Carrier Ethernet Aggregation Architecture

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The Connected Life

Morning—Commute

Use Phone as a Wallet and Ticket

Watch TV on Train, Program DVR for Tonight

Day—Office

Conduct Telepresence Meeting

Evening—Home and About Town

Child's Game and Update Virtual Community Pages en Route Home
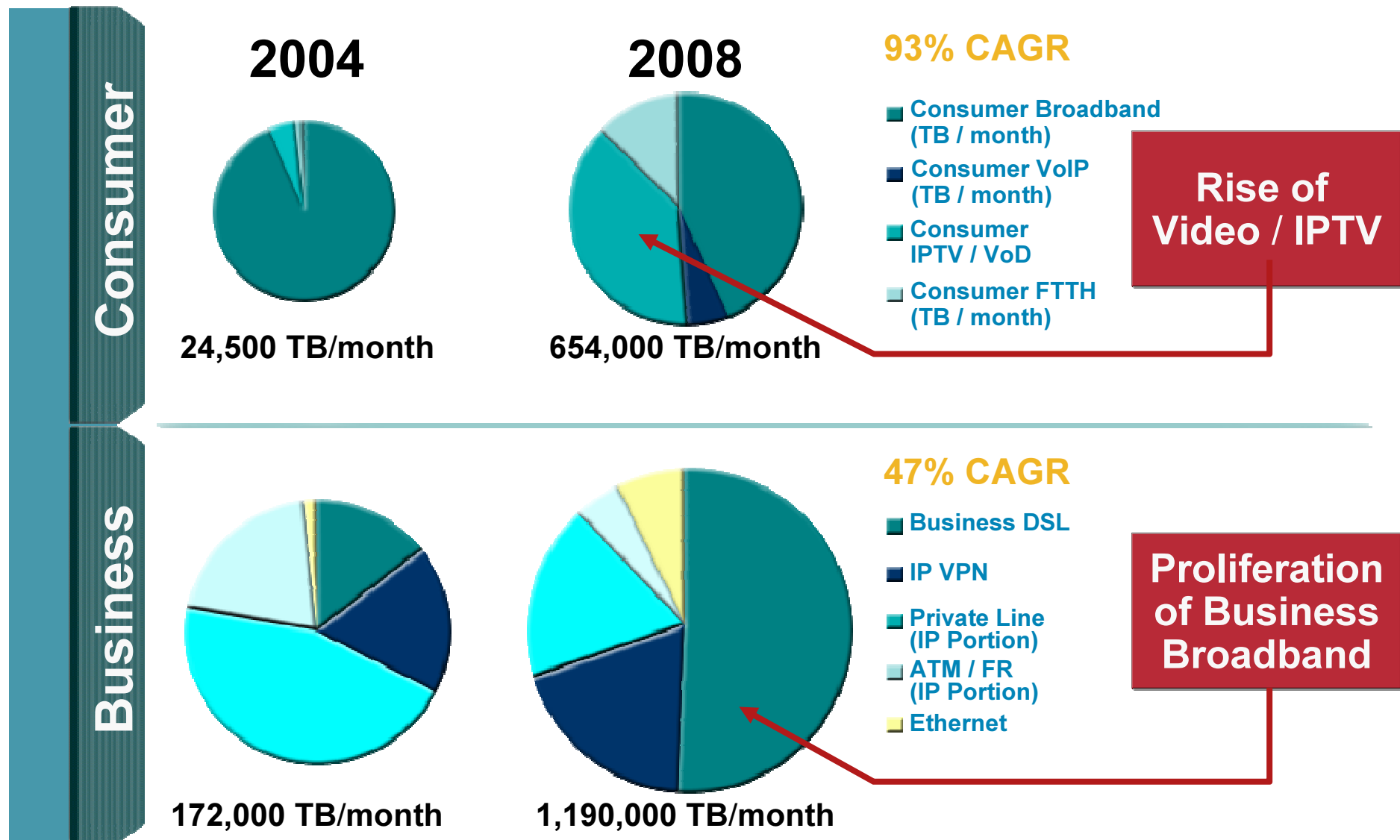
Find Child's GPS Location on TV

Watch Shows on Demand, Answer Video Call on TV

Customer Profiles & Traffic Mix is Changing
New Demands, New Opportunities

Consumer

2004

2008

93% CAGR

- ■ Consumer Broadband (TB / month)
- ■ Consumer VoIP (TB / month)
- ■ Consumer IPTV / VoD
- ■ Consumer FTTH (TB / month)

24,500 TB/month

654,000 TB/month

Rise of Video / IPTV

Business

172,000 TB/month

1,190,000 TB/month

47% CAGR

- ■ Business DSL
- ■ IP VPN
- ■ Private Line (IP Portion)
- ■ ATM / FR (IP Portion)
- ■ Ethernet

Proliferation of Business Broadband

Agenda

- IP NGN Carrier Ethernet Design – Introduction
- System Architecture Overview
- Consumer / Residential Services
- Business Services
- Wholesale Services
- High Availability
- Quality of Service
- Video transport over IP , Video quality
- Ethernet OAM
- Cisco 7600 New Features
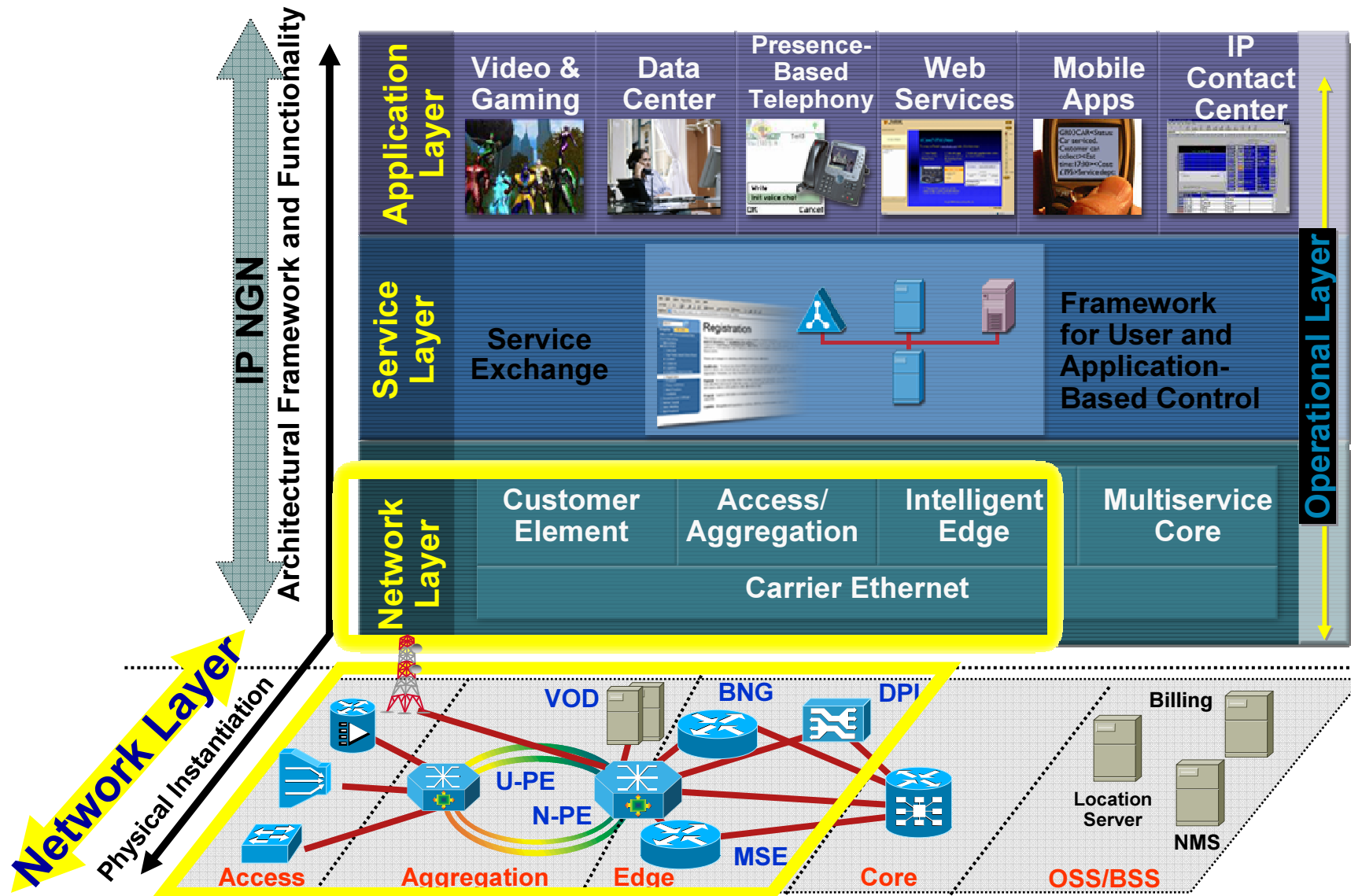- Customer Success / Case Studies

IP NGN Carrier Ethernet Design - Introduction

What is Carrier Ethernet about ?

- Provide end-to-end system context, architecture and set of hardware and software elements for Ethernet-based aggregation networks..

- It is based on MEF, IEEE, IETF and DSL Forum standards

- Support converged residential, business and wholesale services over a single Carrier Ethernet infrastructure

- Leverage MPLS-based aggregation, Ethernet Virtual Circuit (EVC), Intelligent Subscriber Gateway (ISG) and service optimized transport technologies to provide scalability and resiliency.

- Deliver system level guidance aligned closely with FCS of component hardware and software that includes management system capabilities.

- Continuous development for higher scalability and other service models (like Equal Access Networks)

IP NGN Carrier Ethernet Design

IP NGN — Architectural Framework and Functionality

Network Layer — Physical Instantiation

Application Layer

Video & Gaming	Data Center	Presence-Based Telephony	Web Services	Mobile Apps	IP Contact Center

Service Layer

Service Exchange

Framework for User and Application-Based Control

Network Layer

Operational Layer

Customer Element	Access/Aggregation	Intelligent Edge	Multiservice Core

Carrier Ethernet

VOD BNG DPI Billing

U-PE N-PE MSE Location Server NMS

Access Aggregation Edge Core OSS/BSS

Key Carrier Ethernet System Enhancements

- Support for DSL Forum and MEF with a flexible UNI and connectivity models, delivering flexible VLAN translation, push and pop operations.

- Greater scalability by leveraging Ethernet Virtual Circuit service instances, rather than existing IDB approaches that extend the number access interfaces up to 32000 and beyond per system.

- Supports DSL, Fiber, hub/spoke and ring based ethernet access, as well as WiMax access options

- Converged residential, business, and wholesale services on same infrastructure

- 50 msec service restoration target for services on link failures

- Full validation of all models and selected access options desired by the customers.

- Support of E-OAM protocols like 802.1ag, 802.3ah, E-LMI, Y.1731
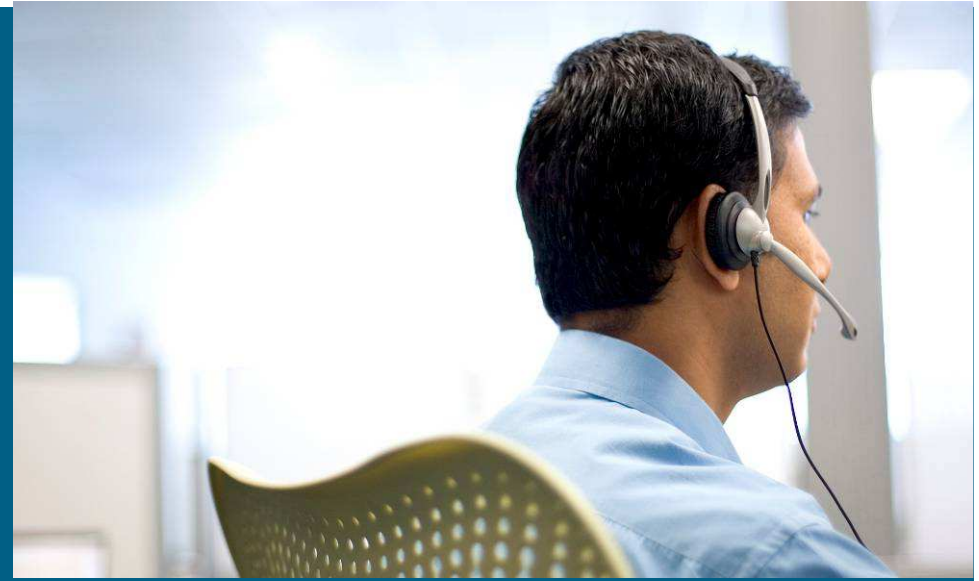
IP NGN Carrier Ethernet System Design Market and Service Mapping

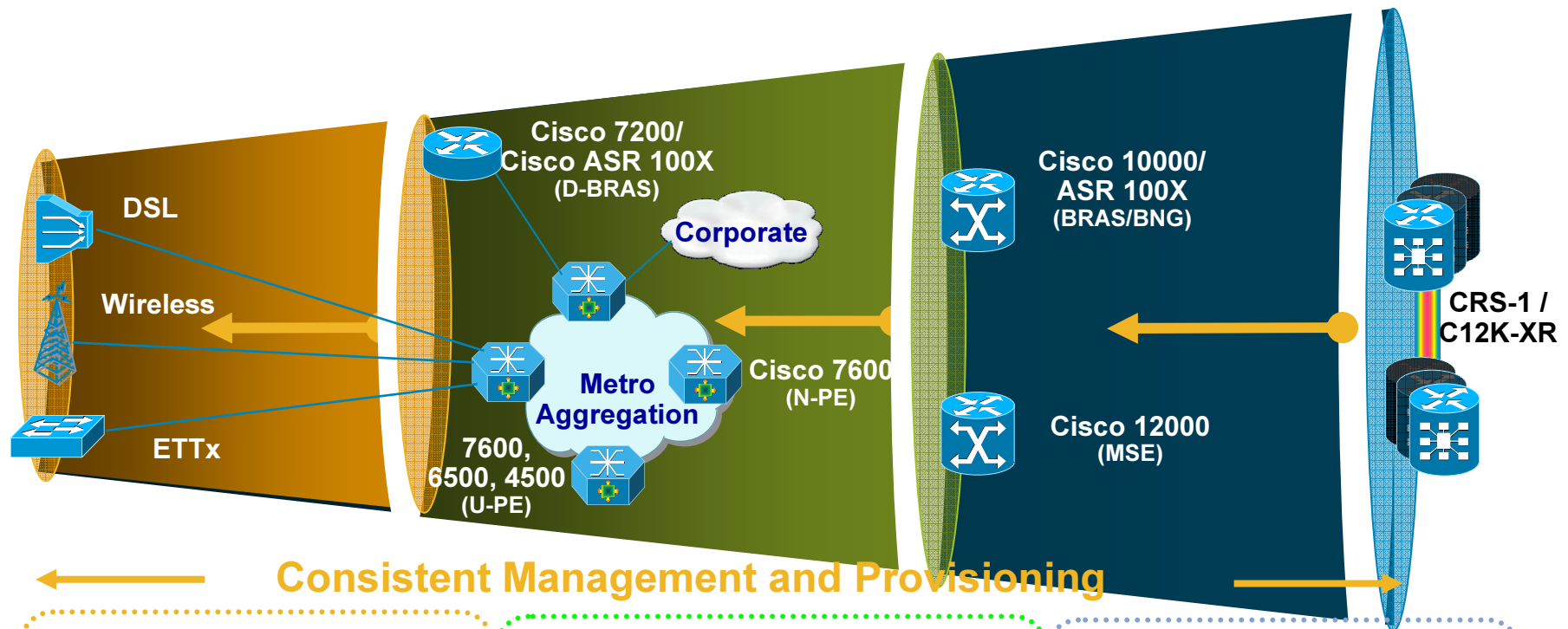| Market	Services	Access	QoE Type	SLA Example
Residential	Internet Access	Ethernet, PON, DSL, WIMAX	Transport	Dynamic access bandwidth, session/idle timeout, advertisements, post paid/prepaid (time and volume)
	VoIP Telephony	Ethernet, PON, DSL, WIMAX	Application	The number of VoIP appliances, SIP URLs/PST Phone numbers, active calls, VoIP call quality
Business	L3 VPN MPLS/Multicast	Ethernet, PON, DSL, WIMAX	Transport	Access bandwidth, differentiated services support, L3 VPN topology, managed services (MPLS/Multicast VPN)
	E-Line	Ethernet, PON, DSL, WIMAX*	Transport	Access bandwidth, differentiated services support, transparency
	E-LAN	Ethernet, PON, DSL, WIMAX*	Transport	Access bandwidth, differentiated services support, multipoint transport, transparency
Wholesale	L3 (P2P, MP)	DSL	Transport	Aggregated bandwidth on ISP level, differentiated services support, with subscriber management at ISP
	L2 (P2P, MP)	DSL	Transport	Aggregated bandwidth on ISP level, differentiated services support, transparent Ethernet transport P2P and MP (multicast optimized)

* Ethernet Relay Point to Point and Multipoint only

Cisco Passes IPTV test:

http://www.lightreading.com/document.asp?doc_id=126475&site=nxtcomm

IP NGN Carrier Ethernet Design – System Architecture Overview

Cisco IP NGN Architecture
What is Cisco Carrier Ethernet?

