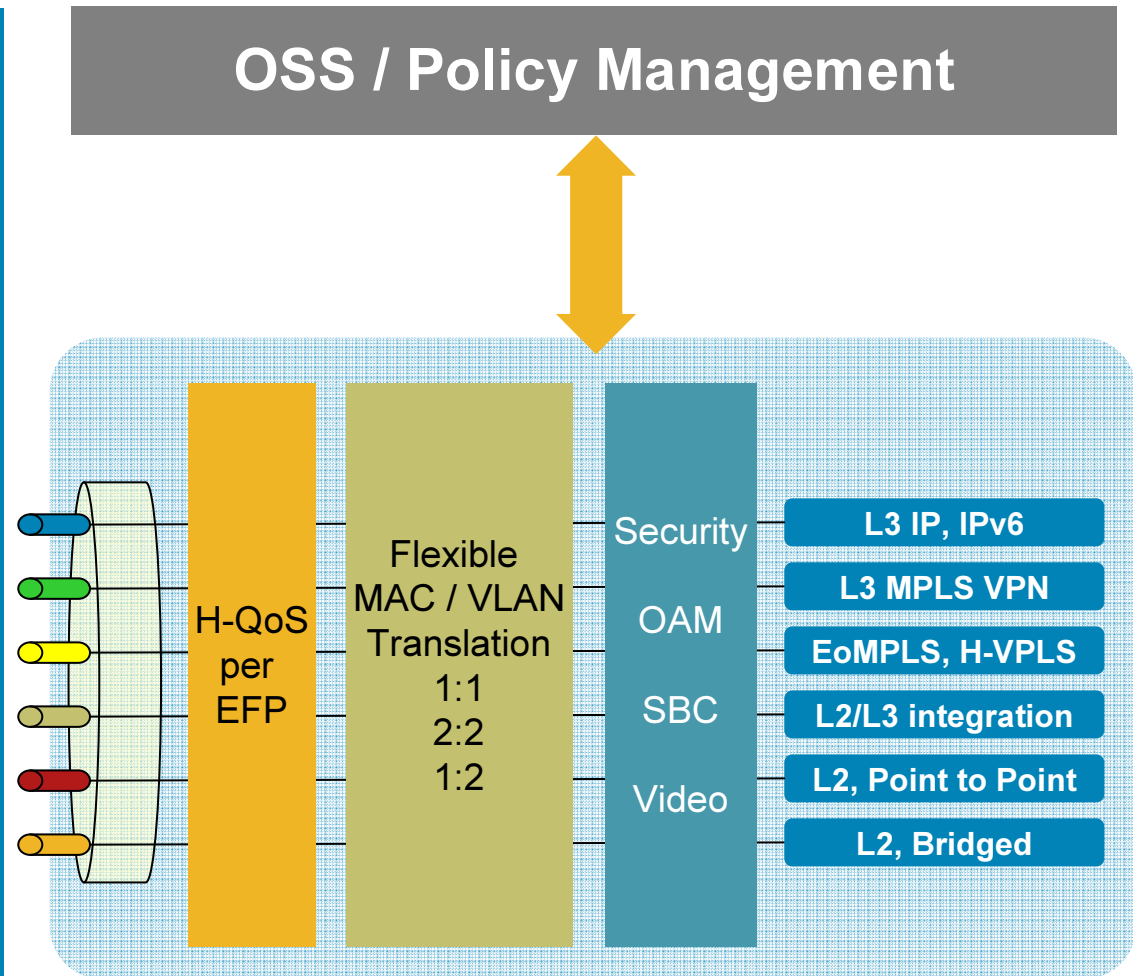
- A service instance can be a MAC address, VLAN, Q-in-Q VLAN, L2 VPLS pseudowire, IP address, or L3 MPLS VPN

- **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



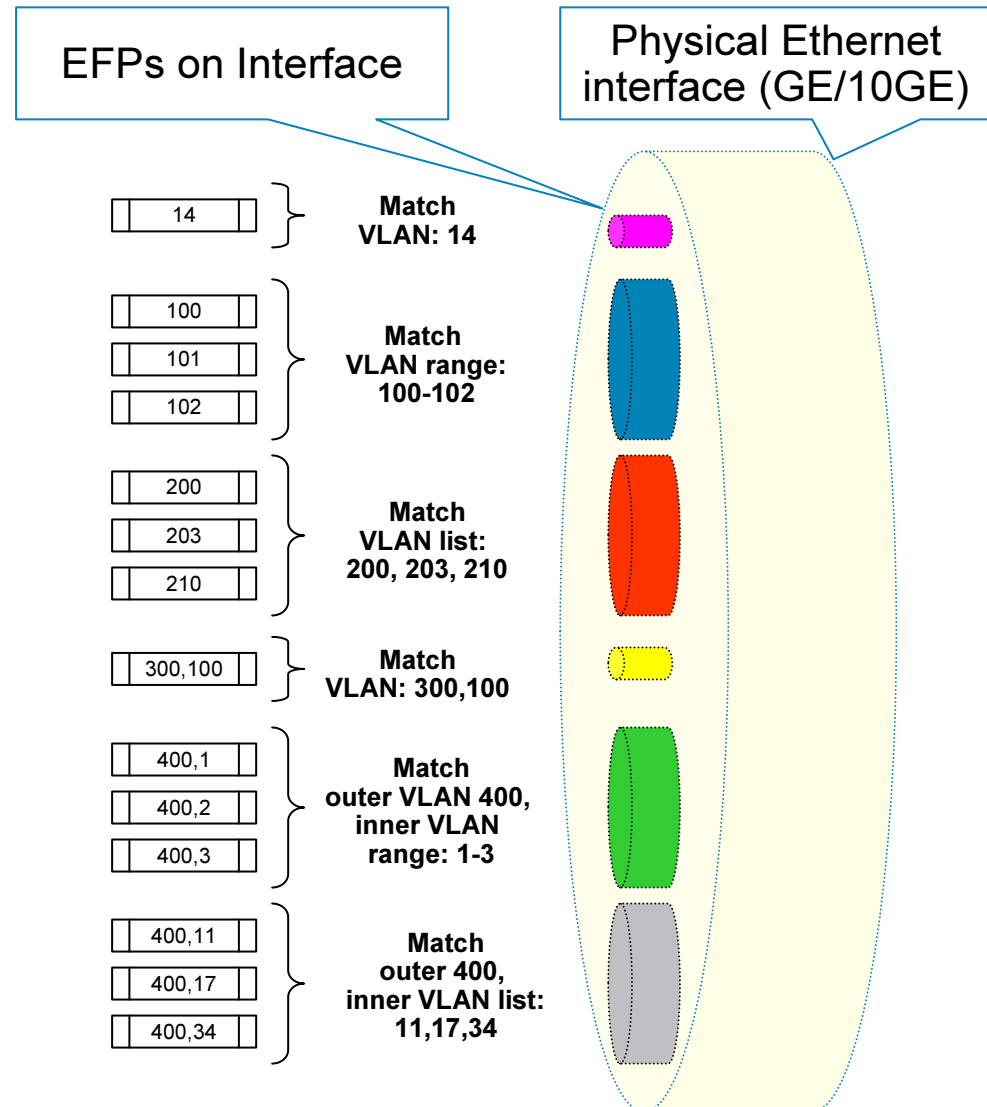
EVC UNI Flexible Frame matching

EFP (Ethernet Flow Points)



- EFPs ...

- Provide classification of L2 flows on Ethernet interfaces
- Are also referred to as EVC service-instances
- Support dot1q and Q-in-Q
- Support VLAN lists
- Support VLAN ranges
- Support VLAN Lists and Ranges combined
- Coexist with routed subinterfaces

