Aggregation Networks for Residential and Business Services

BRKBBA-3002

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Cisco Networkers 2007

HOUSEKEEPING

- We value your feedback, don't forget to complete your online session evaluations after each session and complete the Overall Conference Evaluation which will be available online from Friday.
- Visit the World of Solutions on Level -01!
- Please remember this is a 'No Smoking' venue!
- Please switch off your mobile phones!
- Please remember to wear your badge at all times including the Party!
- Do you have a question? Feel free to ask them during the Q&A section or write your question on the Question form given to you and hand it to the Room Monitor when you see them holding up the Q&A sign.

Agenda

- DSL Forum's TR-101

  …And Cisco's implementation

- Aggregation Network Vision and Requirements

  …Not all services are equal

- Aggregation Network Transport Options

  …Ethernet? MPLS? IP?
  …How Video influences the choice

- Carrier Ethernet Aggregation System 1.0

  …An end-to-end Architecture for business, residential and wholesale services

- Summary

  …Now and the Future

DSL Forum's TR-101

An architecture towards Ethernet Aggregation

DSL beyond Best Effort ?

- Significant current interest in making residential DSL more than a best effort service
  - Lower initial cost of entry and incremental revenue through value added services
  - Dynamic bandwidth services – bandwidth on demand
  - Differentiated services support voice, broadcast TV, video telephony, Video-on-demand
- Number of catalysts
  - DSL Forum TR-59 (ATM aggregation) and now TR-101 (Ethernet Aggregation)
  - Ethernet to the Home deployments
  - IPTV Service Delivery Maturing
  - MPEG-4 Part 10 / Media Player 9
    - broadcast quality video at ~1.2Mbps

TR-101 Scope and Content

- Technical Considerations

  VLAN architecture

  Multicast considerations

  Use of a video optimised Service Router (next to 'traditional' TR-59 type BRAS)

  Resilience in the Ethernet Aggregation Network

  QoS in the Ethernet Aggregation Network

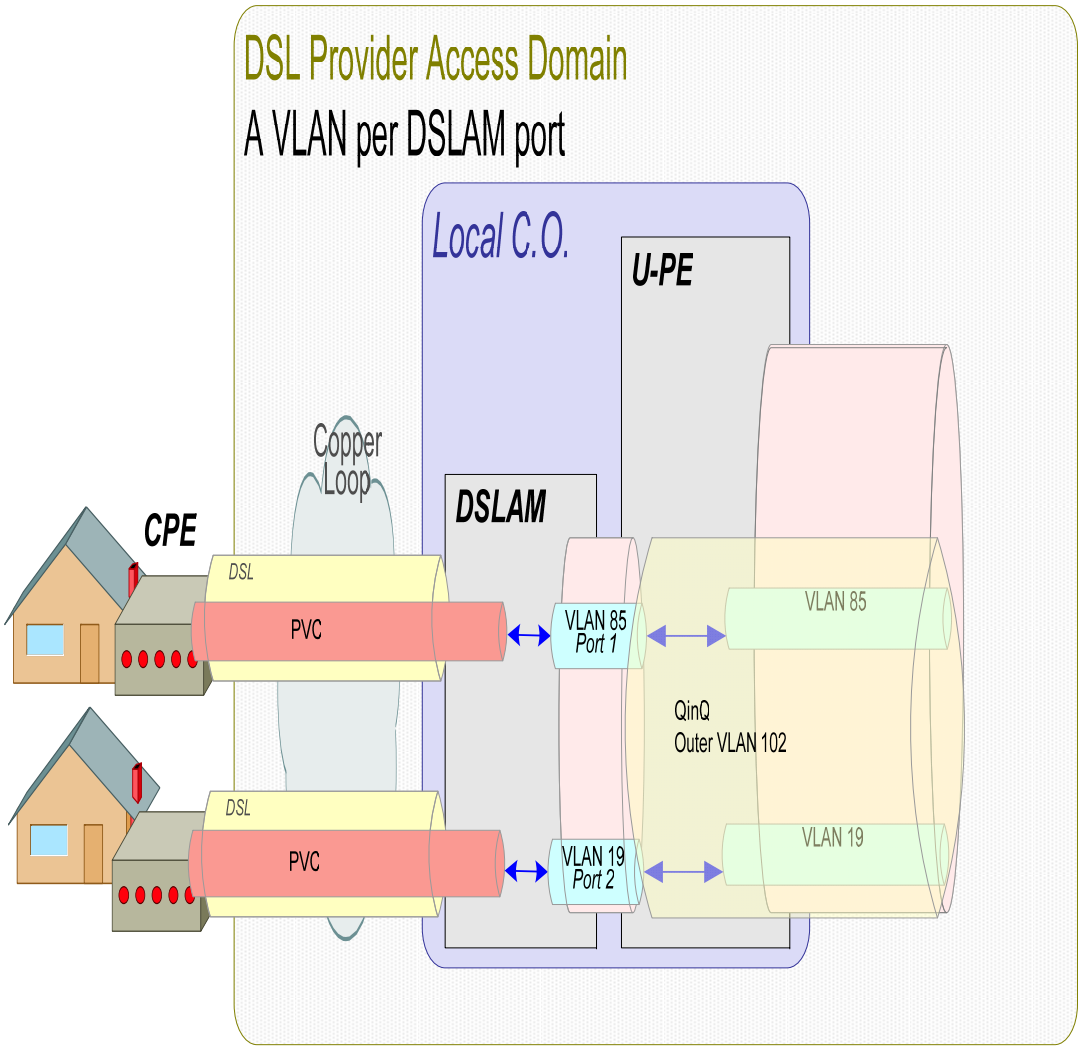
  Ethernet OAM

  Support for PPPoA and IPoA (aka interworking between XoA and XoE)

Note: TR-101's introduces the term Broadband Network Gateway (BNG) to differentiate from the legacy 'BRAS' term

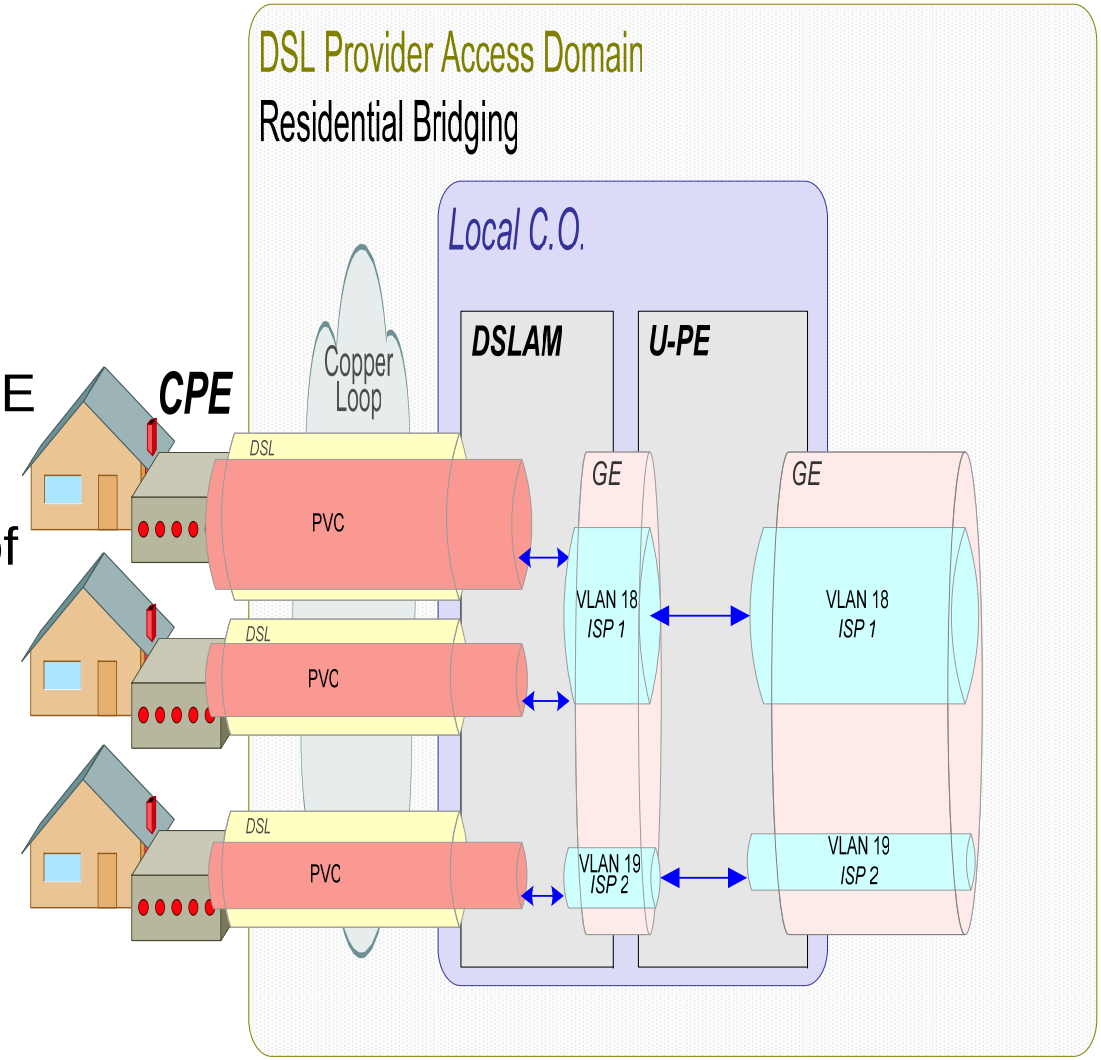
VLAN Architecture : VLAN per User (1:1)

- VLAN use similar to ATM i.e. connection oriented i.e. configuration intensive
- IEEE802.1ad – Inner Tag = Port Identifier, Outer Tag = DSLAM Identifier
- Multicast replication inside Single BNG, not inside Ethernet Aggregation Network
- Multi-homing to 2 BNGs is complex
- Good for p2p business services ; less ideal for Triple-Play Services



VLAN Architecture : VLAN Per Service/SP (N:1)

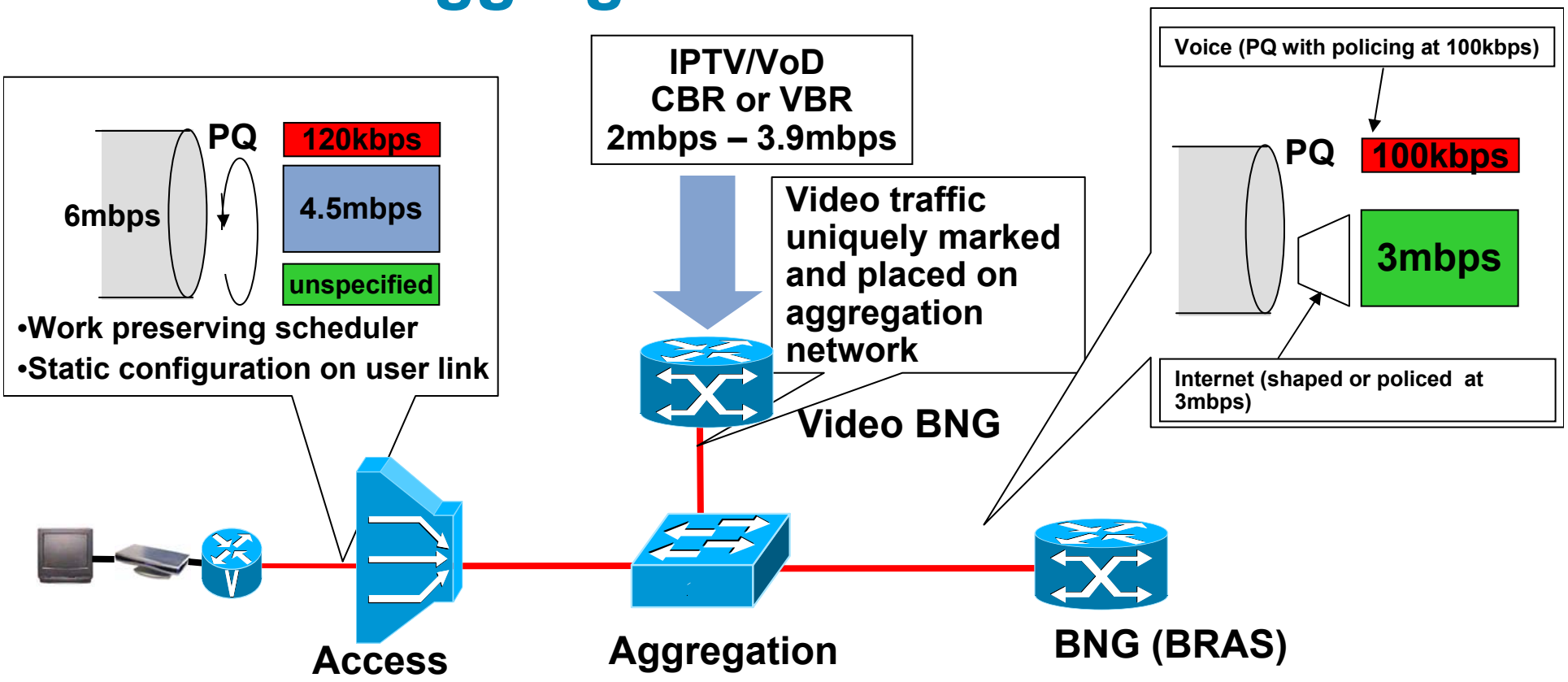
- Single tagged (802.1Q or 802.1ad) VLANs – Double tagging not needed
- Connectionless provisioning benefit ; Access Node inserts Line ID (DHCP Opt 82 , PPPoE Intermediate Agent)
- Network Elements take care of subscriber MAC isolation through 'split horizon forwarding'
- Multiple injection points per VLAN (BRAS AND Video Service Router) possible
- Multicast replication within access/aggregation



DSLAM Connectivity Models

- The models considered are part of DSL Forum TR-101 section 2.5.1
  - Multiple VC DSL UNI
  - Trunk UNI - Single VC DSL or Ethernet
  - Non-Trunk UNI - Single VC DSL or Ethernet
- In the Multiple VC DSL UNI model, the VC is used for both service prioritization and service connectivity.
- In the Single VC DSL and Ethernet UNI models, these functions are distributed in 802.1p COS and 802.1Q VLANs
- Choice of model will be dependent on Access Node and RG capability, number and type of services offered and available bandwidth on local loop

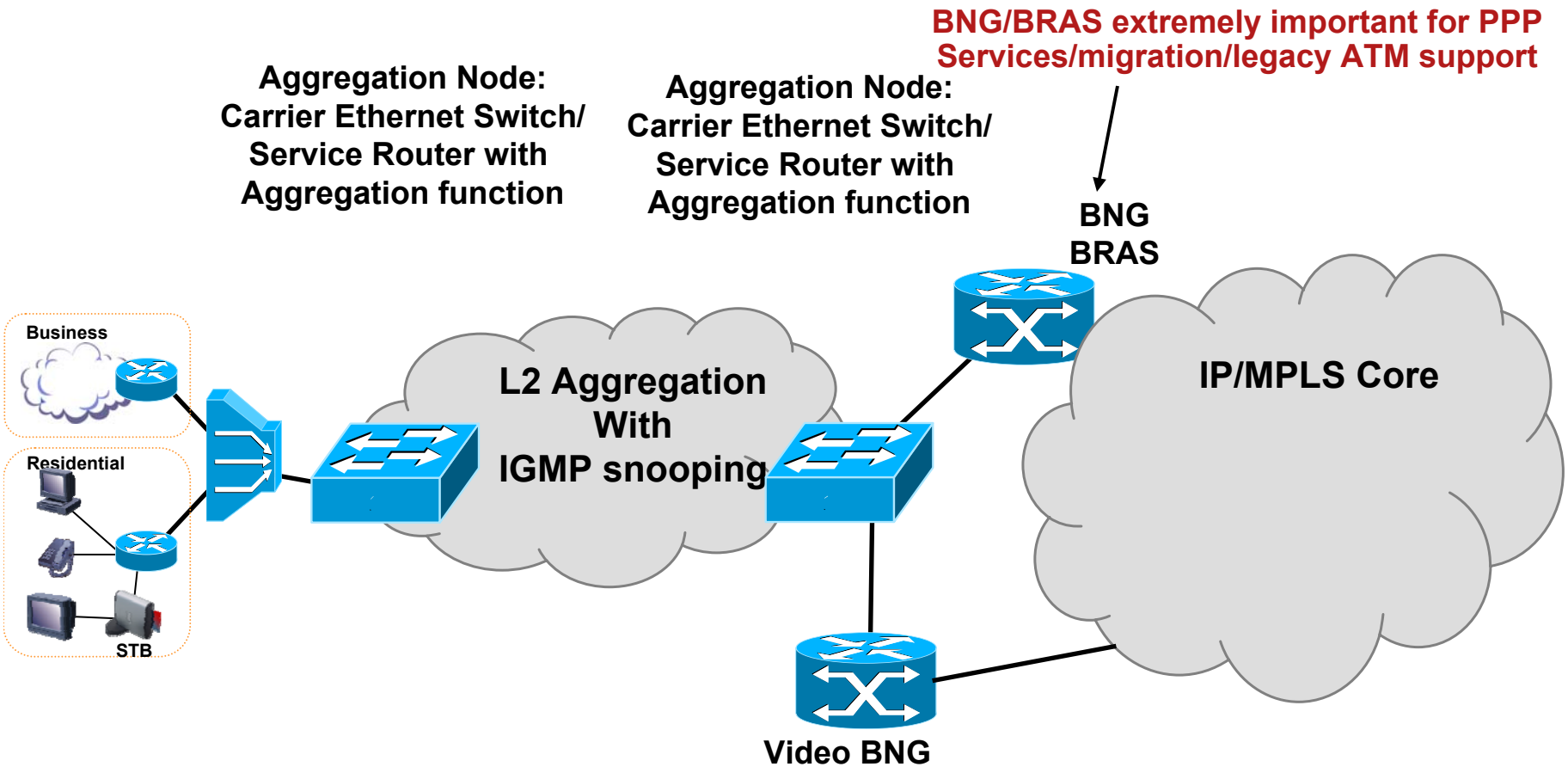
Ethernet Aggregate QoS within the Access/Aggregation Network



- Per Class scheduling within Access/Aggregation Network
- Per Class scheduling is essential for Video as the Access Node is effectively a multicast insertion/replication point (replicating per subscriber line)
- Per Class scheduling essential when separate Video BNG is deployed