DSL

Wireless

ETTx

Cisco 7200/
Cisco ASR 100X
(D-BRAS)

Corporate

Metro
Aggregation

7600,
6500, 4500
(U-PE)

Cisco 7600
(N-PE)

Cisco 10000/
ASR 100X
(BRAS/BNG)

Cisco 12000
(MSE)

CRS-1 /
C12K-XR

Consistent Management and Provisioning

Access

• **Media and Access Technology Agnostic**

• **Ethernet over Anything**

• **Consistent Service Level Agreements**

• **Rapid Deployment Velocity**

Aggregation

Convergence :

  • **Business & Consumer**

  • **Wireline & Mobile**

• **Personalized Service Distribution**

• **Policy Enforcement**

Service Edge

Centralized Services

  • **Business VPNs**

  • **Policy Management**

• **Flexible Business Models**

Slide 11

**CSI5**   A few comments on this slide:

Please update BRAS to BNG, to be consistent with the Design Guide and the rest of this presentation.

Why is the uBR shown both in the access and aggregation area? I would just put Cisco uBR

Why are the arrows in the center of the graphic only pointing in the downstream direction?
Cisco Systems, Inc., 6/6/2007

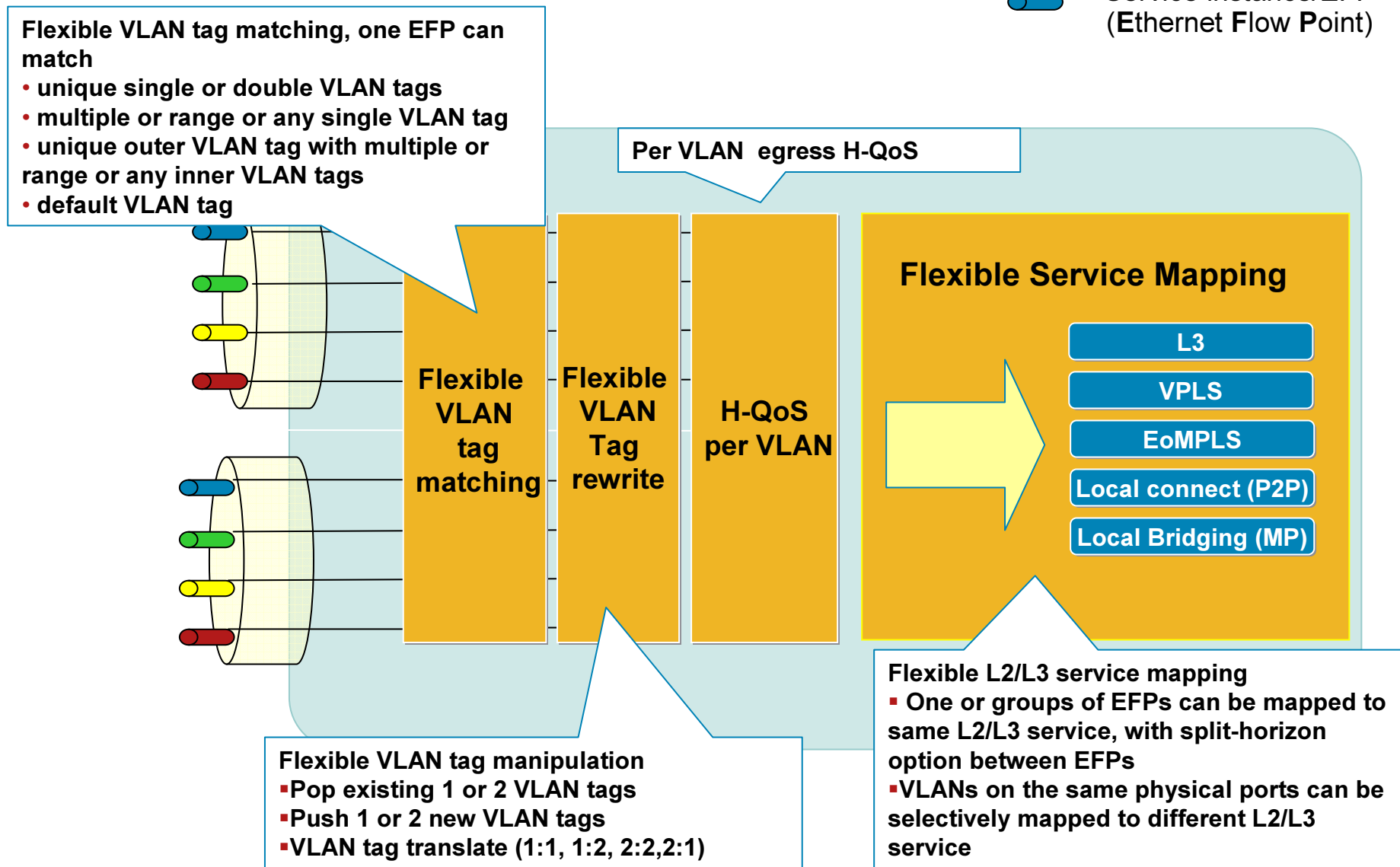# Carrier Ethernet Aggregation System
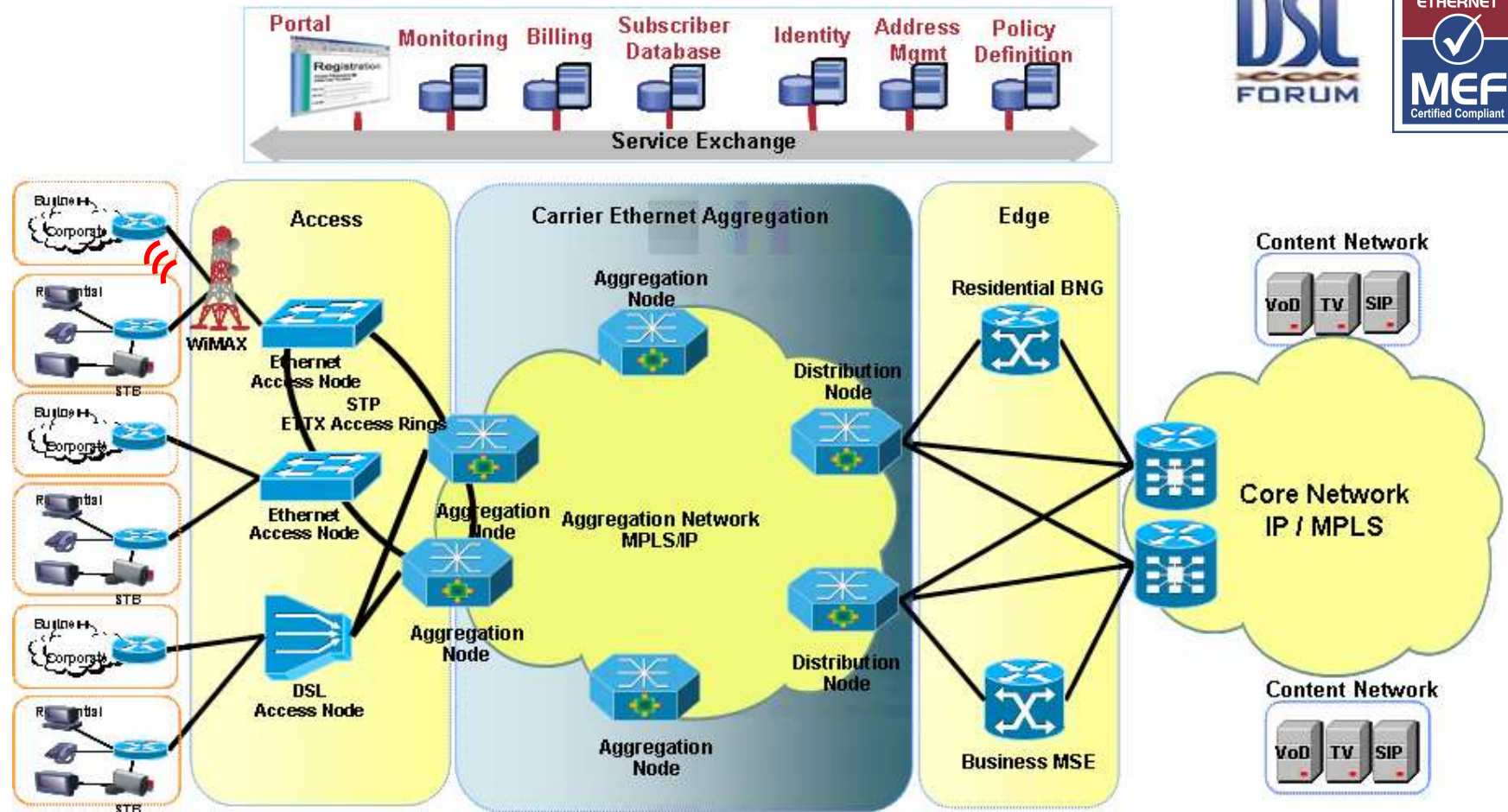
- Residential SLAs Enforced at BNG. BNG can be centralized / distributed
- Business Services Centralized at MSE / distributed on Agg. Nodes
- Video Services Bypass BRAS/BNG
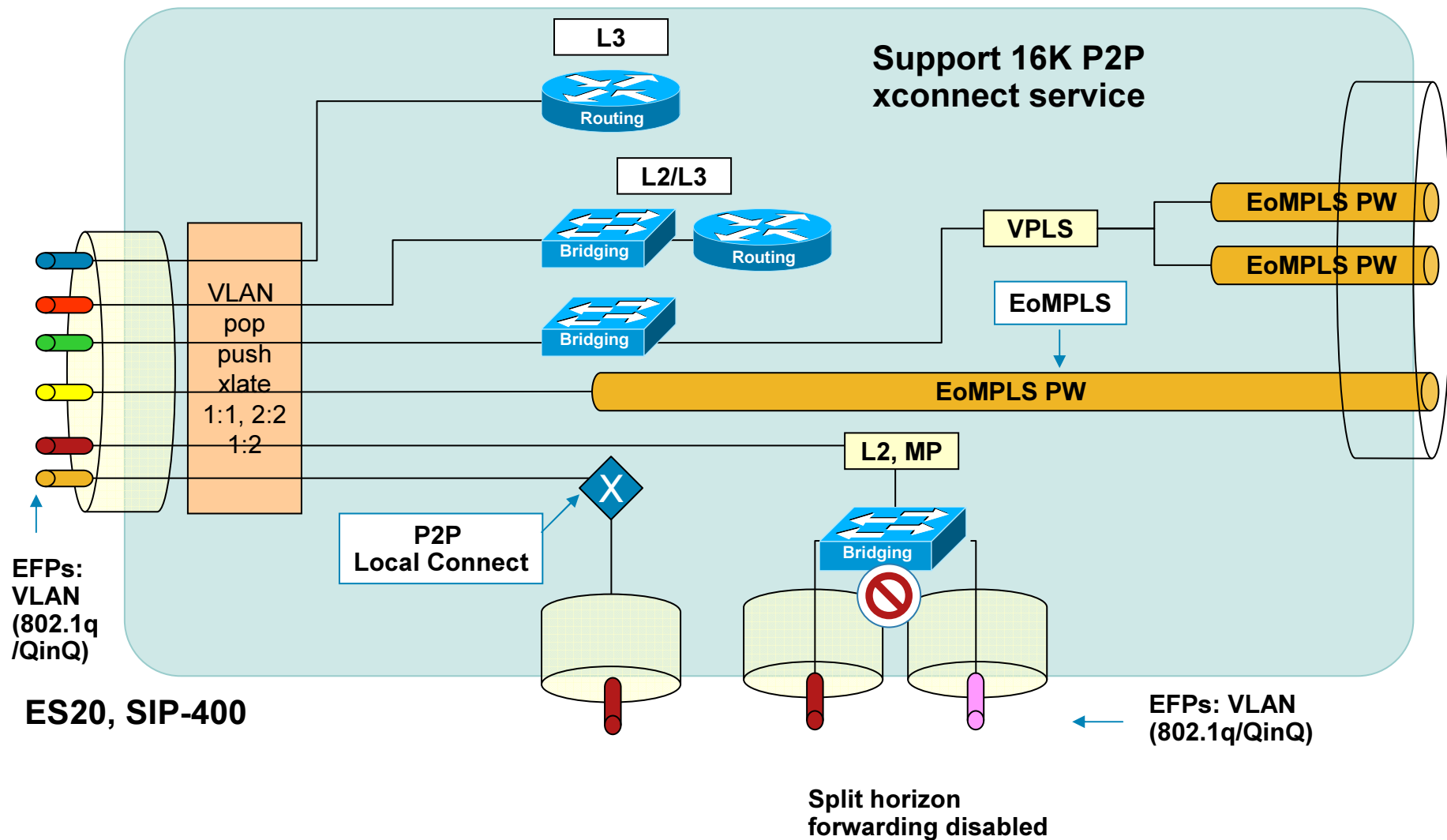- Access Agnostic Ethernet UNI Models

Flexible Ethernet UNI - EVC
Technology enabler of Carrier Ethernet Aggregation

Service instance/EFP
(**E**thernet **F**low **P**oint)

Flexible VLAN tag matching, one EFP can match
• **unique single or double VLAN tags**
• **multiple or range or any single VLAN tag**
• **unique outer VLAN tag with multiple or range or any inner VLAN tags**
• **default VLAN tag**