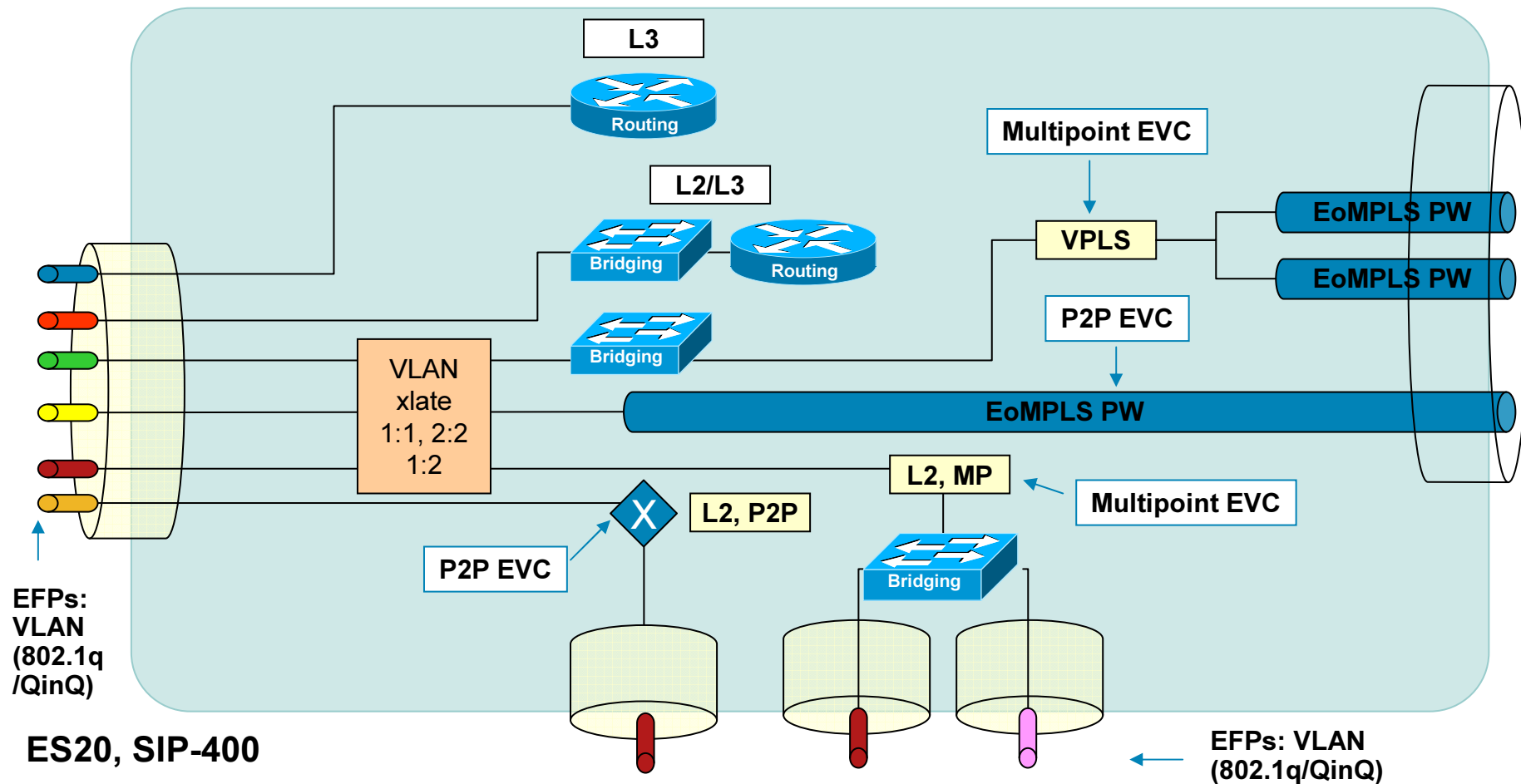


EVC Model

EVC / EFP Forwarding Model

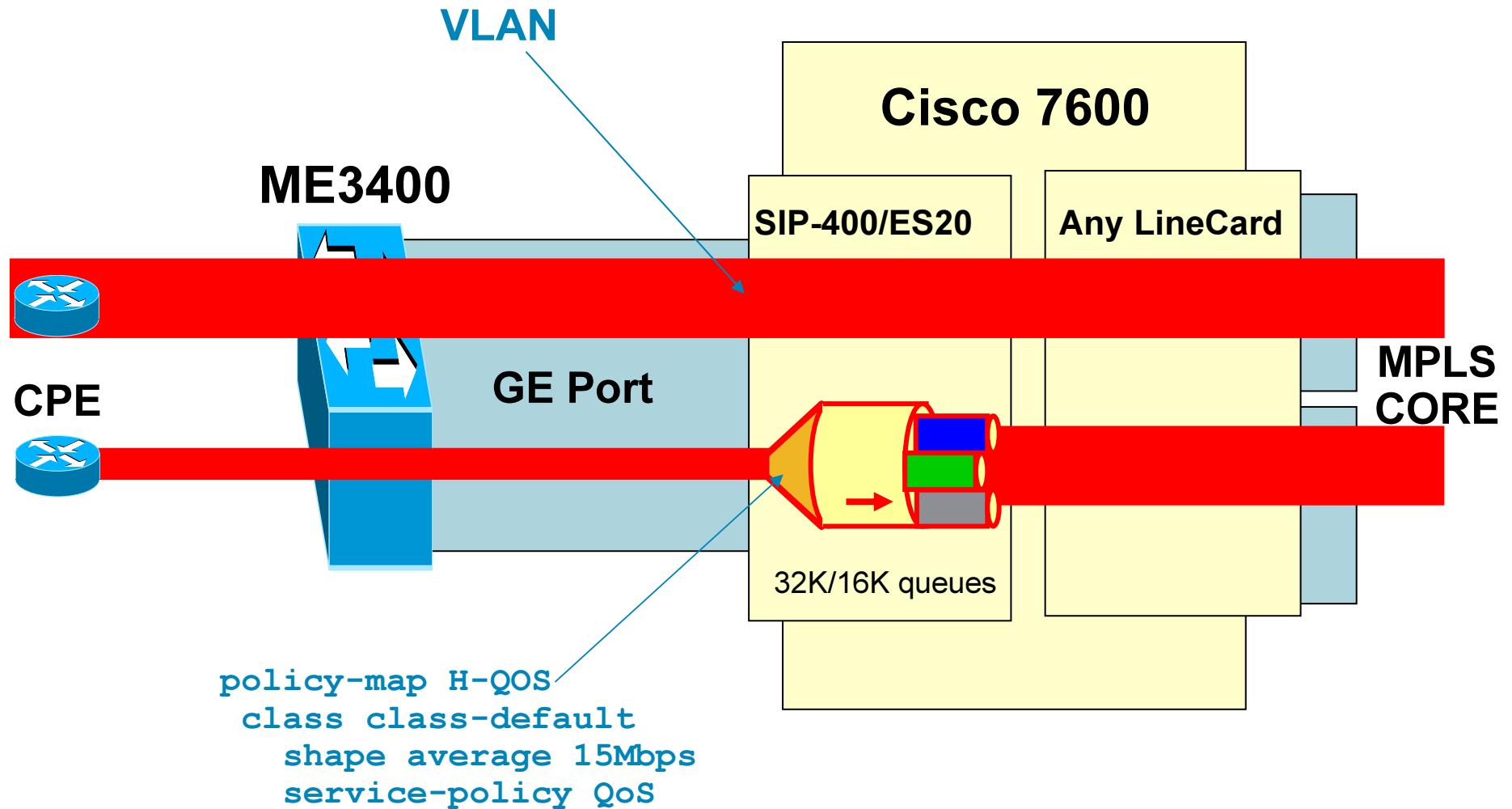
EFP – Ethernet Flow Point

EVC – Ethernet Virtual Circuit



Carrier Ethernet per-VLAN H-QoS

SIP-400/ES20 Linecards – Customer-Facing



EVC Infrastructure

IOS 12.2SR, 12.2SE, XR 3.7

Switchport or Subinterface CLI:

```
interface Gig1/1.100
```

```
encapsulation dot1q 100
```

```
ip address | vrf | xconnect
```

```
interface Gig1/1
```

```
switchport trunk allowed vlan 100
```

EVC CLI: unified software infrastructure!!!

```
interface Gig1/1/1
```

```
service instance 101 ethernet CUSTOMER-1
```

```
encapsulation dot1q 101 second 2001
```

```
rewrite ingress tag translate dot1q 101 second 2001 dot1q 102
```

```
bridge-domain 100
```

```
service-policy output H-QoS
```

```
ethernet lmi ce-vlan map 101
```

```
!
```

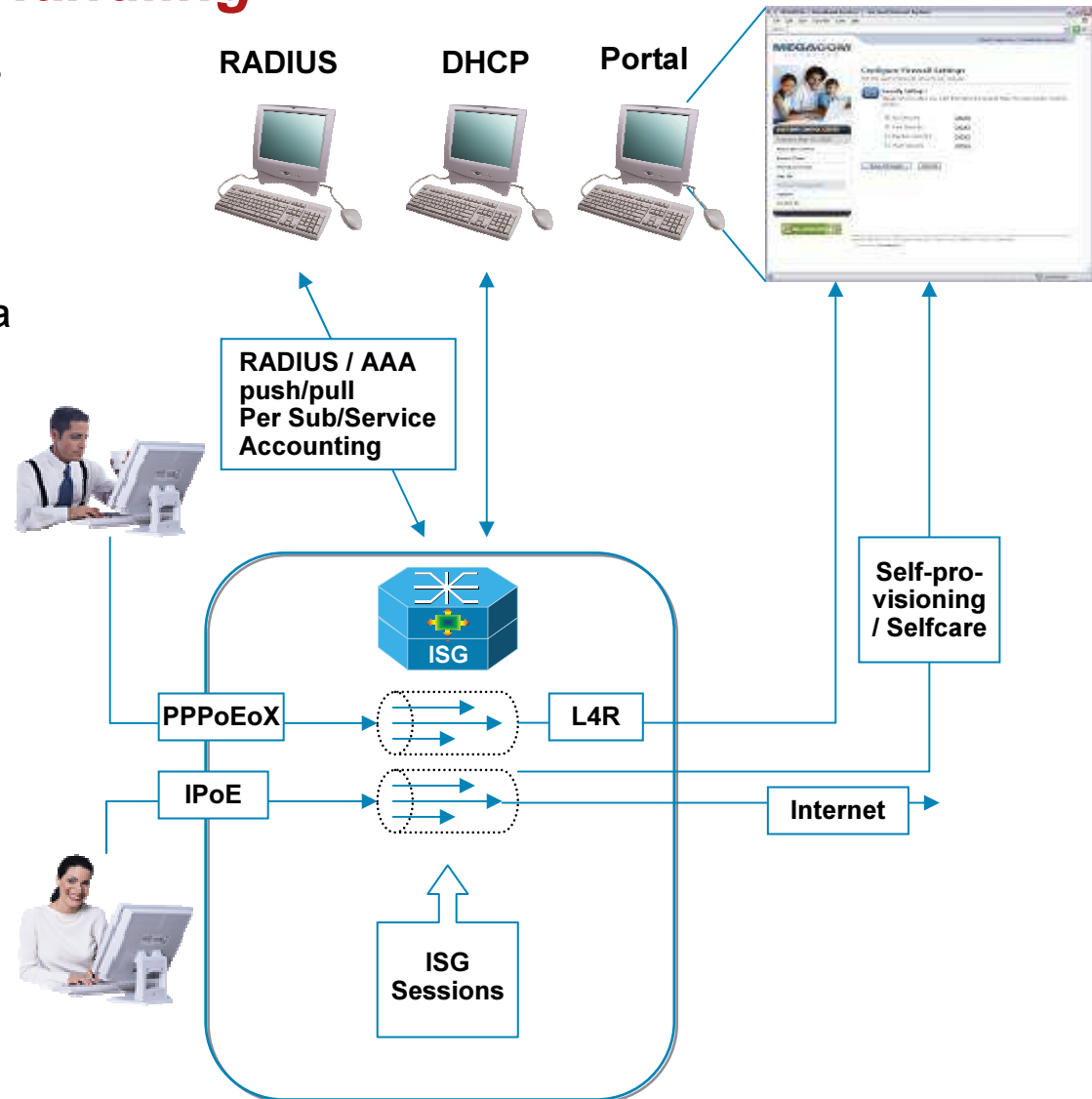
```
interface Vlan 100
```

```
ip address | vrf | vfi
```

Intelligent Services Gateway

Subscriber Session Handling

- Identifies sessions and service flows
 - Traffic classification for all access architectures
 - Session and flow provides per user granularity
- Dynamically assigns the session to a configured QOS policy (MQC) via Radius
- Establishes Virtual Route per Session
- Provides Policing, Access Control, Accounting, via Radius Push/Pull
 - Authentication
 - Logon
 - Change of Authorization (Policy Push)
 - L4 re-direction
 - Accounting details
- Limitations of SSG are removed
 - E.g. mapping traffic to VRF, various routing tables