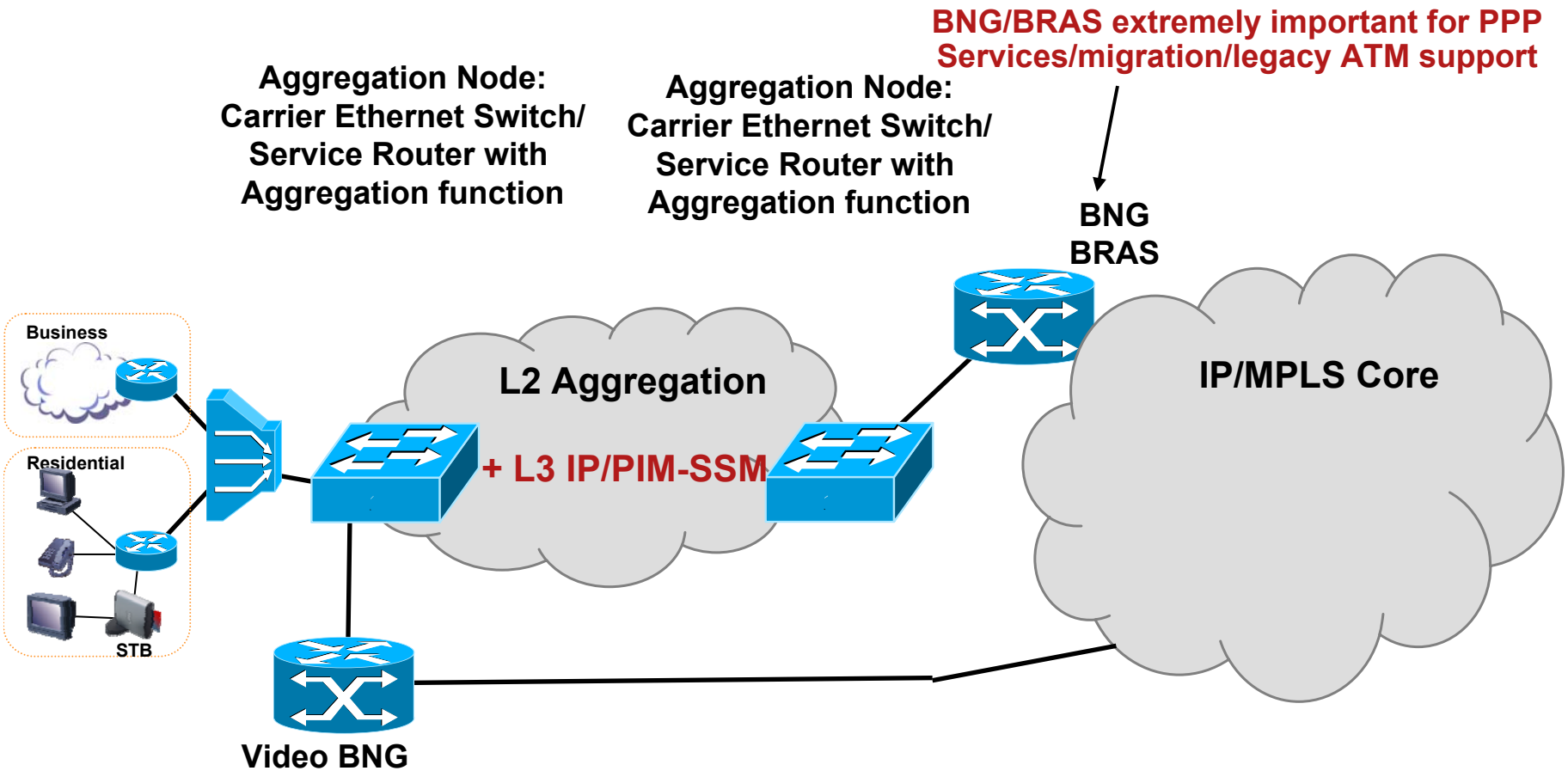
Cisco's TR-101 architecture

…from discrete elements



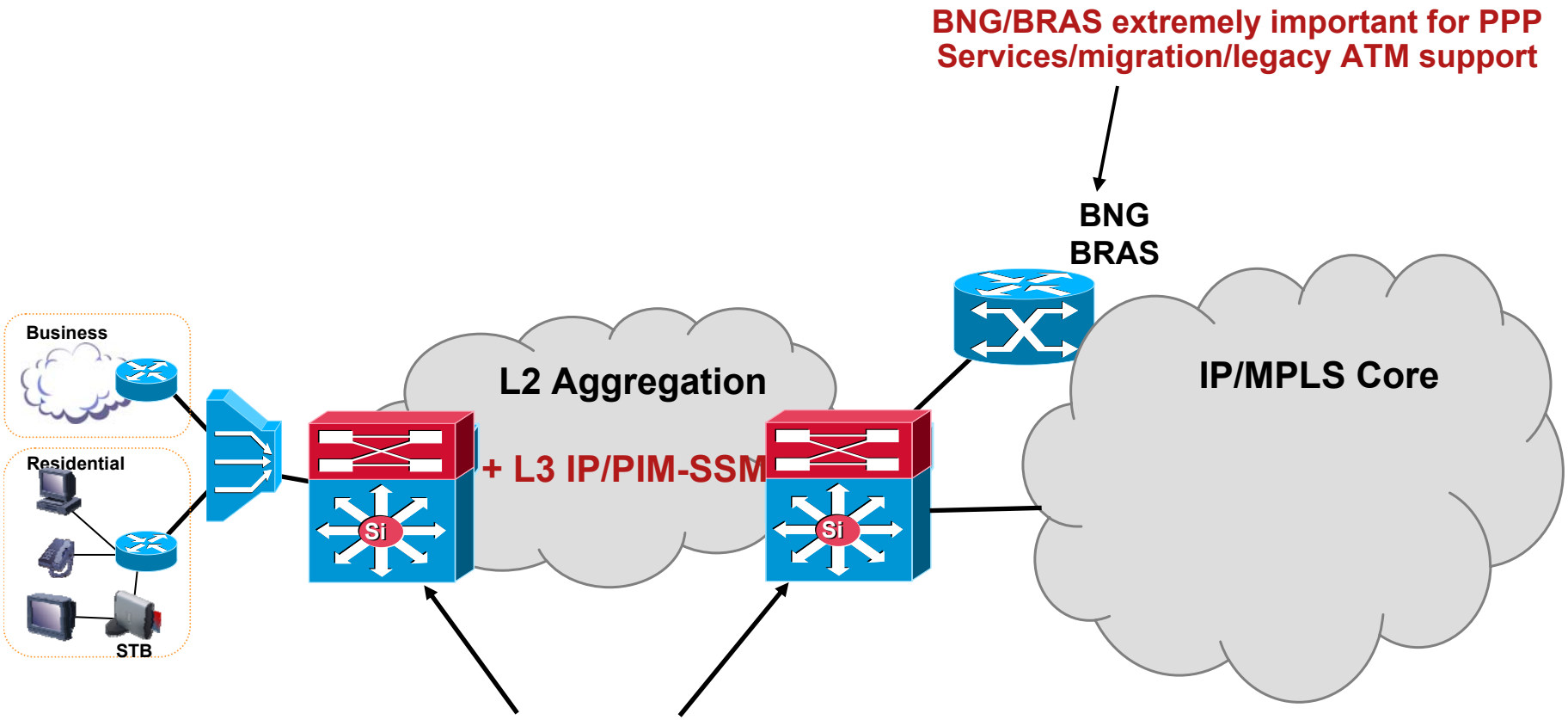
Cisco's TR-101 architecture

…via video optimization



Cisco's TR-101 architecture

…to integrated network elements



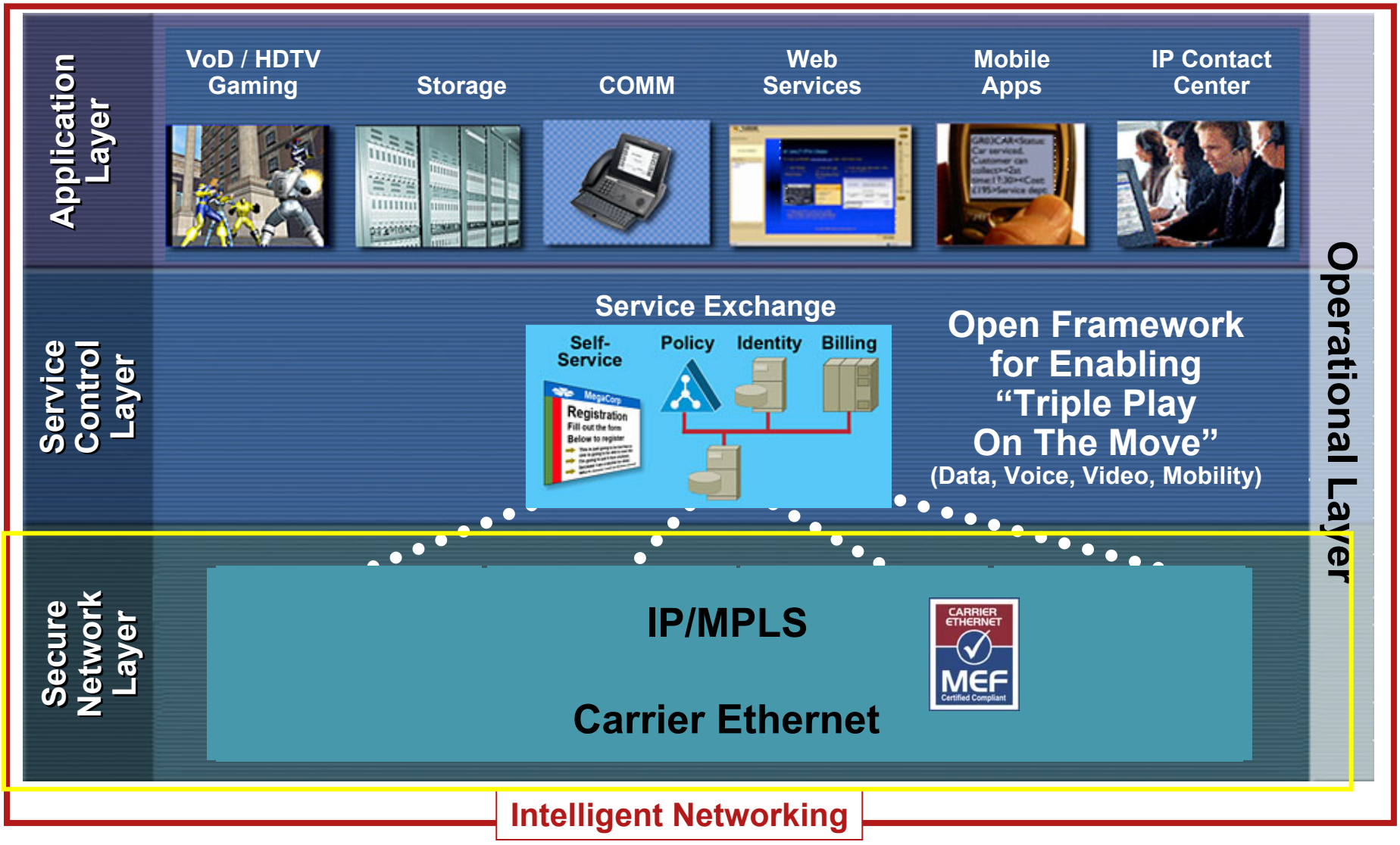
Carrier Ethernet Service Router (L1, L2, L3)
Video BNG (L3 IP/PIM-SSM) + L2 aggregation
Option to virtualize L2 aggregation (IP control layer, MPLS techniques)

Aggregation Network Vision & Requirements

Towards a Converged Infrastructure for Quad-Play, Wholesale and Business Services

Cisco IP NGN Architecture

Achieving a Whole Greater Than the Sum of the Parts



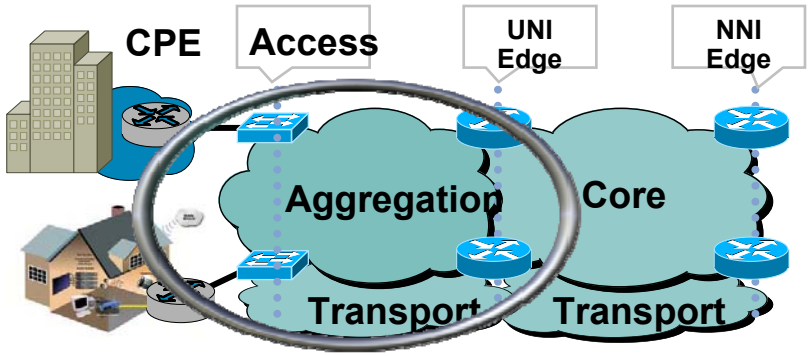
Cisco Carrier Ethernet Services
MEF 9 Certification

System Name	Carrier Ethernet Services Certified
Cisco Catalyst 3750 Metro Series Switch	EPL, EVPL and E-LAN
Cisco Catalyst 4500 Series	EPL, EVPL and E-LAN
Cisco Catalyst 4948 - 10G	EPL, EVPL and E-LAN
Cisco Catalyst 6500 Series Switch - Supervisor 720	EPL, EVPL and E-LAN
Cisco Catalyst 6500 Series Switch - Supervisor 32	EPL, EVPL and E-LAN
Cisco 7600 Series Router - Cisco 7600 Series Supervisor Engine 720	EPL, EVPL and E-LAN
Cisco CNS 15310 ML-Series	EPL, EVPL and E-LAN
Cisco CNS 15310 CE-Series	EPL
Cisco CNS 15454 ML-Series	EPL, EVPL and E-LAN
Cisco CNS 15454 CE-Series	EPL
Cisco ONS 15310 MA ML Series	EPL, EVPL, E-LAN
Cisco ONS 15310 MA CE-Series	EPL
Cisco ME 6524 Ethernet Switch	EPL, EVPL and E-LAN
Cisco ME 3400 Ethernet Access Switches	Pending

In original testing (Sept 05), 16 Vendors Participated & Cisco Represent 25% of all Platforms Certified

Cisco Aggregation Architecture is aligned with major standardization efforts

- Ethernet technologies maturing for Carrier Aggregation Networks
- IEEE and IETF provide Ethernet and MPLS aggregation options
- DSL Forum defines architecture models for EtherDSL aggregation
- MEF defines Ethernet services and UNI options
- Cisco Systems has an active role in these standards bodies



Focus on the User-Perspective: Ethernet Services, UNI, Traffic Engineering, E-LMI, ...

SP-Ethernet: Provider Bridges (802.1ad); EFM (802.3ah); Connectivity Management – OAM: 802.1ag; 802.1ah Backbone Bridges, 802.1ak Multiple Registration Protocol, 802.1aj Media Converters, etc.

L2VPN, PWE3 WG – Building the Network Core: VPWS, VPLS

SG15/Q12, SG13/Q3; Architecture of Ethernet Layer Networks, Services etc. – from a Transport perspective. E2E OAM.

Ethernet to Frame-Relay/ATM Service Interworking

TR-101 alignment : BRAS-requirements, Ethernet Aggregation / TR-59 evolution, subscriber session handling, ...

Video/IPTV is key but hardest to deliver

Video Challenges

Business Challenges
"Content Scope & Control"

- High Quality of Experience (QoE)
- Differentiated offer / content explosion
- Niche and local content
- Growth of "on-demand" TV
- Need to deploy new services
- Impact of "over the top" video

Technical Challenges
"Open, Balanced System"

- Stringent packet loss requirements
- Accurate CAC for VOD
- Efficient multicast for local insertion and to accommodate new services
- <1s recovery in any failure scenario
- Fast channel change
- Managing video in scope of larger Triple Play & Business Services portfolio

Traditional Web-Based Services

VoIP Services

Video-Based Services

Easiest → **Most Difficult**

Next Generation Broadband Services

Have Different Transport and Operational Needs

Internet Access

Operational Intensive, Transport SLA

Triple Play (Voice, VoD, TV)

Transport Intensive, Application SLA

Wholesale Services

Aggregate Transport SLAs,

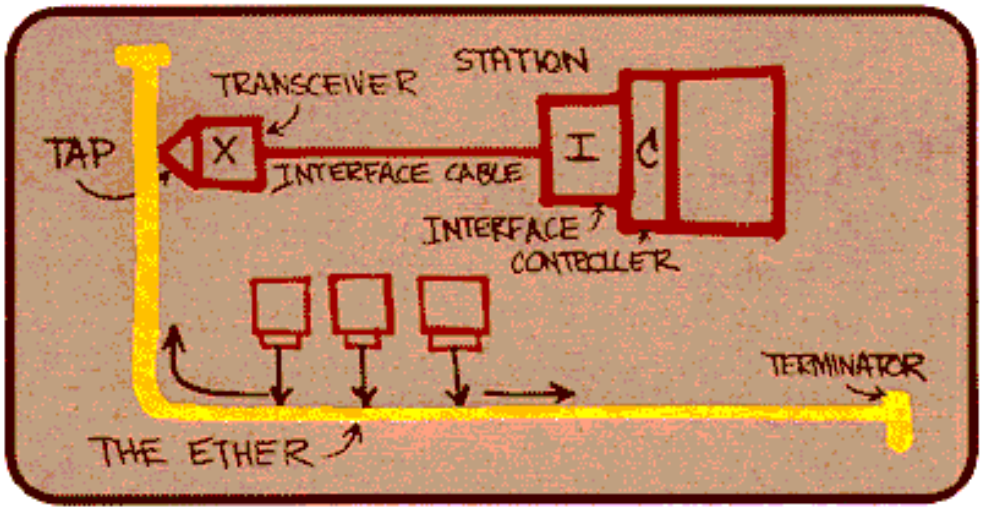
Ethernet to the Business

Operational Intensive, Transport SLA

Service Type	Transport Driven Service	Managed Application Service
SLA Type	**Transport SLA** –Access Behavior –Bandwidth Access Rates –Drop, Delay, Jitter per Service –Service Level Destinations and Accounting	**Application SLA** –Video: # of Set Tops, TV Package, PVR, HDTV vs SDTV –Voice: # of Voice Calls, # of Phones, Telephony Services, Telephone Numbers, etc.
Subscriber Control	**Network Based** –Service and Session Gateway –PPPoE, IPoE Session Management –PPPoE LineID VSA, DHCP Option 82, Username, MAC….	**Application Based** –SIP Proxy –Video Middleware
SLA Enforcement	**Network Based** –Enforced by Service Gateway –Traffic Policies per Subscriber Session	**Application Based** –Based on Application Signaling
QoS	**Subscriber & Service Class Level** –Different Service Classes –Per subscriber service classification, queuing and shaping	**Service Aggregate Level** –Single Queue per Service Class –Differentiated Service QOS Model –Network Connection Admission Control

Generalizing SP Ethernet Access

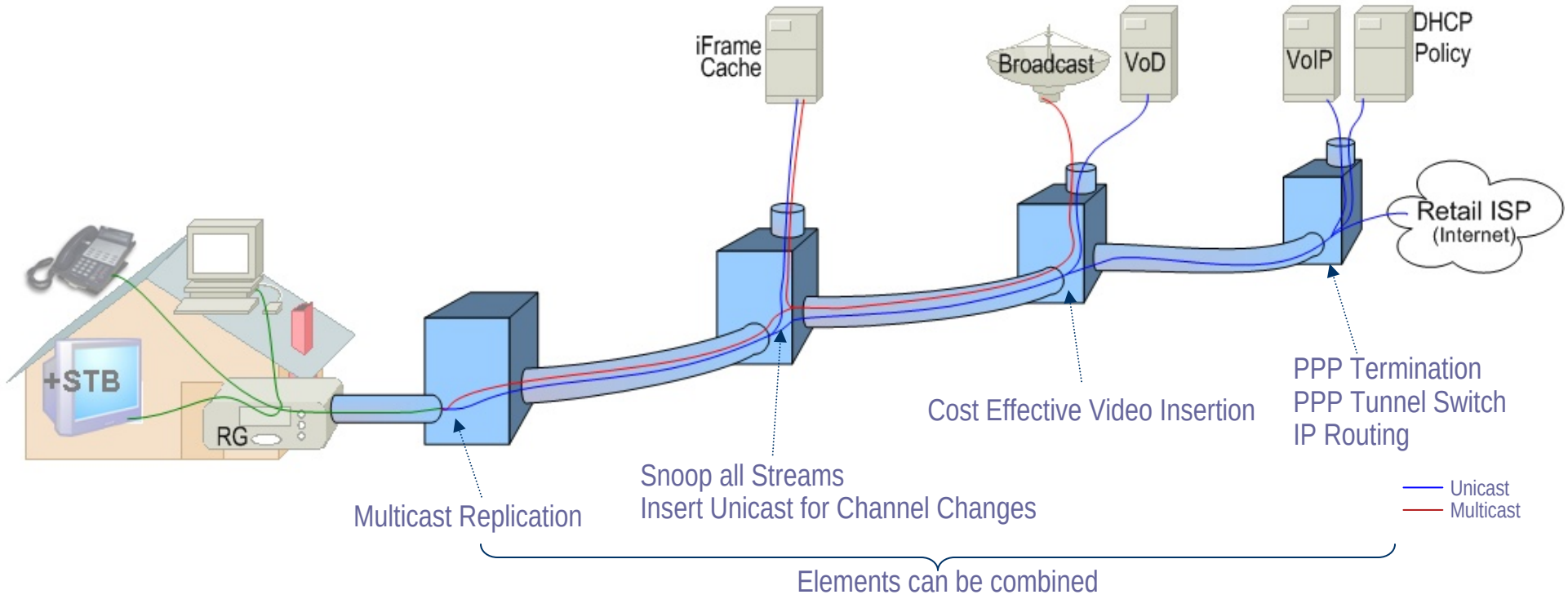
Evolving the Original Idea of the Ethernet Service Bus



Metcalfe's Original Concept of Ethernet (1976)

- Ethernet began as Shared Media Tap points for workstations & bridges
- leverage the multipoint nature of Ethernet in SP access. There is a *lot* of value here…
  - Service Insertion Point Economics
  - Optimizing Transport Cost versus Operational Costs

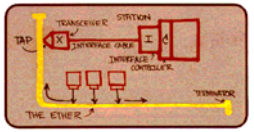
Application Mix Can Require Multipoint at Sequential Hops

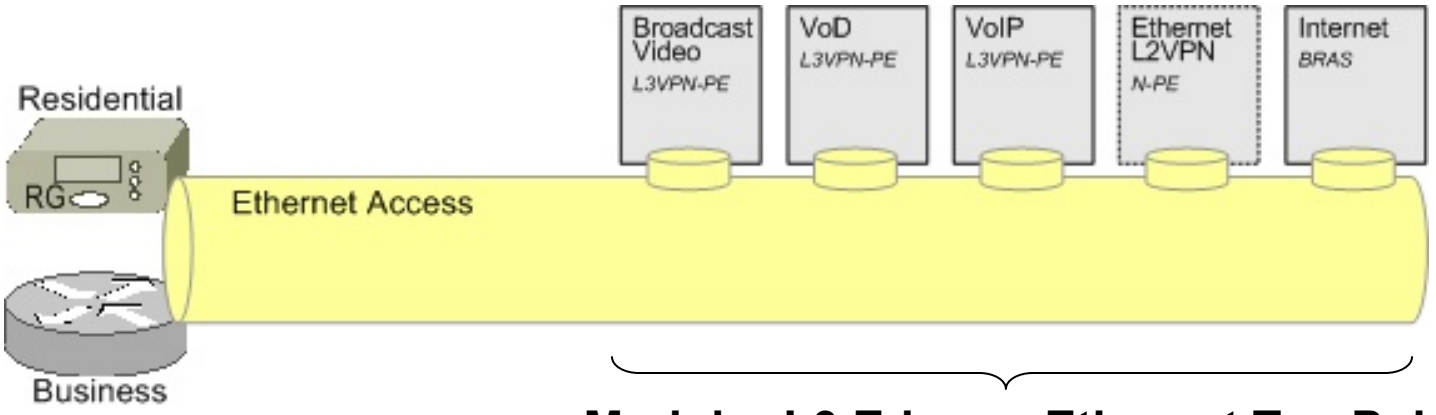


- Cost Optimization (OPEX and CAPEX) leads to multiple service insertions
- Application Servers only have *limited* economic ability to move towards or away from Residential Gateway (RG)
- Application Layer Services don't care if insertion points are L2 or L3 Network Elements, and whether they bridge, route, use MPLS, Ethernet or SDH as a transport

The Multi-Edge Architecture

View from CE: Ethernet Tap Points by Application

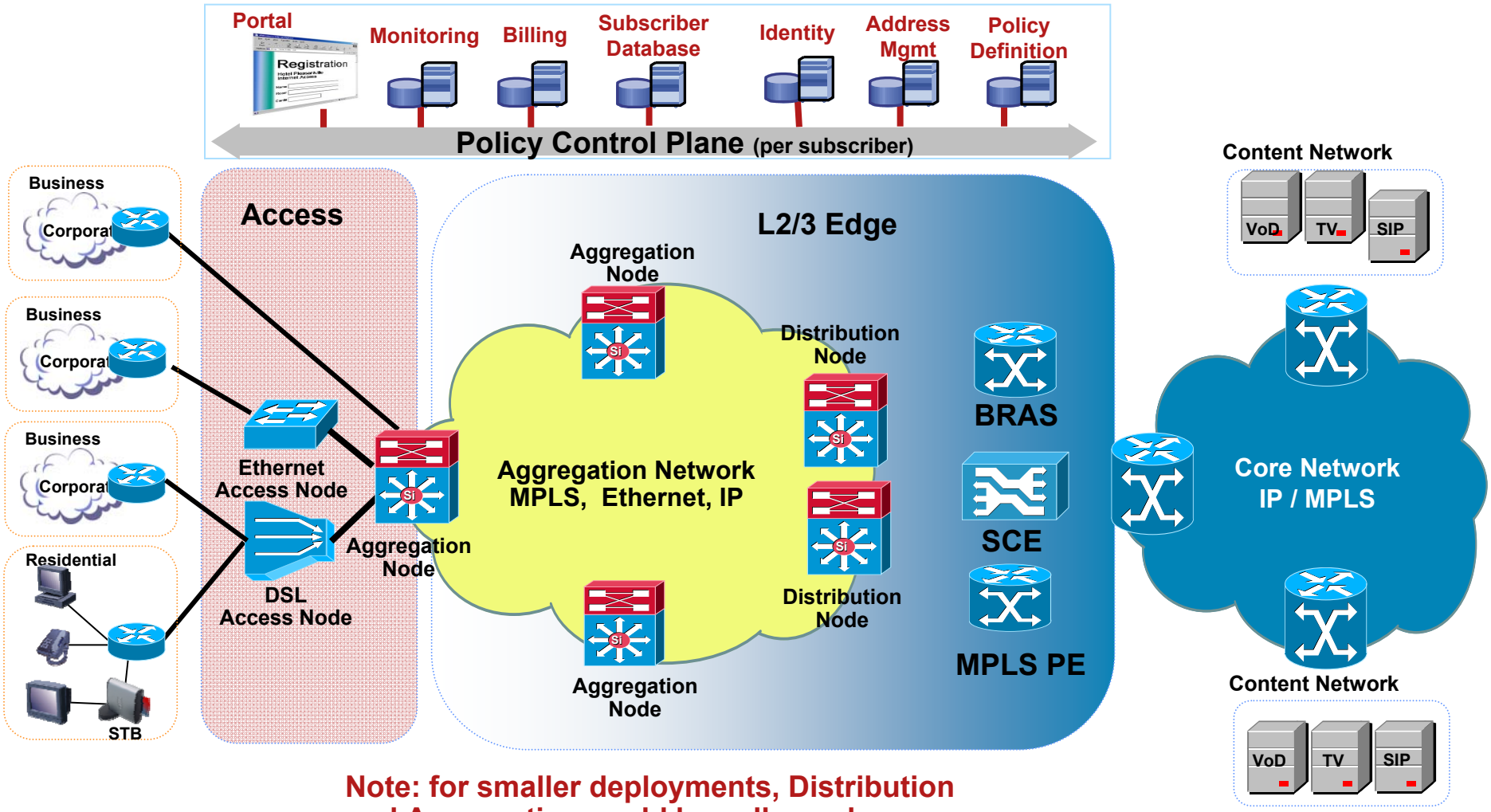




Modular L3 Edge → Ethernet Tap Points

- Different L3 Edge by service, services can be added and managed independently
- SP Edge physically could be one L3 box, but likely is many
  - Eliminates the need for a “God-Box” that serves all applications
  - Supports Geographic segmentation of application servers
  - Allows the use of distributing IP on a per service basis (e.g. multicast!), rather than using L2
  - Services needing per subscriber policies (internet, peer2peer, Lawful Intercept) inserted centrally, while ‘simpler’ services (IPTV, VoD) are distributed
- Allows services & transport to be reused across a variety of access technologies
- Intermediate tunneling technologies transparent to the CE .
  - Can use Ethernet Bridging (802.1ad or Backbone Bridging, 802.1ah) and/or MPLS pseudo-wires

Next Generation Broadband Architecture



Note: for smaller deployments, Distribution and Aggregation could be collapsed.