Per VLAN egress H-QoS

Flexible VLAN tag matching

Flexible VLAN Tag rewrite

H-QoS per VLAN

Flexible Service Mapping

L3

VPLS

EoMPLS

Local connect (P2P)

Local Bridging (MP)

Flexible L2/L3 service mapping
▪ **One or groups of EFPs can be mapped to same L2/L3 service, with split-horizon option between EFPs**
▪ **VLANs on the same physical ports can be selectively mapped to different L2/L3 service**

Flexible VLAN tag manipulation
▪**Pop existing 1 or 2 VLAN tags**
▪**Push 1 or 2 new VLAN tags**
▪**VLAN tag translate (1:1, 1:2, 2:2,2:1)**

EVC – Flexible Forwarding Model

ES20, SIP-400

EFPs:
VLAN
(802.1q
/QinQ)

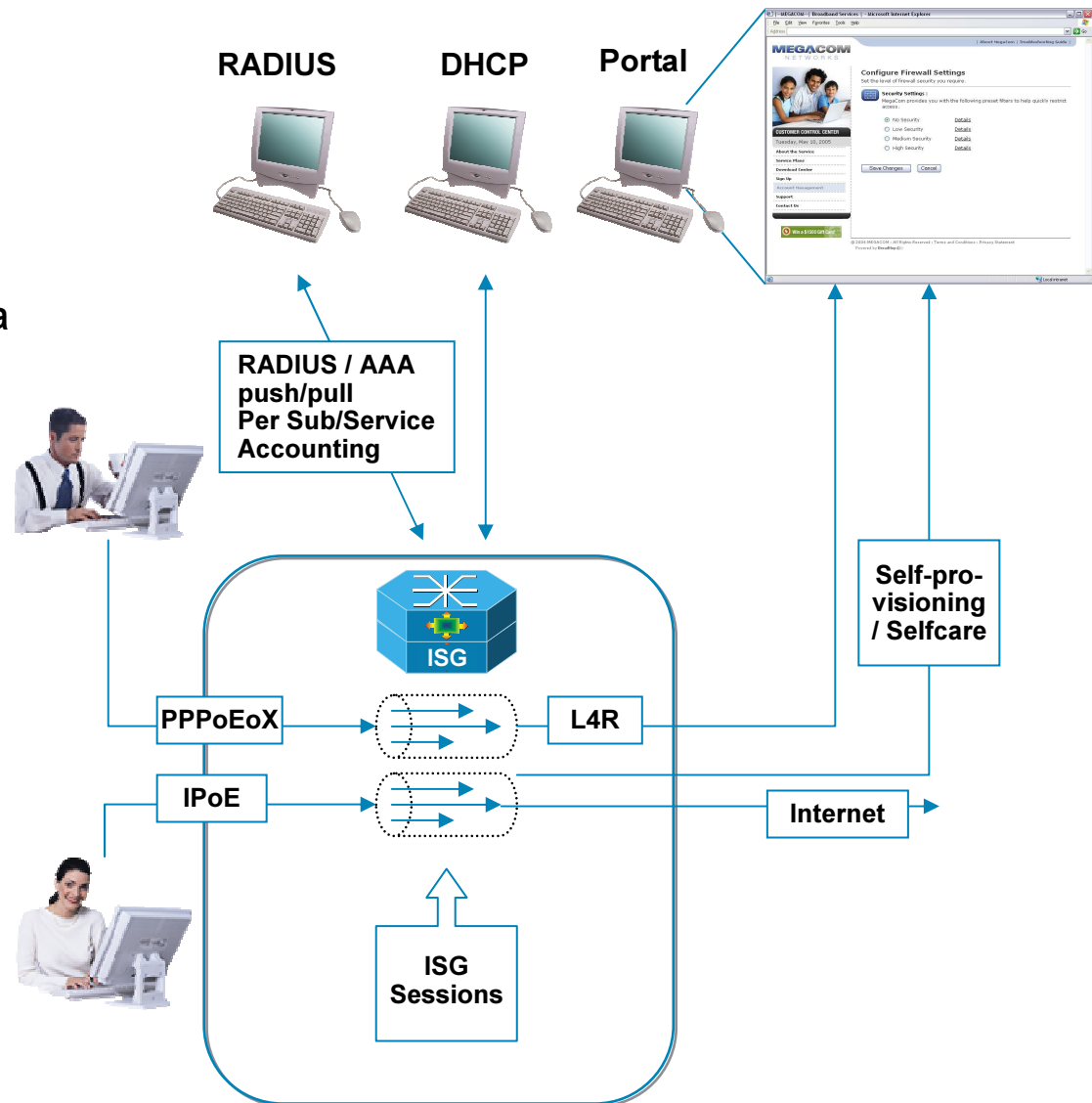Support 16K P2P xconnect service

EFPs: VLAN
(802.1q/QinQ)

Split horizon
forwarding disabled

Intelligent Services Gateway
Technology enabler of Carrier Ethernet Aggregation

- **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**
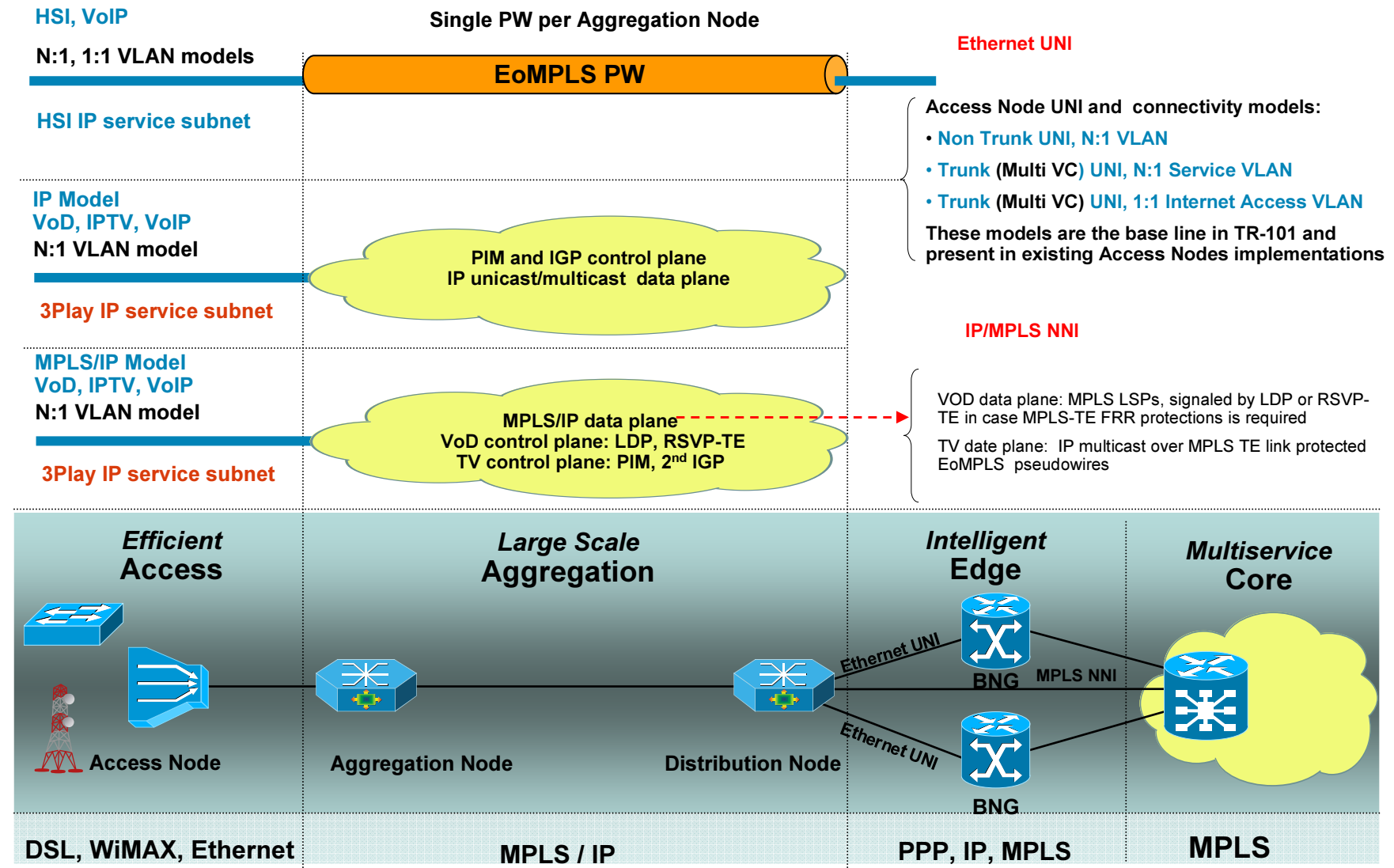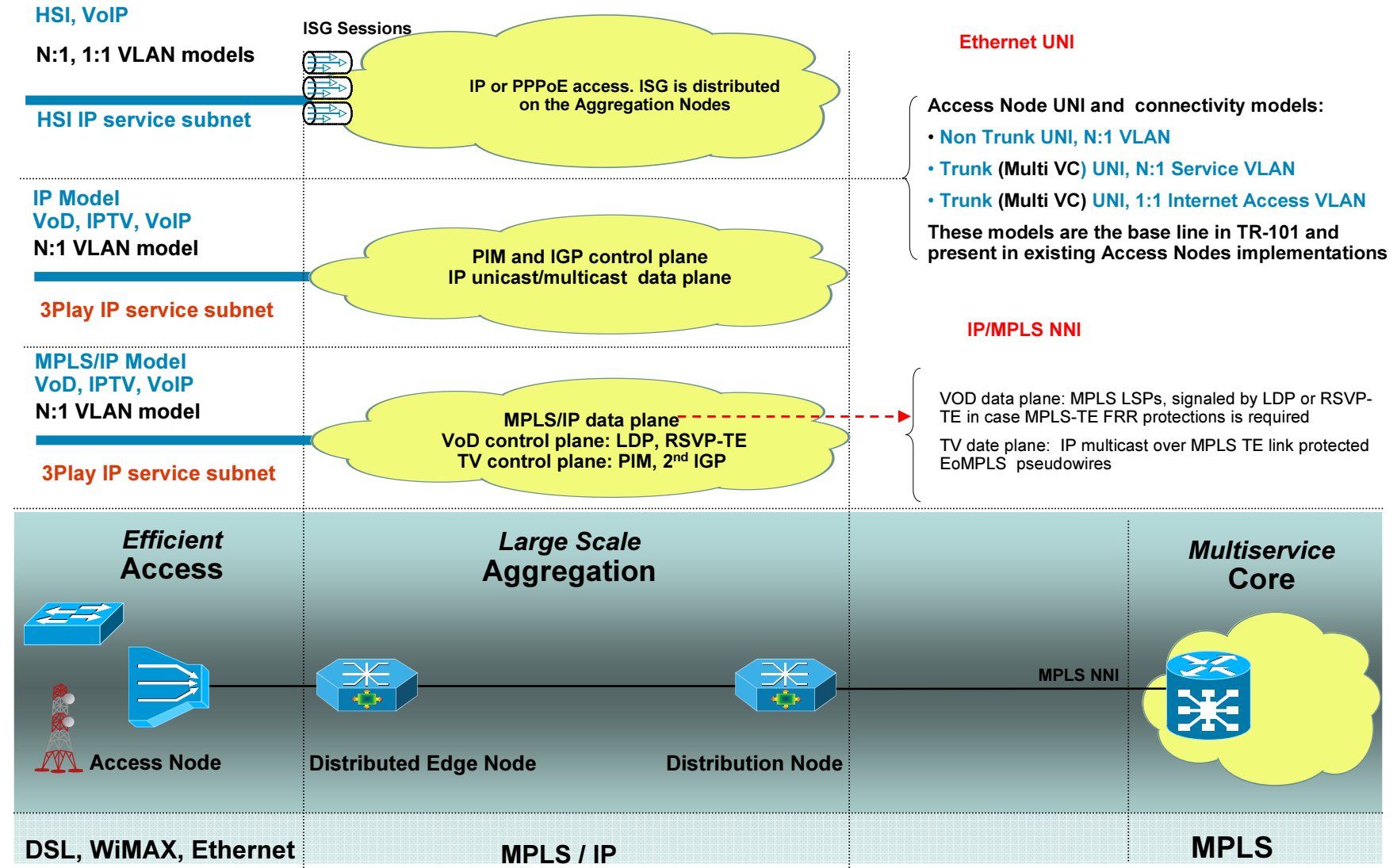 - E.g. mapping traffic to VRF, various routing tables

RADIUS   **DHCP**   **Portal**

RADIUS / AAA push/pull Per Sub/Service Accounting

Self-pro-visioning / Selfcare

ISG

PPPoEoX — L4R

IPoE — Internet

ISG Sessions

Consumer / Residential Services

Retail Residential Services (Centralized BNG)

HSI, VoIP

Single PW per Aggregation Node

Ethernet UNI

N:1, 1:1 VLAN models

EoMPLS PW

HSI IP service subnet

Access Node UNI and connectivity models:
- Non Trunk UNI, N:1 VLAN
- Trunk (Multi VC) UNI, N:1 Service VLAN
- Trunk (Multi VC) UNI, 1:1 Internet Access VLAN

These models are the base line in TR-101 and present in existing Access Nodes implementations

**IP Model
VoD, IPTV, VoIP
N:1 VLAN model**

PIM and IGP control plane
IP unicast/multicast data plane

3Play IP service subnet

IP/MPLS NNI

**MPLS/IP Model
VoD, IPTV, VoIP
N:1 VLAN model**

MPLS/IP data plane
VoD control plane: LDP, RSVP-TE
TV control plane: PIM, 2nd IGP

VOD data plane: MPLS LSPs, signaled by LDP or RSVP-TE in case MPLS-TE FRR protections is required

TV date plane: IP multicast over MPLS TE link protected EoMPLS pseudowires

3Play IP service subnet

Efficient
Access

Large Scale
Aggregation

Intelligent
Edge

Multiservice
Core

Access Node

Aggregation Node

Distribution Node

Ethernet UNI

BNG

MPLS NNI

Ethernet UNI

BNG

DSL, WiMAX, Ethernet

MPLS / IP

PPP, IP, MPLS

MPLS

Retail Residential Services (Distributed BNG)

HSI, VoIP

ISG Sessions

N:1, 1:1 VLAN models

Ethernet UNI

HSI IP service subnet

IP or PPPoE access. ISG is distributed on the Aggregation Nodes

Access Node UNI and connectivity models:

- Non Trunk UNI, N:1 VLAN
- Trunk (**Multi VC**) UNI, N:1 Service VLAN
- Trunk (**Multi VC**) UNI, 1:1 Internet Access VLAN

IP Model
VoD, IPTV, VoIP
N:1 VLAN model

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3Play IP service subnet

PIM and IGP control plane
IP unicast/multicast data plane

IP/MPLS NNI

MPLS/IP Model
VoD, IPTV, VoIP
N:1 VLAN model

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VoD control plane: LDP, RSVP-TE
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3Play IP service subnet