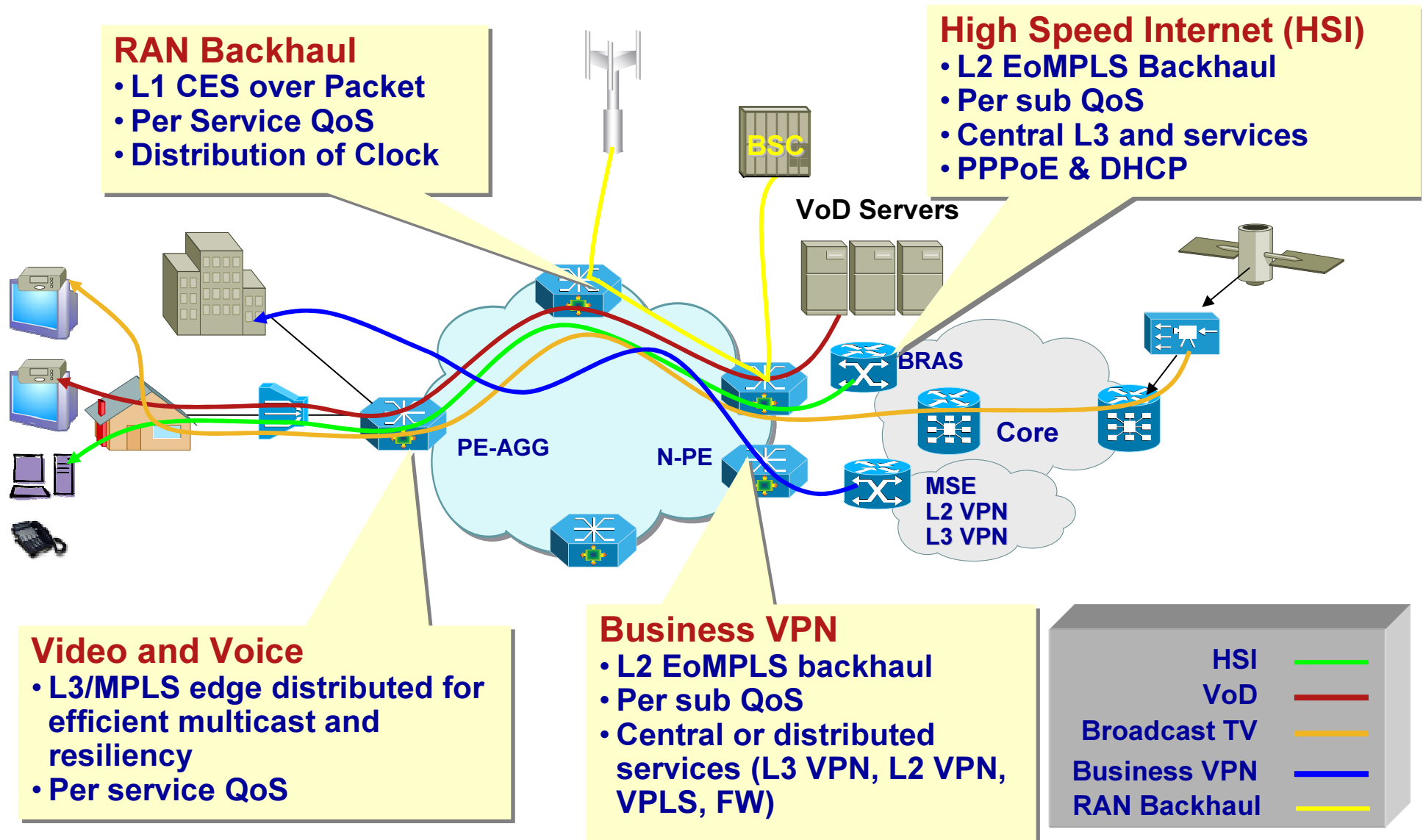


Carrier Ethernet Services

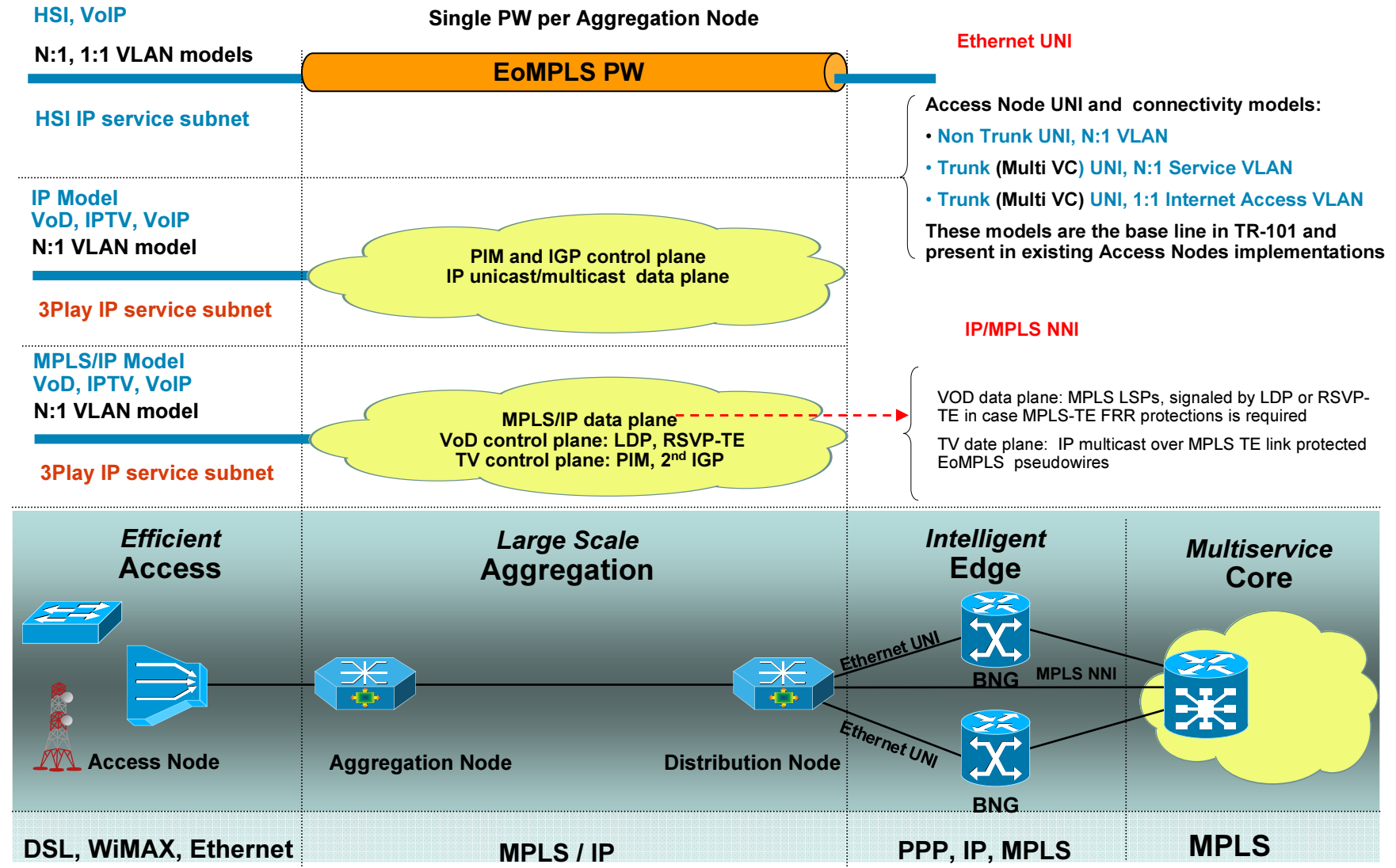


From Design Principles to Implementation

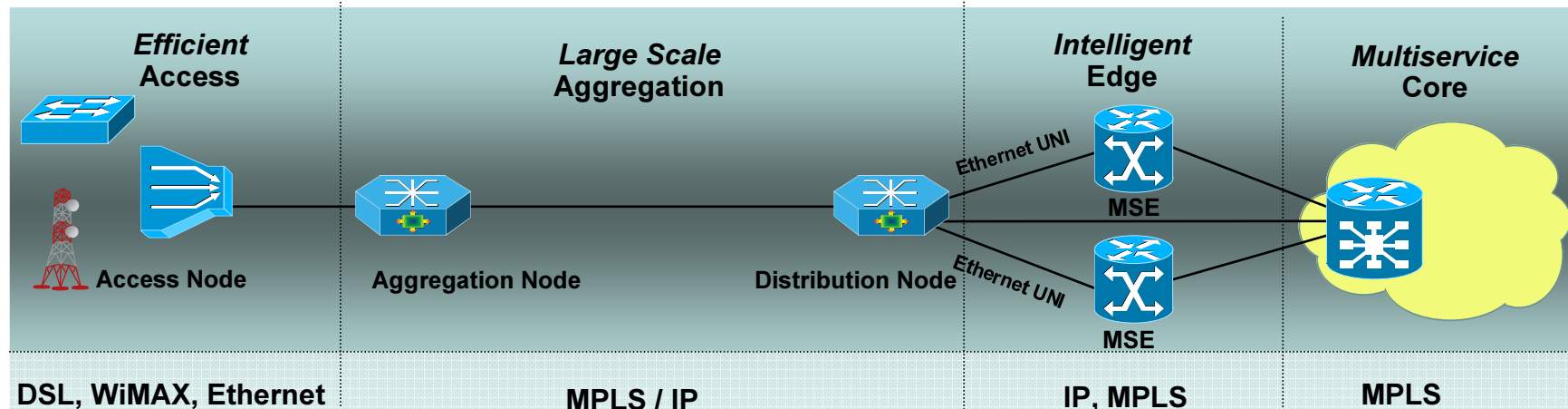
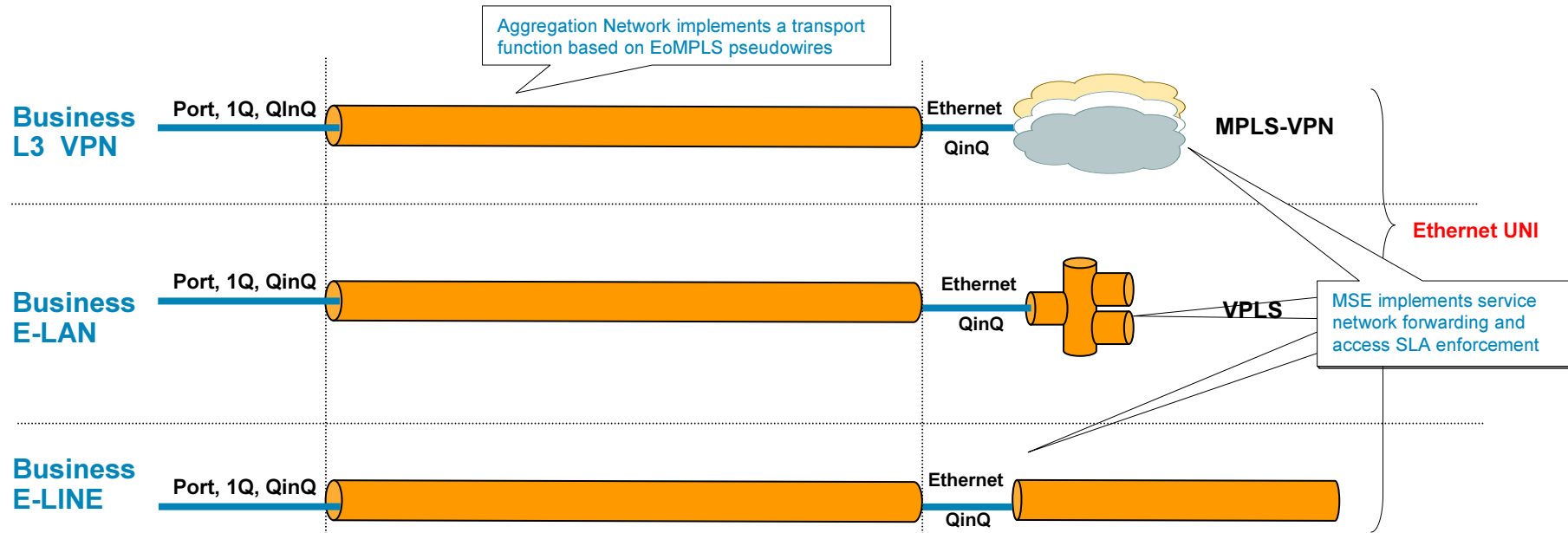
One Carrier Ethernet Design



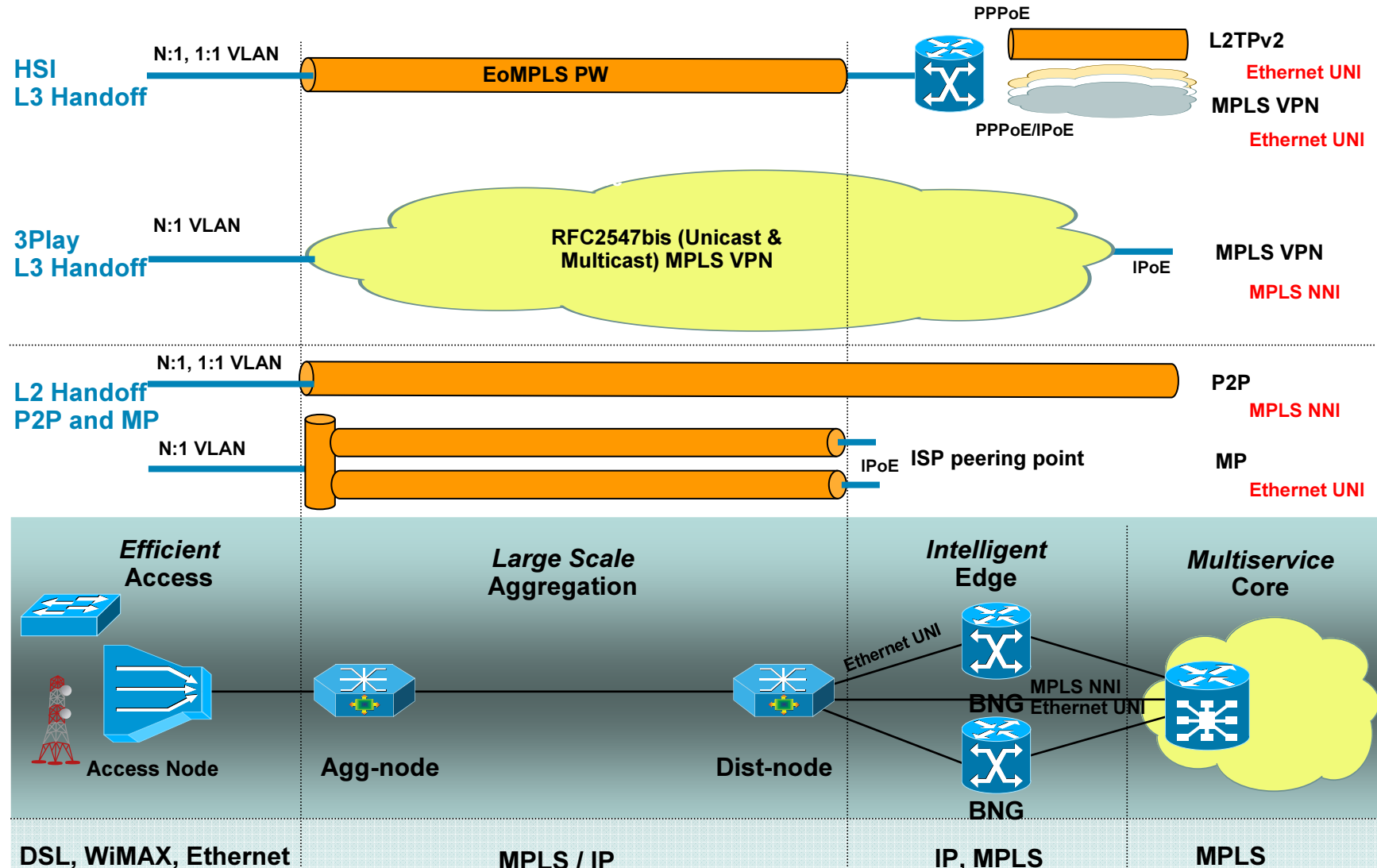
Retail Residential Services



MSE Service Edge Business Ethernet Services



Wholesale Services Deployments





Network Management



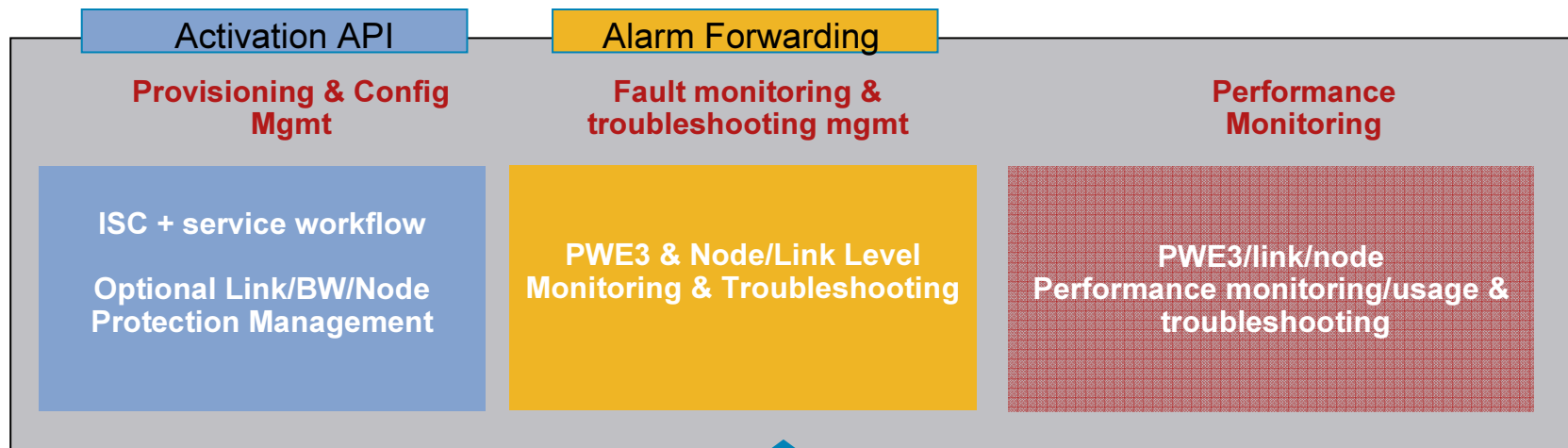
Slide 26

JGD45

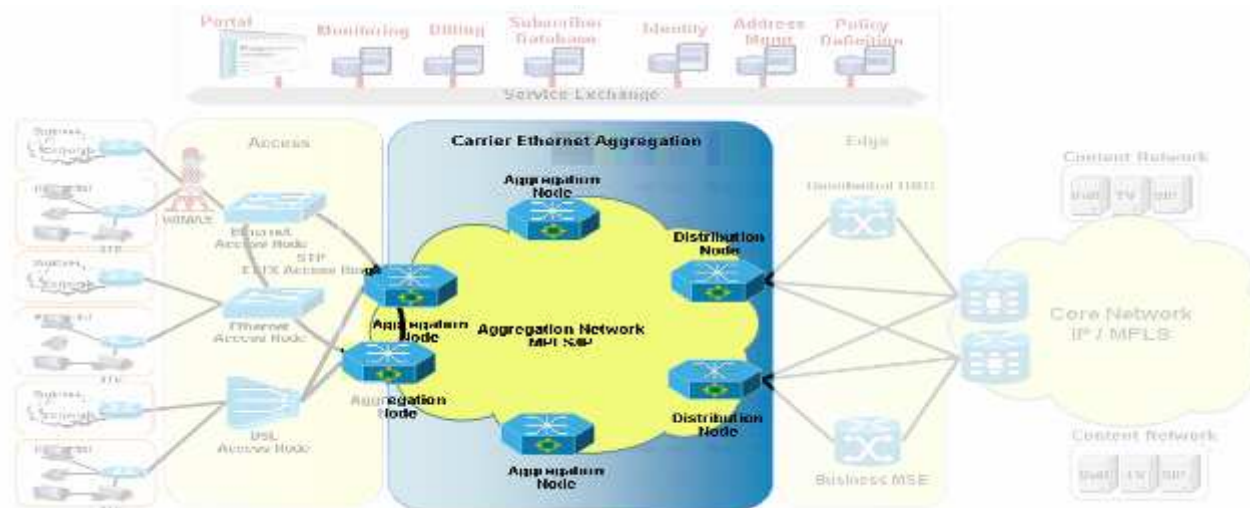
I agree with Andrew's comments on this section. Make system testing a separate section, and split QoS and High Availability into separate sections. Add a section on security would be a nice addition; I have some slides used to talk with BT that I will forward along as well.