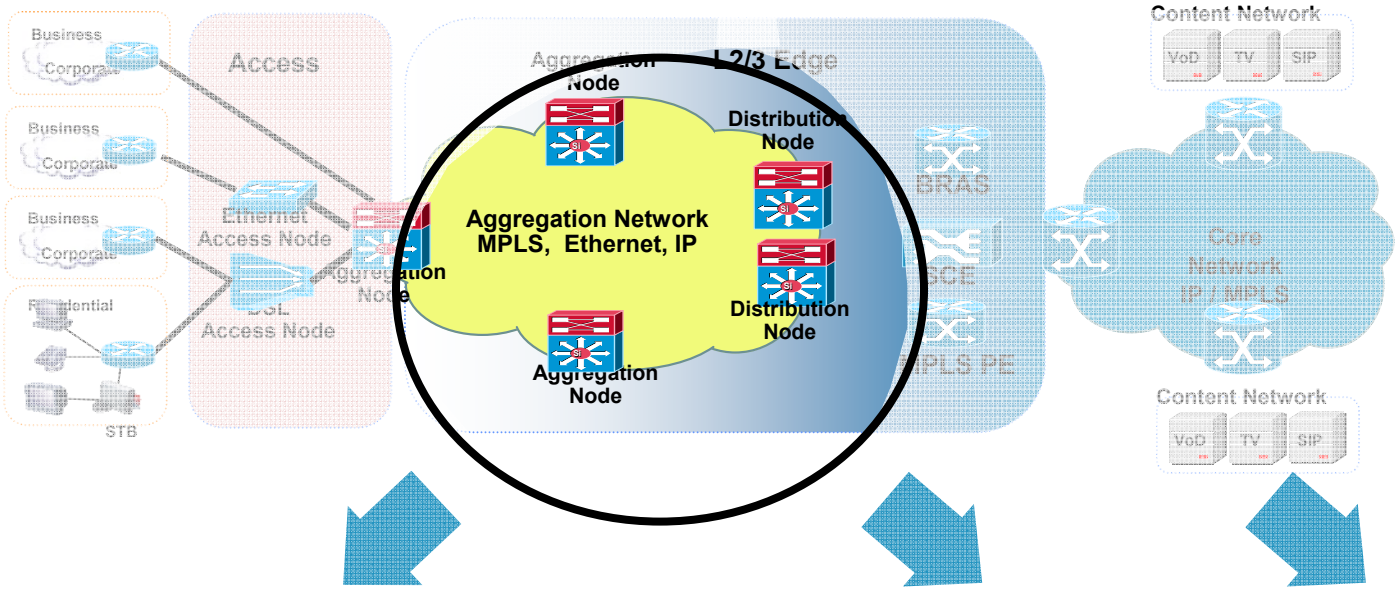
Services Considerations

Service	Transport Topology	Service Governance	Application Elements	Service Edge Element (L3)
Internet Access	**P2P, Unicast**	**Subscriber**	**Policy Server, Portal**	**BRAS**
VoIP Telephony	**P2P, Unicast**	**Application**	**Call Control Server**	**Aggregation Node**
VoD	**P2P, Unicast**	**Application**	**Video Middleware - STB**	**Aggregation Node**
TV Broadcast	**P2MP, Multicast**	**Application**	**Video Middleware – STB**	**Aggregation Node**
MPLS VPN	**MP, Unicast**	**Subscriber**	**None**	**MPLS PE**
Ethernet Virtual Lines	**P2P**	**Subscriber**	**None**	**Aggregation Node**
Ethernet Virtual LANs	**MP**	**Subscriber**	**None**	**Aggregation, Distribution Node, MPLS PE**

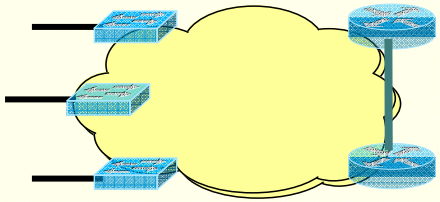
Aggregation Network Transport Options

IP, Ethernet, MPLS, or …?

Aggregation Network Transport Options

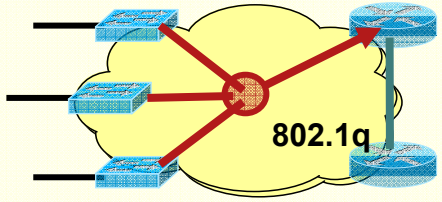


Layer 3 - IP, MPLS



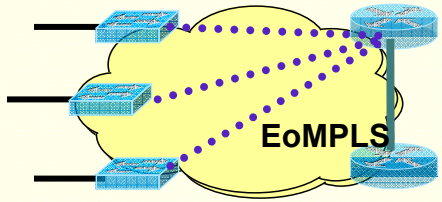
„Distributed L3 Service Edge“

Layer 2 – Ethernet
IEEE 802.1q / 802.1ad



„Centralised L3 Service Edge“

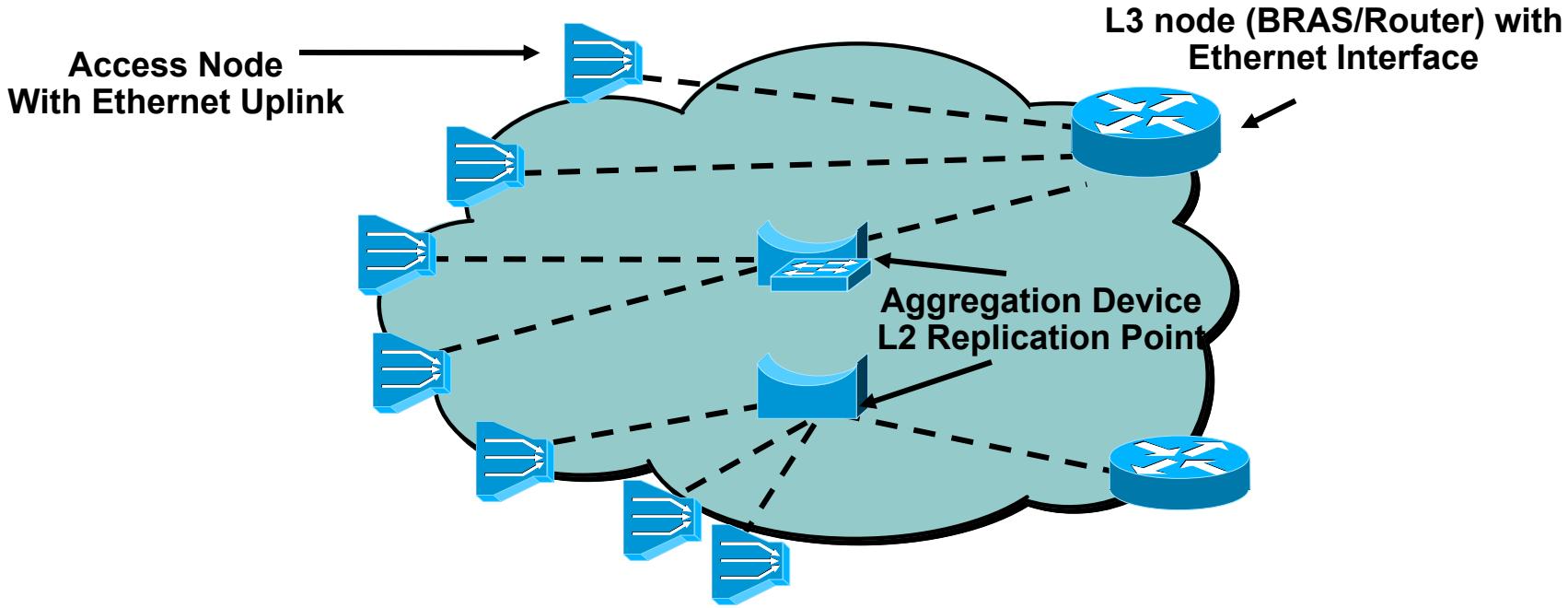
Layer 2 – MPLS
EoMPLS/ H-VPLS



„Centralised L3 Service Edge“

How to build the L2/L3 BUS (Ethernet or MPLS ?)

The Logical Picture



- Some Services might require L2 replication (Video Multicast) i.e. VLANs (“N:1” or multipoint VLANs)
- Some Subscribers are receiving traffic from multiple L3 nodes i.e. N:1 VLAN with MAC-address based forwarding
- Other Services can be built with point to point constructs (“1:1” VLANs)
  - Requires a lot of provisioning in access and aggregation network!
  - Does not easily allow different edges per subscriber
- MPLS or native Ethernet used to create the ‘*VLAN*’ ? Other Options exist ?

Ethernet N:1 VLANs

- Ethernet N:1 VLANs are multipoint and connection-less
  - Good IP address efficiency (see RFC3069) through VLANs
  - Excellent multicast replication capability
  - Service Injection across a VLAN (Servers, Caches, Routers)
  - No circuits, eases provisioning
- 1:1 VLANs does allows for
  - Line/Circuit identification at BNG
  - Preventing subscriber to subscriber communication
- But can be done in N:1 VLANs through
  - Line ID through DHCP Option 82 ; PPPoE Intermediate Agent Tag
  - 'Split Horizon Forwarding' within N:1 VLAN ('Private VLANs')

Scalable MAC-Address Learning

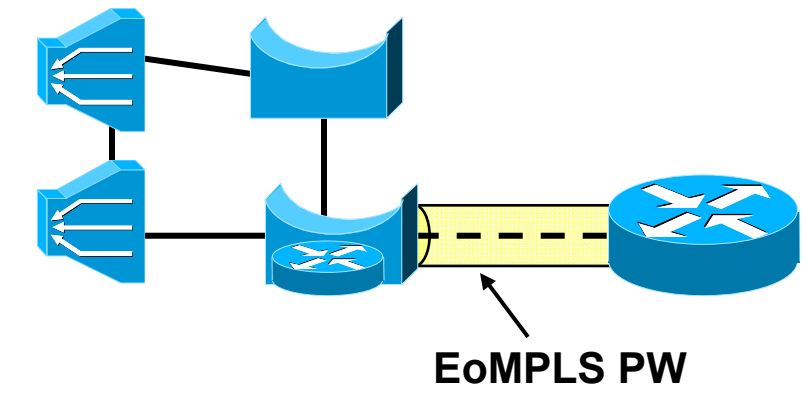
- Learning can be disabled
  - If only two ports exist in a VLAN (P802.1ad clause 16.6)
  - Manually (today)
  - Dynamically (switch counts active port per VLAN ; future)
  - GVRP/MVRP needed when using STP; work in progress
  - Other options exist for redundancy (802.1ad + EoMPLS redundant PW, Cisco FlexLink®)
- Fits all possible DSLAM Aggregation architectures (Ring/Star) as most VLANs are Point-to-point (at least in the aggregation network) !
  - If Unique VLANs per DSLAM no learning is needed at all
  - If Unique VLAN per 1st Aggregation switch, learning is local to that switch
- Bridge table entries can still be added while learning is disabled
  - Through IGMP Snooping
  - Static entries for BRAS/ L3 Service edge MAC-address
  - Static entries can be dynamically installed/maintained (Port Security!)
- 802.1ah (MAC-in-MAC) future option (learning only at first aggregation node)

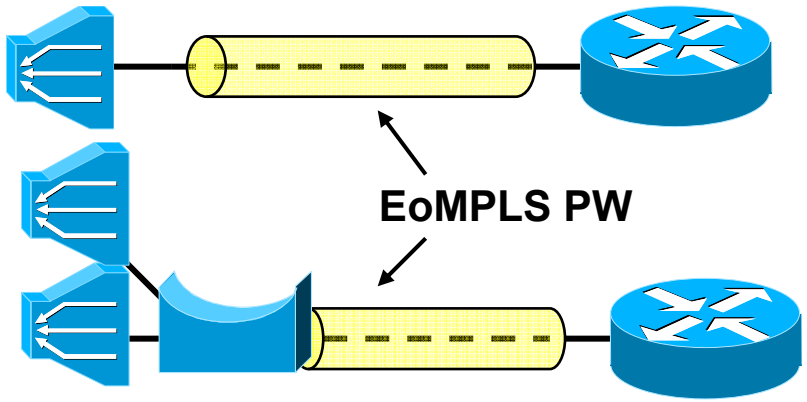
Native Ethernet Bridging Limitations ?

- Multipoint Character of VLANs is NOT a limit ; No need for Per Subscriber VLANs for residential Services
- Business Services require single insertion point, hence Per Subscriber VLANs → Potential Scaling Issue
- Spanning Tree is not the perfect solution for Large Scale NGN Networks
  - Convergence Times are non-deterministic and perceived as 'slow'
  - Introduces another control plane into aggregation whereas the possibility exists to run a common control plane (IP/MPLS!)
- It is certainly possible to use MPLS in the aggregation
  - But care needs to be taken that the 'nature' of Ethernet is not changed (multipoint, efficient L2 replication, etc, multiple injection points, etc)
  - Whoops…. MPLS pseudowires are essentially point to point ??...
- Solution: use EoMPLS to emulate 'bridge trunks'
  - All previous concepts (bridging, multicast, scaleable learning techniques) stay the same

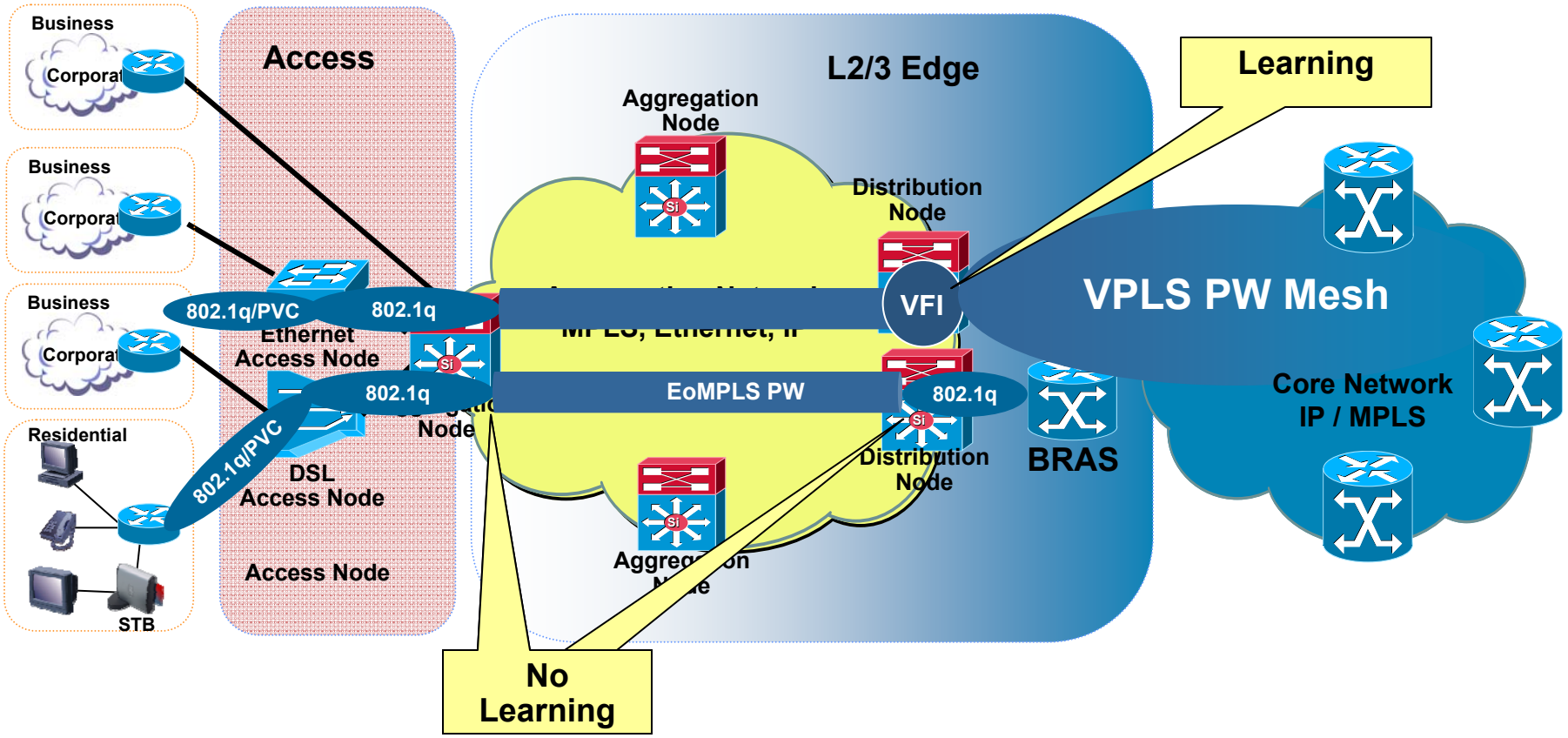
Emulating Ethernet Links with EoMPLS/VPWS

- EoMPLS can be used to overlay virtual L2 Ethernet Aggregation Islands over an MPLS network
  - Allows logical separation of subscribers based on MAC-address and VLAN scaling characteristics of Ethernet Aggregation Island
- EoMPLS can be used to emulate links between Access Nodes and L3 nodes
  - 1:1 VLAN scheme
- EoMPLS could be used to emulate links between L2 aggregation nodes and L3 nodes
  - N:1 VLAN scheme
  - 1:1/N:1 VLAN Scheme with redundantly attached Access Nodes
- Leverages advantages of MPLS AND Ethernet
  - Same 'Bridging' techniques can be deployed
  - IP Control Plane (same as in core)
  - Fast Convergence options
  - EoMPLS tunnel 'never' goes down
  - Sometimes referred to as H-VPLS (No Full Mesh of Pseudowires!)
  - Can also transport TDM and other L1/L2 services if needed





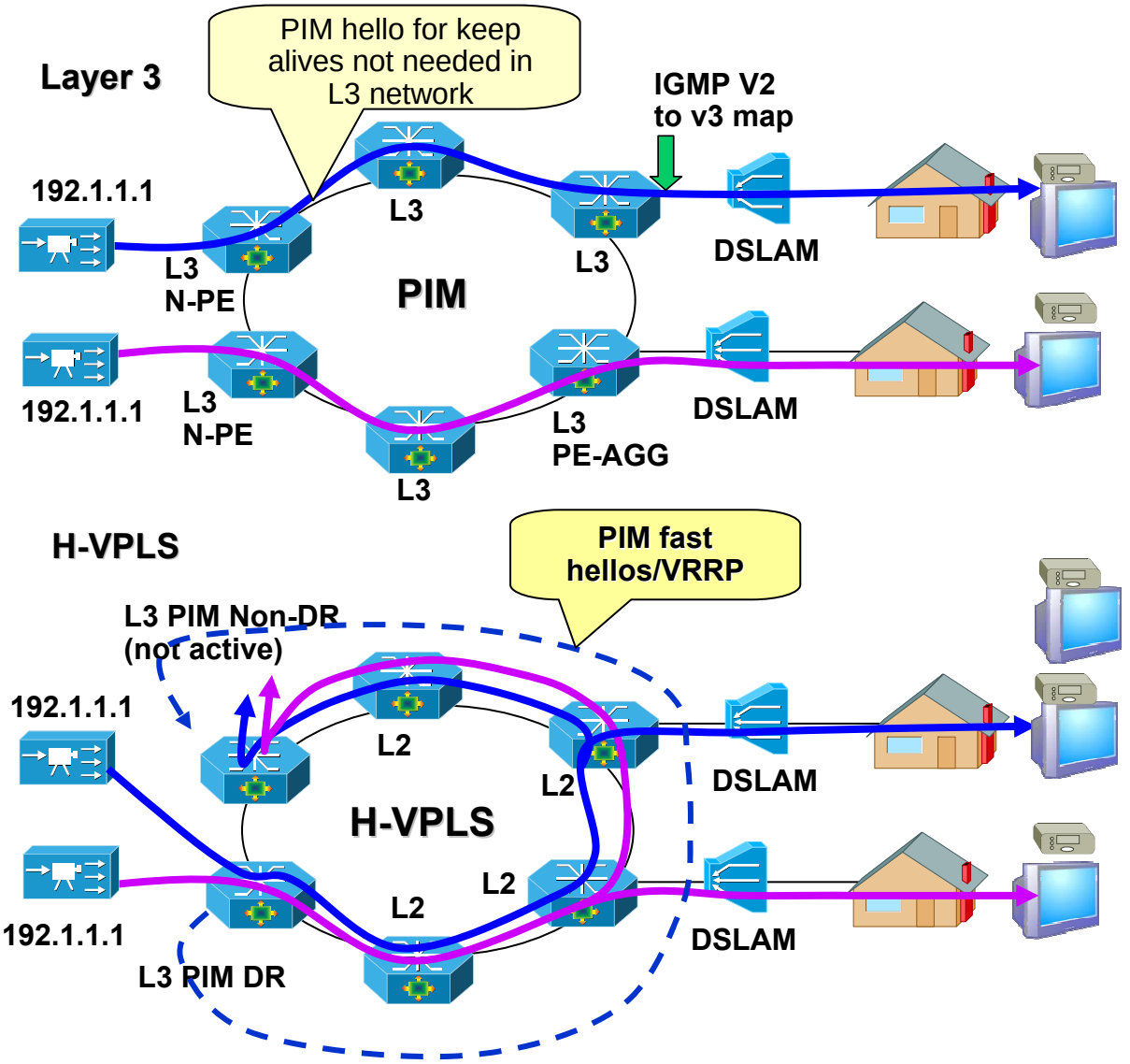
MPLS Layer 2 Scalability
EoMPLS and VPLS VFI MAC Address Learning



- Multipoint Layer 2 Transport – VPLS VFI requires MAC learning
- Point to Point Layer 2 Transport - EoMPLS doesn't require MAC learning
- Exactly the same as normal Ethernet

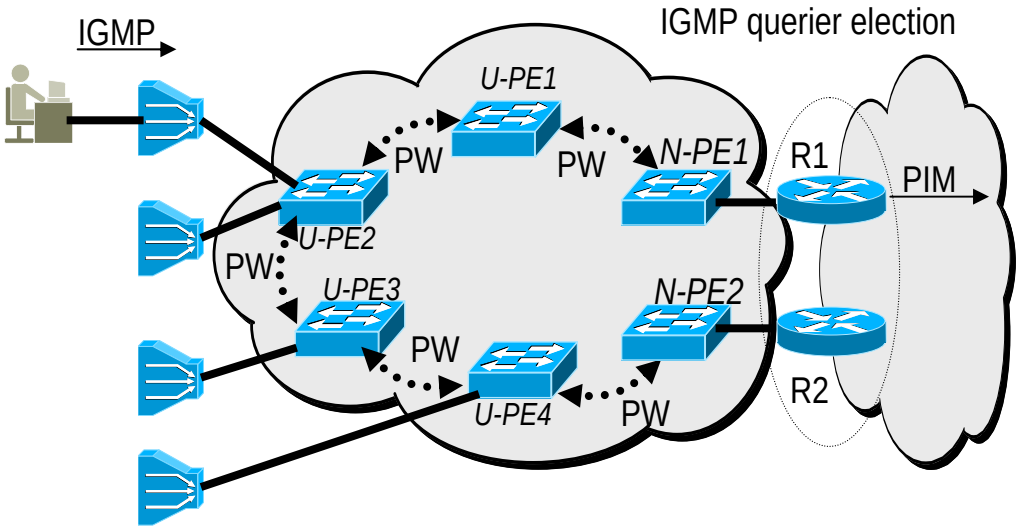
Benefits of Distributed L3 Edge for Video:
More reliable, more efficient, more secure

- L3 allows better load-balancing and use of the links across the ring
- Important for Anycast (redundant head-ends) and local ad insertion
- Better security through anti spoofing behaviour of SSM Mapping
- Node to Node signalling more reliable versus signalling across L2 domain
  - PIM fast hellos
  - VRRP (VoD)

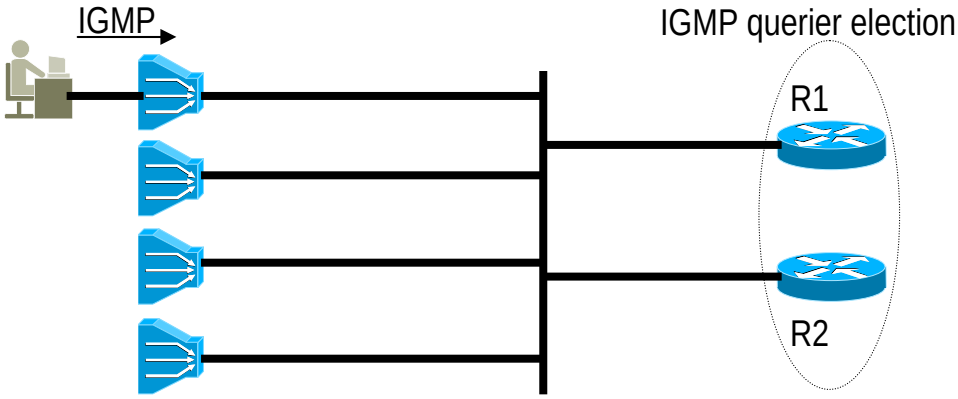


Using EoMPLS across rings for Multicast distribution

- Single Mcast „VLAN“ connects all DSLAMs for video delivery
  - Video flooded to all DSLAMs
- “Daisy-Chained VPLS”; U-PE connected by PW
  - N-PE VFI‘s NOT interconnected with PW
  - Otherwise you might need to run a ‘STP’ over the emulated LAN!
- MPLS-FRR for PW/link protection – 50ms restoration claimed
  - Weird traffic patters across ring after failure
  - No spatial re-use
- Node failure (U-PE, N-PE)
  - Split topology in access
  - R1 and R2 behave independent from each other (Querier for each segment): Convergence dependent on IGMP election failure (2-3s claimed, default = 120s!)
  - Problem pushed to L3 edge!