Efficient
Access

Large Scale
Aggregation

Multiservice
Core

MPLS NNI

Access Node

Distributed Edge Node

Distribution Node

DSL, WiMAX, Ethernet

MPLS / IP

MPLS

Business Services

Aggregation Network Service Edge
Business Ethernet Services Architecture

MPLS-VPN

Business L3 VPN — Port, 1q, QinQ

Business E-LAN — Port, 1Q, QinQ

H-VPLS

MPLS NNI

Business E-LINE — Port, 1Q, QinQ

EoMPLS

Efficient **Access**

Implements service network forwarding and access SLA enforcement

Large Scale **Aggregation**

Intelligent **Edge**

Multiservice **Core**

Access Node

Aggregation Node

Distribution Node

MPLS NNI

Inter AS, PW switch

DSL, WiMAX, Ethernet

MPLS / IP

IP, MPLS

MPLS

MSE Service Edge
Business Ethernet Services

Aggregation Network implements a transport function based on EoMPLS pseudowires

Business L3 VPN

Port, 1Q, QInQ

Ethernet

QinQ

MPLS-VPN

Ethernet UNI

Business E-LAN

Port, 1Q, QInQ

Ethernet

QinQ

VPLS

MSE implements service network forwarding and access SLA enforcement

Business E-LINE

Port, 1Q, QInQ

Ethernet

QinQ

Efficient Access

Large Scale Aggregation

Intelligent Edge

Multiservice Core

Access Node

Aggregation Node

Distribution Node

Ethernet UNI

MSE

Ethernet UNI

MSE

DSL, WiMAX, Ethernet

MPLS / IP

IP, MPLS

MPLS

Wholesale Services

Wholesale Services Deployments

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

Efficient **Access**	*Large Scale* **Aggregation**	*Intelligent* **Edge**	*Multiservice* **Core**
Access Node	Aggregation Node	Distribution Node — BNG / MSE	
DSL, Ethernet	**MPLS / IP**	**PPP, IP, MPLS**	**MPLS**
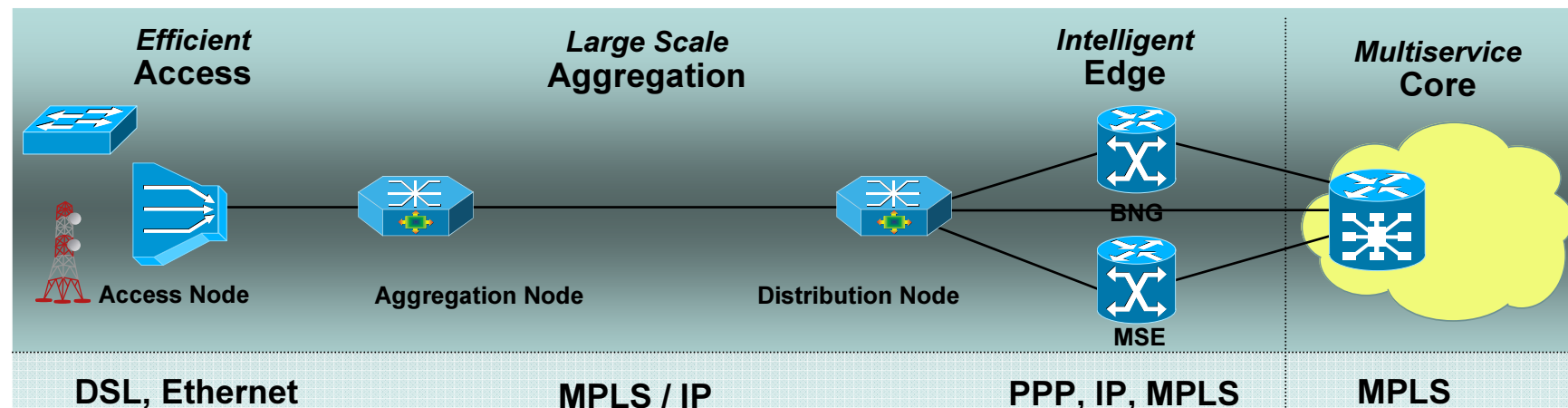
Residential Services
Active/Backup Aggregation Node Redundancy

• 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

PPPoE sessions

Gateway for VOD/IPTV

VLAN 10

VLAN 10

EoMPLS PW

EoMPLS PW

VLAN 10

	20xGE		2x10GE		2x10GE		20xGE	

Access   **Aggregation**   **Distribution**   **BNG**
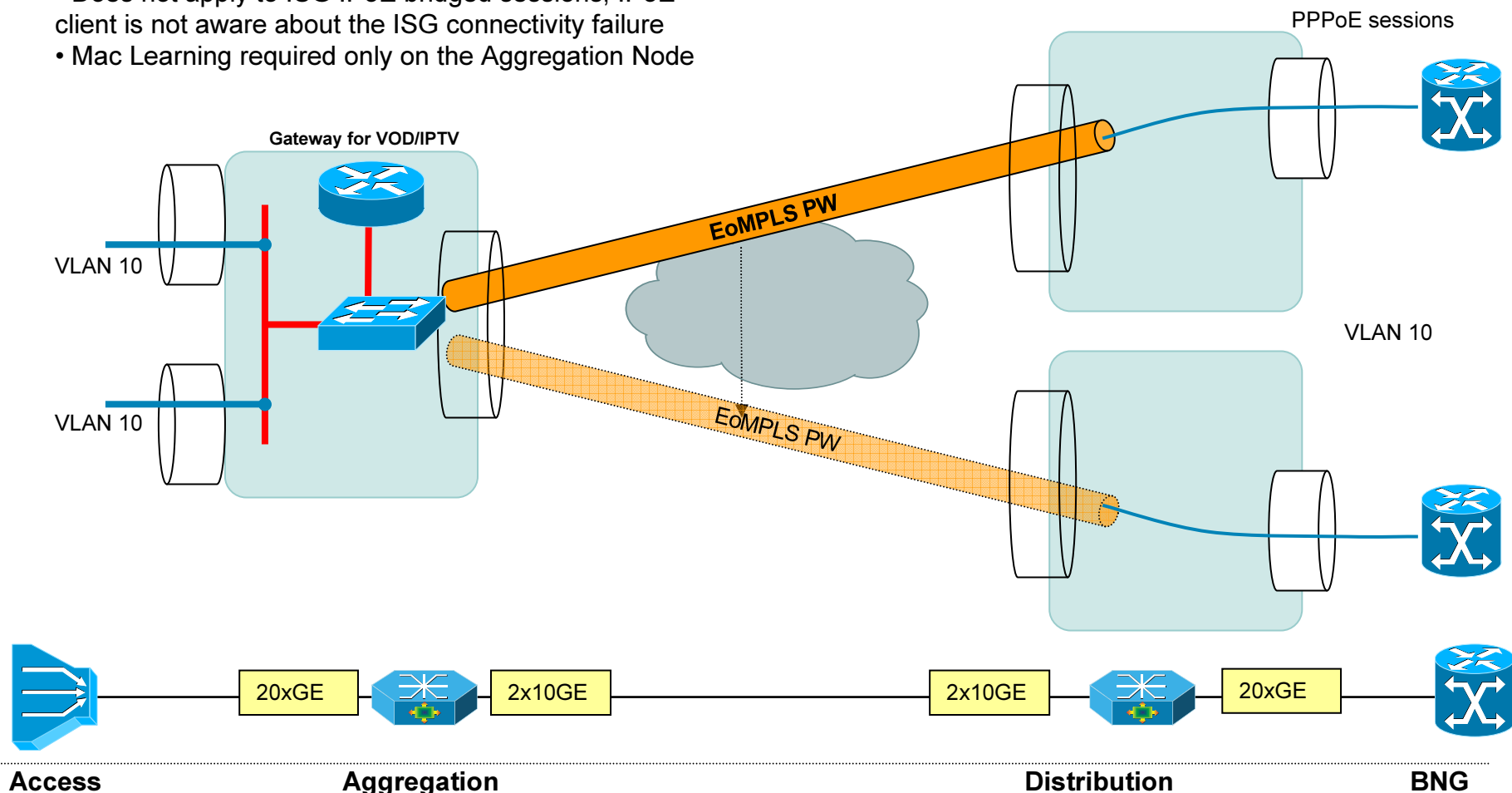
Residential Services
Active/Backup Access Node Redundancy

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

Gateway for VOD/IPTV

Aggregation Node VRRP/HSRP

PPPoE sessions

Active Uplink1

VLAN 10

EoMPLS PW

EoMPLS PW

Gateway for VOD/IPTV

Backup Uplink

VLAN 10

EoMPLS PW

BNG
PPPoE load sharing

| 20xGE | | 2x10GE | | 2x10GE | | 20xGE | |

Access **Aggregation** **Distribution** **BNG**
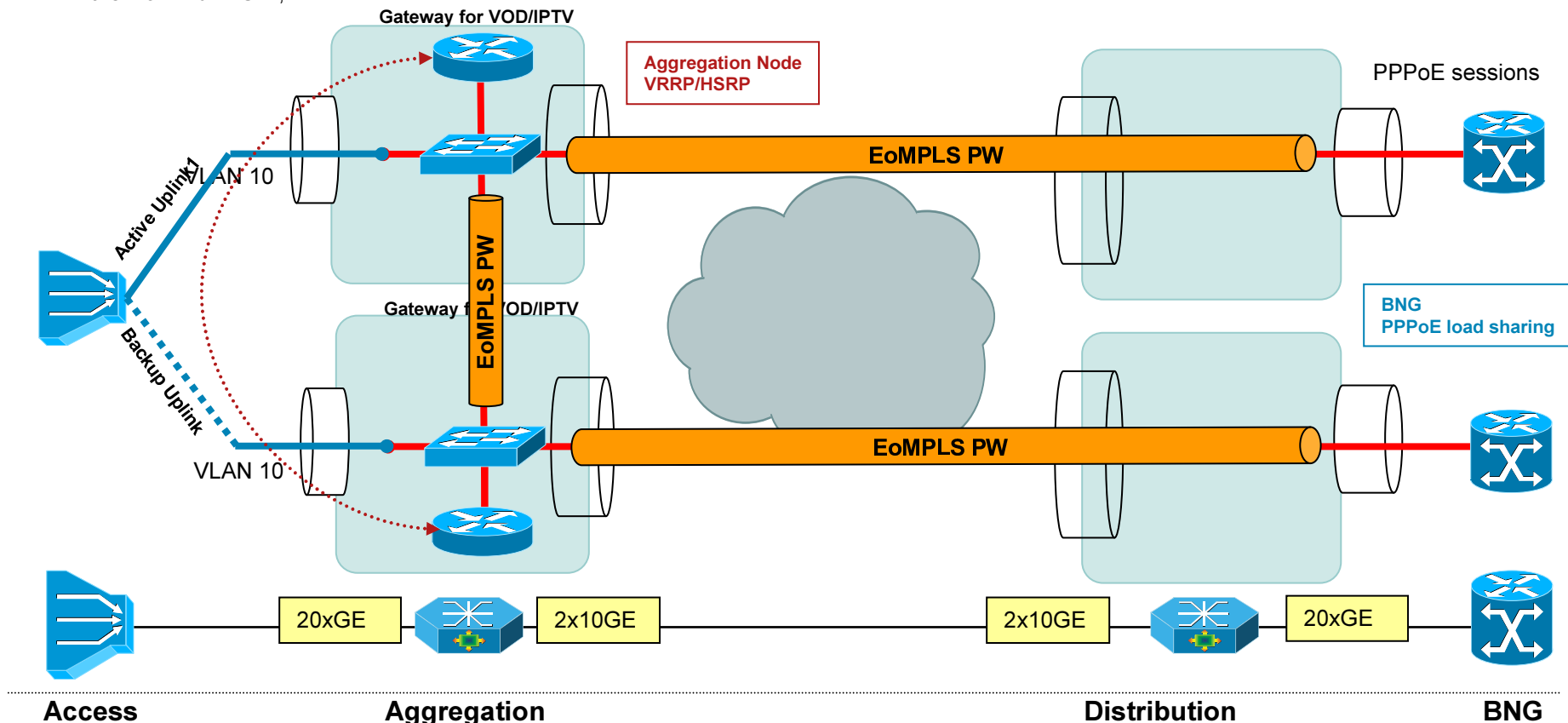
Residential Services – Ethernet Access Ring Redundancy with MST

- MST Protocol is running in the Ethernet access ring
- An extra EoMPLS PW is set up between aggregation nodes for BPDU traffic
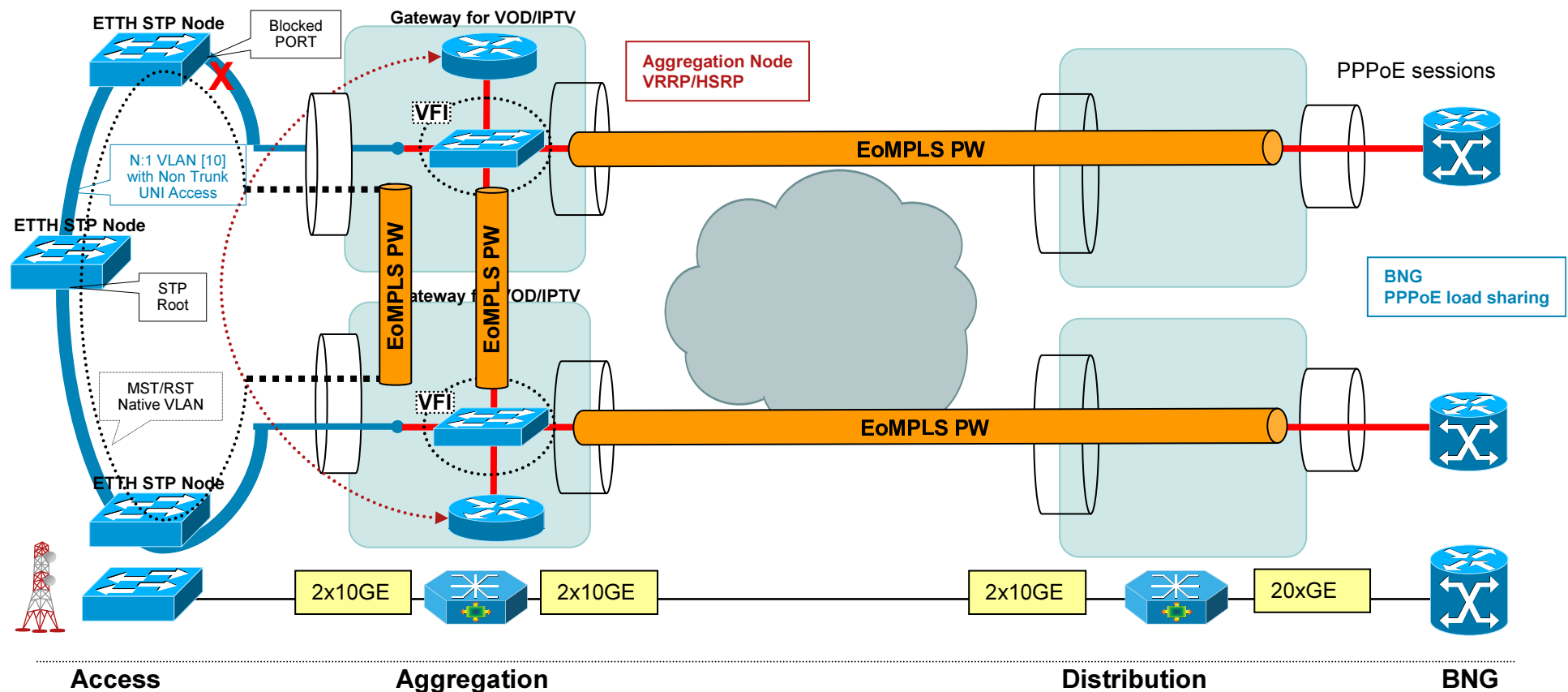
Residential Services – Ethernet Access Ring Redundancy with REP