Jason Dachtler; 6.6.2007

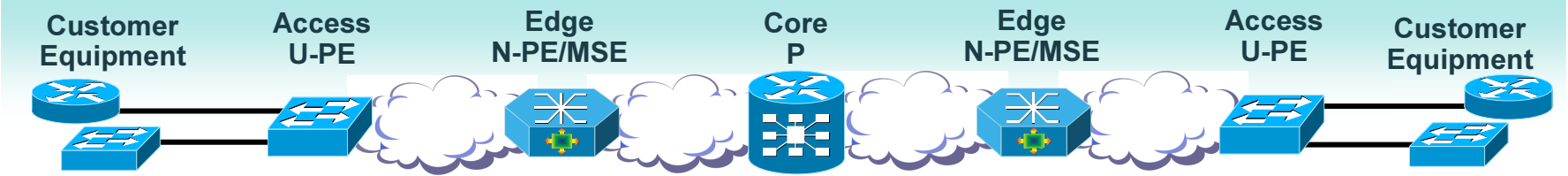
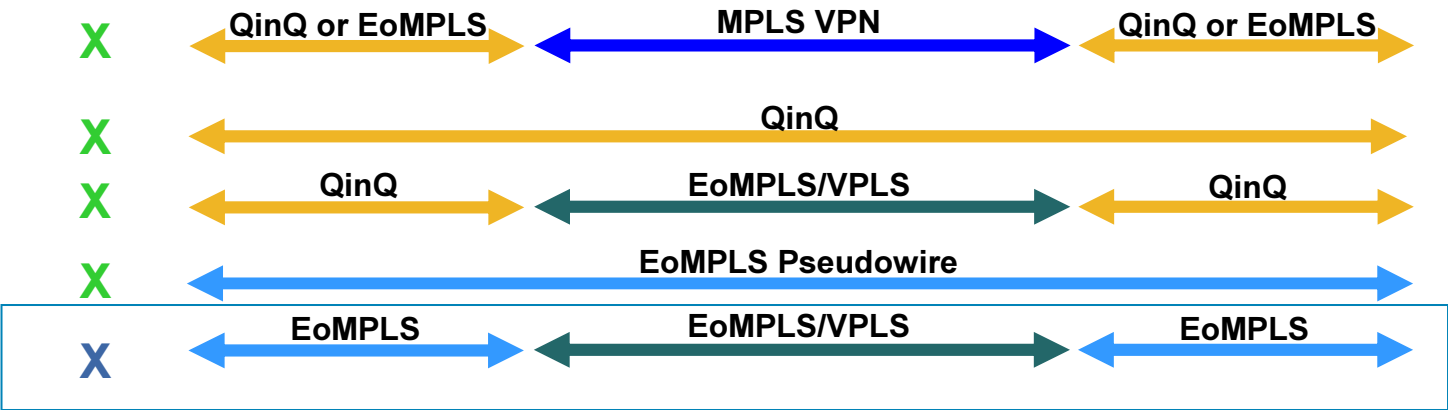
CEMS (Carrier Ethernet Management System)



- ISC + Workflow Engine
- ANA
- Infovista



Service Scenarios Support in ANA



X – ANA 3.6.1

X - Target for ANA 3.6.2



High Availability



Baseline Network Availability Mechanism

IP Services:

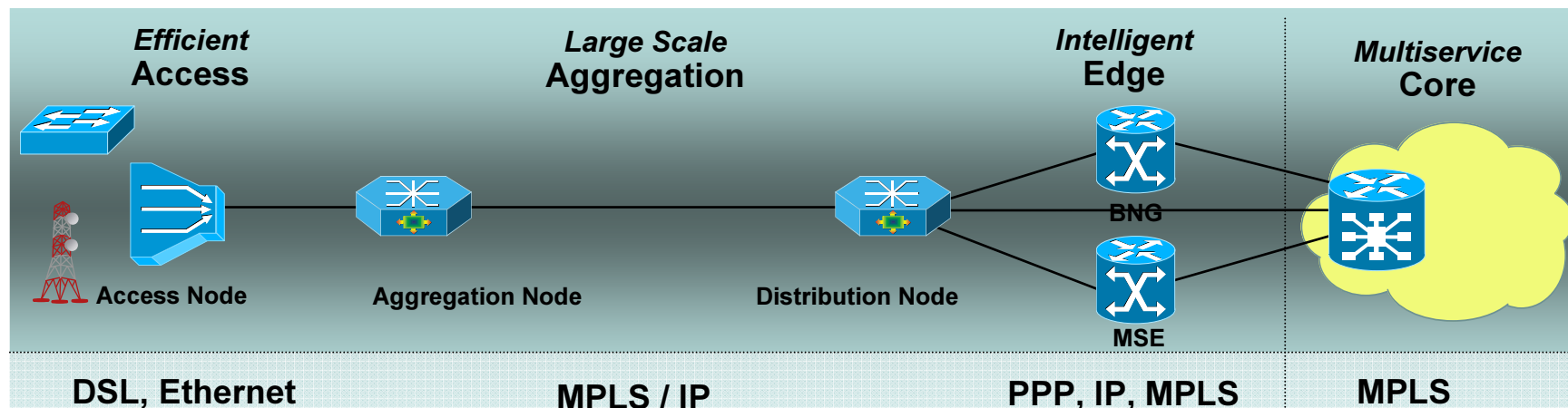
- Fast IGP/BFD convergence
- Multicast Fast Convergence

MPLS Services:

- Pseudowire redundancy
- MPLS TE-FRR Link and Node protection with IP services, PW/VPLS PW tunnel selection

MPLS/IP Services use a combination of MPLS TE-FRR and fast IGP/PIM convergence

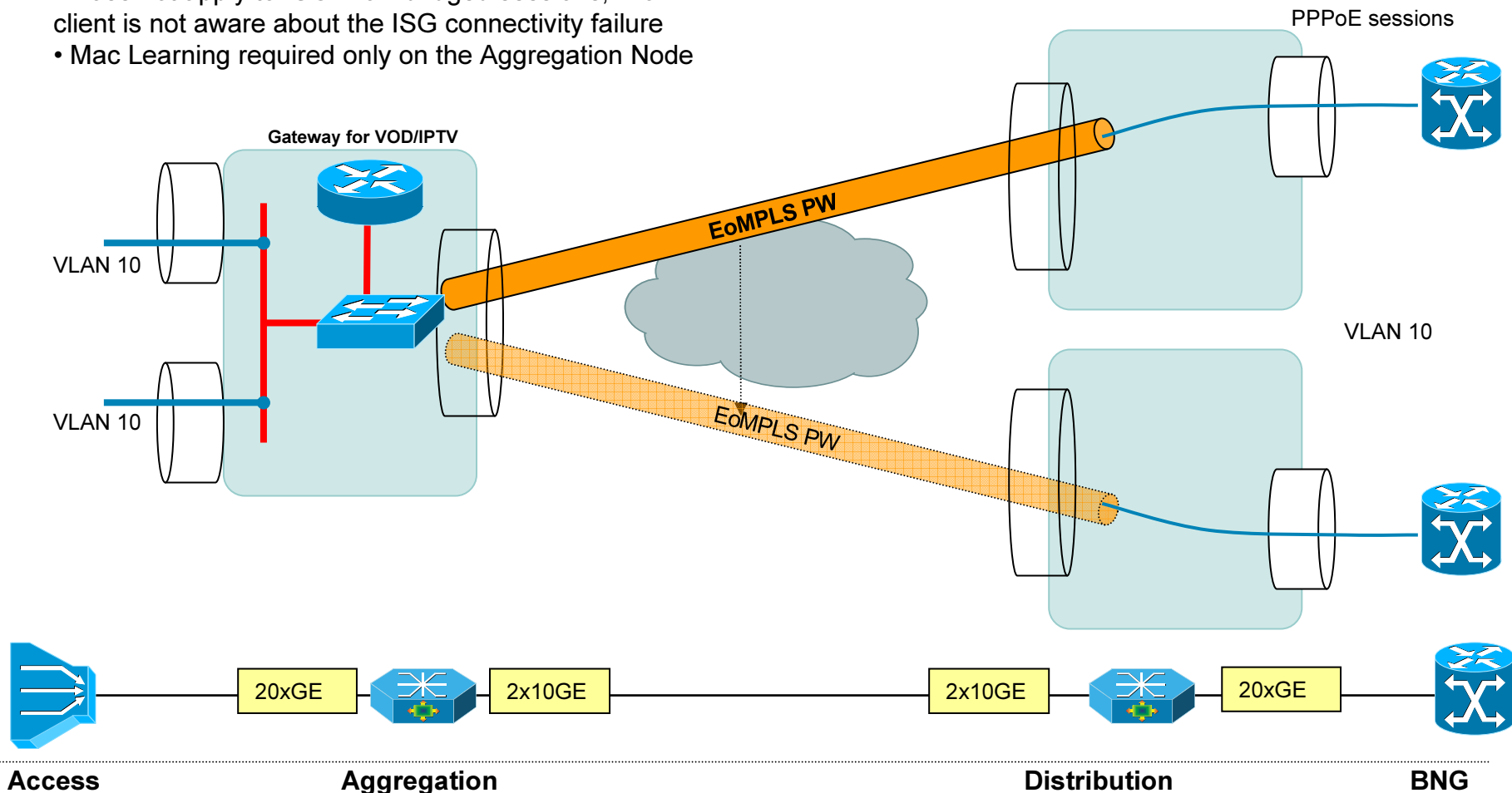
Note: Diffserv-RSVP for VoD CAC and RSVP-TE for MPLS FRR are mutually exclusive



Active/Backup Aggregation Node Redundancy

- Active/Standby redundancy
- Uses EoMPLS PW redundancy
- PPPoE sessions will re-establish on backup BNG
- Does not apply to ISG IPoE bridged sessions; IPoE client is not aware about the ISG connectivity failure
- Mac Learning required only on the Aggregation Node

This network availability model does not apply to the business L3 VPN, E-Line/E-LAN and wholesale service aggregation models