Logical view



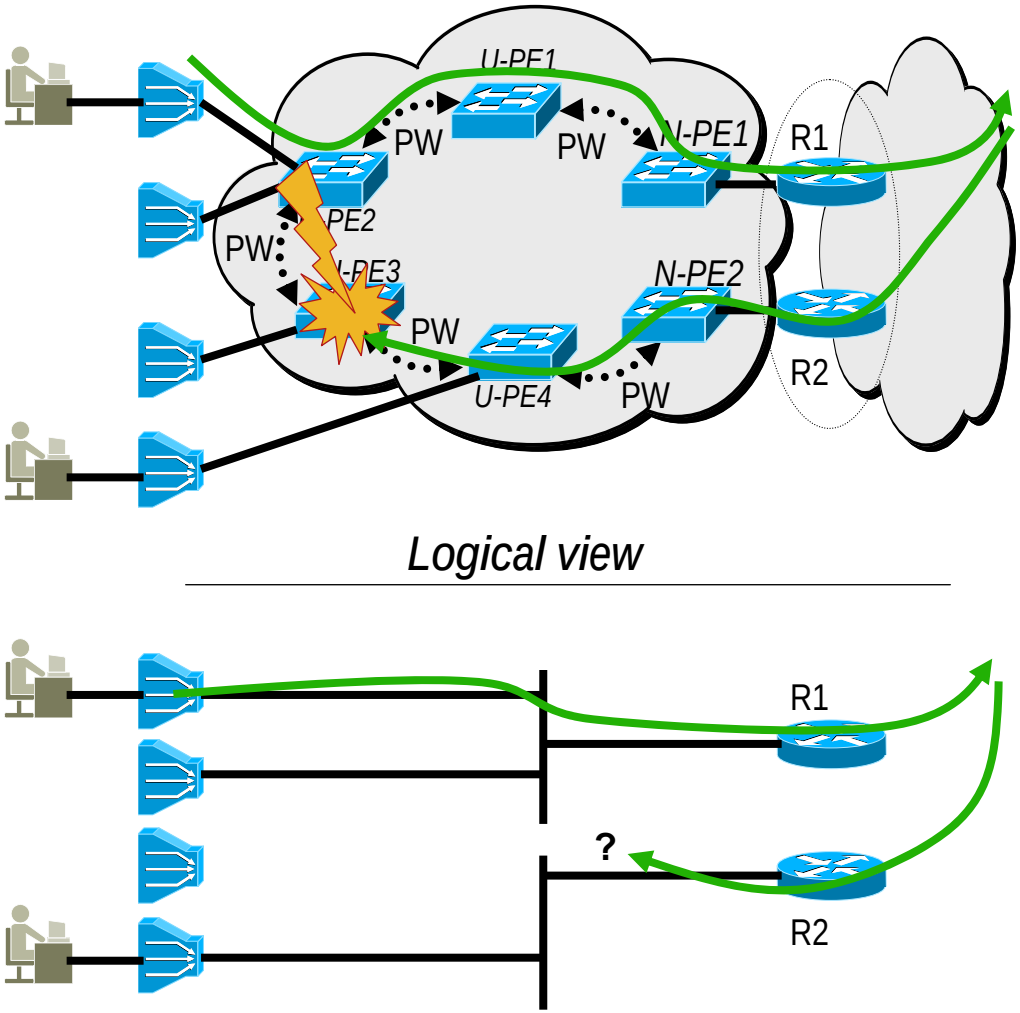
Broadcast Video Distribution
Failure scenarios: Box Failure

- Layer-2 subnet is partitioned into two pieces

  Violation of the fundamental rule that an L2 segment must be contiguous

  Spanning Tree Anyone ?

- Usually there is unicast control traffic in the multicast VLAN (e.g. RTCP, HTTP, MiddleWare traffic)
- Unicast control traffic could be blackholed, unless it uses ANOTHER overlay p2p topology



Additional Benefits of Distributed L3 Video Edge

- Reduces MAC/ARP scale required at centralized L3 edge
  - With L2 the central L3 service routers see every MAC address in the home
  - Central L3 router might need 150,000+ MAC entries and ARPs
- On-path CAC is only possible with Distributed L3 Edge
  - Only form of CAC that can deal with topology changes
  - Leverages RSVP-CAC for unicast and multicast CAC for multicast
- Unidirectional Optics only possible with Distributed L3 Edge
  - Takes advantage of unicast nature of Video
  - Leverages UniDirectional Link Routing (UDLR)
  - Savings of XX% on aggregation network optics
- IPv6 is critical due to proliferation of devices
  - IPv4 address exhaustion
  - NAT & NAT traversal cannot keep up with IP innovation
  - Can be supported in any of these architectures as long as vendor has implemented an IPv6 proof infrastructure

Why is Admission Control Essential for Video?

- Per-service QoS for broadcast video and VOD

  Network must deliver 10^{-6} loss requirement to support video QoE

  Per-sub QoS for video through BRAS function not optimal (not topology aware ; does not take into account multicast replication)

  Per service QoS optimizes quality & operational efficiency

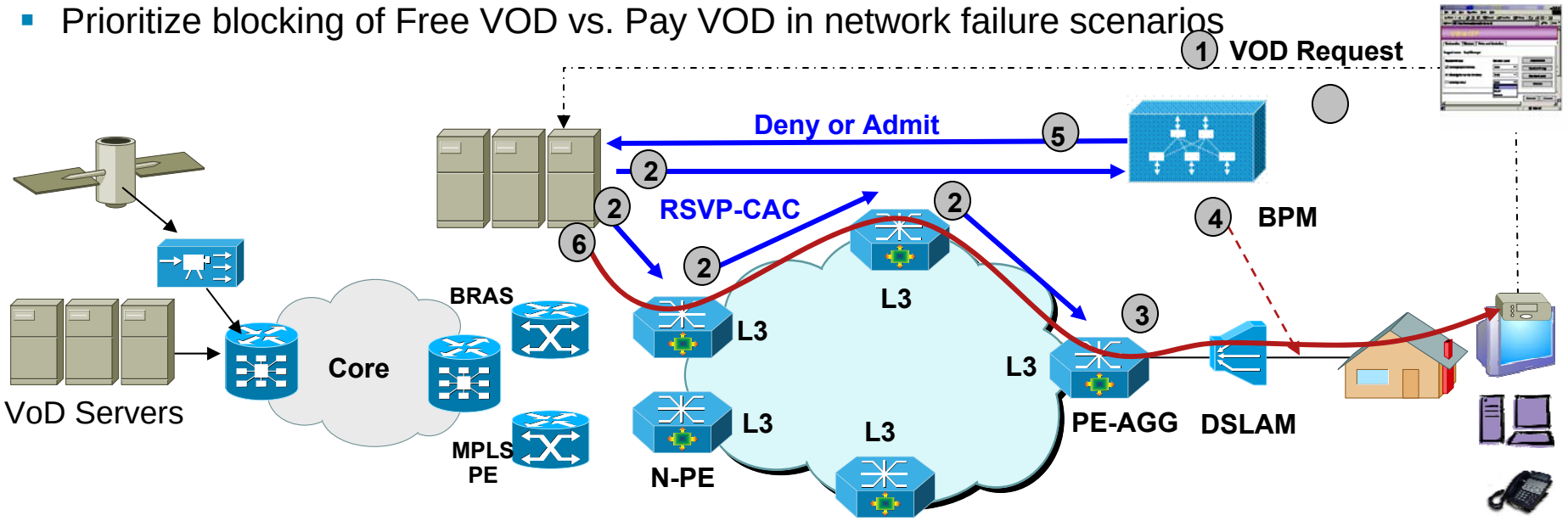
- VOD Connection Admission Control

  Every Link has queue dedicated to video, with a certain amount of planned capacity

  CAC will make sure that queue is NEVER oversubscribed by disallowing the VOD request that would oversubscribe the queue if allowed to flow over the network

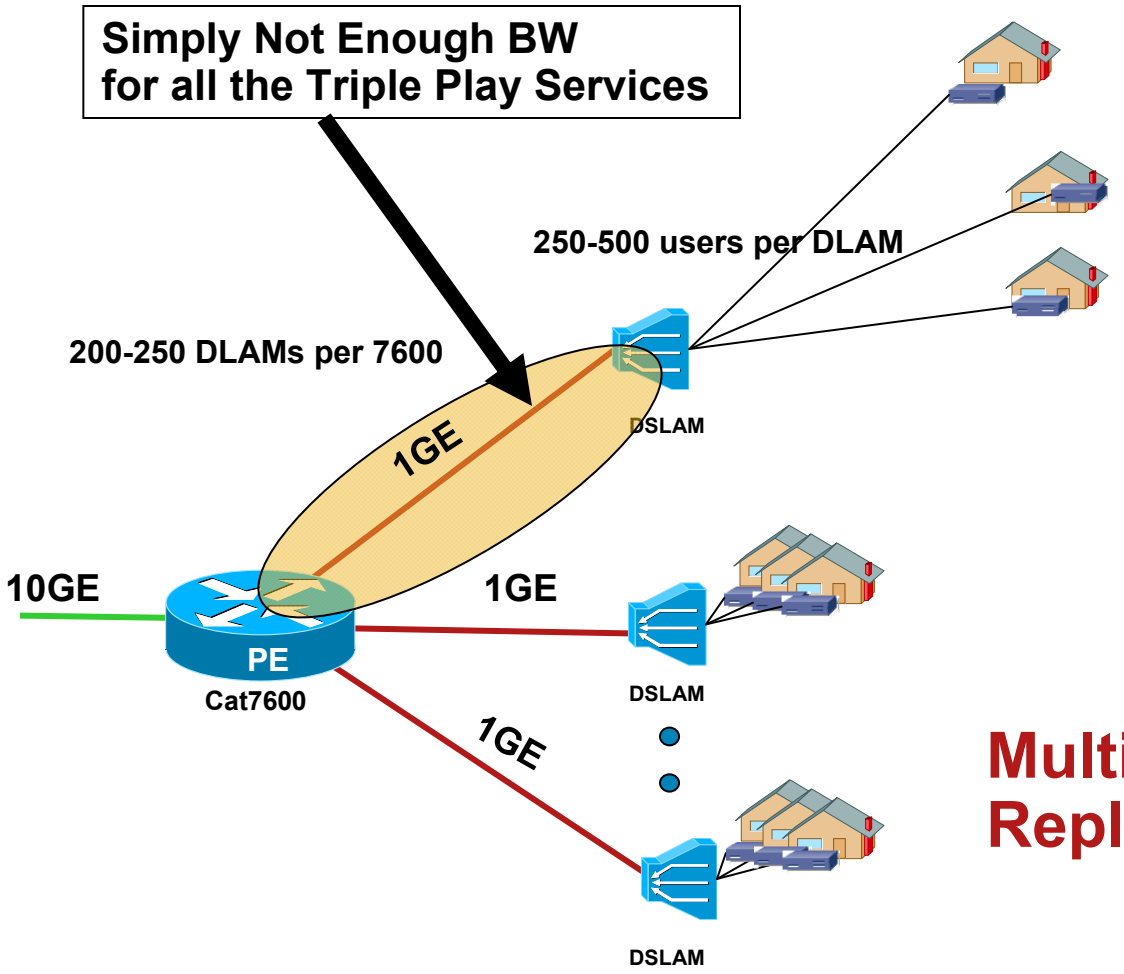
Cisco's Integrated Video CAC

- Integrated Video CAC approach combines two methods
  - On-path RSVP-CAC
    - topology aware, handles dynamic topology changes
    - DSCP based implementation eliminates scale challenges experienced with Intserv
    - Proven scale – tested to 50-100.000 sessions with 500 set ups per second
    - Layer 3 required at PE-AGG to implement path-based CAC
  - Off-path CAC based on Broadband Policy Manager (BPM) for DSL line congestion
- VOD stream will be denied if business rules of either fail
- Prioritize blocking of Free VOD vs. Pay VOD in network failure scenarios



Why is Multicast CAC needed

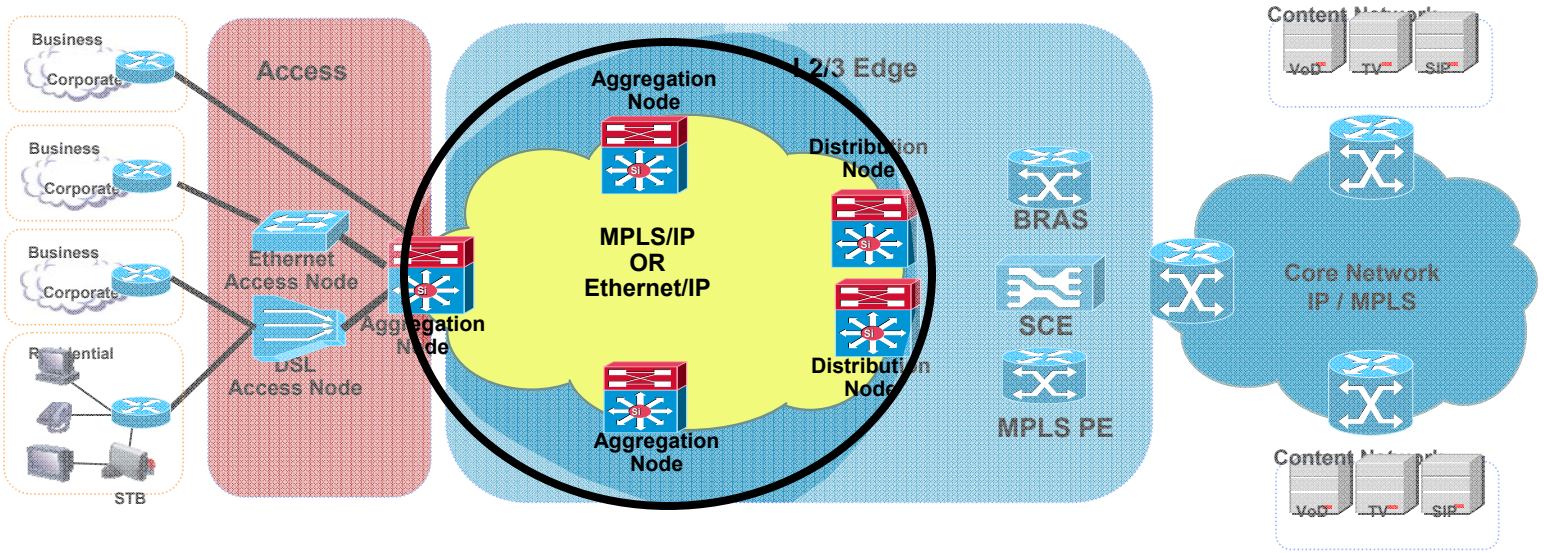
Oversubscription on aggregation link to DSLAM



- Sum of all Multicast Channels > Capacity Planned Bandwidth
- Need to control Multicast replication
  - Per Interface
  - Per Set of Groups
  - Per Content Provider
- IOS feature: Mroute State Replication

Multicast CAC = Handling Replication Limits

Aggregation Network Models



- **MPLS/IP Aggregation Transport Mechanisms**
  - **Distributed Services: IP, MPLS/Multicast VPNs**
  - **Centralised and Transparent Ethernet Services: EoMPLS, H-VPLS**
- **Ethernet/IP Aggregation Transport Mechanisms**
  - **Distributed Services: IP, IP VRF-lite**
  - **Centralised and Transparent Ethernet Services: IEEE 802.1q, 802.1ad, 802.1ah (future)**

Same Control Plane !!

Aggregation Network Models

	MPLS/IP	Ethernet/IP
Characteristics	▪ Allows different or common administrative domains for the aggregation and core network ▪ Supports virtualized Layer 2 and 3 services thru MPLS based VPNs ▪ Supports Traffic Engineering thru MPLS TE mechanisms ▪ Service recovery, as low as 50ms, is implemented with MPLS FRR and Fast IGP convergence ▪ The scalability for Layer 2 Transport is dependent on the network elements ▪ Flexibility for aggregating other access services as: Mobile RAN, Legacy ATM/FR/TDM with MPLS AToM	▪ Requires a STP operational domain for the Layer 2 transport ▪ Provides optimal layer 2 multipoint transport that is topology independent ▪ Supports virtualised Layer 2 services thru native 802.1q and 802.1ad bridges ▪ The scalability of the L2 Transport is dependent on the aggregation network ▪ Service recovery, in average few seconds, is implemented with RSTP and Fast IGP convergence ▪ Possibility to aggregate other access services as: Mobile RAN, Legacy ATM/FR/TDM with L2TPV3

Similarities

- **Similar Layer 2 and Layer 3 Transport mechanisms**
- **Support point to point and multipoint layer 2 and layer 3 transport**
- **Support the same residential, business and wholesale broadband services**

Next Generation Broadband Architecture

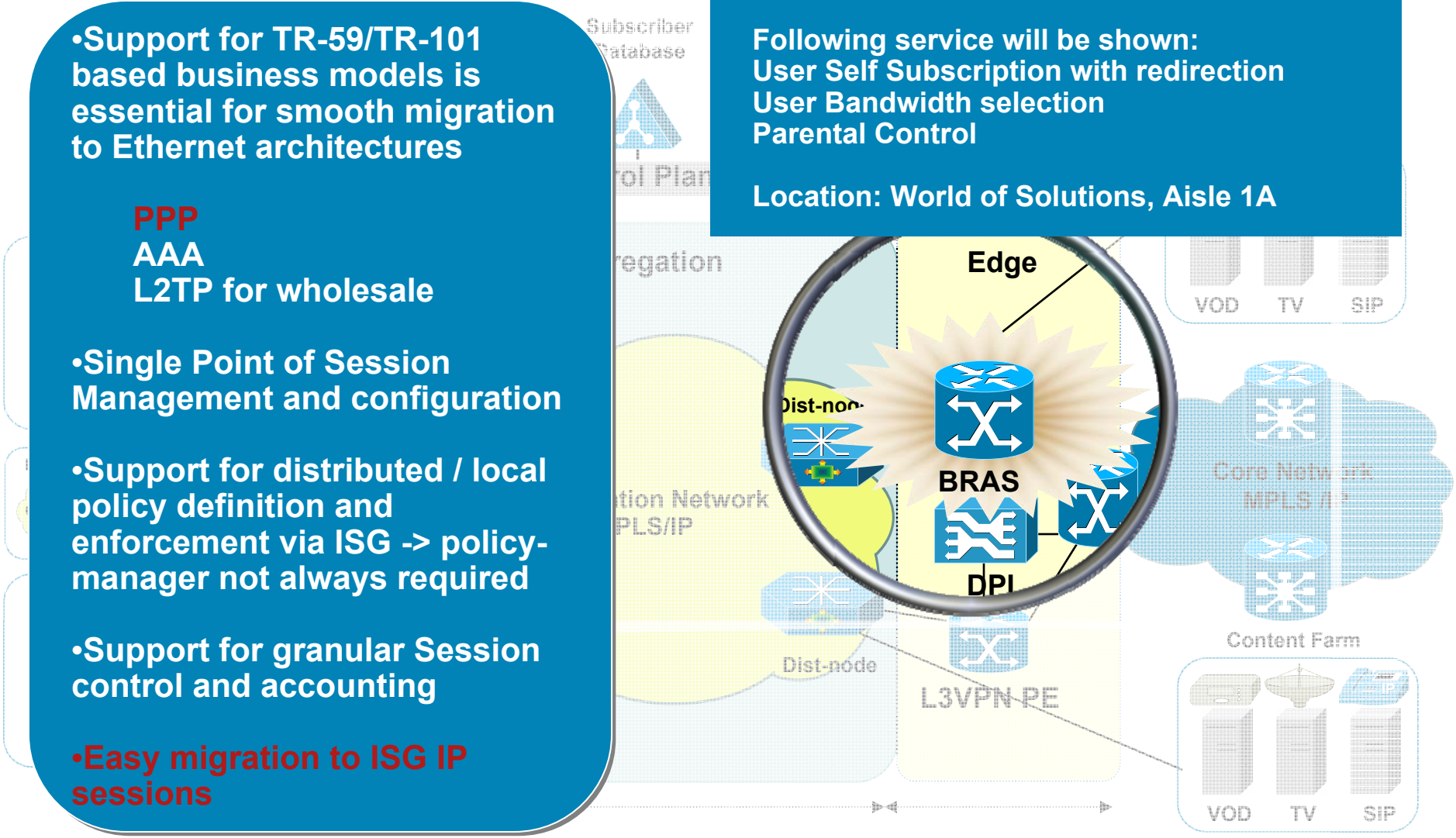
Why a *real* BRAS is required?