- MST Protocol is running in the Ethernet access ring
- An extra EoMPLS PW is set up between aggregation nodes for REP traffic
- REP / Aggregation Node integration will be supported in 2009
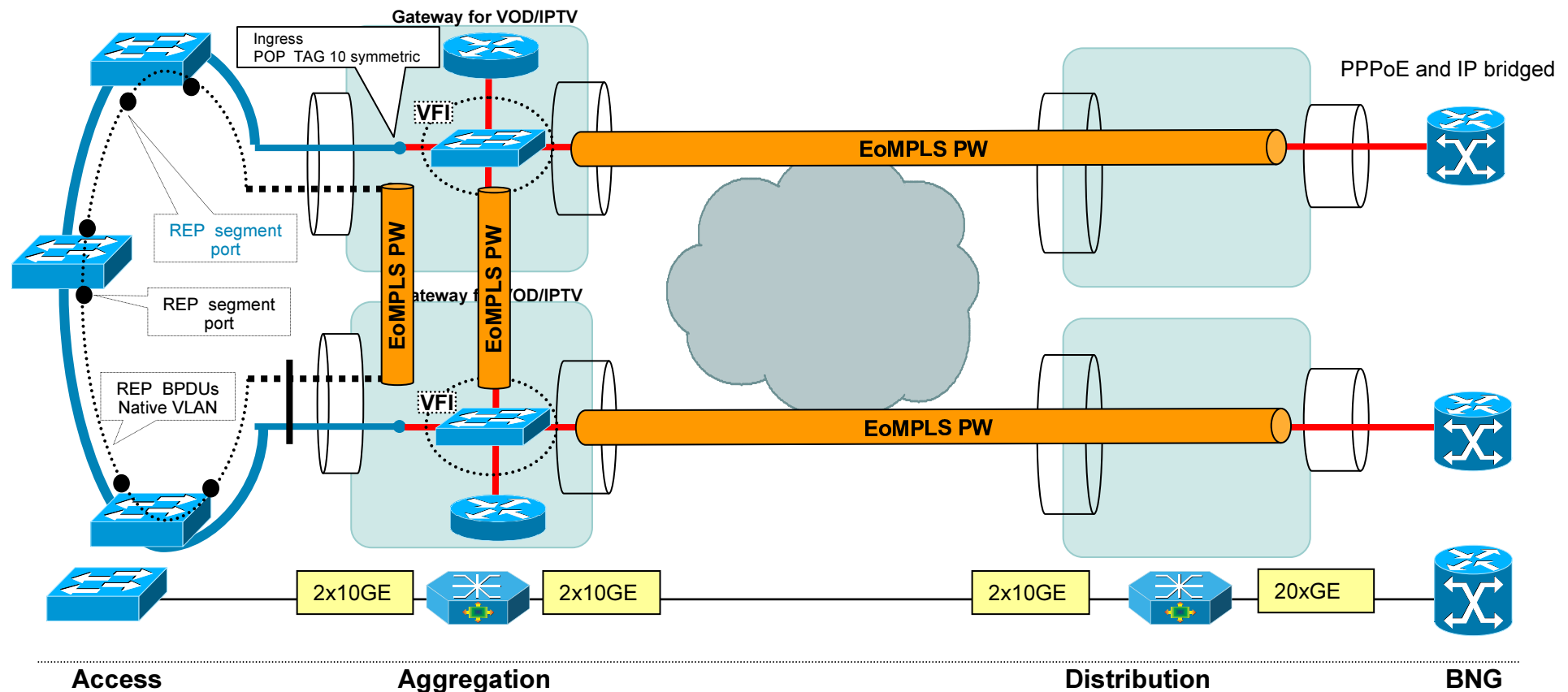
Residential Services
MPLS/IP TV Broadcast Service High Availability

2nd IGP, PIM-SSM routing

EoMPLS PW — 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

MPLS/IP Aggregation Network
any physical topology
EoMPLS PWs with TE-FRR link protection

• EoMPLS pseudowires are protected from link failure with MPLS TE-FRR with no impact on the PIM control plane and fast re-convergence (<50ms) on the IP multicast date plane
  •Should converge in less than 50 ms

• Aggregation Node failures are addressed by PIM fast convergence
  • Should converge is less than 300 ms with 500 groups

| 20xGE | | 2x10GE | | 2x10GE | | 20xGE |

Access   **Aggregation**   **Distribution**   **Core**

Quality of Service

QOS Architecture Direction

Portal   **Monitoring**   **Billing**   **Subscriber Database**   **Identity**   **Address Mgmt**   **Policy Definition**

Registration

Policy Control Plane (Per Subscriber)

Content Network

Business

Corporate

Business

Corporate

Business

Corporate

Residential

STB

Access

Ethernet Access Node

DSL Access Node

Aggregation Node

Access Node

L2/3 Edge

Aggregation Node

Aggregation Network MPLS, Ethernet, IP

Aggregation Node

Distribution Node

Distribution Node

BRAS

SCE

MPLS PE

VoD   TV   SIP

Core Network IP/MPLS

Internet

Business

Corporate

Consumer and Business Traffic Utilize Per-Subscriber or Per Service QoS Model in Access, Aggregation and Core

Differentiated Services QOS Domain

Traffic Class	Core /Edge/ Aggregation			Access	DSL, ETTX	UNI	
	MPLS/IP			Ethernet		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

Video Transport over IP

High Speed Internet (HSI) & Video are different
Transport Services vs. Managed Application Services

Transport Service	Managed Application Service
Service = CIR/PIR pipe with applications hosted by third parties SLA defined by transport parameters Residential HSI = 5Mbps down, 1Mbps up, no guarantee for streaming quality Business VPN = CIR & PIR, jitter, delay, loss guarantees, no app. guarantees	▪ Application hosted by provider ▪ SLA is defined by Quality of Experience (QoE) expectation ▪ Video = 1 artifact per 2 hour movie ▪ Voice = no sound quality impairments, blocked calls rare

Network QoS Requirements
 	
Shape & drop packets over CIR, leverage TCP back-off
 	
QoS can change dynamically per sub (turbo button, bandwidth on demand)
 	
Transport SLA must be enforced per subscriber
	Network QoS Requirements
	
	▪ QoE mapped to network QoS requirements
	
	▪ Video (1 artifact per 2 hour movie)
	    10^{-6} loss, cannot shape/drop video packets
	    VOD CAC so 1001st stream doesn't force drops for all users
	
	▪ QoS same for all subs of a particular app
	
	▪ No need to enforce transport SLA per sub,

HSI & Business VPNS	**Residential VoIP & Video**

VQE Appliance

- **Fast Channel Change:** Improves channel change experience via directed UDP streaming during IGMP leave / join (similar approach like Microsoft A / D server, but integrated into the aggregation network)

- **Error Repair:** Improves Packet Loss Ratio via the selective resending of lost video frames (based on analyzing RTCP signaling between STB and VQE appliance)

- **Video Quality Monitoring:** Generates per-STB statistics based on the analysis of RTP data

Visual Quality Experience - Network Diagram

224.1.1.1 – Channel 001

VQE-S "look-aside"

RTP Multicast from Source

224.1.1.250 – Channel 250

VQE-S

Core

Metro Network

Edge Router

DSLAM

STB

VQE-C integration options

RG

PC

- Consists of a server side component (VQE-S), and client side component (VQE-C)

- VQE-S
  - Joins Multicast Groups, IGMP client
  - Caches few seconds of each channel, DRAM
  - Statistics, RTP
  - **Not** in data path between Head-end and Client

- VQE- C
  - Controls network Jitter buffer
  - RTP encapsulation, RTCP control-plane, statistics
  - Selective retransmission

VoD CAC
Aggregation Network Diffserv RSVP

Aggregation Node

```
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
```

Distribution Node

```
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
```

1. STB HTTP GET(URL) requests VoD stream

2. RSVP PATH, VoD stream BW

3. RSVP PATH, VoD stream BW

RSVP Receiver Proxy CAC

4. RSVP RESV, VoD stream BW

5. RSVP RESV, VoD stream BW

6. HTTP 200 OK (Response to SETUP (URL))

RSVP Receiver CAC

Efficient
Access

Large Scale
Aggregation

*VoD Servers
and Middleware*

Bandwidth Pool

Bandwidth Pool

IP Unicast & Multicast PIM SSM

Access Node

Aggregation Node

Distribution Node

DSL, Ethernet

MPLS or IP

IP
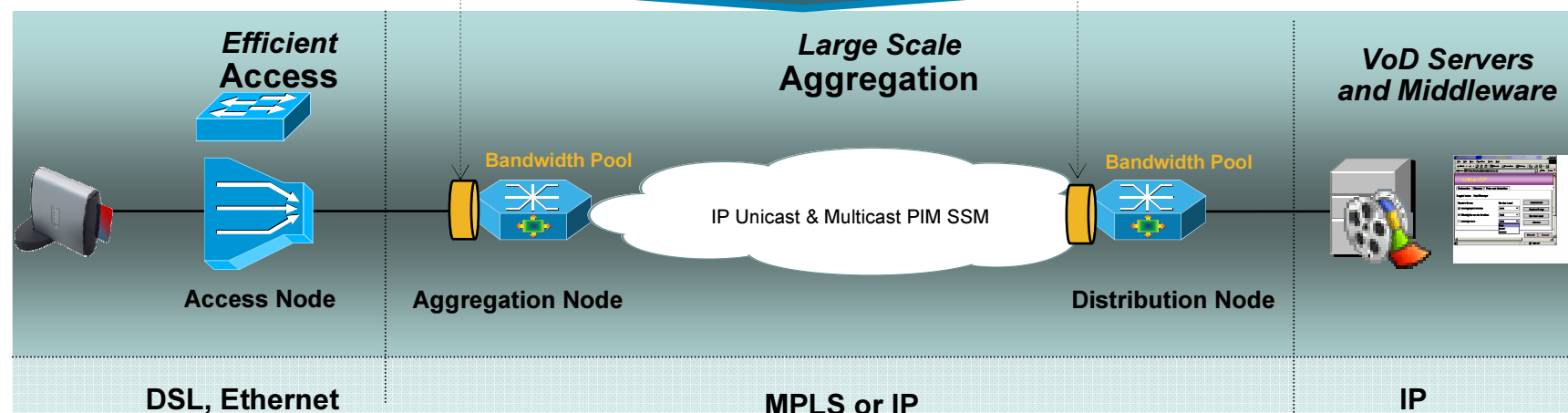
Benefits of Distributed L3 Edge for Multicast:
Enables Efficient & Flexible Anycast for Broadcast Reliability

- Cisco has implemented PIM Anycast -- redundant sources get same address

- L3 in agg uses ring efficiently with set top selecting closest source

- Failure of link, source, N-PE, PE-AGG will result in fast PIM convergence for outage <1s

- H-VPLS can support Anycast at the L3 edge if vendors have implemented

- But uses ring very inefficiently, all m'cast traffic traverses ring

- Set top cannot connect to closest source because mcast traffic only enters through Designated Router

- If DR failure, non-DR waits for time out to take over & entire PIM tree must be rebuilt – many seconds

- H-VPLS link failure uses FRR for 50ms failover, but node failure is in seconds

Layer 3

192.1.1.1

L3 N-PE

L3

PIM

L3

DSLAM

192.1.1.1

L3 N-PE

L3

L3 PE-AGG

DSLAM

H-VPLS

L3 PIM Non-DR (not active)

192.1.1.1

L2

L2

H-VPLS

DSLAM

192.1.1.1

L2

L2

DSLAM

L3 PIM DR
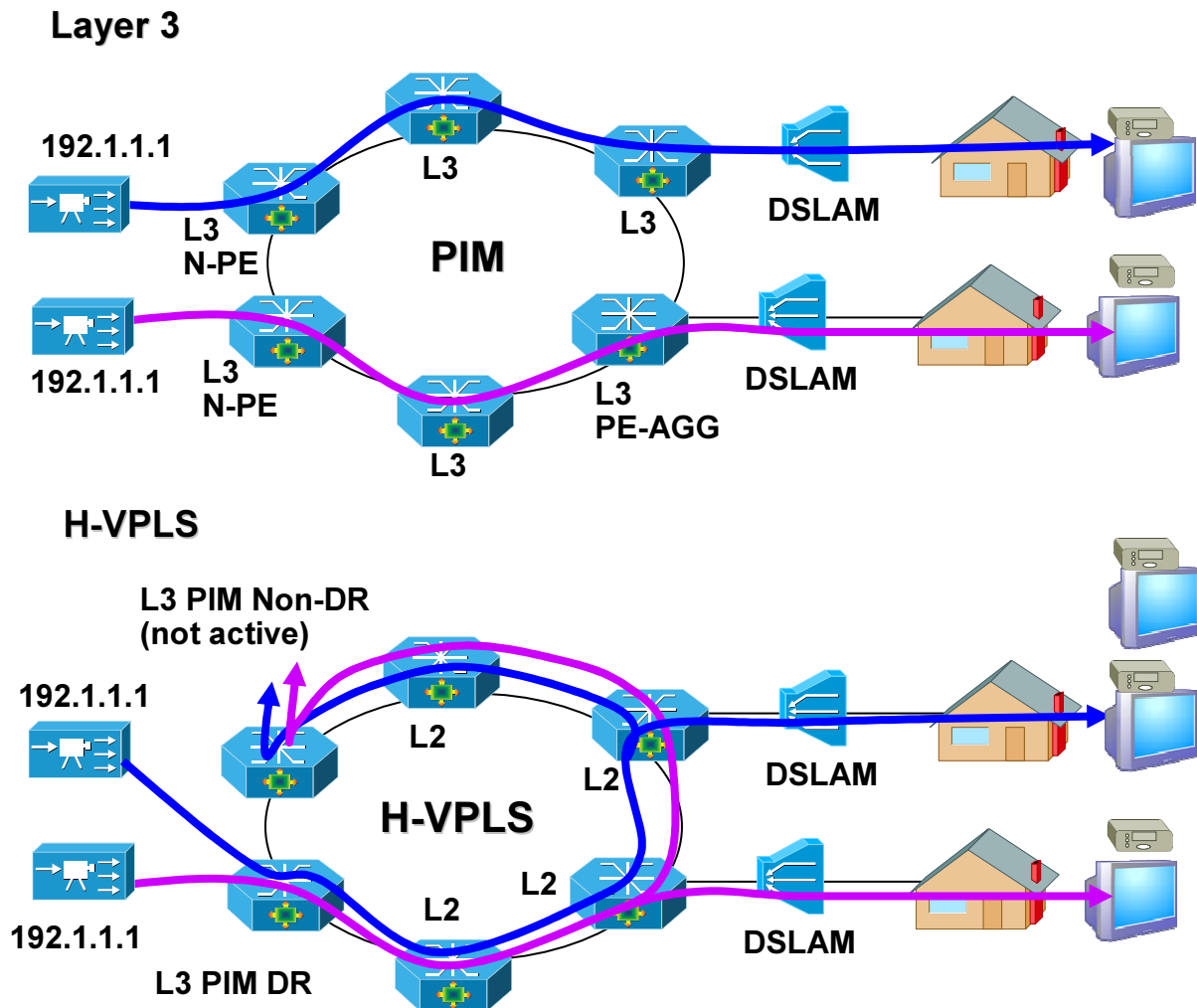
Benefits of Distributed L3 Edge for Multicast:
Source Specific Multicast (SSM) Enhances Security

- **Attack launched from spoofed multicast group** can create outage on ring

- L3 at PE-AGG enables Source Specific Multicast

- SSM inserts a specific IP source address into IGMPv3 join request

- Leverages fact that broadcast sources have predetermine IP address

- Minimizes ability to spoof

- Many STB only support IGMPv2 so Cisco provides SSM mapping of v2 to IGMPv3 at PE-AGG

- With Ciscos implementation Anycast works with SSM!