Active/Backup Access Node Redundancy

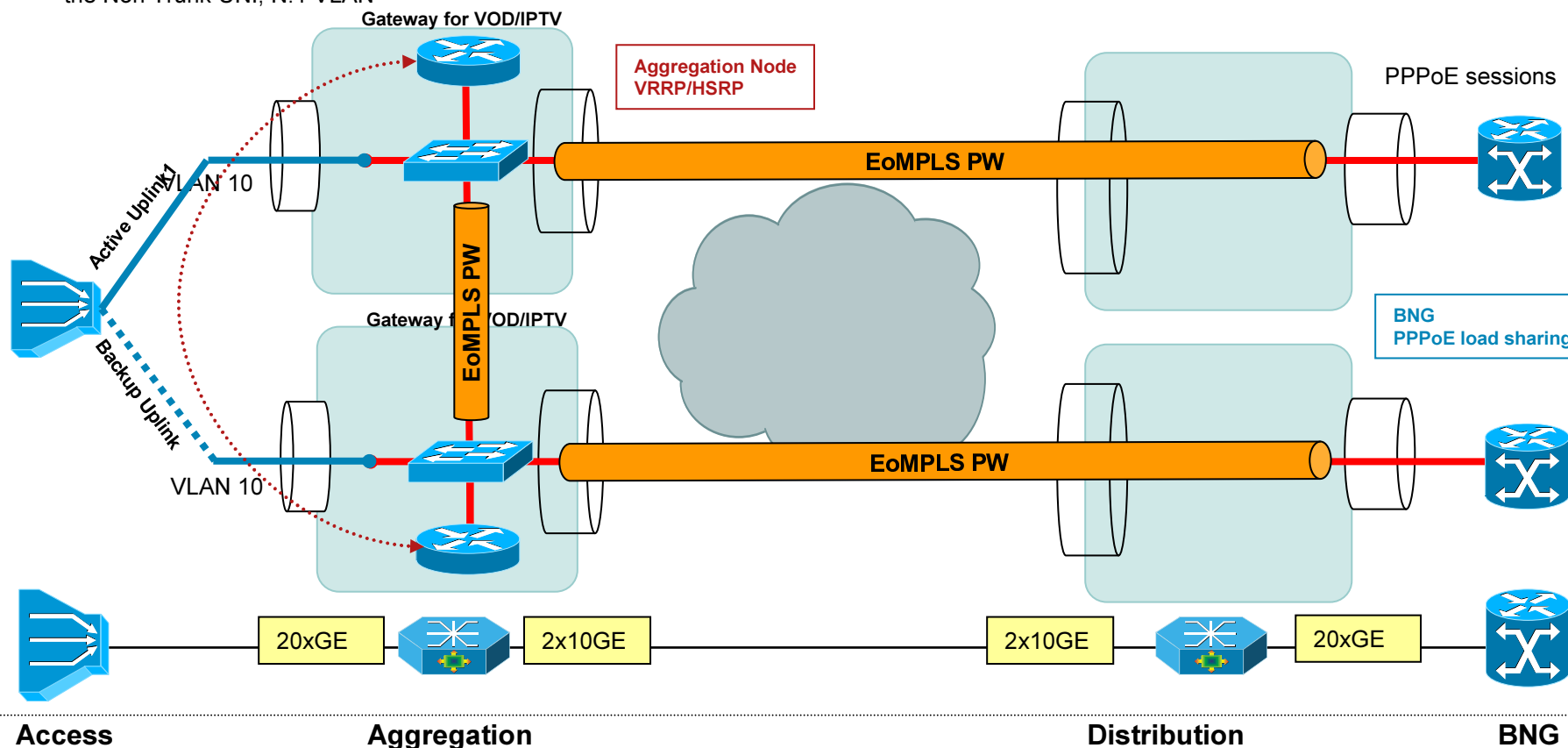
Aggregation Node

- Active/Backup Access Node redundancy
- This network availability model applies to all Residential service aggregation models proposed by the system with two restrictions:
 - One pseudowire required per Access Node
 - IP numbered used for TV/VOD SVIs in the Aggregation Nodes
- Aggregation Nodes TV/VOD SVIs run VRRP/HSRP; The example shows the Non Trunk UNI, N:1 VLAN

BNG

- ISG PPPoE sessions are load shared across BNGs
 - PPPoE sessions affected will reestablish
- The model does not apply to ISG IPoE sessions.

This network availability model does not apply to the business L3 VPN, E-Line/E-LAN and wholesale service aggregation models



ETTH/WiMAX Access Rings Redundancy

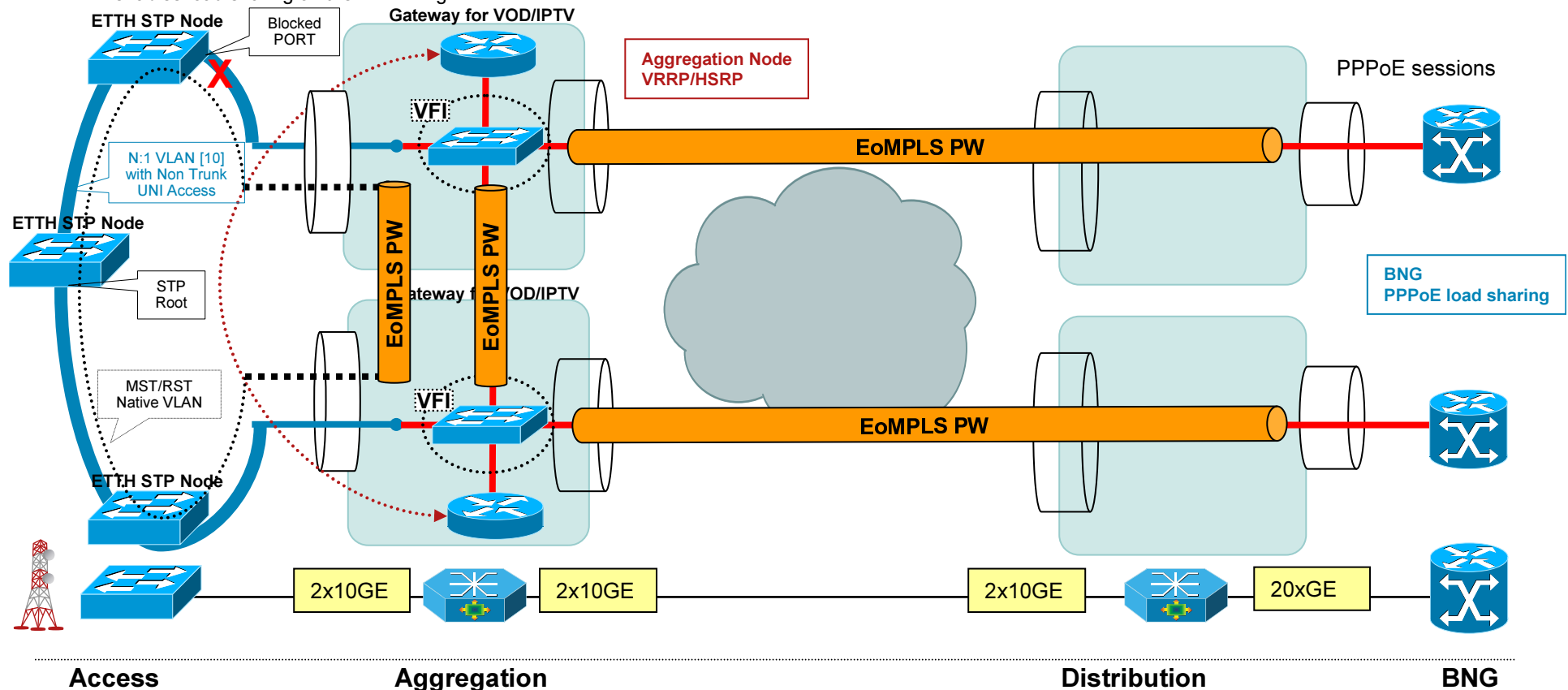
Aggregation Nodes

- Aggregate ETTH STP access wings
- This network availability model applies to all Residential service aggregation models proposed by the system with two restrictions:
 - One pseudowire required per Access Node or Access Ring
 - IP numbered used for TV/VOD SVIs in the Aggregation Nodes
- Aggregation Nodes TV/VOD SVIs run VRRP/HSRP over the local PW; The Aggregation Nodes tunnel MST BPDUs and close the ring with EoMPLS PWs; MST enables load sharing on the ETTH ring

BNG

- ISG PPPoE sessions are load shared across BNGs
 - PPPoE sessions affected will reestablish
- This model does not apply to ISG IPoE sessions.

The model may be applied to DSLAMs connected Hub and spoke or Rings



MPLS/IP TV Broadcast Service High Availability

PIM SSM (Source Specific Multicast)



2nd IGP, PIM-SSM routing



EoMPLS pseudowire (following the physical topology) for each physical link., MPLS TE-FRR for link protection



SVI with EoMPLS PW x connect + PIM SSM



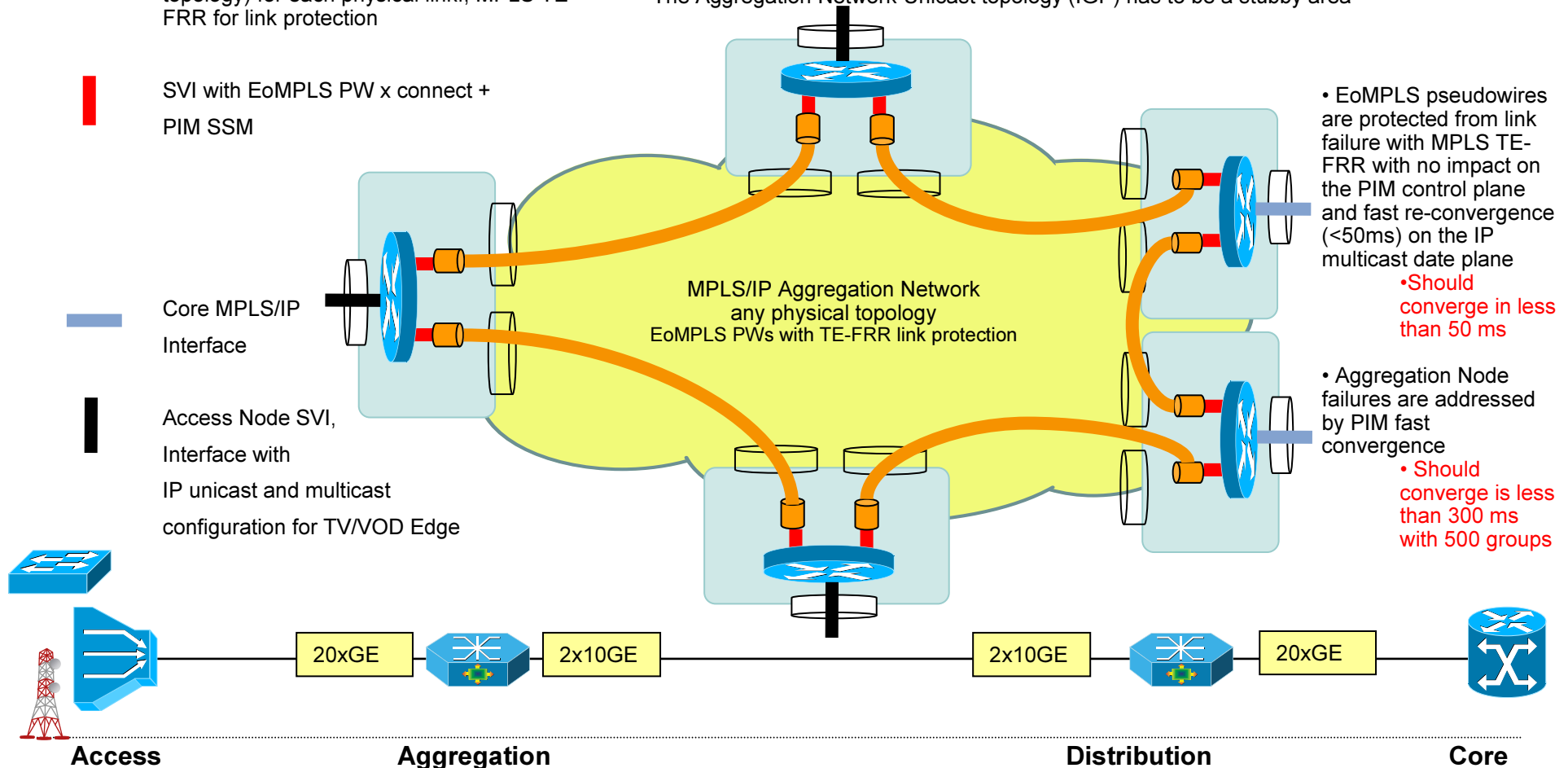
Core MPLS/IP Interface



Access Node SVI, Interface with IP unicast and multicast configuration for TV/VOD Edge

Two routing topologies based on MTR (or two IGP processes)

- UNICAST topology, configured over the physical topology interfaces
- MULTICAST topology, configured over the pseudowire topology interfaces (SVIs)
- The Distribution Nodes have to redistribute the multicast source networks from the UNICAST topology to the MULTICAST topology and the RED SVIs networks in the opposite direction. The Aggregation Network Unicast topology (IGP) has to be a stubby area