- Demonstration of Cisco ISG Based on Cisco 7200/7301

  Following service will be shown:
  User Self Subscription with redirection
  User Bandwidth selection
  Parental Control

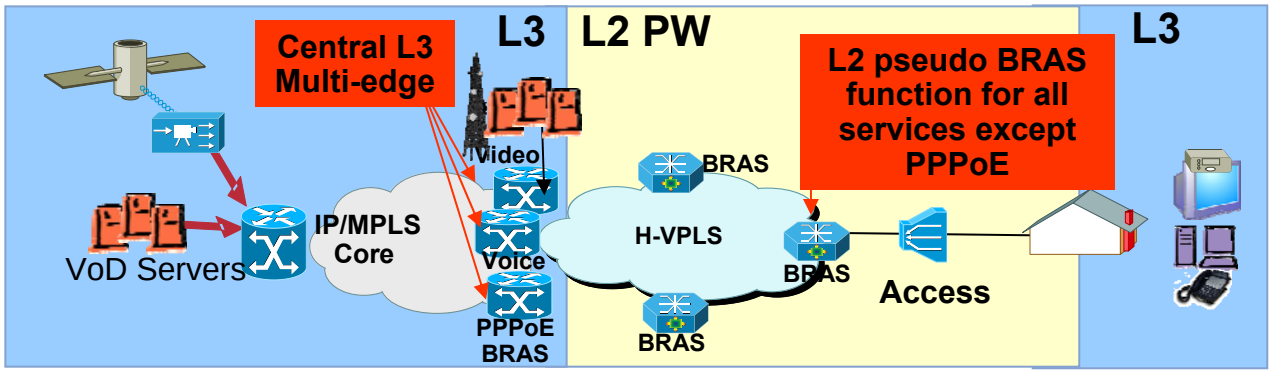
  Location: World of Solutions, Aisle 1A

- Support for TR-59/TR-101 based business models is essential for smooth migration to Ethernet architectures
  - PPP
  - AAA
  - L2TP for wholesale
- Single Point of Session Management and configuration
- Support for distributed / local policy definition and enforcement via ISG -> policy-manager not always required
- Support for granular Session control and accounting
- Easy migration to ISG IP sessions

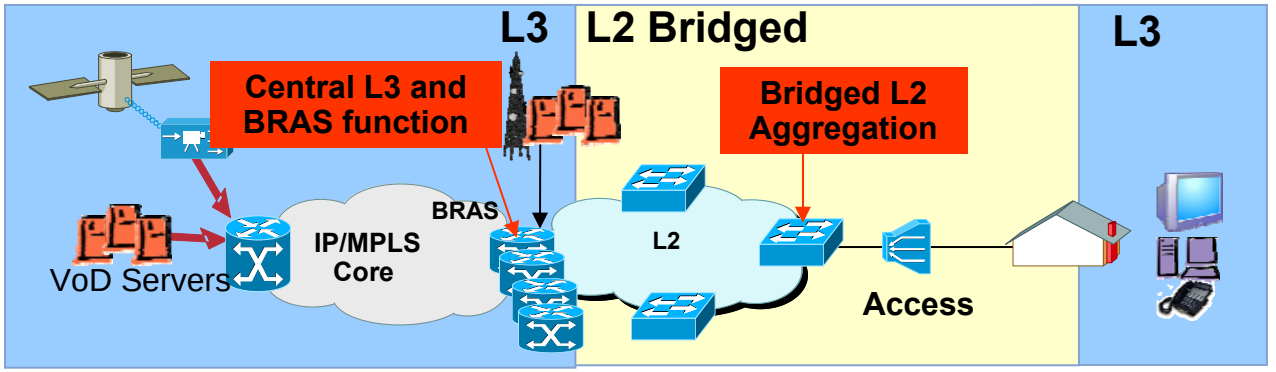


Three Architectural Approaches

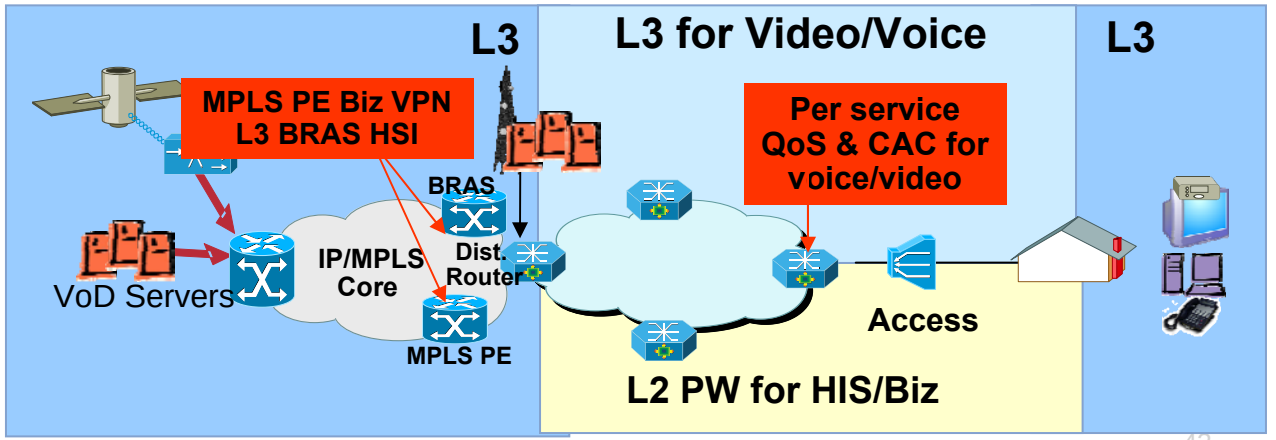
Distributed
L3: central for all services
Agg: H-VPLS for all services
QoS: per sub for all services



Centralized
L3: central for all services
Agg: L2 bridging all services
QoS: per sub for all services

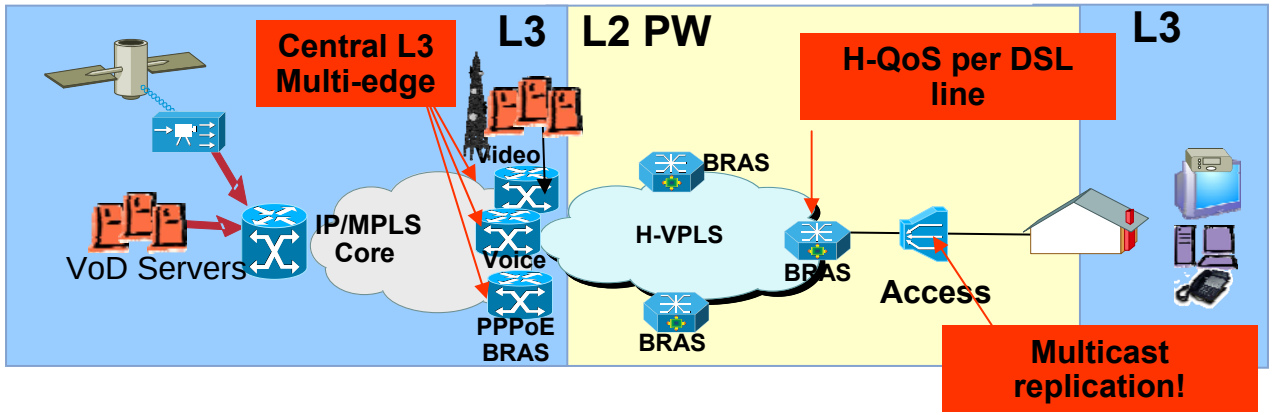


Cisco "ServiceFlex"
Optimized architecture based on service type
L3: distributed for video & voice, central for HSI/biz
QoS: Per service for video & voice, per sub for HSI/biz



Distributed Hierarchical QoS for Triple Play

… Does not make much sense



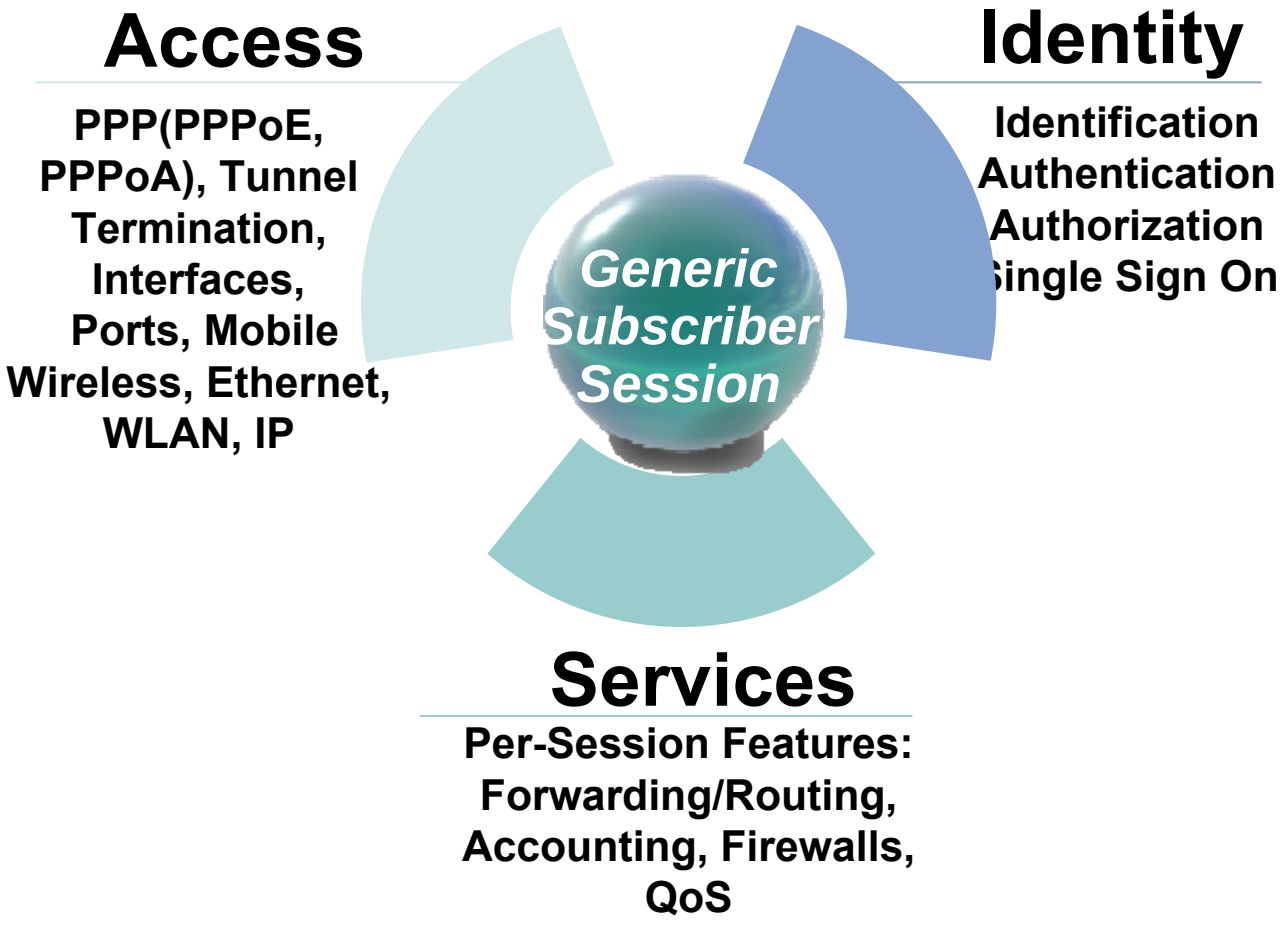
- "L2 Pseudo BRAS" could enforce per subscriber (DSL Line) queuing through hierarchical shaping and queuing
- HOWEVER! Usually Multicast is delivered through a dedicated multipoint path (H-VPLS instance only for multicast) , where DSLAM 'leaks' multicast into subscriber port
- Scheduler does not take that multicast into account
- Even if it would , it has NO knowledge whether the DSLAM is replicating multicast or not !!
- Also operational overhead (subscriber policies distributed)

Carrier Ethernet Aggregation System 1.0

Carrier Ethernet Architecture Models

- All rely on MPLS + IP Transport
  - Leverages Intelligent Service Gateway (ISG) for Per Subscriber Services and new Ethernet Virtual Connection (EVC) constructs
  - Leverages New Ethernet Hardware in the 7600 (ES20 linecards)
- Organizational structures influence architecture choices
  - Organizational consolidation will drive distributed edge architecture
  - The organizational consolidation of the big SPs will happen slowly
  - Focus on two architecture models: centralized and distributed edge
- Drivers for the centralized edge architecture (with distributed video)
  - Align with existing SP organizational and operational structures
  - An order of magnitude fewer subscriber state aware network elements to manage
  - May improve the CAPEX efficiency especially if services planned allow network oversubscription
  - Operational and organizational differentiation into access, aggregation, edge and core network layers
- Drivers for the distributed edge architecture
  - Simplified operations by removing the overlay circuit based aggregation network transport
  - Single point of implementing (L2/L3) services edge (exception large scale VPLS)
  - Consolidation of functions eliminates seperate infrastructure (BNG + MSE + Mobile backhaul)
  - Increased penetration of 3play services (VOD) drives lower oversubscription on the aggregation network and makes less suitable centralized edge devices

ISG – Subscriber and Service Control Infrastructure



ISG Infrastructure

Enables session and service awarness in the operating system (IOS) that may be applied to residential and business, L3 and L2 (future) services

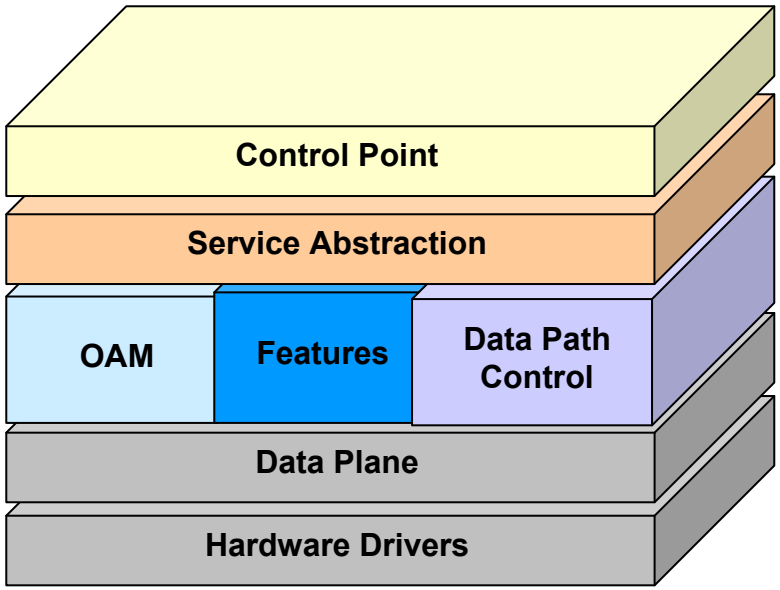
BRAS today, Agg. and Distr. PE tomorrow

Works for both PPP AND IP Sessions!

EVC – Carrier Ethernet Services Infrastructure

- *Carrier Ethernet systems require a functional and software infrastructure, that scale in performance, memory footprint and enable new services based on Ethernet*

- ***The goal of the EVC infrastructure is to identify a common framework for Ethernet service provisioning that applies across all IOS Carrier Ethernet platforms***



- Uniform CLI Across Platforms
- Common model for all Ethernet based services
- Hierarchical structure w/ inheritance
- Scalable through 'templates'

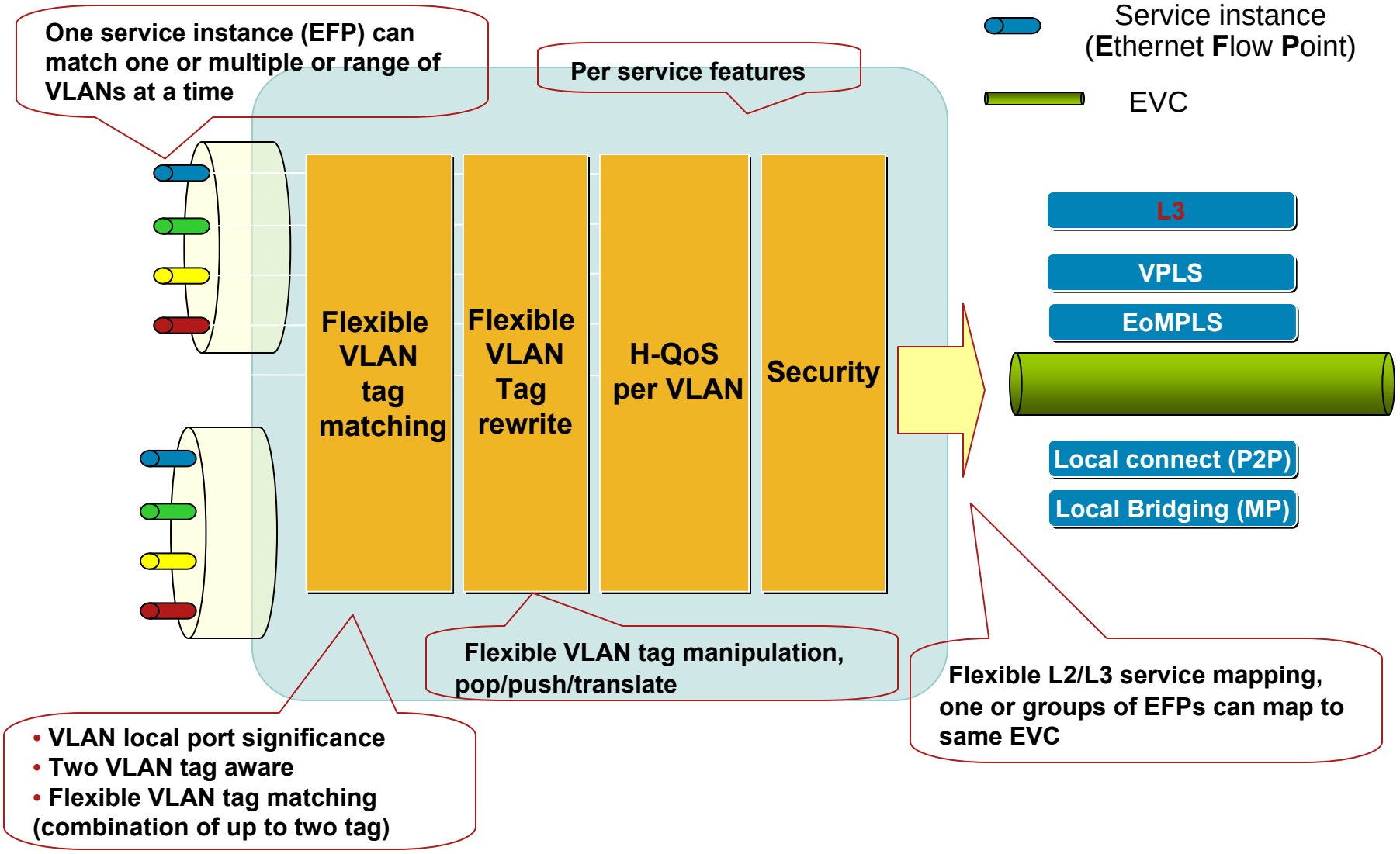
- Ethernet Flow Point (EFP) Model
- Define Service independent of Ethernet encapsulation
- L2 construct, can be associated with L3 if needed.

- Service Level OAM (CFM aka 802.1ag)
- Link Level OAM (802.3ah)
- E-LMI (auto-provisioning / service availability)
- Interworking w/ MPLS OAM

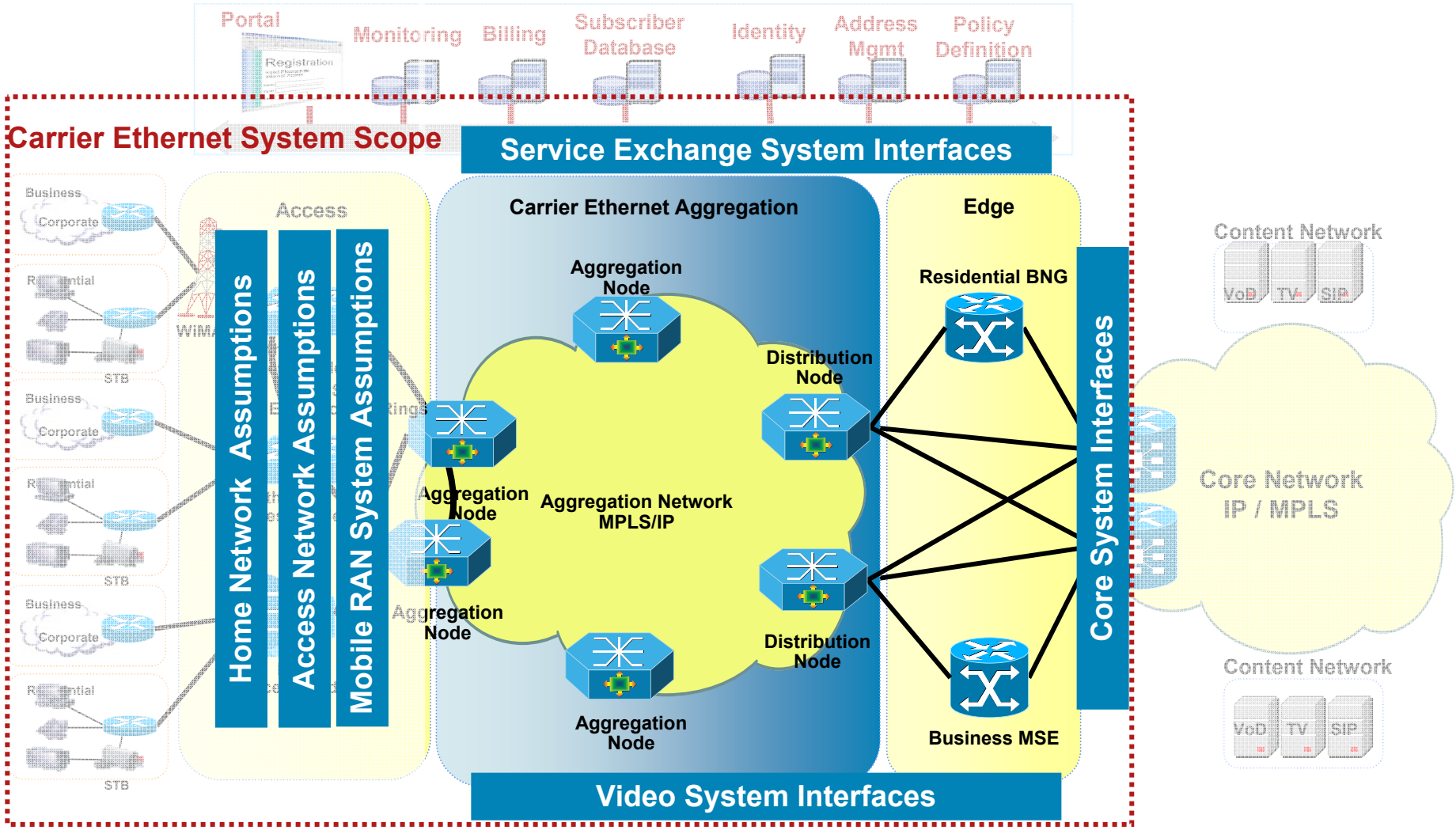
- Granularity of applying QoS and ACLs per 'flow'. 'Flow' can be a VLAN or range of VLANs or 802.1ah ServiceID

- Flexible association of 'Ethernet Flows' to Bridge Domains
- Uniform framework for support of packet encapsulation rewrite acrobatics (selective Q-in-Q, VLAN hopping, 802.1ah, etc…)

EVC Overview



Carrier Ethernet Aggregation System



System Functional Overview

Carrier Ethernet Aggregation System

Access Network Functions

DSL, Ethernet and Fixed WiMAX Access

- DSL Forum TR-101 functions
- MEF Ethernet services models
- N:1 and 1:1 VLAN Multiplexing Models
- Multi VC, Trunk and Non Trunk UNI options
- ETTX STP Access Rings and Hub and Spoke
- WimAX nodes integrated in the ETTX Access
- DSL Access Nodes with redundant connectivity

Residential, Business, Ethernet Bitstream services

Aggregation Network Functions

Transport Functions between Access and Edge

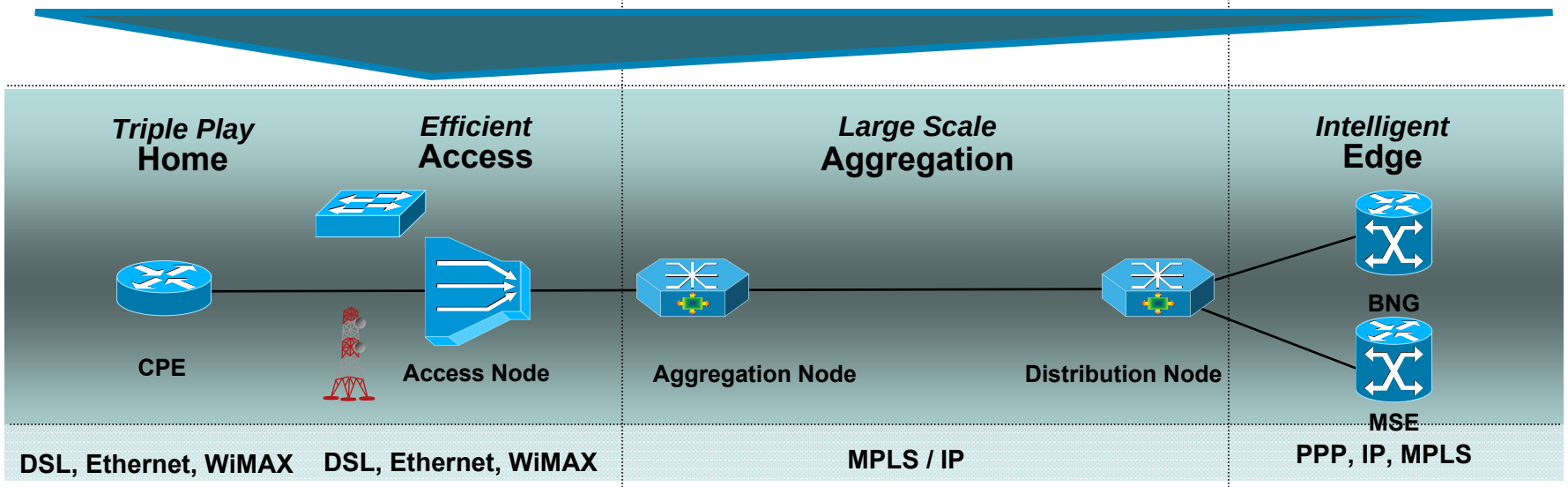
- Intelligent Access Multiplexing
- MPLS/IP Layer 2 and Layer 3 transport services
  - Transparent virtualized Ethernet P2P and MP transport (EoMPLS and H-VPLS) for services with IP/L3VPN/L2VPN Edge in BNG and MSE Service aware IP transport for 3play (IPTV, VoD, Voice) services.
- The L2/L3 MPLS/IP transport layer provides flexibility scalability, transparency, virtualization and service awareness when required
- The Aggregation Network provides the option for implementing L2/L3 Business VPN Services