Layer 3

IGMP V2 to v3 map

192.1.1.1

L3

L3

PIM-SM Anycast + SSM

L3

DSLAM

192.1.1.1

L3

L3

DSLAM

L3

Spoofing not possible

Multi-Gig attack floods ring

H-VPLS

192.1.1.1

L3

L2

L2

DSLAM

H-VPLS

L3 DR

L2

DSLAM

192.1.1.1

L2

Spoof Mcast Group Launch Attack
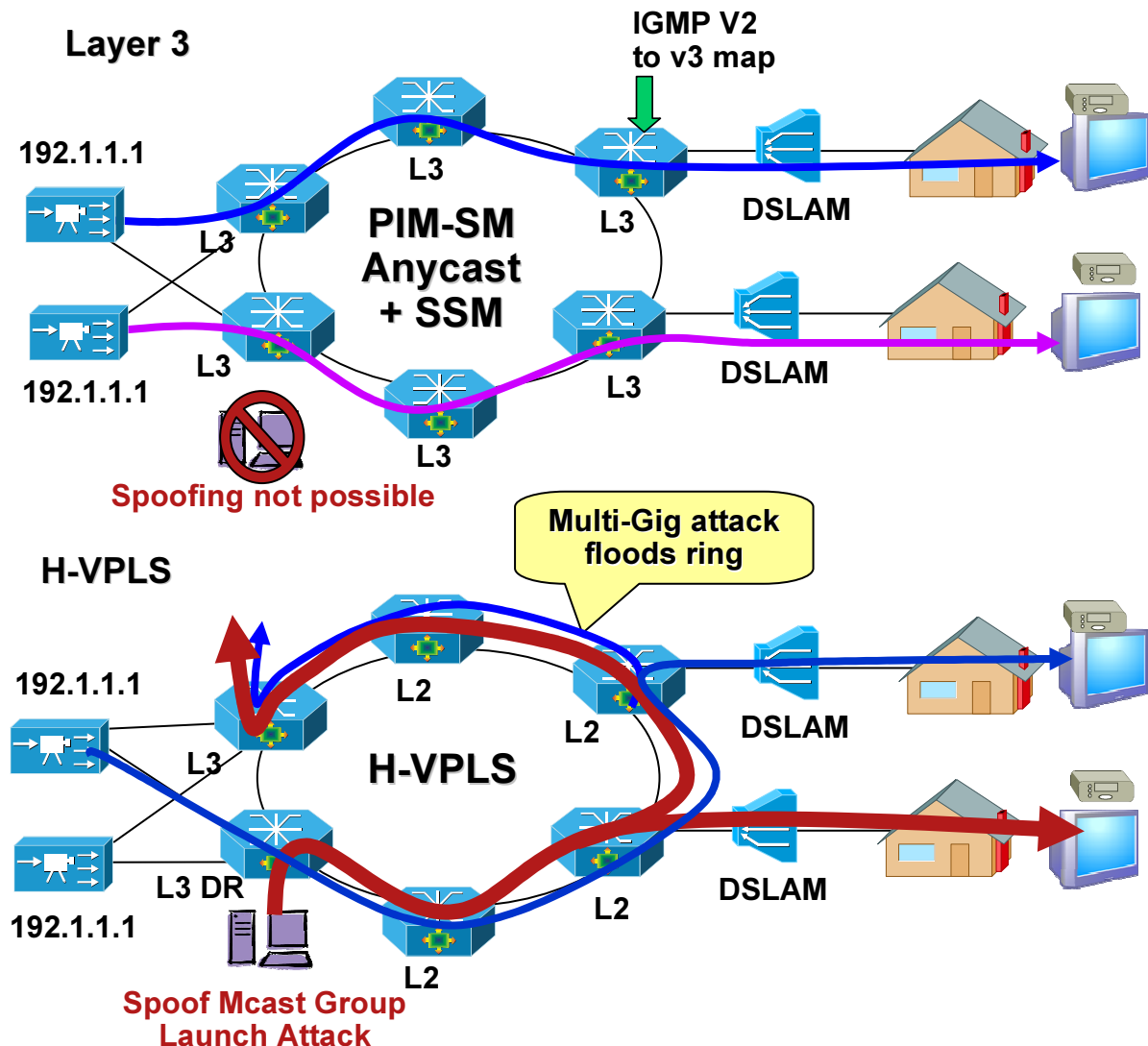
Convergence Issues

- L3 Multicast with Cisco's fast IGP

  Provides consistent convergence <1s in all scenarios

- Broadcast Source Redundancy

  Broadcast reliability is critical due to

  L3 solution supports Anycast for dual redundant headends

  B'cast headend failure could affect millions of users

- H-VPLS transport of video

  MPLS FRR for link failures for <50ms

  Failure of Agg Node, Designated Router, Source, or Headend result in slow STP or IGP based convergence

  Many outages can be in the seconds

Potential outage due to failure at various locations

Millions		SHE
100 thousands		VHO
10 thousands		VSO
thousands		PE-AGG
hund-reds		DSLAM
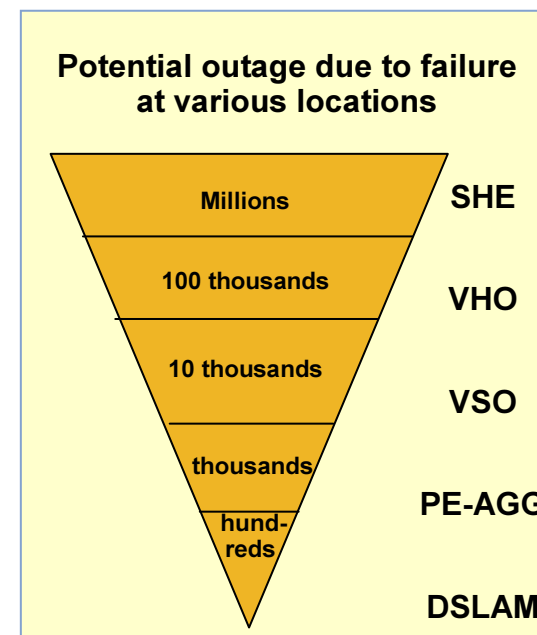
If less than 1s calls to customer service will be avoided.

	Link	Node	Source
VPLS solution	<1s	2-3s	2-3s
Cisco	<1s	<1s	<1s

Ethernet OAM Protocol Overview

Drivers for Ethernet OAM

- **OAM benchmarks**

    Set by TDM and existing WAN technologies

- **Operational Efficiency**

    Reduce OPEX, avoid truck-rolls

    Downtime cost

- **Management Complexity**

    Large Span Networks

    Multiple constituent networks belong to disparate organizations/companies

Application of Ethernet OAM

Fault Management
- Fault detection
- Fault verification
- Fault isolation
- Fault recovery
- Fault notification

Carrier Ethernet Services

Performance Management
- Frame loss measurement
- Delay measurement
- Delay variation measurement
- Availability measurement

Configuration Management
- Service Provisioning
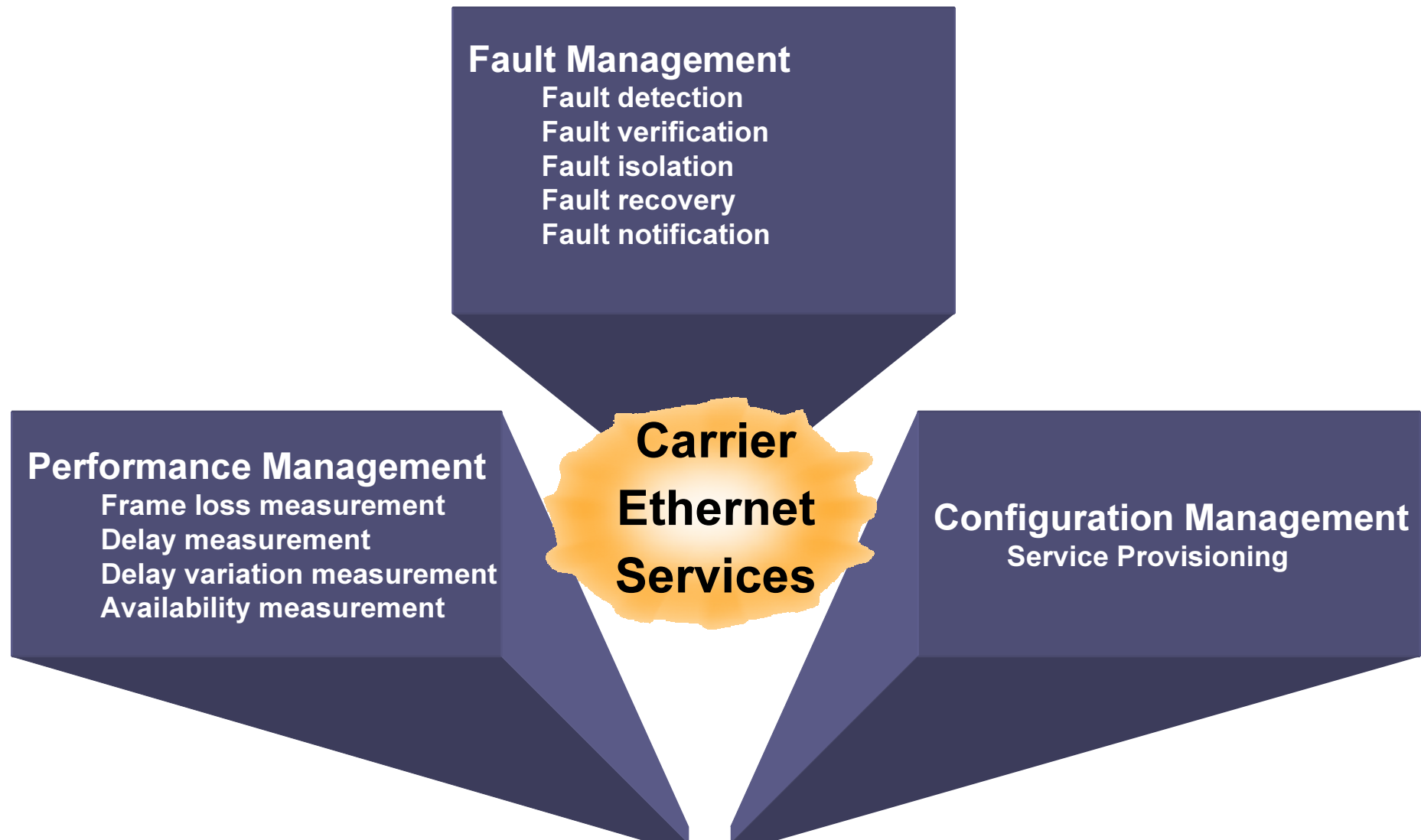
Ethernet OAM
Building Blocks
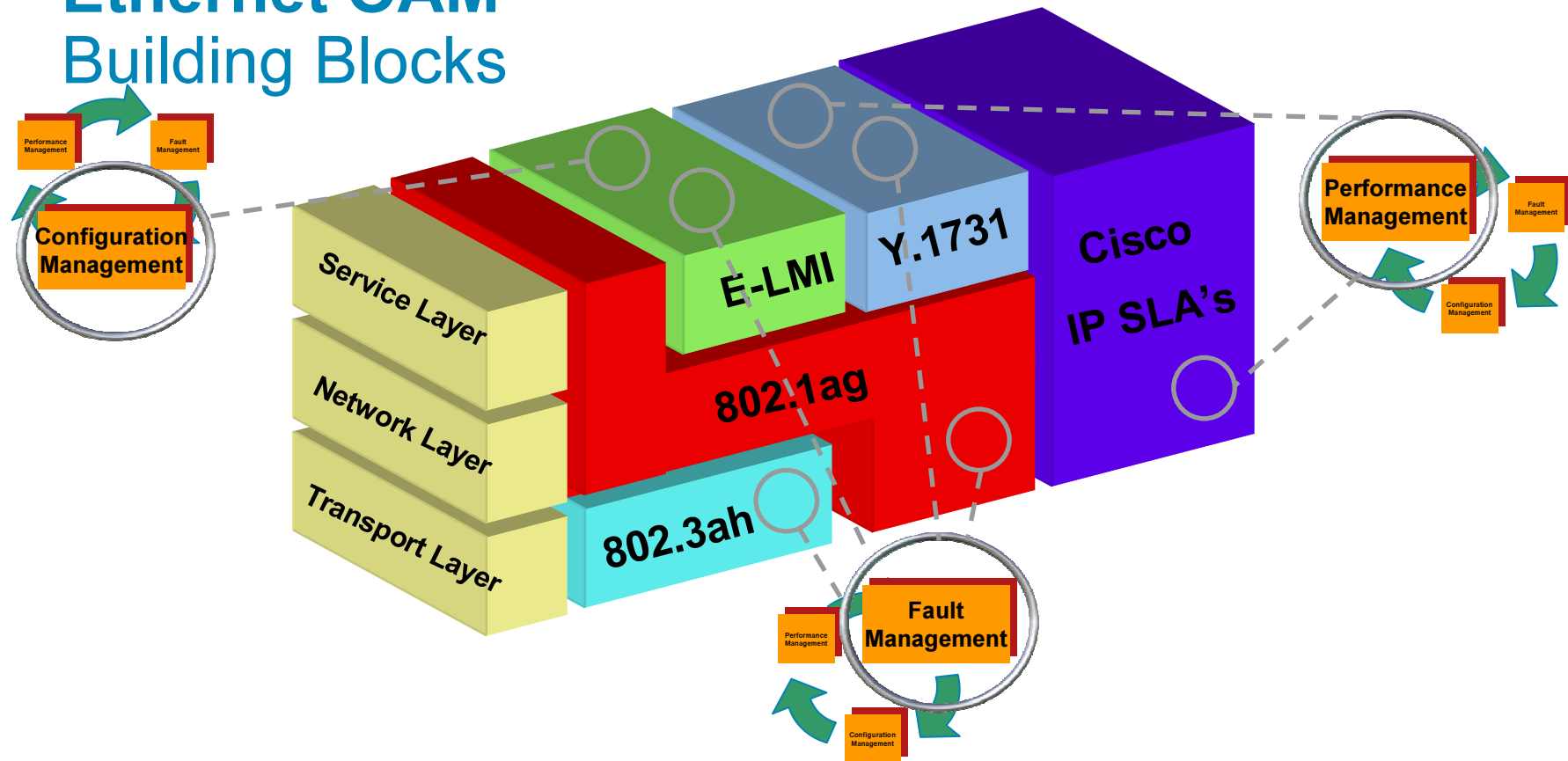
- **IEEE 802.1ag: Connectivity Fault Management (CFM)**
- **ITU-T Y.1731: OAM functions and mechanisms for Ethernet based networks**
- **IEEE 802.3ah: Ethernet Link OAM (EFM OAM)**
- **MEF E-LMI: Ethernet Local Management Interface**
- **Cisco IP SLA's: Performance Management using CFM and Y.1731 mechanisms**