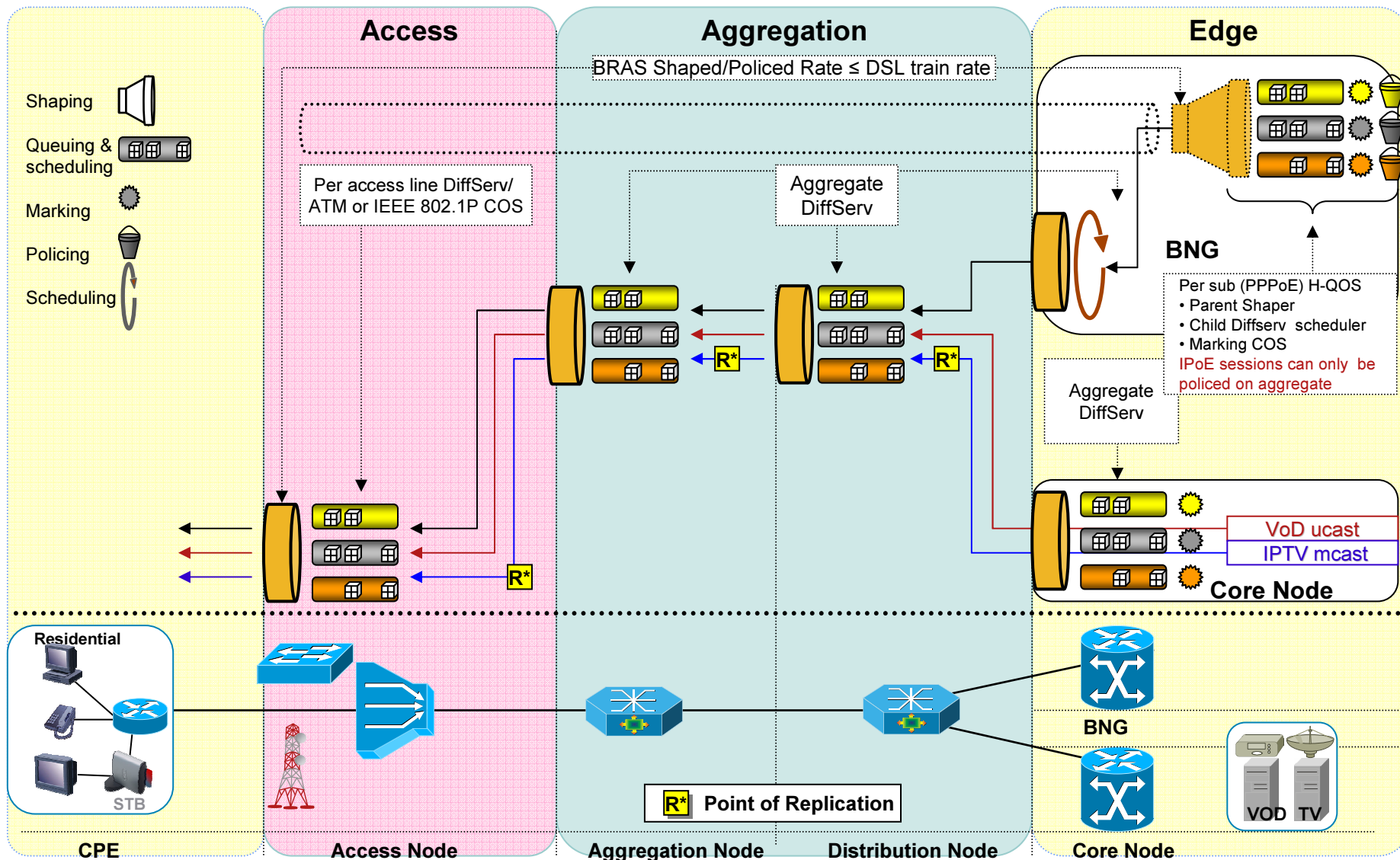


Quality of Service



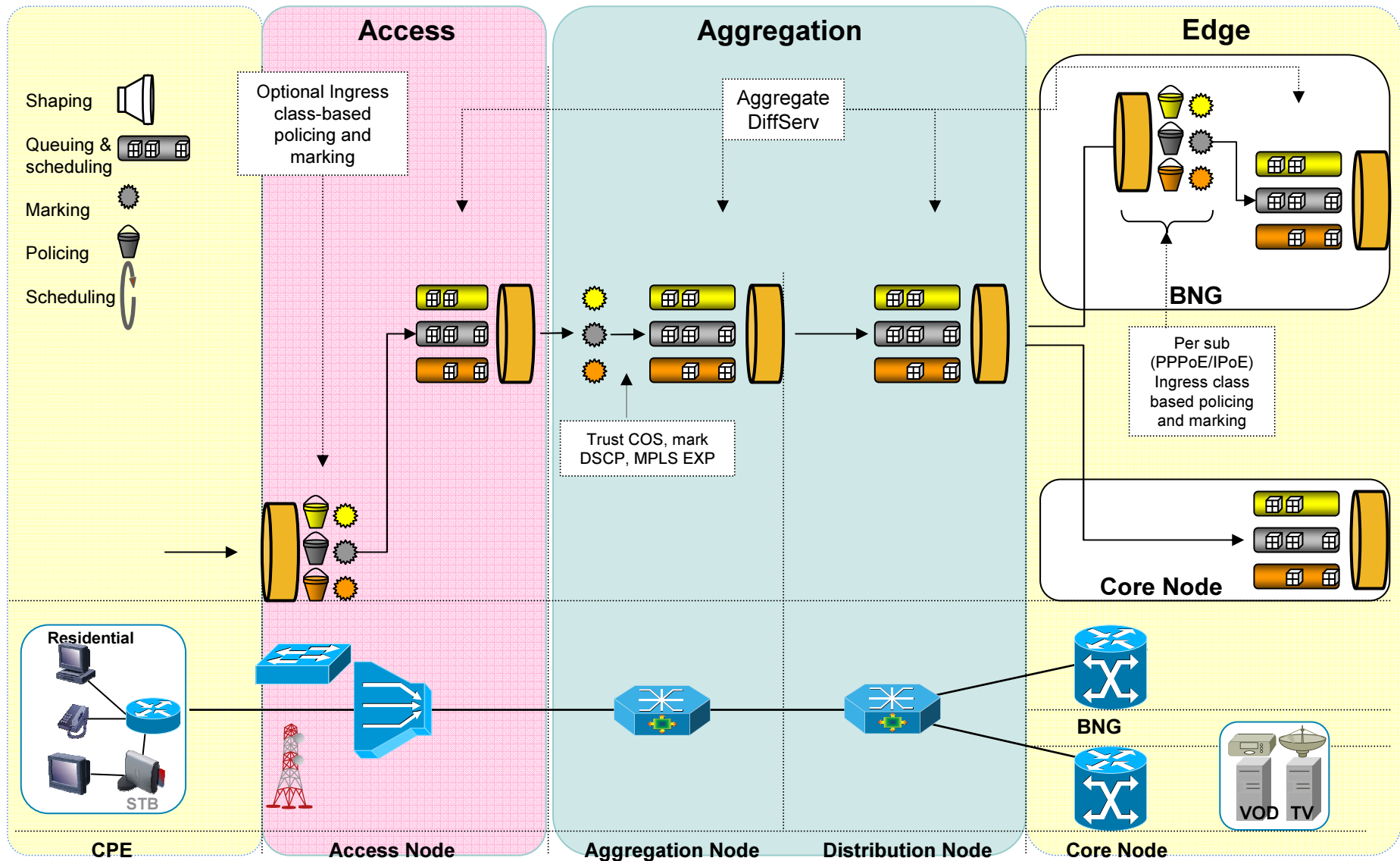
QOS Model - Downstream

Centralized Triple-Play and Business Services



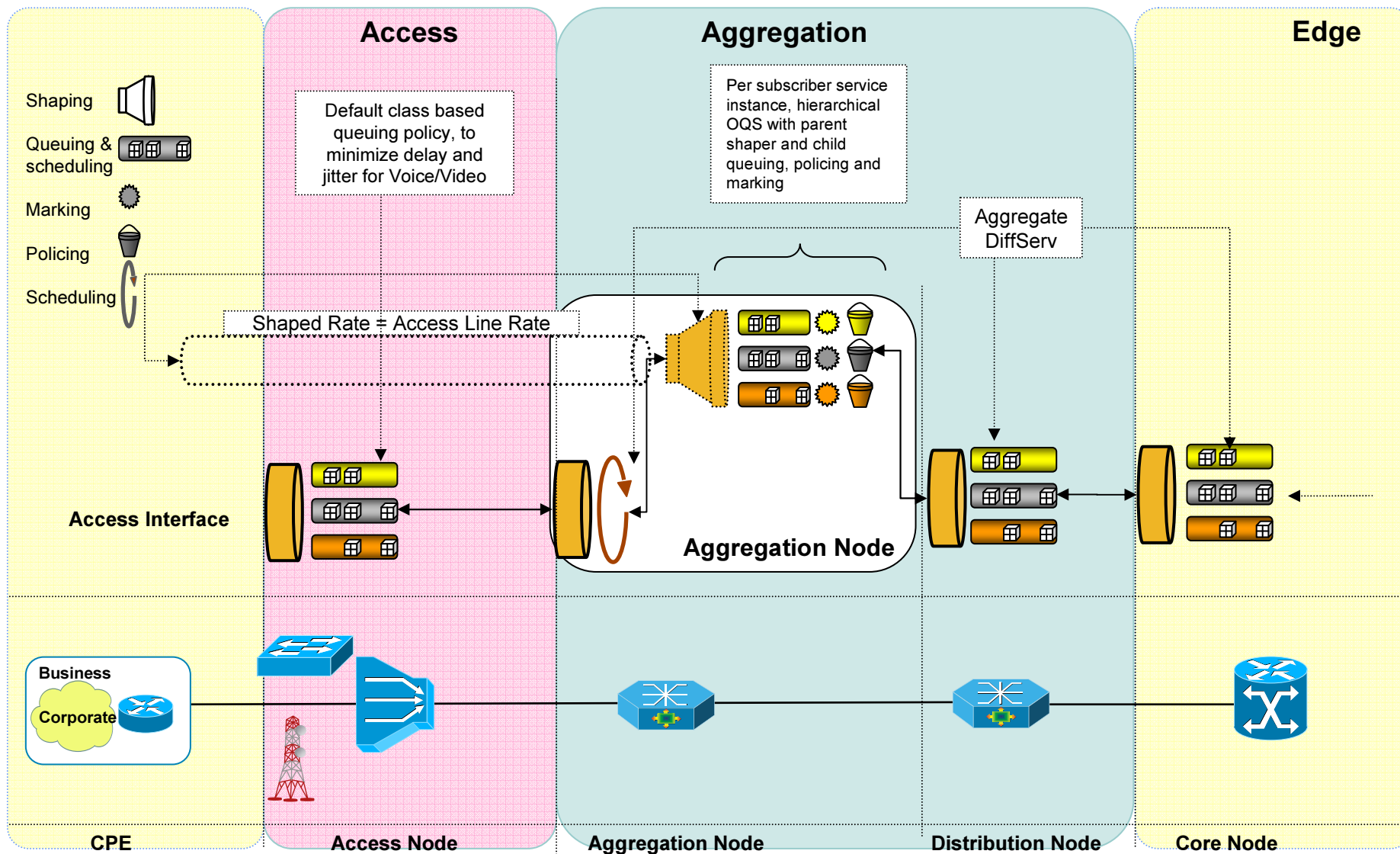
QOS Model - Upstream

Centralized Triple-Play and Business Services



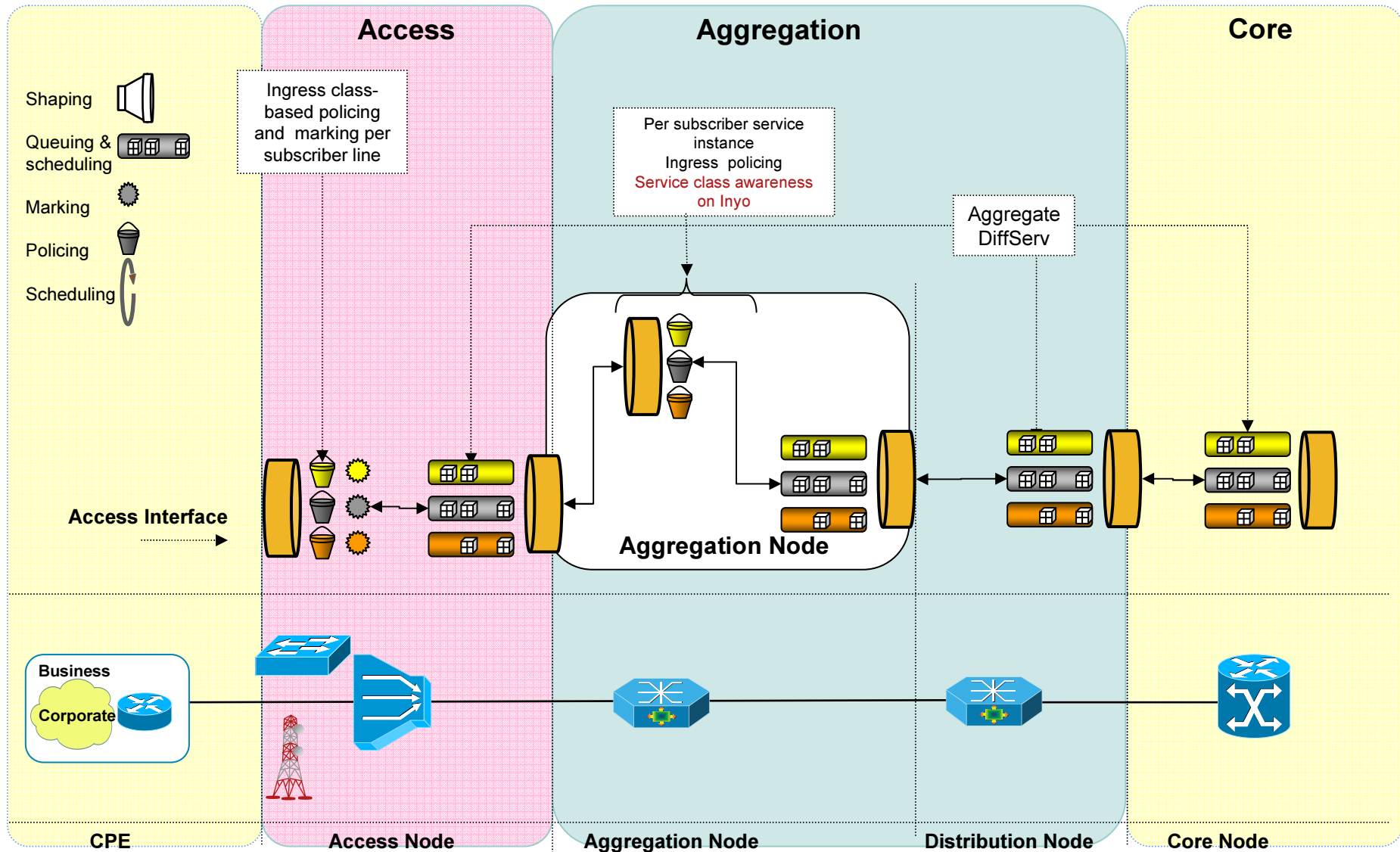
QOS Model - Downstream

Distributed Business L2/L3 VPN Services



QOS Model - Upstream

Distributed Business L2/L3 VPN Services

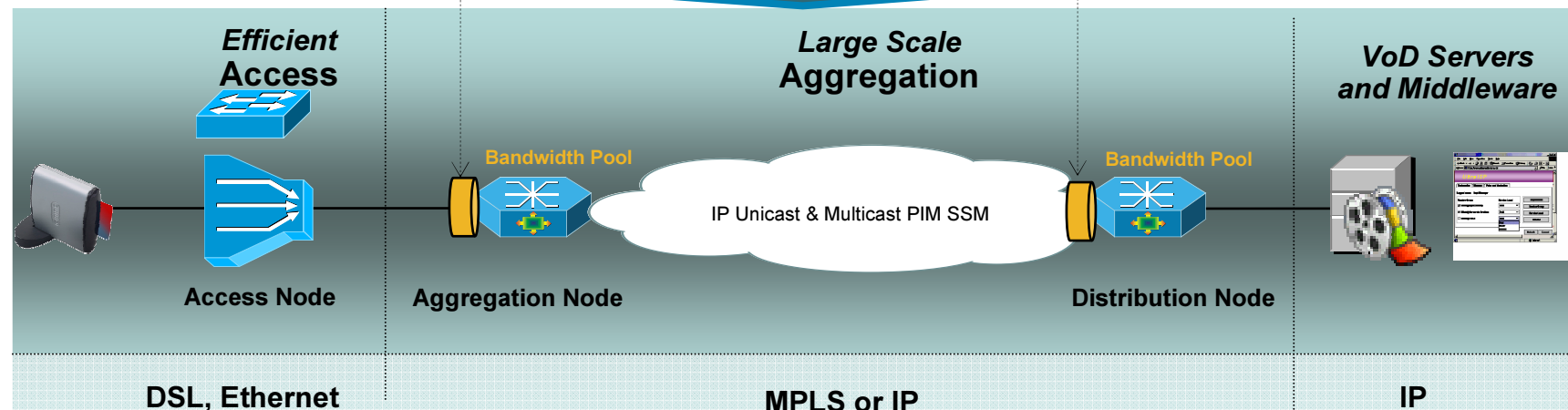
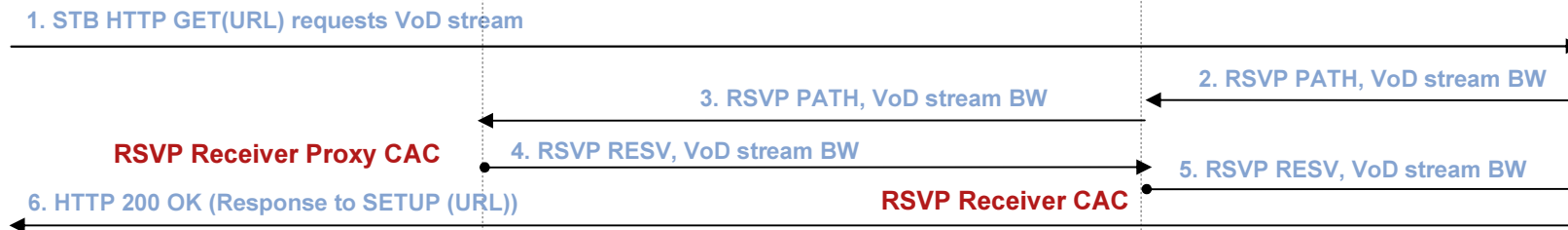


Differentiated Services QOS Domain

Traffic Class	Core /Edge/ Aggregation			Access	UNI		
	MPLS/IP			Ethernet	DSL, ETTX	DSL	WIMAX
	PHB	DSCP	MPLS EXP	802.1P	802.1P	ATM	802.16
Control Protocols Network Management	AF	48	6	(6)	(6)	VBR-nrt	nrtPS
Residential Voice	EF	46	5	5 and 7	5 or 7	VBR-rt	rtPS
Business Real-time	EF	56	7				
Residential TV and VoD	AF	32	4	4 and 3	4	VBR-nrt	NA
Residential D-Server Video	AF	24	3				
Business Critical In Contract	AF	16	2	2 and 1	2	VBR-nrt	nrtPS
Business Critical Out of Contract		8	1		1		
Residential HSI Business Best Effort	BE	0	0	0	0	UBR	Best Effort

VoD CAC (Call/Stream Admission Control) Aggregation Network Diffserv RSVP

Aggregation Node	Distribution Node