Edge Nodes Functions

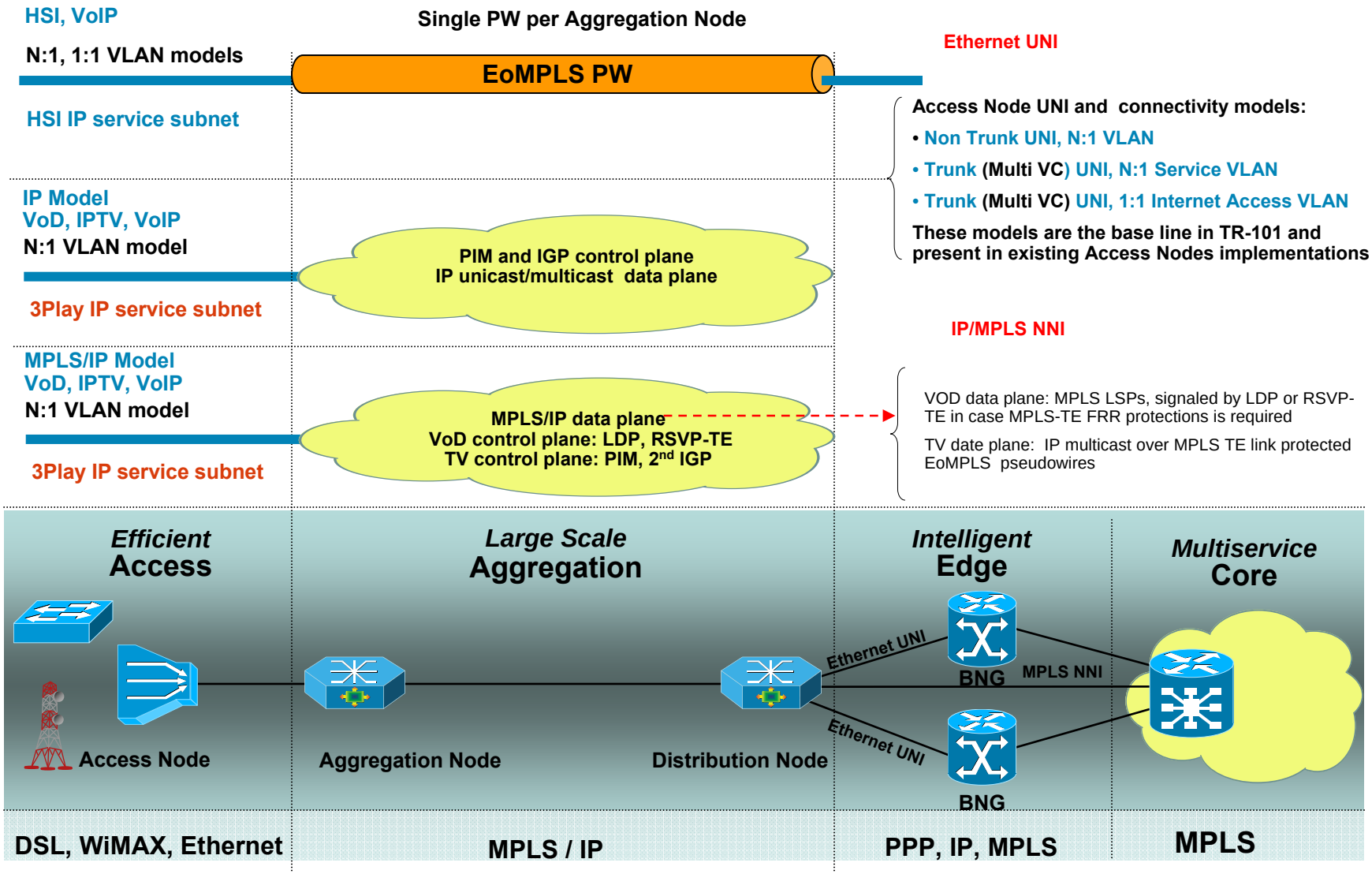
Subscriber and Service Edge

- Residential HSI in BNG
- Business L2/3VPNs in MSE

This network layer may be already present

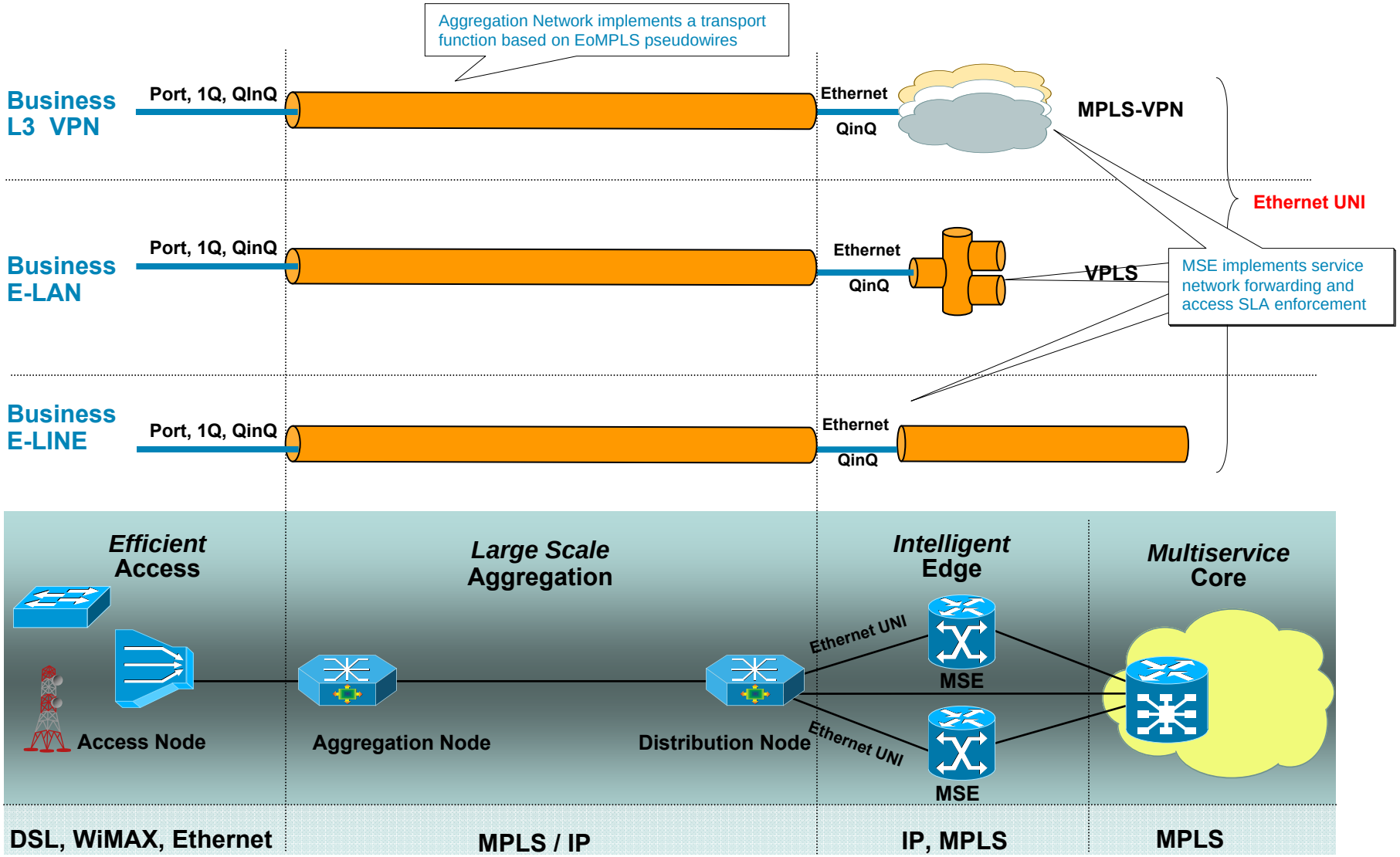


Retail Residential Services Architecture



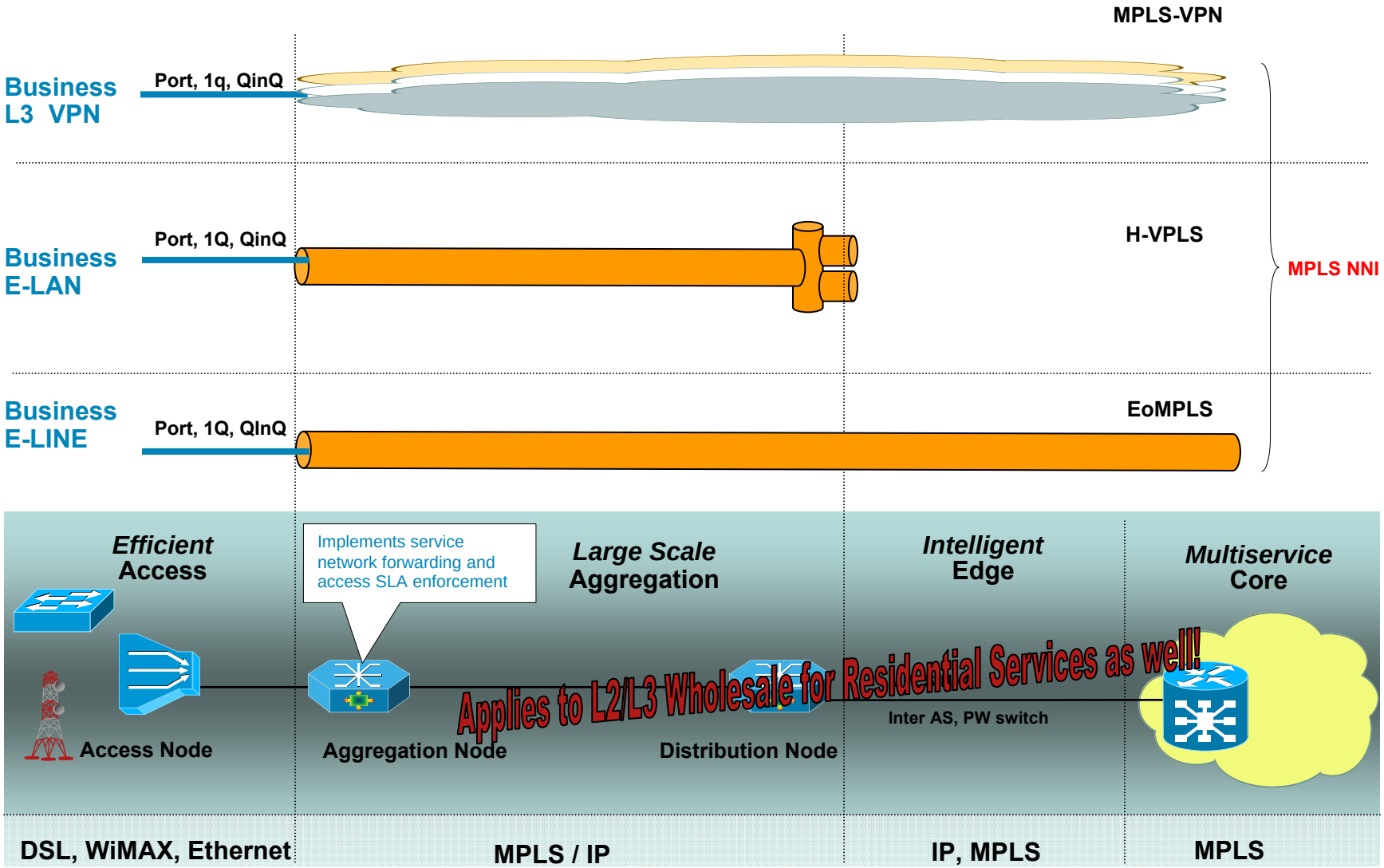
MSE Service Edge

Business Ethernet Services Architecture

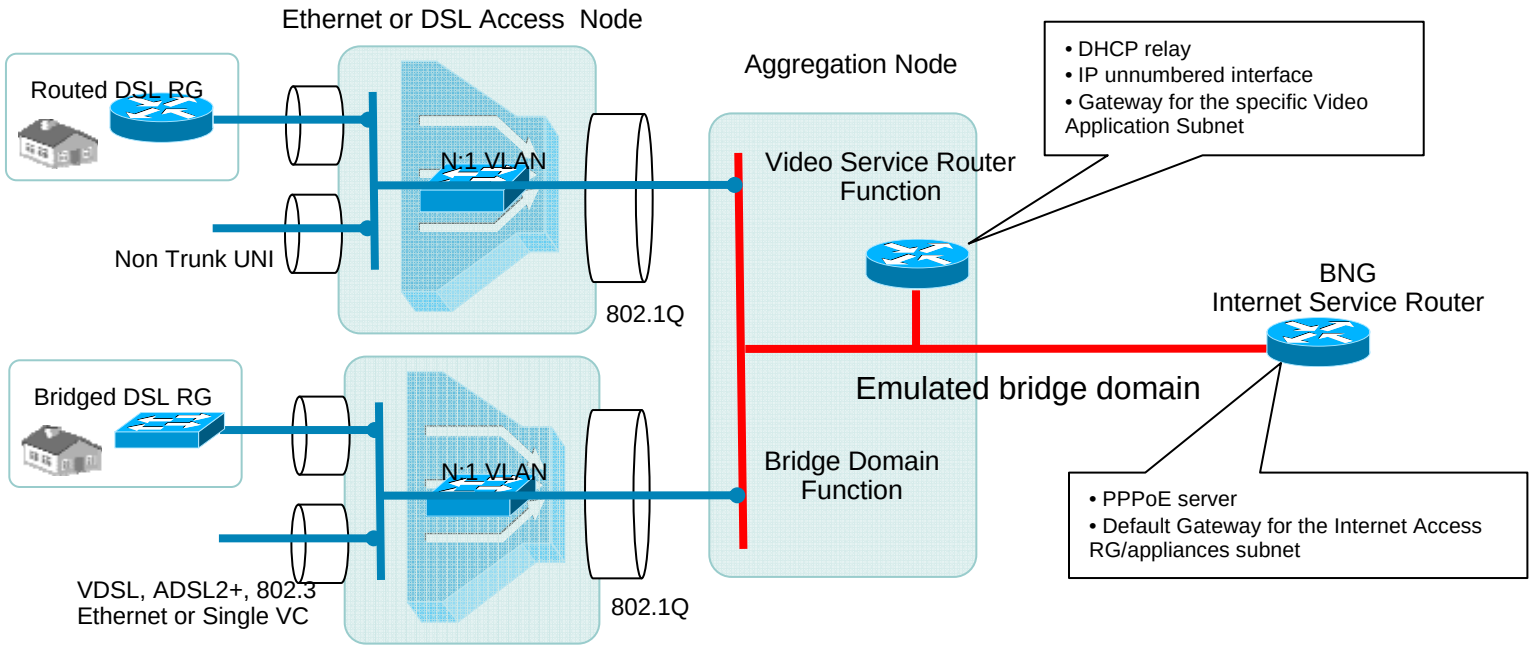


Aggregation Network Service Edge

Business Ethernet Services Architecture



Non Trunk UNI, N:1 VLAN
Residential Services Connectivity Overview

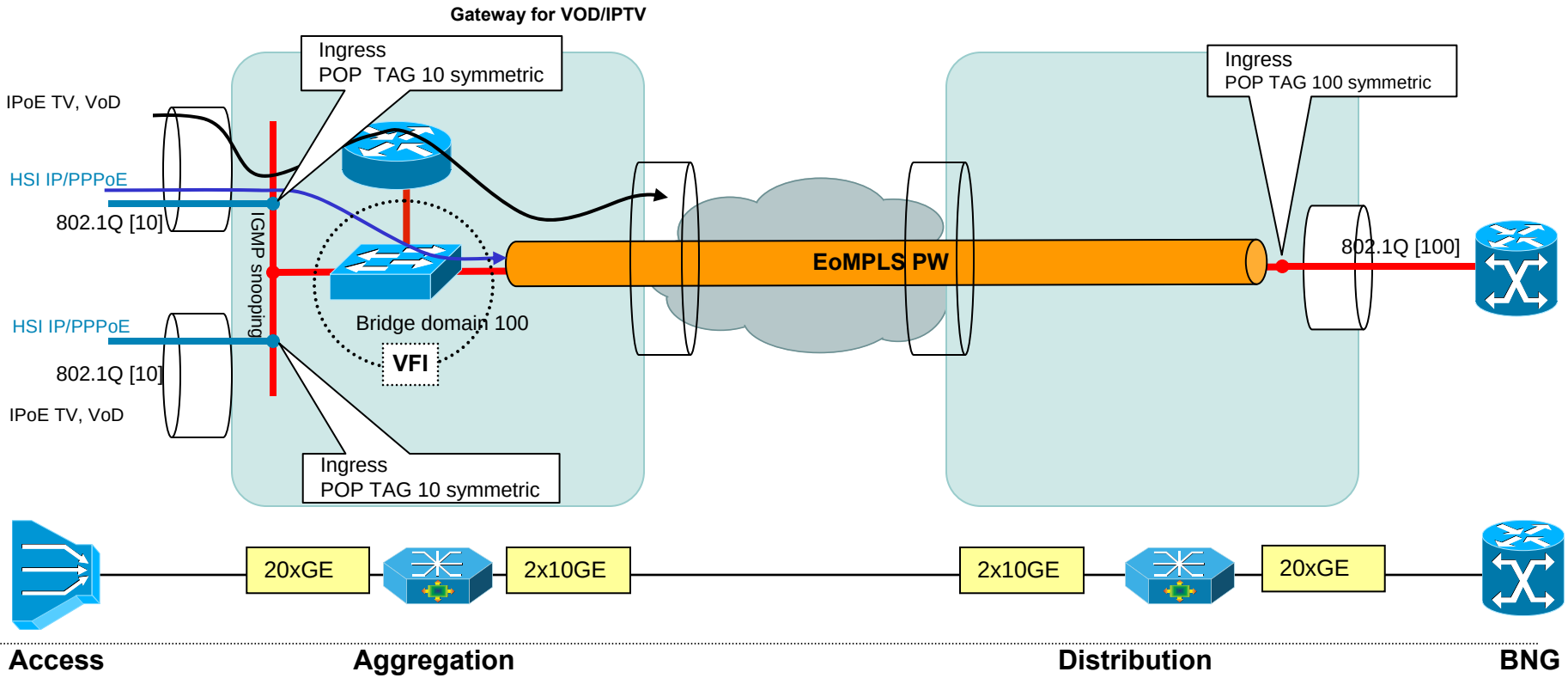


•Common bridge domain with Split horizon forwarding and Subscriber Line Identity through PPPoE Tag Line ID or DHCP Option 82

• Default Route pointing to BNG, specific router pointing to Video Service Router (through RG GUI, TR-69, DHCP Option 121)

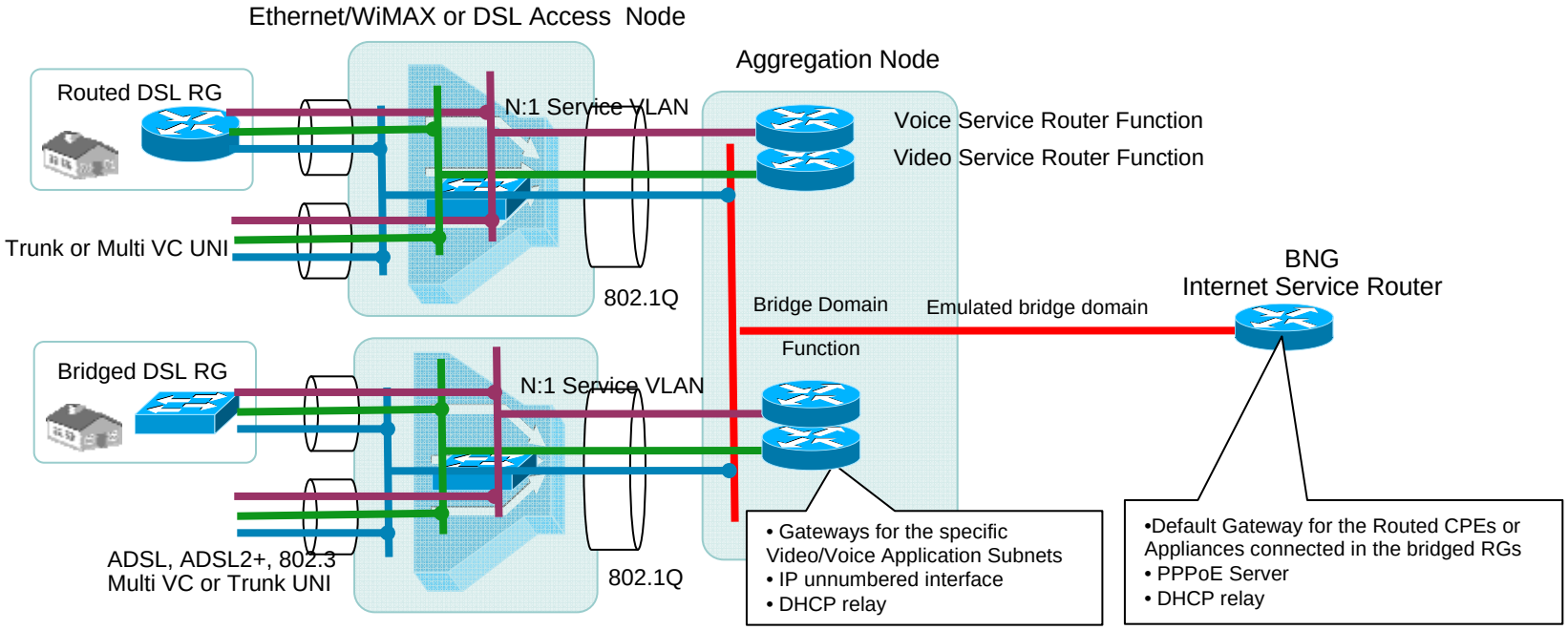
Non Trunk UNI, N:1 VLAN
Residential Services Aggregation Model

- Port-significant VLAN ids removed on ingress
- Routing AND bridging in a common N:1 VLAN
- VLAN id added on egress towards BNG



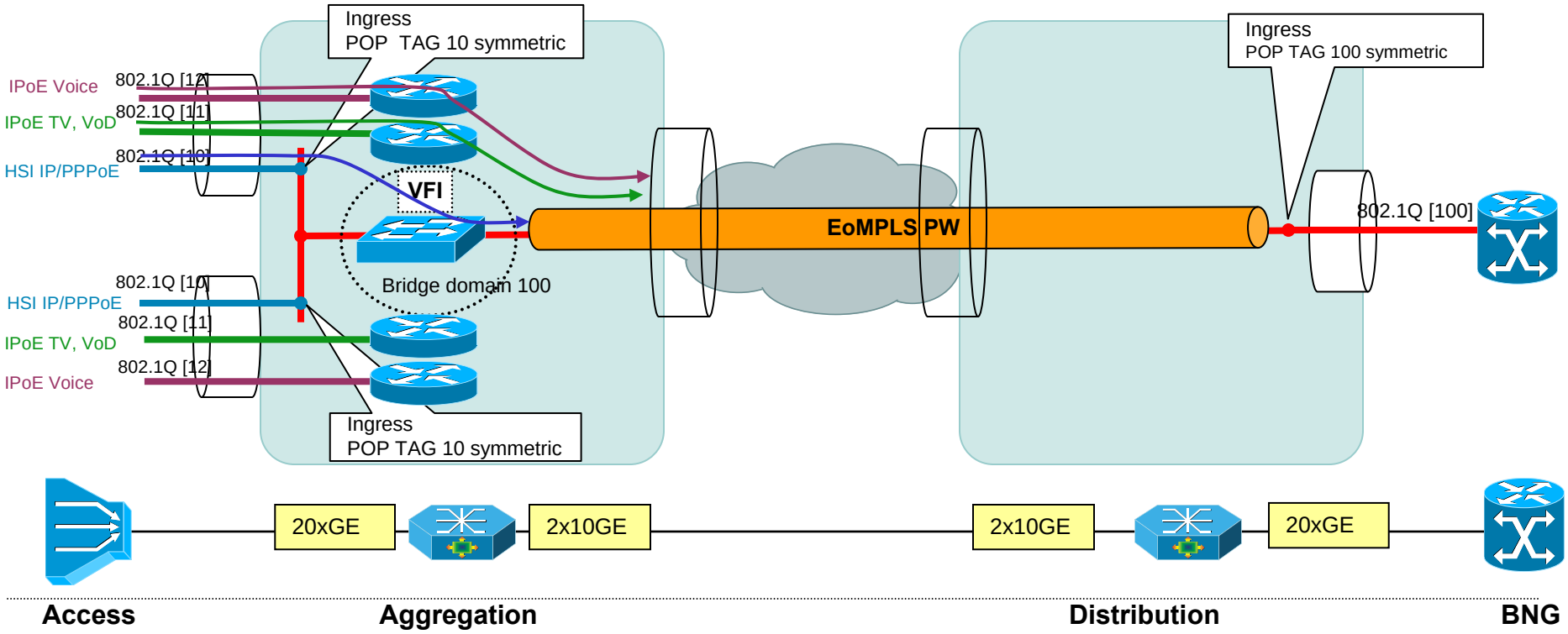
Trunk UNI, N:1 Service VLAN Residential Service Connectivity Overview