Ethernet OAM
Protocol positioning
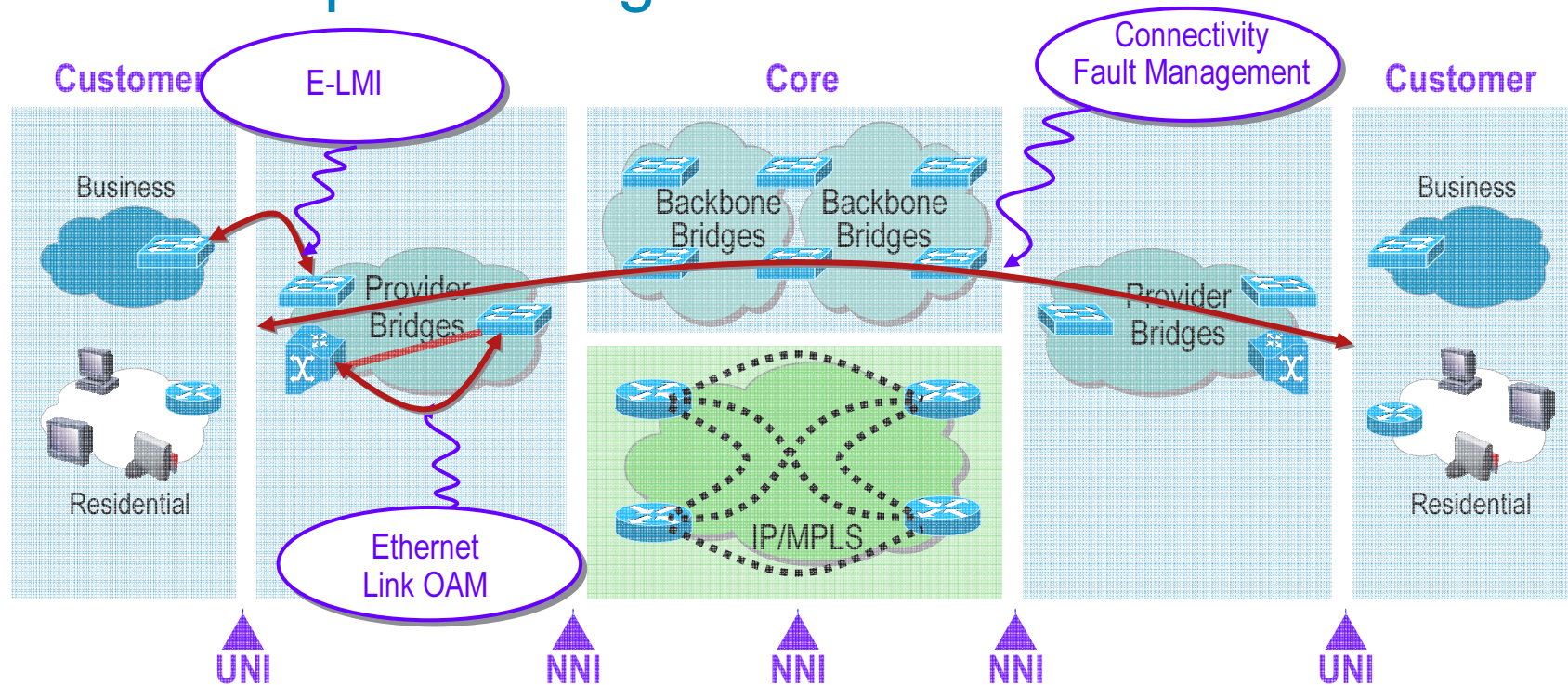
- E-LMI: User to Network Interface (UNI)
- Link OAM: Any point-point 802.3 link
- CFM: End-to-End Ethernet virtual connection

The Cisco 7600 Family

New

Engines
Supervisor 32
Supervisor 720
Route Switch Processor 720
Route Switch Processor 720 -10G
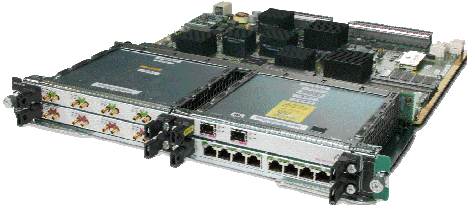
SPA Interface Processors
Modular Carriers Cards
for WAN and Metro
Shared Port Adapters

Enhanced FlexWAN
7500 Parity and
PA Investment Protection

Ethernet Services Modules
GE and 10GE
with Rich QoS, Distributed,
Line-rate Performance
ES20, ES40

S Chassis
7609-S, 7606-S,
7603-S, 7604

Traditional Chassis
7606, 7609,
7613

High-Density Ethernet Modules
High-Density GE and 10GE
with Distributed, Line-rate Performance
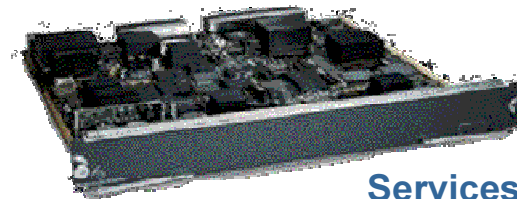
Services Modules
Distributed Security;
IPSEC, Firewall, IDS,
DoS Protection

"S" Class Chassis

- **High Availability**
  - **Enables fast fabric sync (<100 ms switchover)**
  - **Redundant channels for inter-line card control plane communication**
  - **Redundant fan trays in 7609-S**

- **80G/slot ready**

- **Power and Cooling**
  - **Power & cooling capacity of over 600W per slot to support new high-density Ethernet linecards**

S Chassis	Availability
7609S	Shipping
7606S	Shipping
7604	Shipping
7603S	Shipping
7613S	Future

Cisco 7613-S		
Slots	Rack Units	Rack Density
13	18	2

Cisco 7609-S		
Slots	Rack Units	Rack Density
9	21	2

Cisco 7606-S		
Slots	Rack Units	Rack Density
6	7	6

Cisco 7604		
Slots	Rack Units	Rack Density
4	5	9

Cisco 7603-S		
Slots	Rack Units	Rack Density
3	4	11

7600 Engines Comparison

	SUP720	RSP720	RSP720-10GE
Control Plane	MSFC3	MSFC4	MSFC4
Ctrl Plane CPU	600Mhz MIPS	1.2GHz PowerPC	1.2GHz PowerPC
DRAM	1GByte (DDR)	Up to 4GByte (DDR2)	Up to 4GByte (DDR2)
NVRAM	2Mbyte	4MByte	4MByte
Bootflash/bootdisk	64MByte	512MByte	512MByte
Forwarding Plane	PFC3B, PFC3BXL	PFC3C, PFC3CXL	PFC3C, PFC3CXL
MAC (CAM) Table Size (pract./theor.)	32k/64k	80k/96k	80k/96k
IP Subscriber Termination	x	32k	32k
IP Forwarding	30Mpps	30Mpps	30Mpps
MPLS Forwarding	20Mpps	20Mpps	20Mpps

Ethernet Services 20G Modules

- *Service-Rich Ethernet Linecards*

  Two 20 Gbps (full-duplex) linecard options:

  2-port 10 Gigabit Ethernet, XFP LAN-PHY optics

  Future support for XFP WAN-PHY optics

  20-port Gigabit Ethernet, SFP optics

  Up to 48 Mpps distributed performance per linecard

  Line rate for 64-byte packets, L2 or L3

  512 MB packet buffering (200 ms) per 10G ports

  Full support for online insertion and removal (OIR)

  Choice of hardware-based scale for L2 & L3 services:

  DFC-3C daughter-card

  TCAM entries: 256K IP FIB & 128K Netflow

  DFC-3CXL daughter-card

  TCAM entries: 1M IP FIB & 256K Netflow

- *Flexible Carrier Ethernet Service Options*

  Layer 2 Switched Ethernet Control Plane

  Q-in-Q with Rapid Spanning Tree

  Layer 2 MPLS Control Plane

  Ethernet over MPLS and H-VPLS pseudo-wires

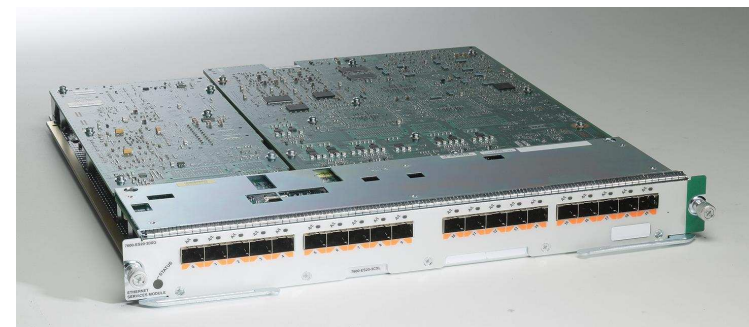 MPLS FRR with pseudo-wire redundancy

  Layer 3 IP / MPLS Control Plane

  IP Multicast for efficient video delivery

  Layer 3 MPLS VPN for business services

2-port 10GE XFP (baldur)

20-port GE SFP (loki)

Cisco Carrier Ethernet Evolution
ES40 Line Cards

- **Carrier Ethernet Convergence with Scale:**

  L2 & L3 Ethernet services to 40 Gbps (ISG+EVC coexistence)

  Support for full suite of L2+L3 features:

  H-QoS: 128k queues with 5-level hierarchy capable hardware
  MPLS: EoMPLS, H-VPLS, 2547 VPN

  Native Ethernet: 802.1ad, 802.1ah (MAC-in-MAC), VLAN translation

  E-OAM: 802.1ag (CCM in hardware), 802.3ah, E-LMI, IP SLA

  Inline Video Monitoring

- **Product details**

  4-port 10GE & 40-port GE

  2-port 10GE & 20-port GE also available

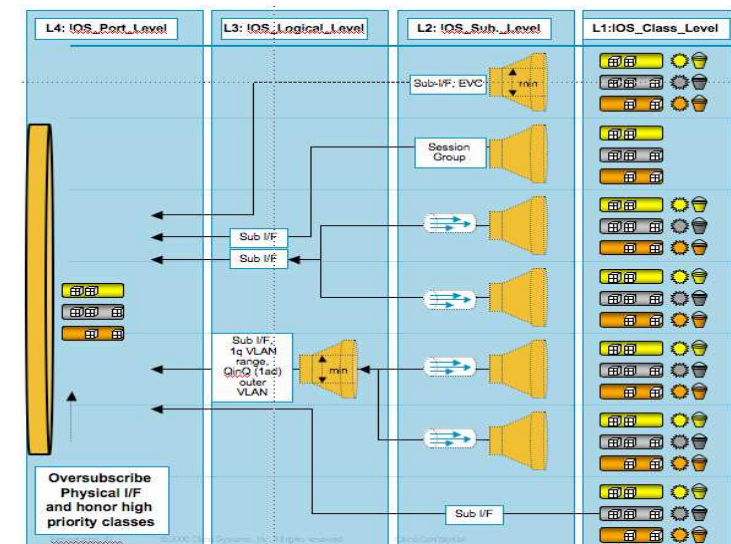 Combo Card: 2x10G + 20x1GE ports on the same card

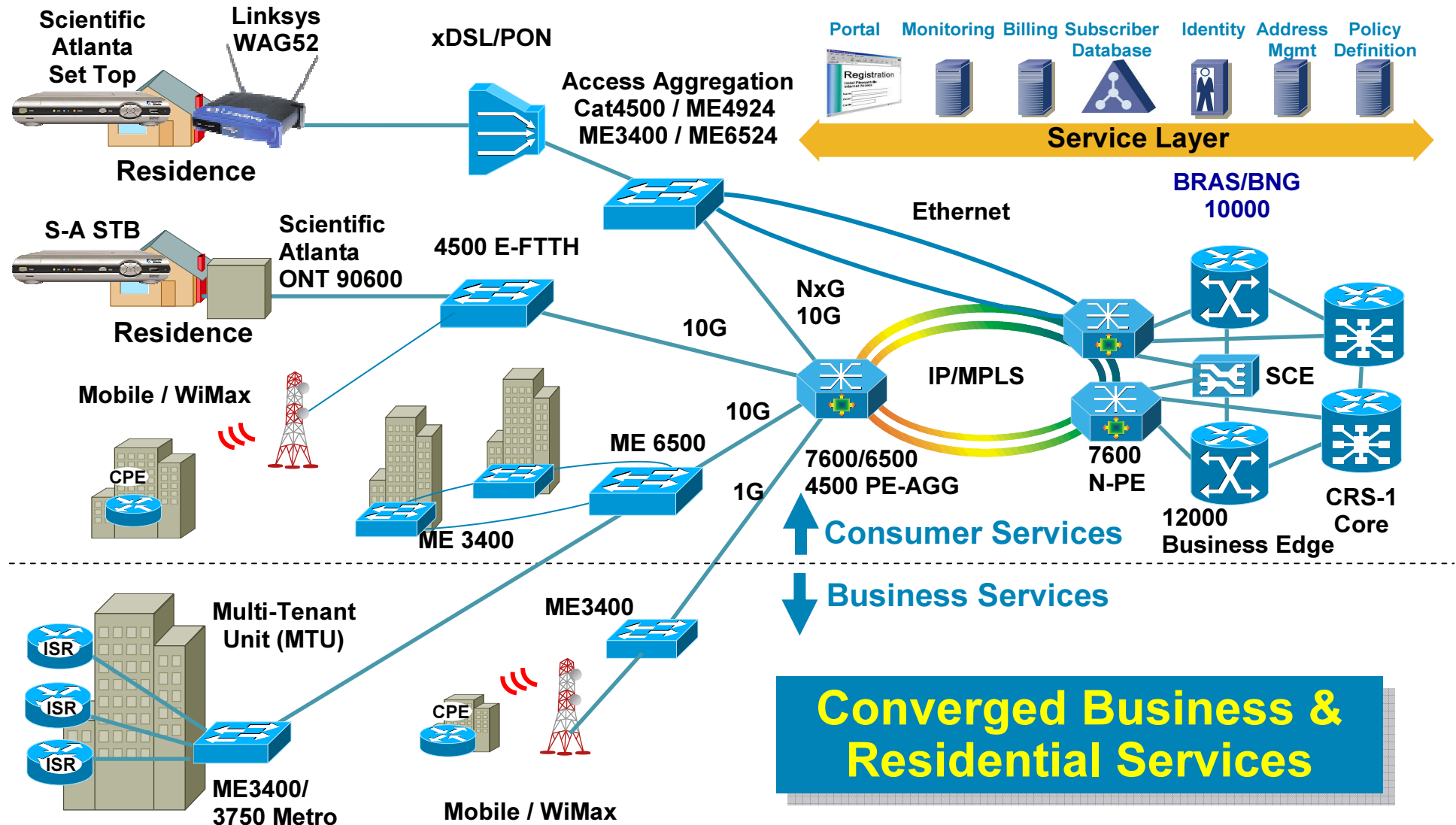## Intelligent Subscriber Services

| 802.1ah | ISG | Video | H-QOS |

Comes in Q3 2008

L4: IOS_Port_Level   L3: IOS_Logical_Level   L2: IOS_Sub._Level   L1:IOS_Class_Level