<pre> Interface VLAN 10 !DSLAM trunk, 250Mb allocated for VoD; stream 4Mb ip rsvp bandwidth 250000 4000 ip rsvp listener outbound reply ip rsvp data-packet classification none </pre>	<pre> Interface GigabitEthernet 1/0/1.1 !Aggregation Trunk, 10Gb allocated for VoD; stream 4Mb ip rsvp bandwidth 10000000 4000 ip rsvp data-packet classification none </pre>

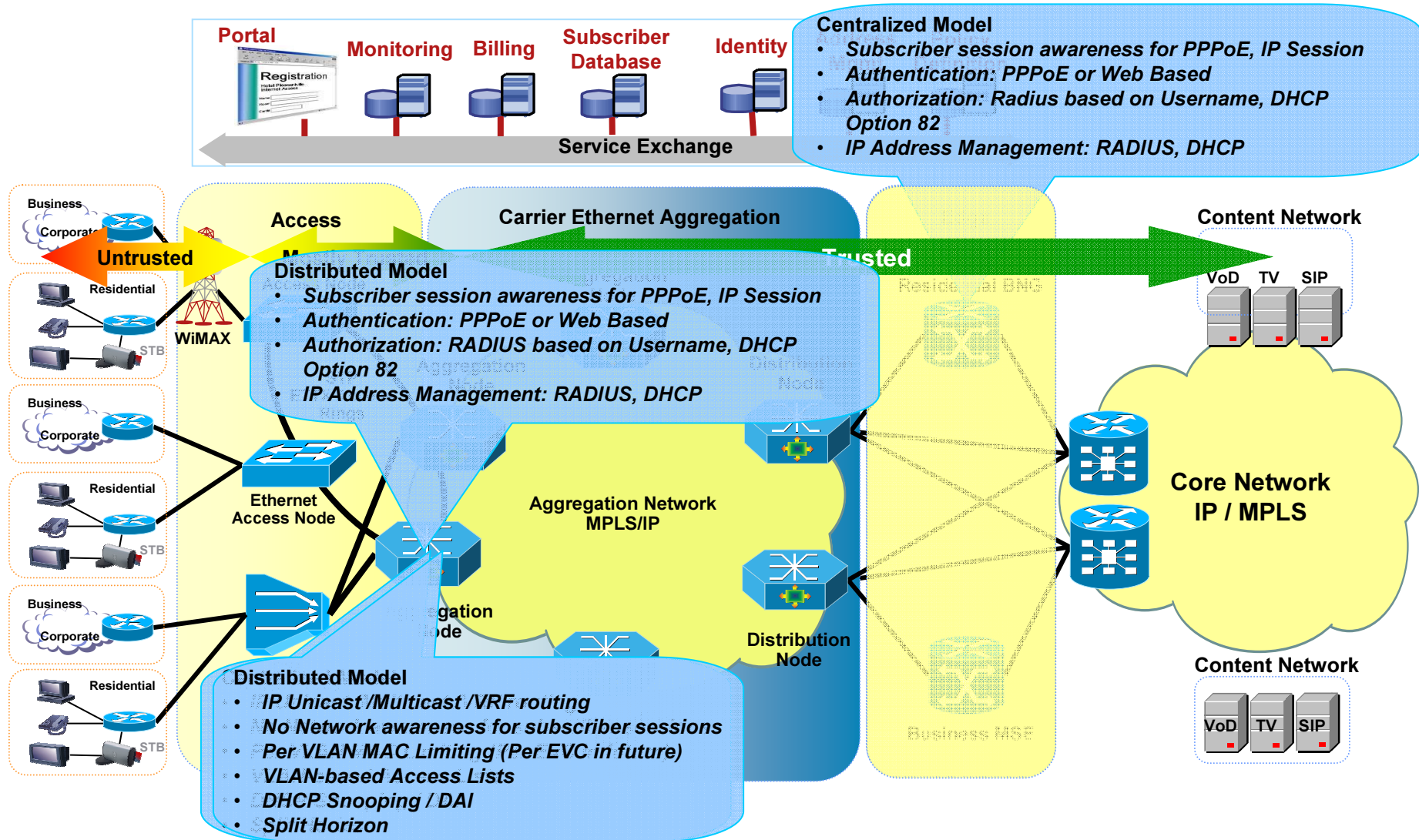




Security Considerations



Carrier Ethernet – Security Model



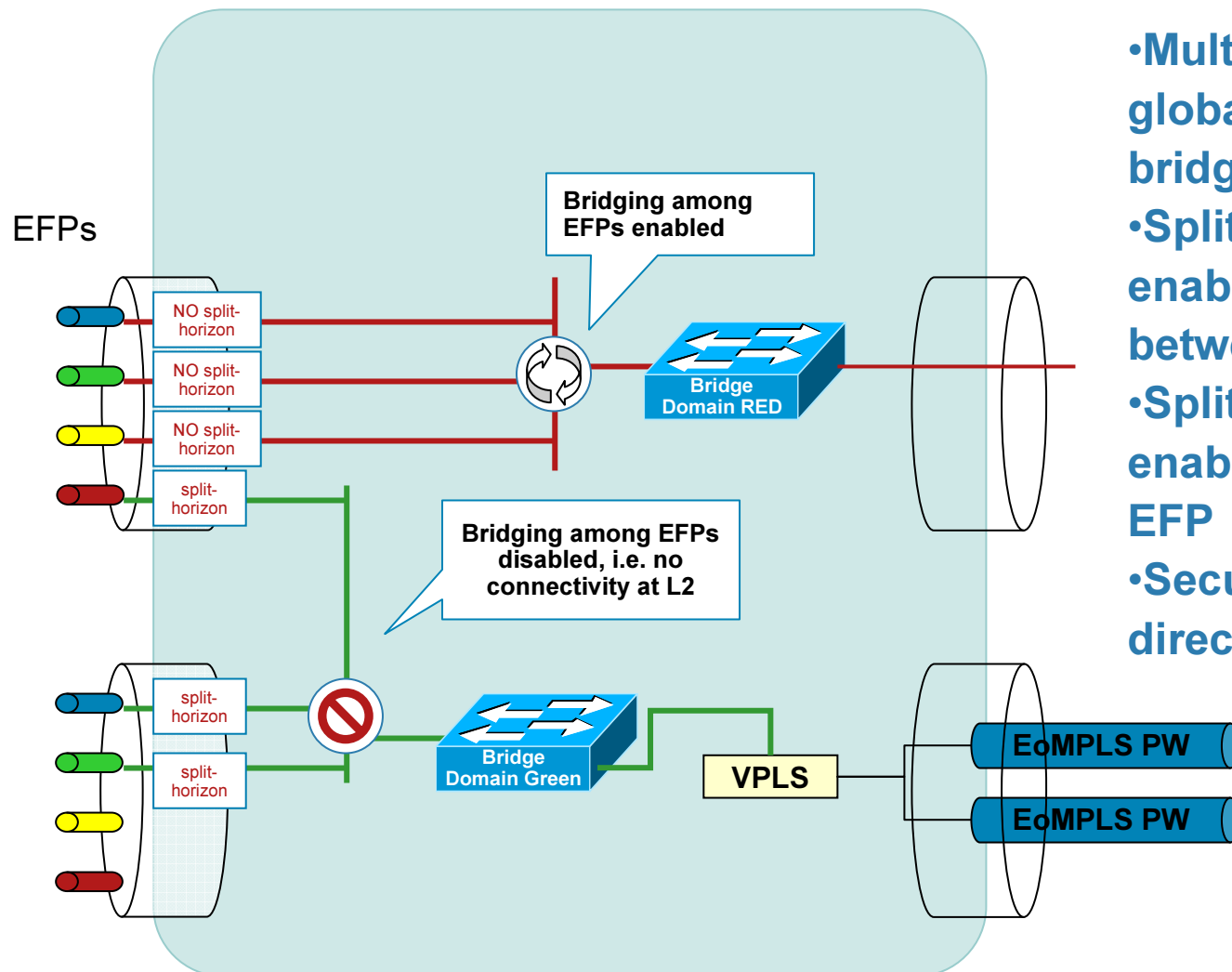
Common Security Recommendations

How to Secure the Network Against Attacks

Leading Practice Category	Examples	Protects against threats
Disable Unnecessary Services	ICMP redirects, CDP, IP Source Routing	Reconnaissance, DoS
Control Device Access	TACACS+, Radius, Password Encryption	Unauthorized access
Secure Ports and Interfaces	Disable unused interfaces, VLAN Pruning	Reconnaissance, DoS
Secure Routing Infrastructure	MD5 Authentication, Route Filters	DoS, Collateral damage
Secure Switching Infrastructure	Port Security, Storm Control	DoS, Collateral damage
Control Resource Exhaustion	CoPP, Hardware-based Rate Limiters	DoS, Collateral damage
Policy Enforcement	uRPF, iACLs	IP spoofing, DoS
DSLAM	MAC Forced Forwarding, Virtual MACs, DHCP Option 82, IGMP Whitelist	Reconnaissance, MAC spoofing, Theft-of-Service