- Split Horizon Forwarding, locally significant VLAN ids combined into a per service ‘Bridge Domains’ (N:1)
- Video routed (unnumbered) in Aggregation, other transported to Distribution

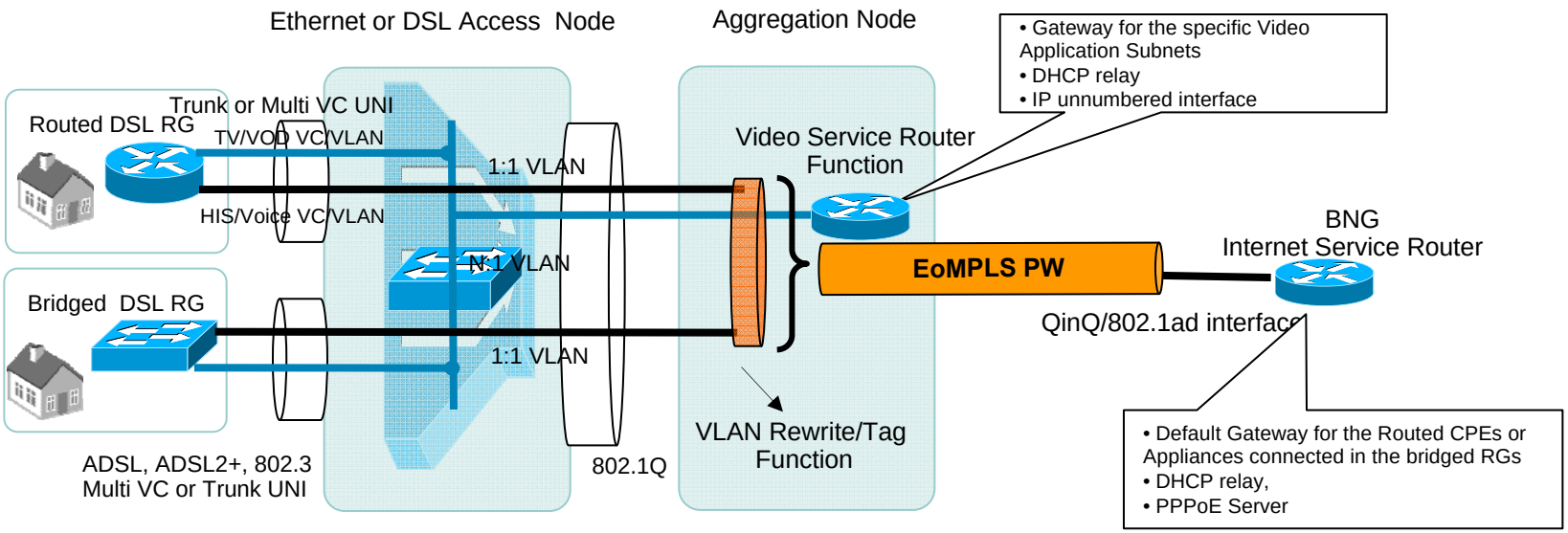


Trunk UNI, N:1 Service VLAN Residential Services Aggregation Model

- Port-significant VLAN ids removed on ingress
- Some VLANs routed, other bridged
- Common Bridge Domain allows to use single MPLS PW per Aggregation Node
- VLAN id added on egress towards BNG



Trunk UNI, 1:1 Internet Access VLAN Residential Services Connectivity Overview



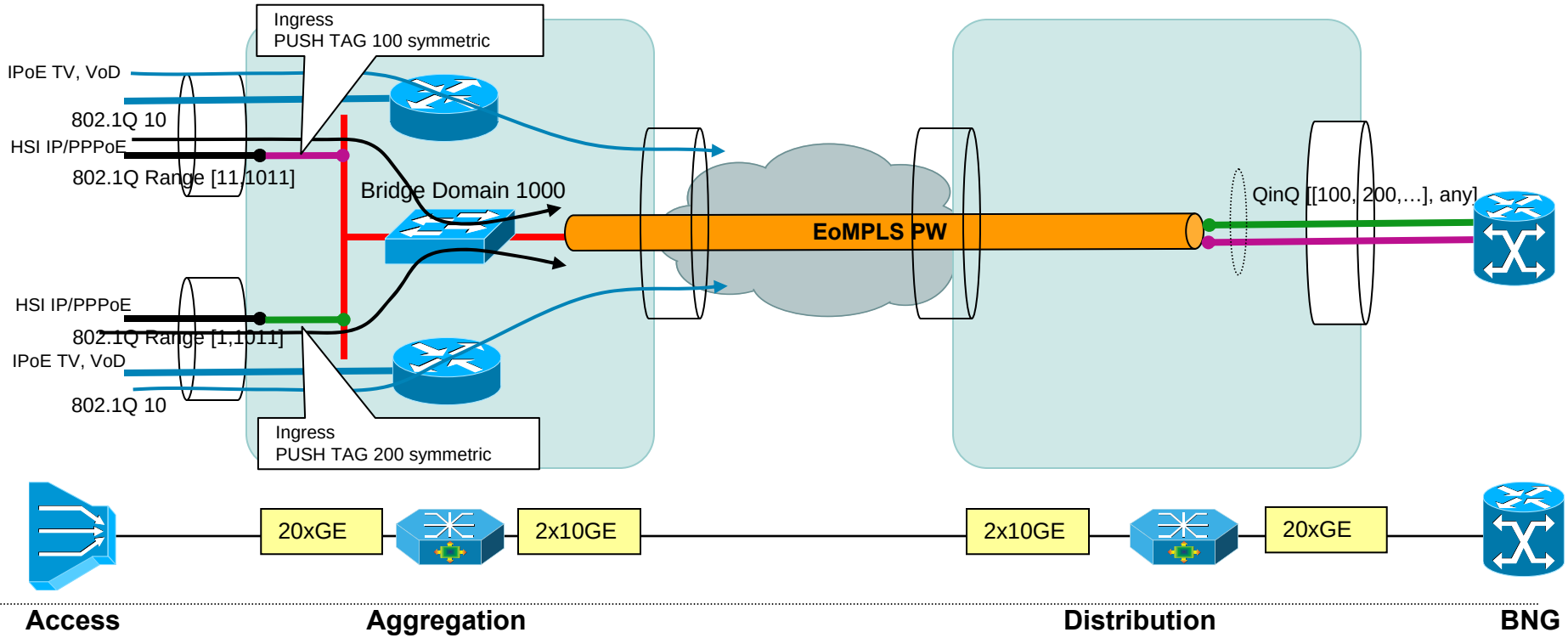
- This models allows to migrate from a single/dual-play 1:1 scenario to a triple play one WITH video optimisation
- Different Bridge Domains:

  N:1 VLAN for TV/VOD with Split Horizon forwarding in Access and Aggregation

  1:1 VLAN for InternetAccess/Voice)

Trunk UNI, 1:1 Internet Access VLAN Residential Services Aggregation Model

- Internet Access 1:1 VLANs are selectively double-tagged, added to a Bridge Domain, and tunnelled across a single PW
- TV/VOD N:1 VLAN routed in Aggregation



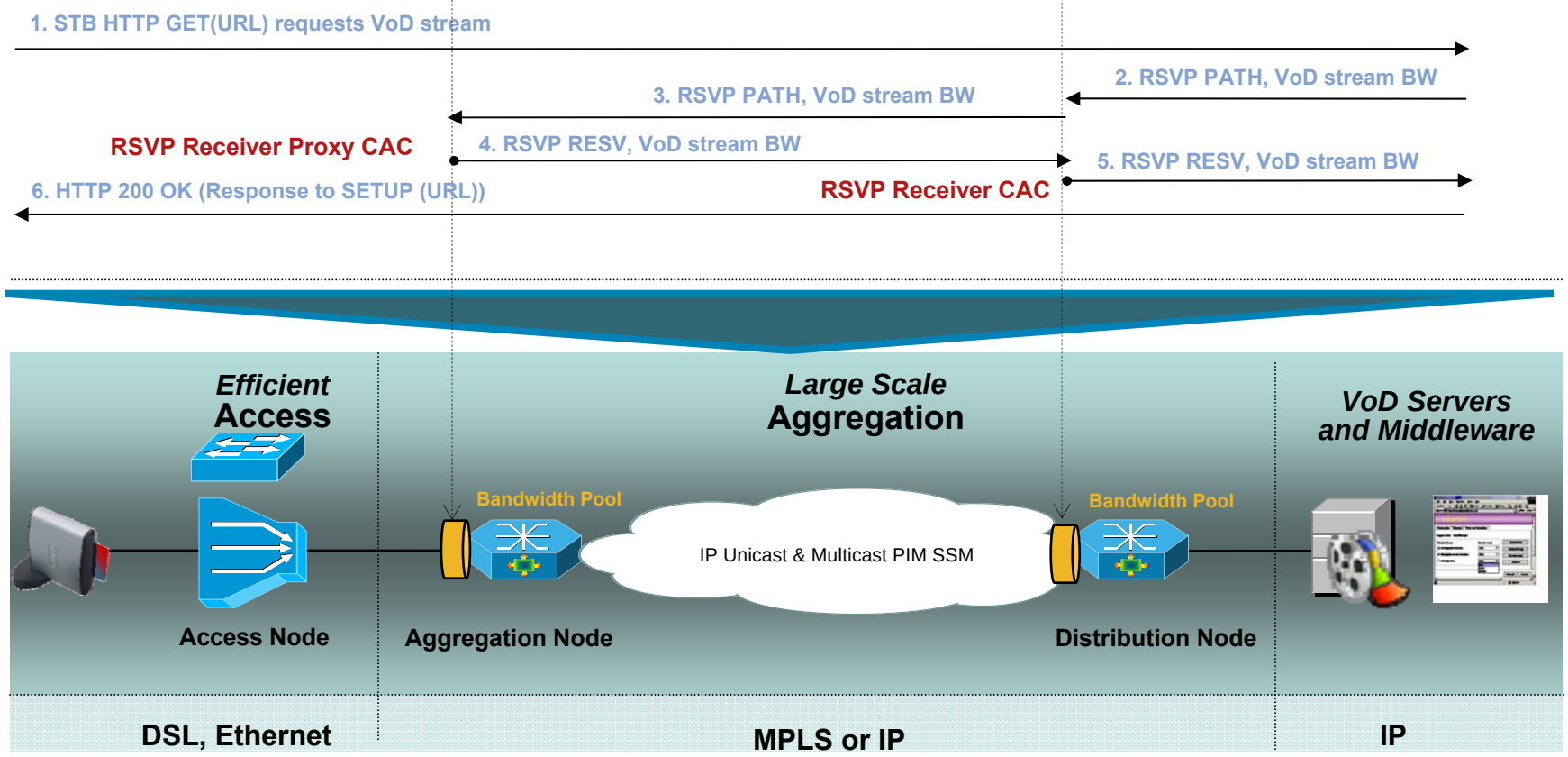
VoD CAC
Aggregation Network Diffserv RSVP

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
```

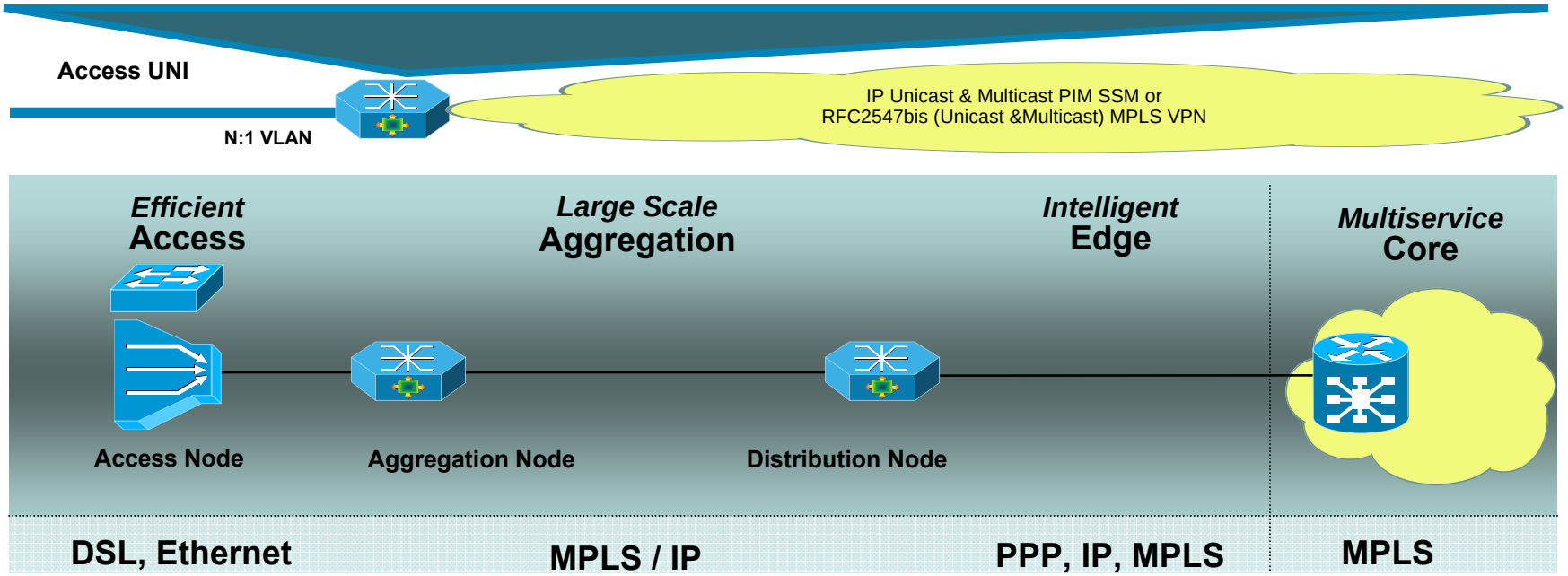
Distribution Node