Sub-I/F; EVC

Session Group

Sub I/F

Sub I/F

Sub I/F; 1q VLAN range, QinQ (1ad) outer VLAN

Oversubscribe Physical I/F and honor high priority classes

Sub I/F

Customer Success
Case Studies

IP NGN Carrier Ethernet Design
End-to-End Consumer and Business Services

Scientific Atlanta Set Top

Linksys WAG52

Residence

xDSL/PON

Access Aggregation
Cat4500 / ME4924
ME3400 / ME6524

Portal Monitoring Billing Subscriber Database Identity Address Mgmt Policy Definition

Registration

Service Layer

BRAS/BNG
10000

Ethernet

S-A STB

Scientific Atlanta ONT 90600

4500 E-FTTH

Residence

NxG
10G

Mobile / WiMax

10G

CPE

10G

IP/MPLS

7600
N-PE

SCE

ME 6500

ME 3400

1G

7600/6500
4500 PE-AGG

12000
Business Edge

CRS-1
Core

Consumer Services

Business Services

Multi-Tenant Unit (MTU)

ME3400

ISR

ISR

ISR

CPE

ME3400/
3750 Metro

Mobile / WiMax

Converged Business & Residential Services

Cisco's Carrier Ethernet Leadership
Continued Customer Success Worldwide

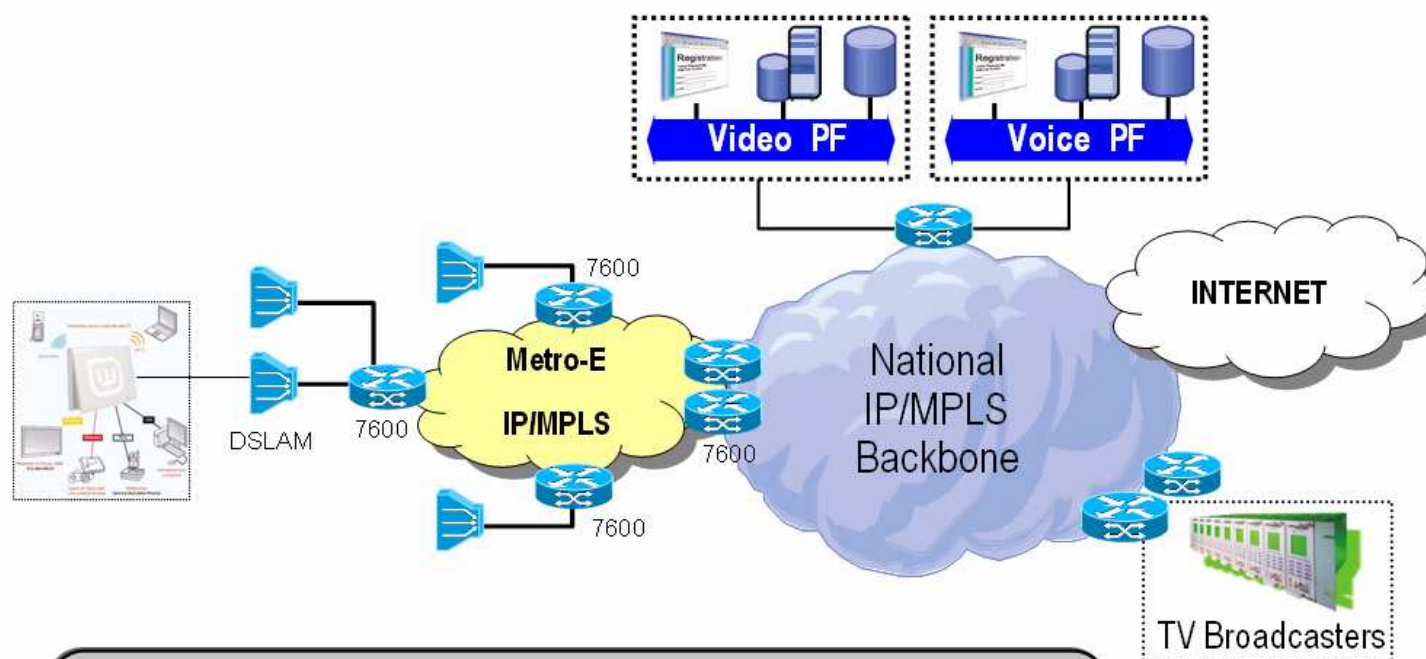**Americas**   **EMEA**   **Asia-Pacific**

Hong Kong Broadband
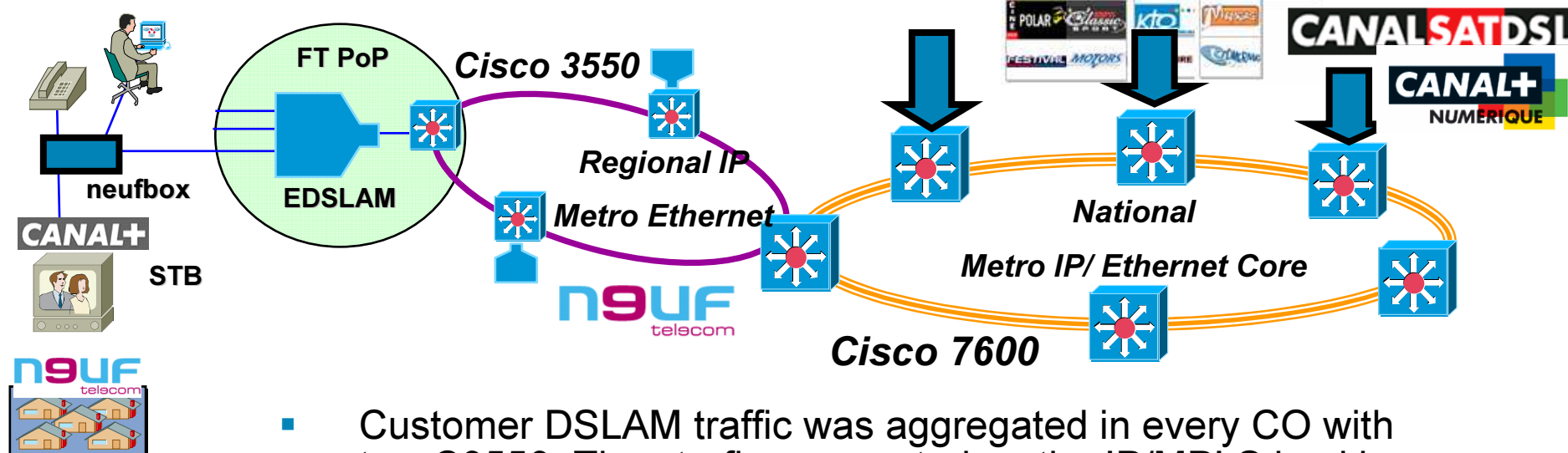
Cisco Carrier Ethernet Solution

Ethernet Backhaul Overview

- IP Unicast for VOD Traffic
- IP Multicast for TV Broadcast traffic
- L2VPN Pseudowires for PPPoE Internet Traffic from Metro-E Node to BRAS
- L3VPN for future SIP-based Voice services.
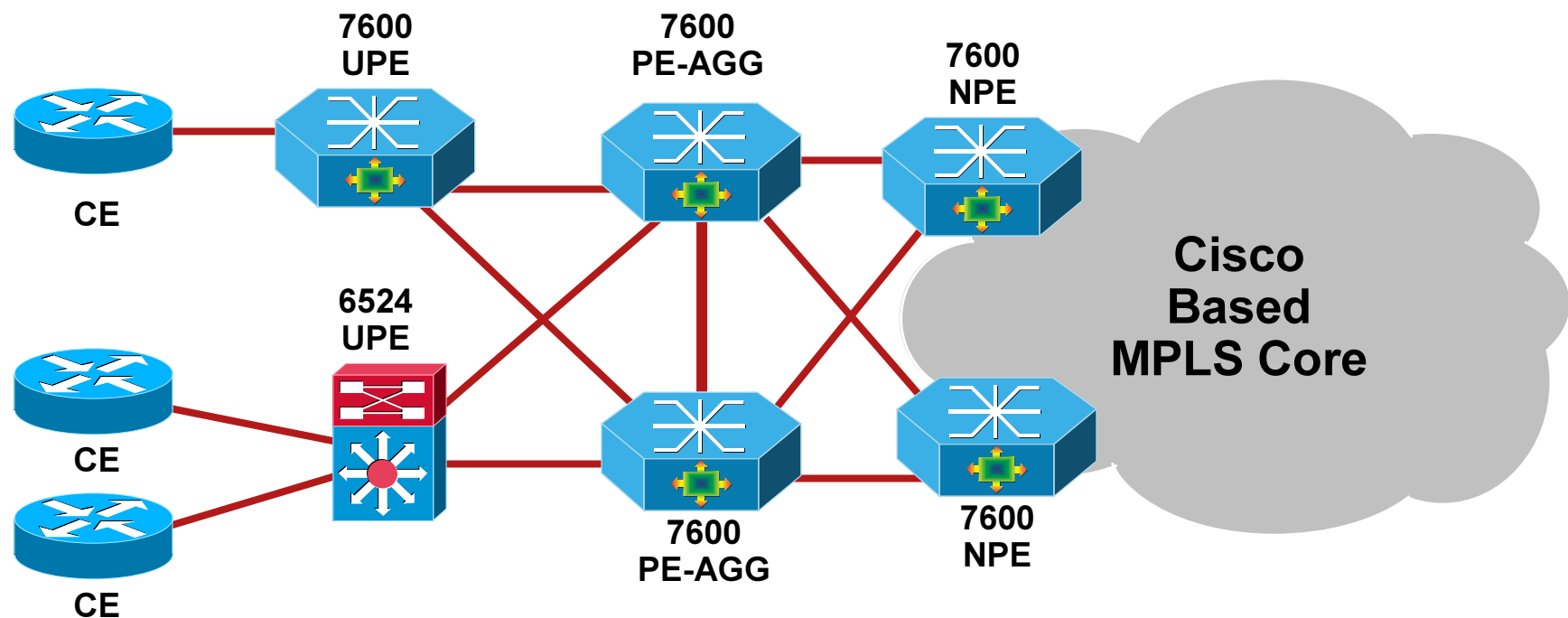- ... more to come

Cisco Carrier Ethernet Solution

- Digital quality TV over DSL
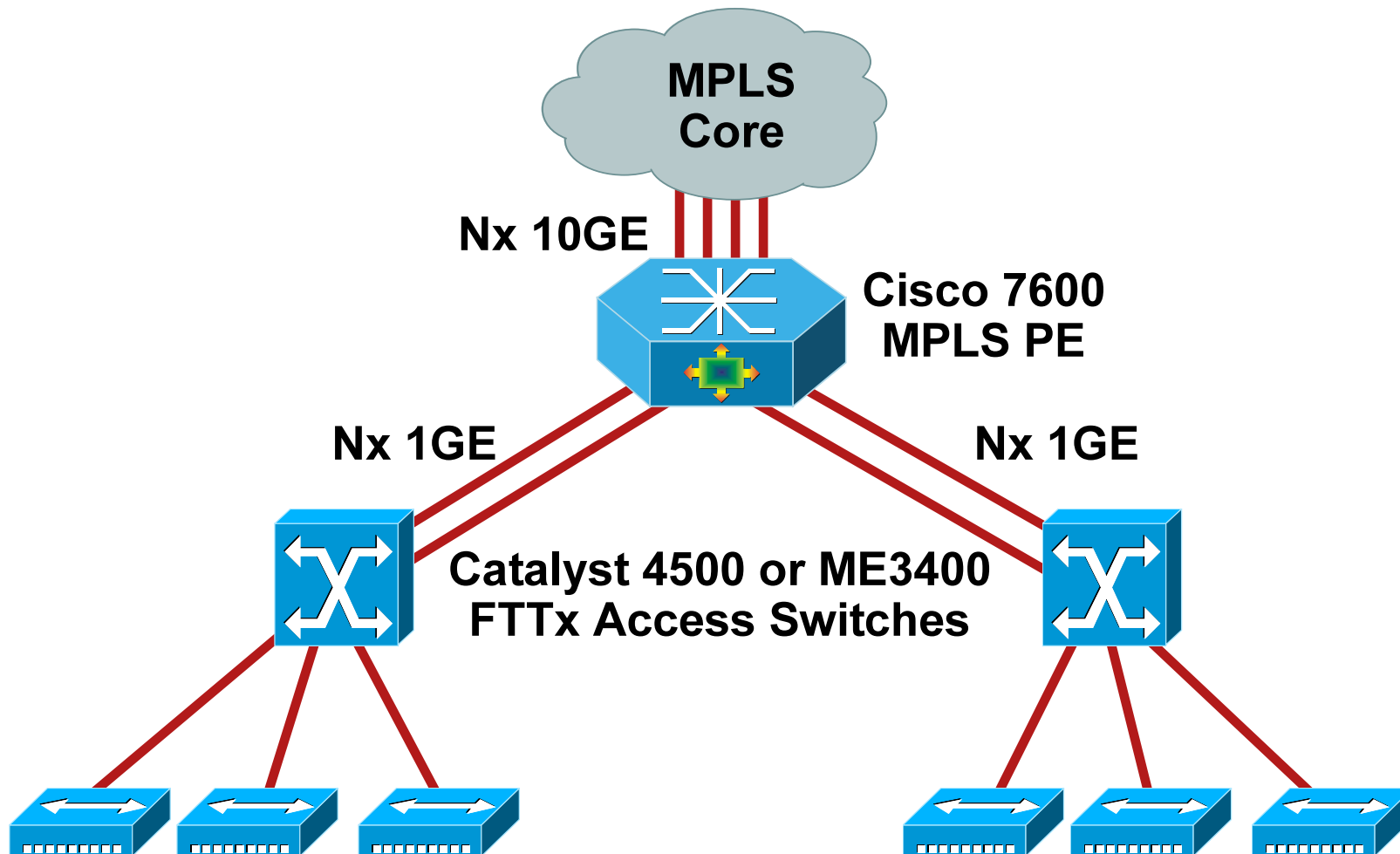- QoS enabled, Intelligent Video distribution

- Customer DSLAM traffic was aggregated in every CO with two C3550. Then trafic was routed on the IP/MPLS backbone based on C7600 to finally reach the internet network.

- 12 PoP with 2 Cisco 7600 each deployed nationwide.

- Basic configuration is Cisco7606 (DC), single SUP720-3BXL (MPLS P), WS-X6724-SFP line cards.

Cisco Carrier Ethernet Solution

Cisco 7600 Series Routers x 50 (MPLS to the edge)
Cisco ME 6524 Ethernet Switch x 386 (L2/L3 VPN)

Cisco Carrier Ethernet - EFTTH Solution

MPLS Core

Nx 10GE

Cisco 7600 MPLS PE

Nx 1GE   Nx 1GE

Catalyst 4500 or ME3400 FTTx Access Switches

Questions ?