EVC Bridging Functions

Split-Horizon Forwarding



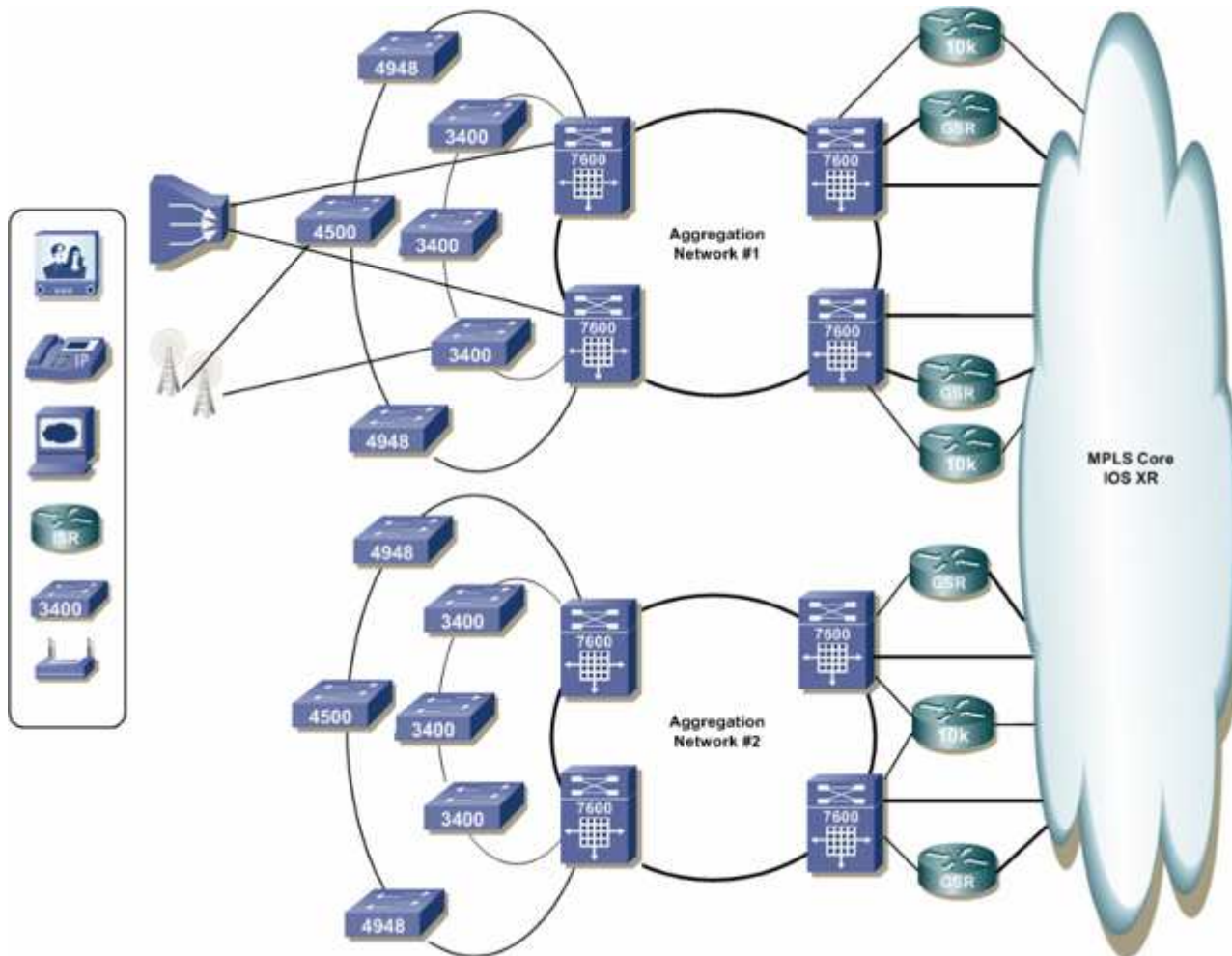
- Multiple EFPs into one global Bridge Domain for L2 bridging
- Split-horizon option to enable/disable bridging between EFPs
- Split-horizon can be enabled and disabled per EFP
- Security feature to prevent direct connectivity at L2



System Testing



Carrier Ethernet System Test Topology (End to End Functionality Test Bed)



Access Nodes:

- 1 x ALA ISAM 7302 DSLAM
- 1 x UTS AN-2000 DSLAM
- 2 x Redmax AN-100U
- 3 x Catalyst 4948
- 3 x ME 3400

Aggregation/Distribution Nodes:

- 4 x Cisco 7609
 - RSP720/SUP720-3BXL
 - ESM 2x10GE/SIP-600
 - ESM 20xGE/SIP-400

Edge:

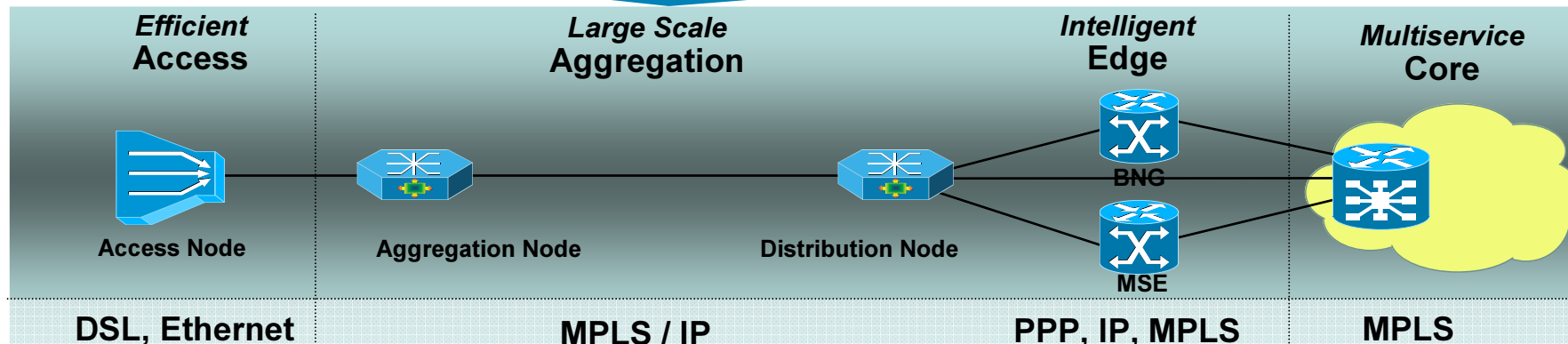
- 2 x Cisco 10008 (BNG)
 - PRE3
 - HH-GE
- 2 x Cisco 12410 (MSE)
 - PRP2
 - SIP-601/10G SPA
 - SIP-600/10G SPA

Core:

- 2 x CRS-1 (Core)
 - 8x10 GE LC

IP NGN Carrier Ethernet - Scalability

MSE Scalability		Aggregation Network Scalability		BNG Scalability	
Sub interfaces/ Port	2000	EVC per Port	4K	802.1q interfaces	32k
Sub interfaces/ Card	4000	EVC per Line card	16K	QinQ Interfaces	32k (system and card)
Sub interface /System	4000	EVC per System	16K	ISG PPPoE/IP sessions	40k
H-QOS policies /System	4000	EVC per Bridge Domain	120	L2TP tunnels	16k
H-QOS polices / Card	1000-2000	EVC with H-QOS per system	16K	RADIUS authorization	200 cps
Bridge Domains/ System	4000	EVC with H-QOS per line card	2k	LI Ta[s	4k without CPU impact
Queues / Card	8000	Bridge Domains per System	4K	VRFs	4k
Policers / Card		Queues/ Line card	16k	IPv4 Routes	1M
ARPs / System	128k	Policers/ Line card	1K		
MACs / System	256k	ARPs per system	128k		
TE tunnels	2000/30000	MAC per system	80k		
IPV4 routes	1M	SVIs per system	4k		
IPV4 mrputes	25000	TE tunnels	600/10k HE/Mid points		
VRFs	4000	IPV4 routes	1M		
		IPV4 Mroutes	256k		
		VRFs	1k		



Reports: **EXCLUSIVE!** Testing Cisco's IPTV Infrastructure

JUNE 14, 2007 - The first independent test of Cisco's IPTV infrastructure

- * 1 million potential users
- * Scaling, QOS, resilience
- * What makes IPTV so tough?

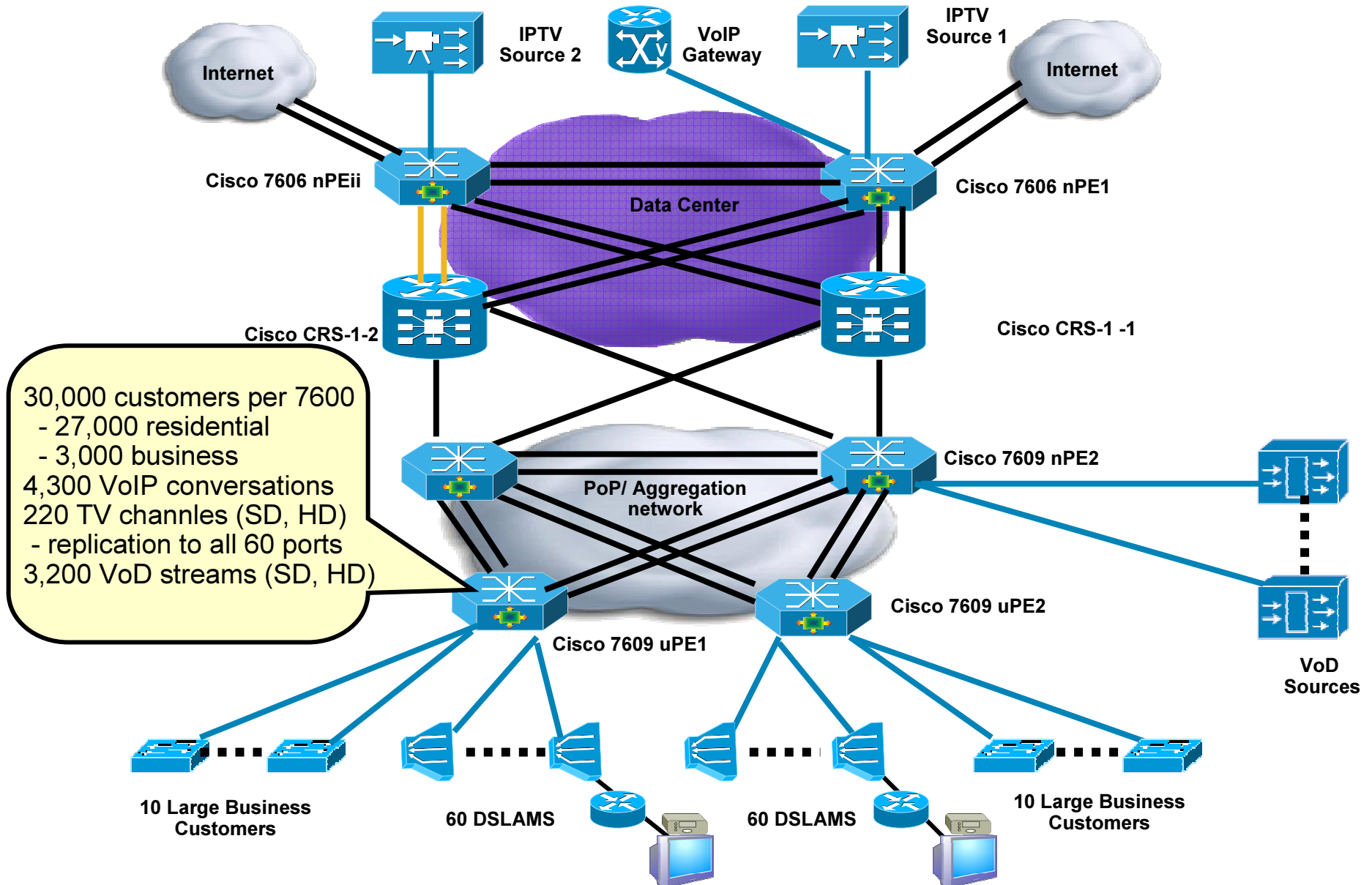
Conducted by EANTC (European Advanced Networking Test Center AG)

- not paid by Cisco
- based on a mock RFP
- 1 PoP tested

http://www.lightreading.com/document.asp?doc_id=126173

End to End Setup

— Gigabit Ethernet
— 10Gigabit Ethernet





Conclusion



Conclusion

Carrier Ethernet Technology

- Bringing Ethernet at ATM/SDH level from operational point of view
- Cisco 7600 is the flagship platform

MPLS role in the Metro

- L2 bus (Pseudowires) and L3 bus (IP routing)
- backhaul for L3 VPN and H-VPLS services

ES20 and SIP-400 linecards

- EVC infrastructure to meet SP needs
- various functions at various network places

Business Services Edge

- New Services – Network Scalability and Operability
- Importance of H-QoS

Internet Service and Deep Packet Inspection

- BRAS element function is blurring
- IP Sessions and distributed ISG (Intelligent Services Gateway)


Cisco 7600 Customers & Deployments



**Over 50,000 systems
deployed today**



**2006 IEC
InfoVision
Award Video
CAC**



2007 FROST & SULLIVAN
North American Carrier
Ethernet Equipment Market
Leadership of the Year Award

**2007 North American &
Worldwide Ethernet
Equipment Leadership
of the Year Award**

**LIGHT
READING** **EANTC**

**Cisco 7600 excels in the
End-to-End IPTV
Architecture Test
(1M users scalability)**

Cisco Confidential



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