```
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
```

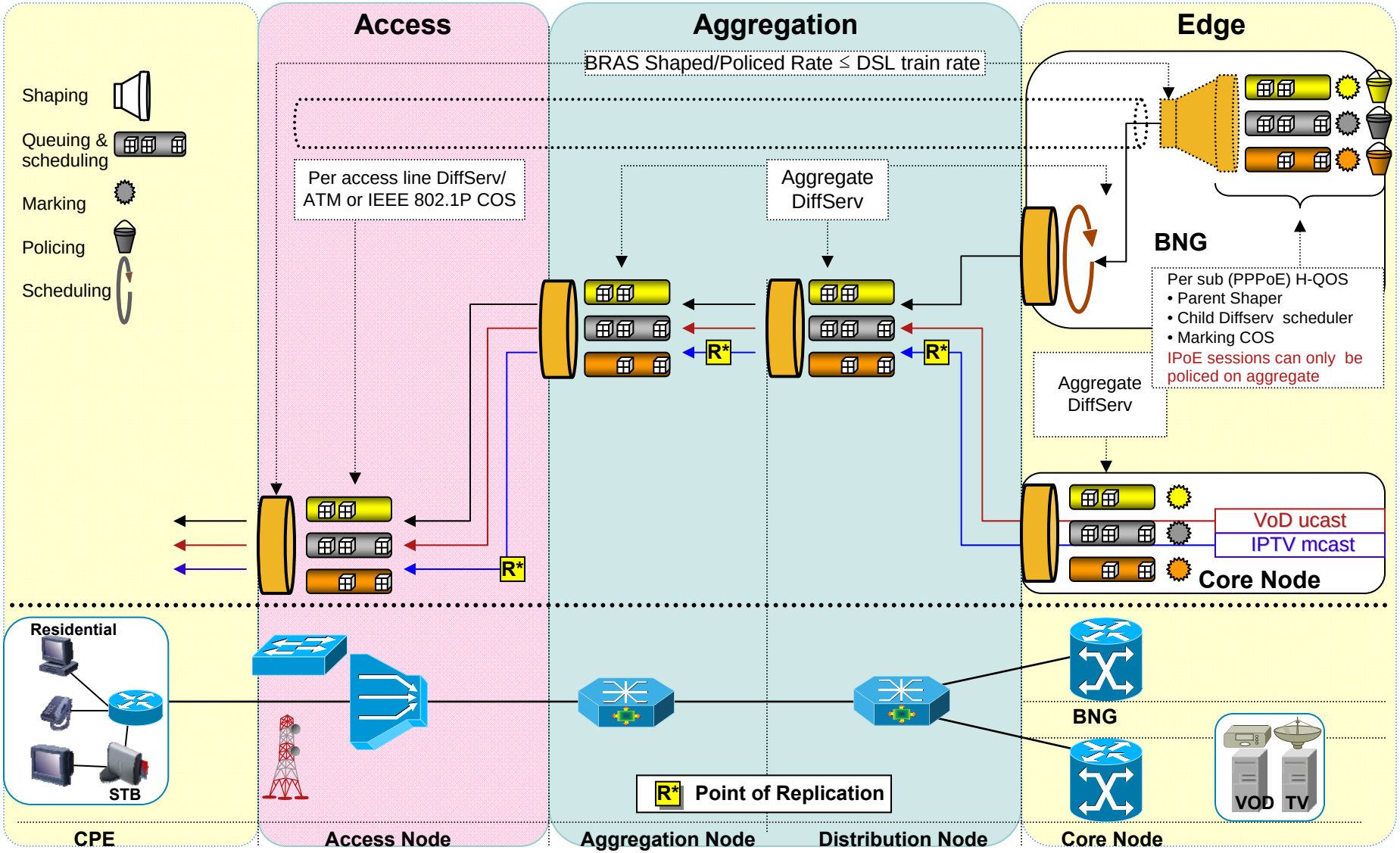


TV Broadcast CAC on the Access Node Interface

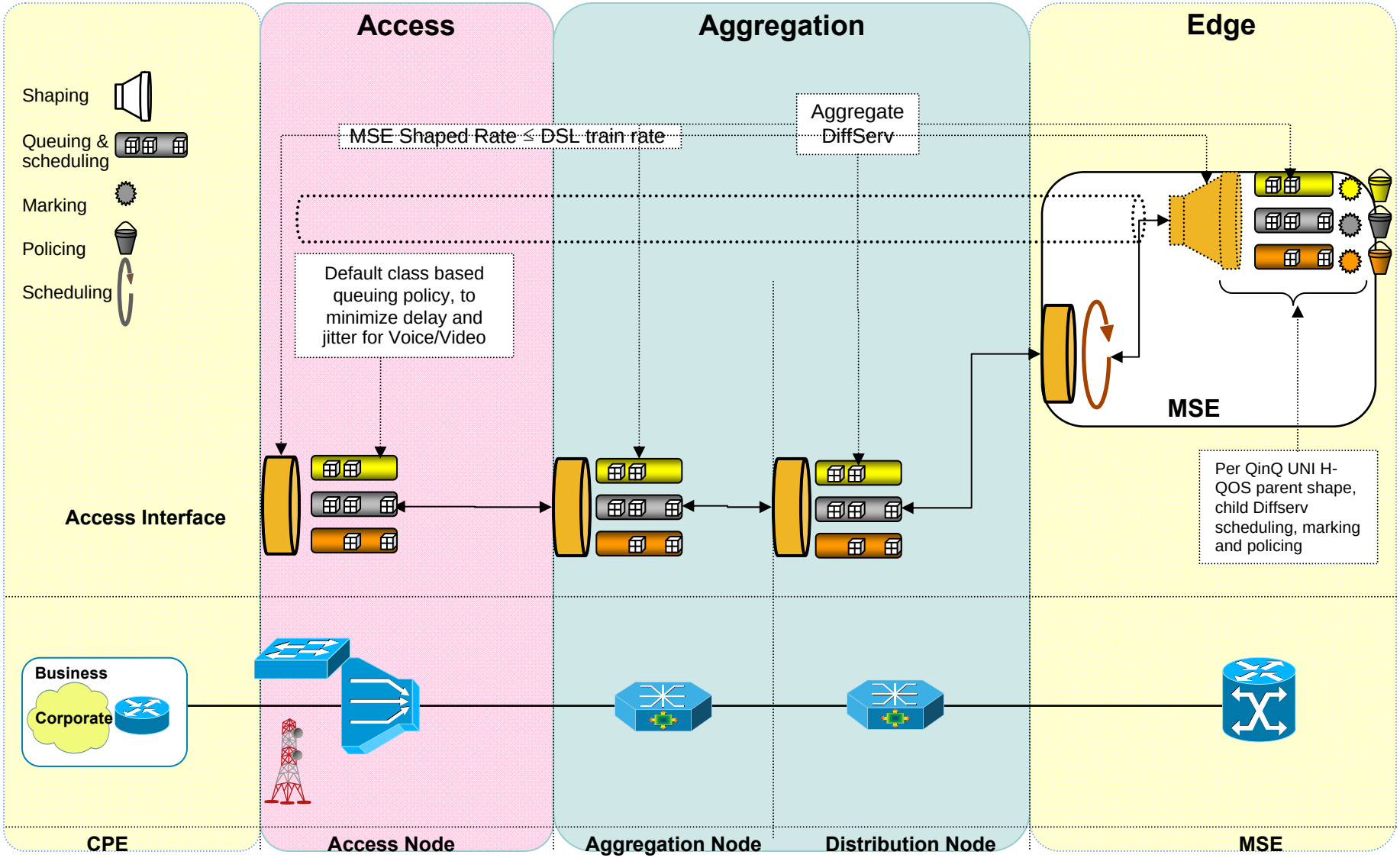
Multicast CAC Models	Single Mroute state limits	Multiple Mroute state limits	Cost factor Mroute state limits
Multicast CAC options on the Access Node VLAN (SVI): • Single Mroute state limits • Multiple Mroute state limits • Cost factor Mroute state limits	• Limits the number of multicast streams sent towards the DSL Access Node • Applies to deployment models that have the same stream encoding and assumes the maximum bandwidth per stream is known and used to calculate the number of possible streams	• Limits the number of multicast streams sent towards DSLAM, per TV programs bundles • Enables TV programs to be bundled and delivered to the DSLAM based on different CAC rules • The streams encoding is the same and known	• Enables bandwidth CAC control per TV bundles or content providers • Enables global bandwidth CAC control per stream types



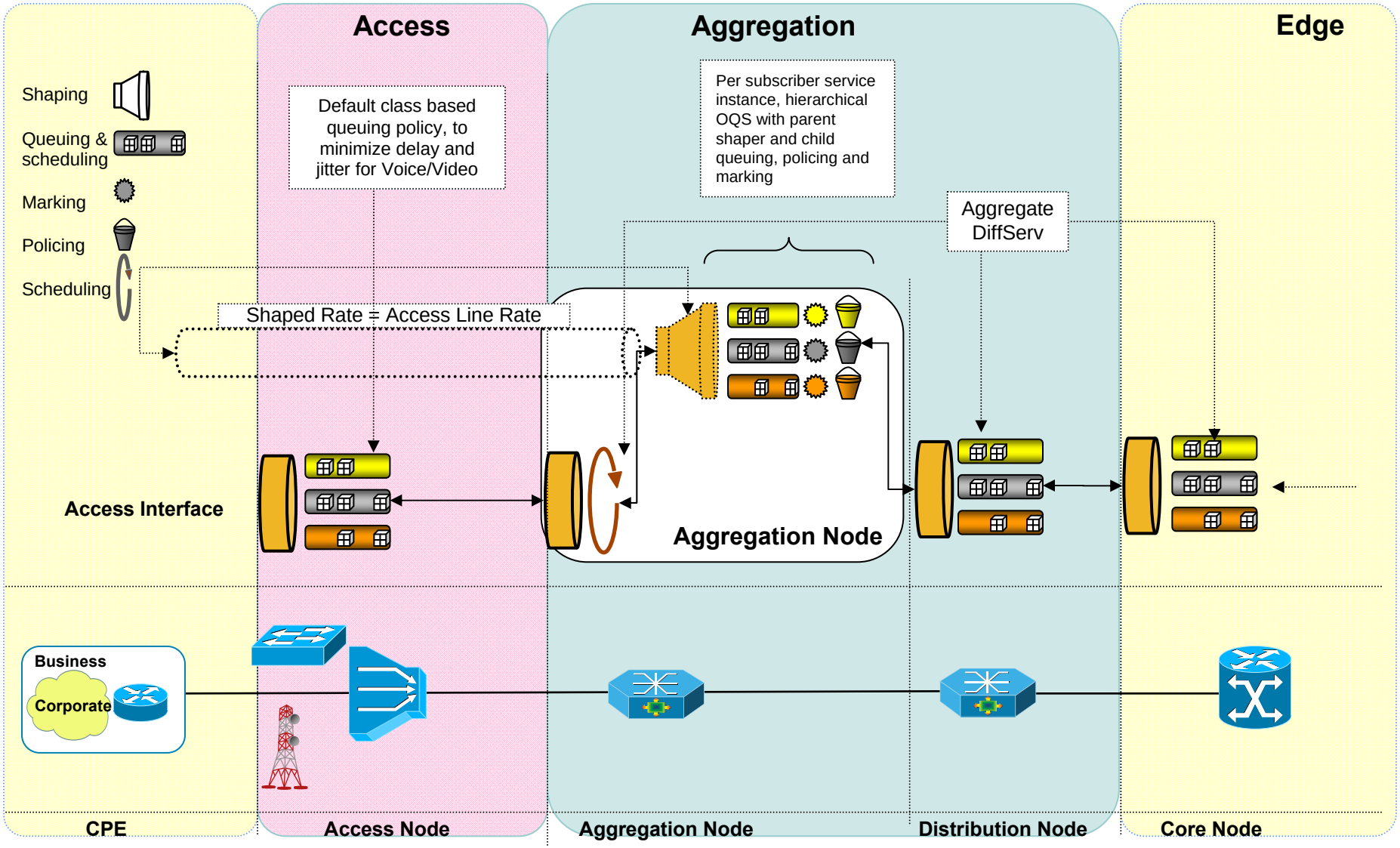
QOS Model - downstream
Residential Triple Play Services



QOS Model - downstream
MSE L2/L3 VPN Services



QOS Model - downstream
Aggregation Network L2/L3 VPN Services



Baseline Network Availability Mechanism

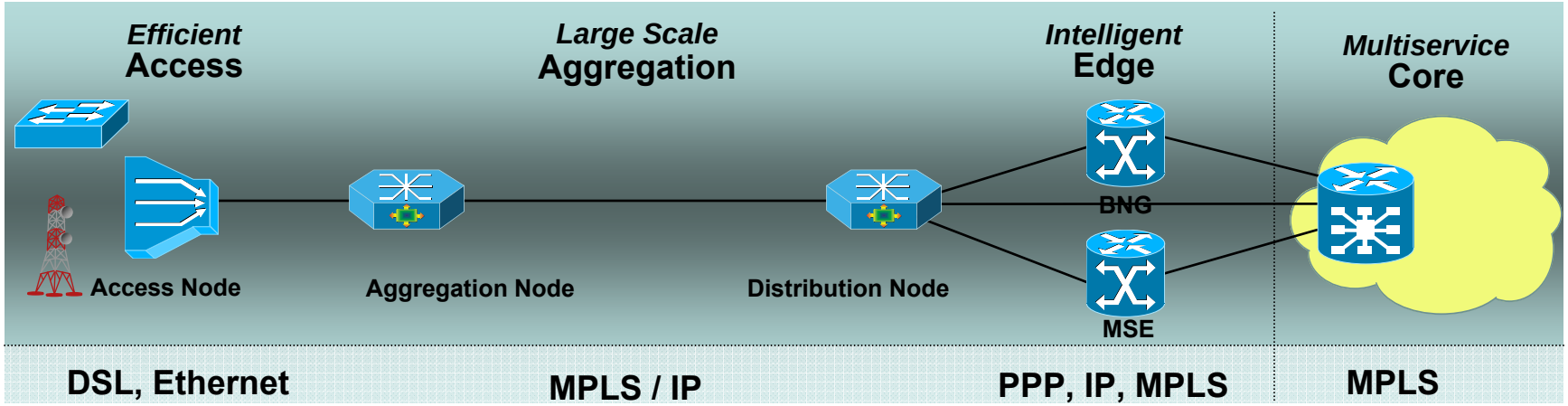
IP Services:

- **Fast IGP/BFD convergence**
- **Multicast Fast Convergence**

MPLS Services:

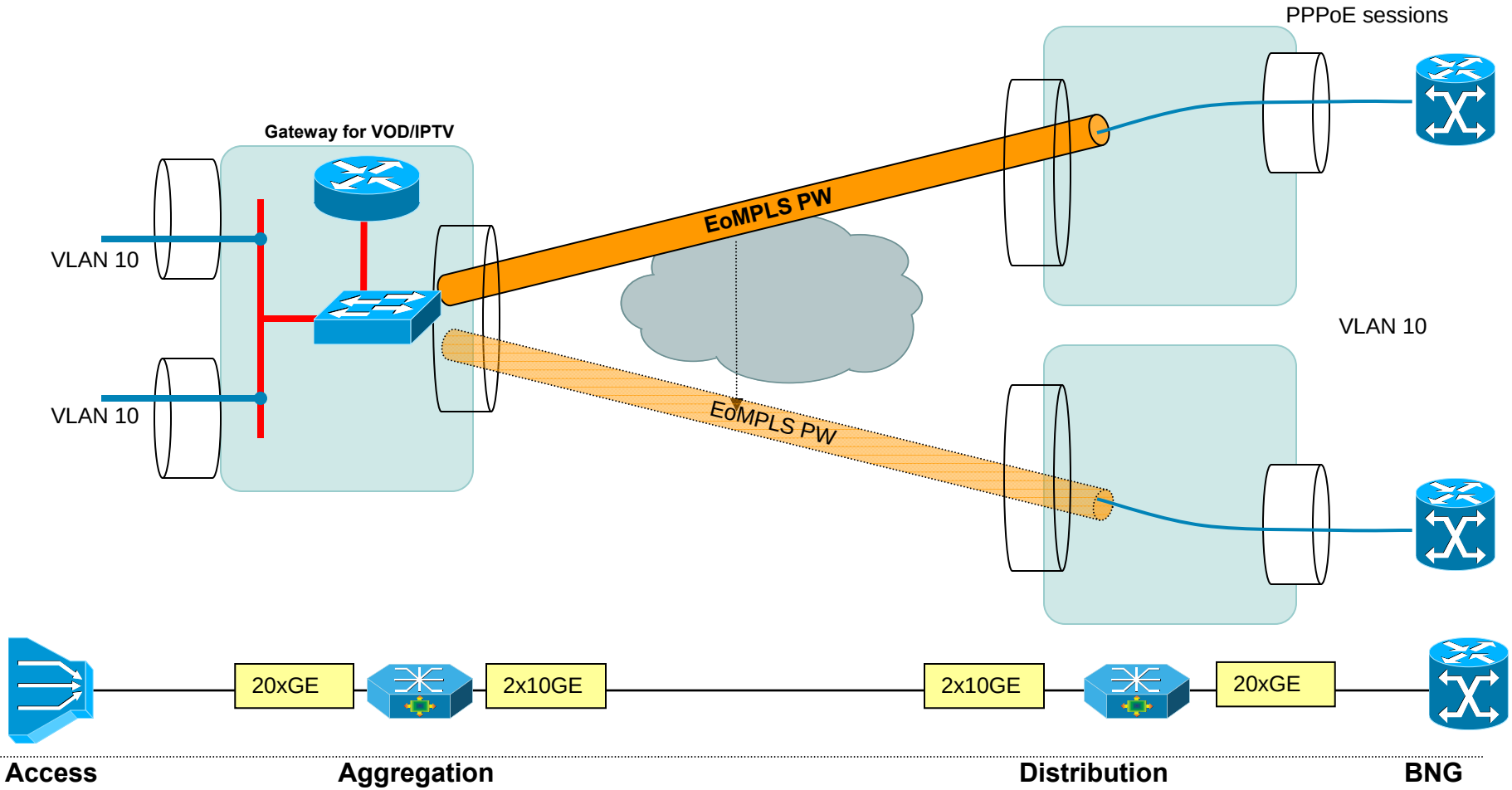
- **Pseudowire redundancy**
- **MPLS TE-FRR Link and Node protection with IP services, PW/VPLS PW tunnel selection**

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



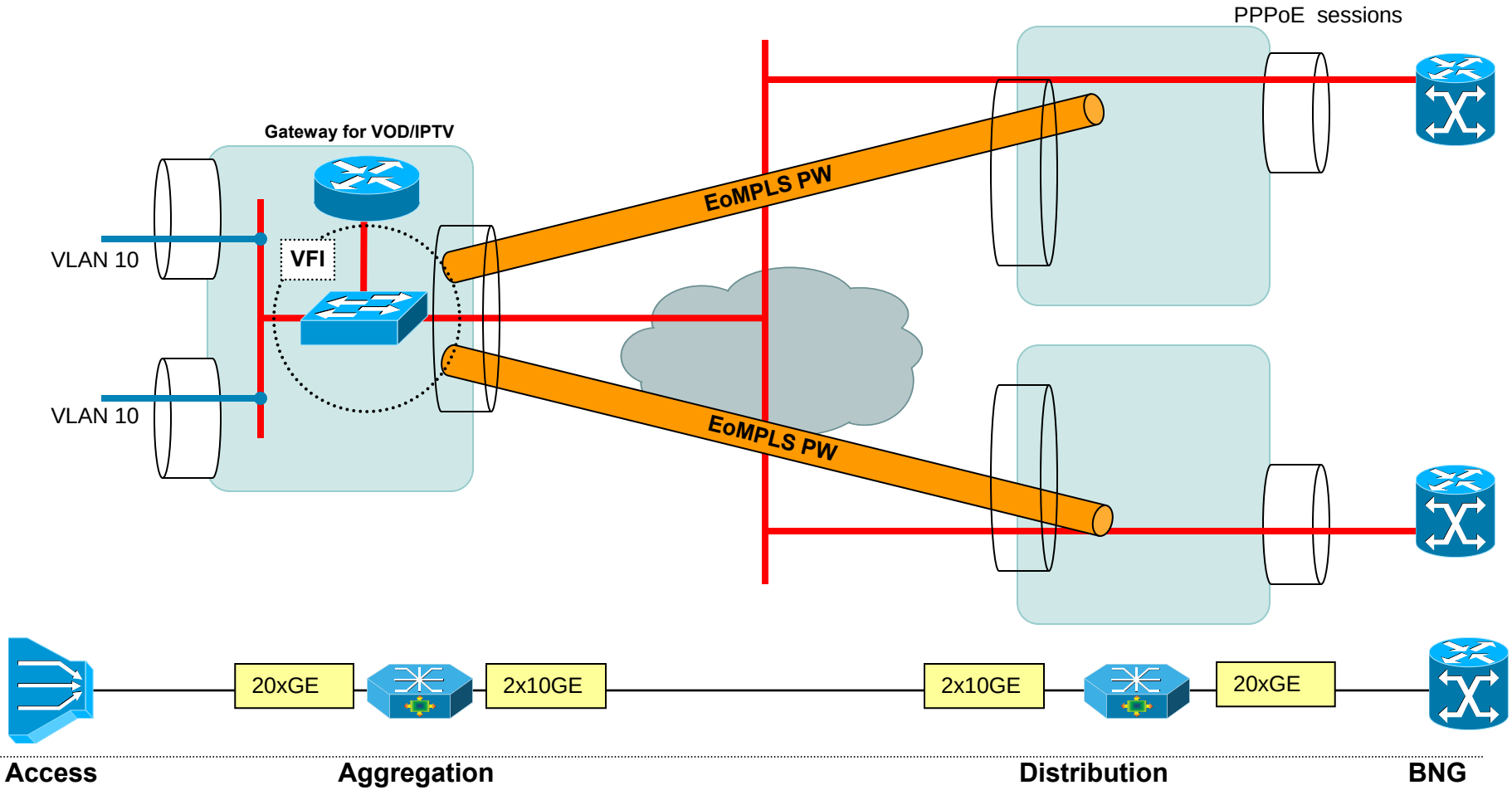
Residential Services

Active/Backup Aggregation Node Redundancy



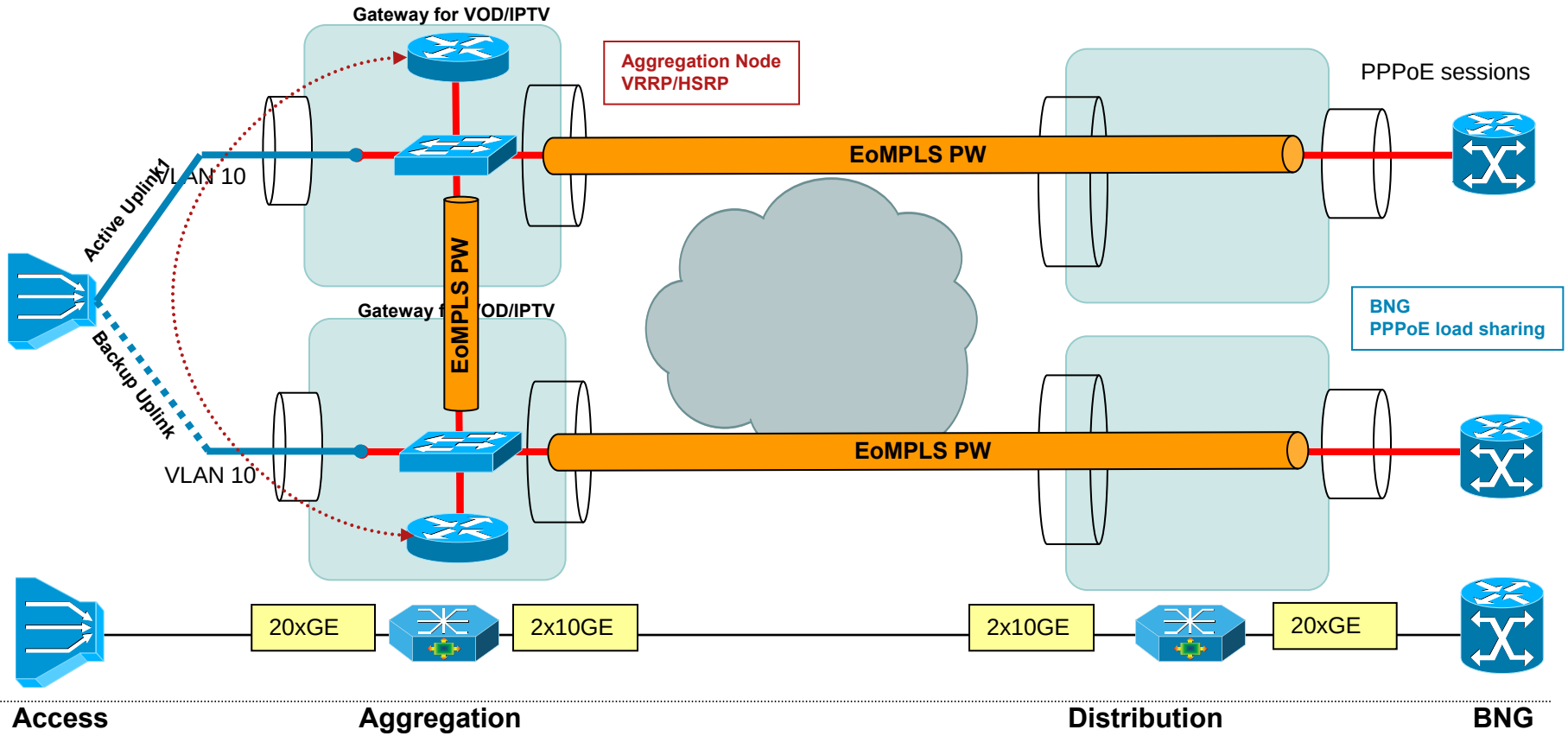
Residential Services

Active/Active Aggregation Node Redundancy



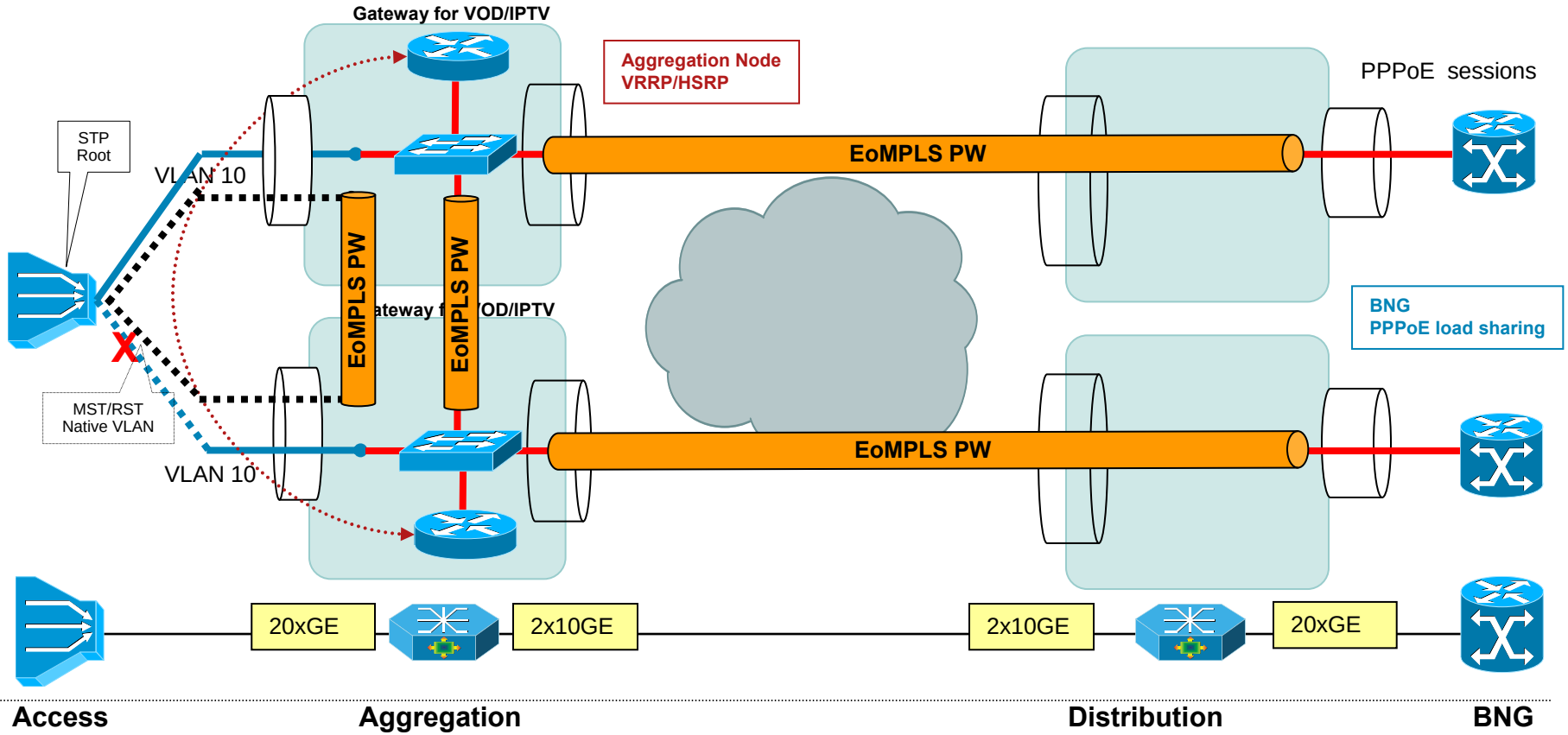
Residential Services

Active/Backup Access Node Redundancy



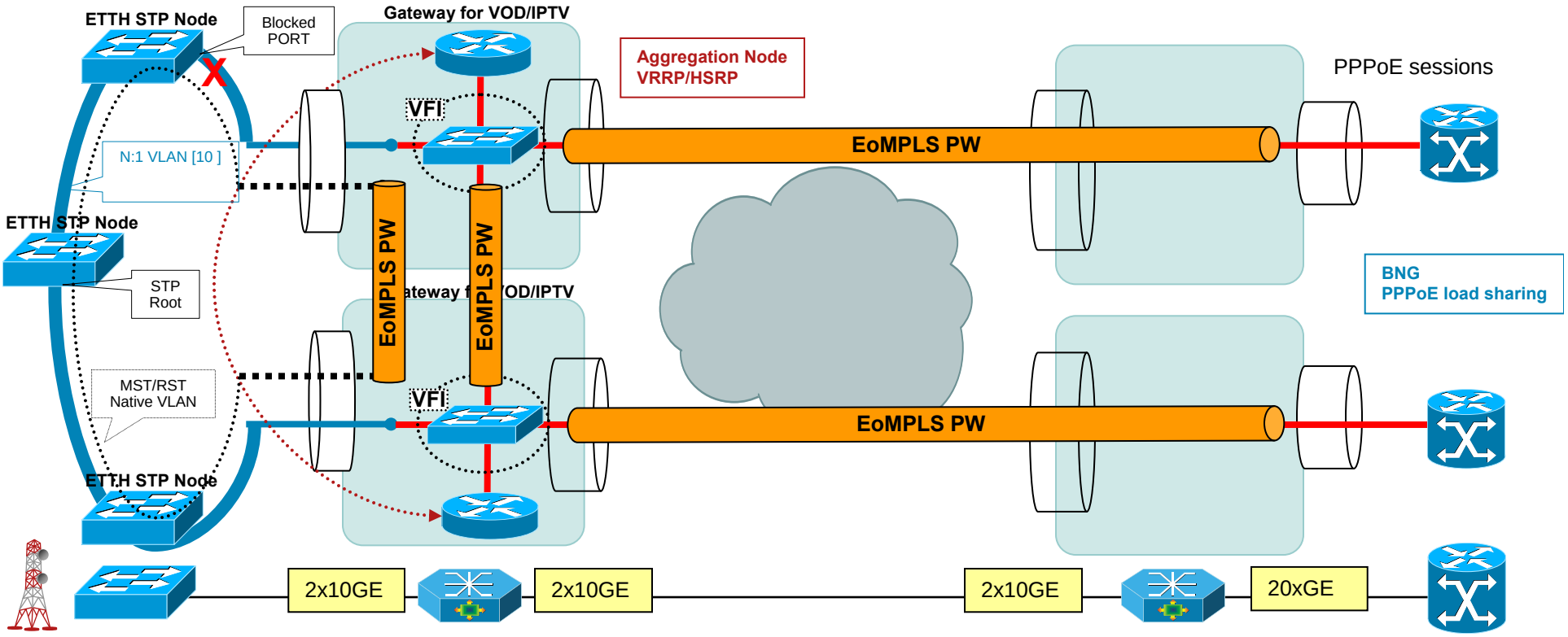
Residential Services

Active/Active Access Node Redundancy



Residential Services

ETTH/WiMAX Access Rings Redundancy



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

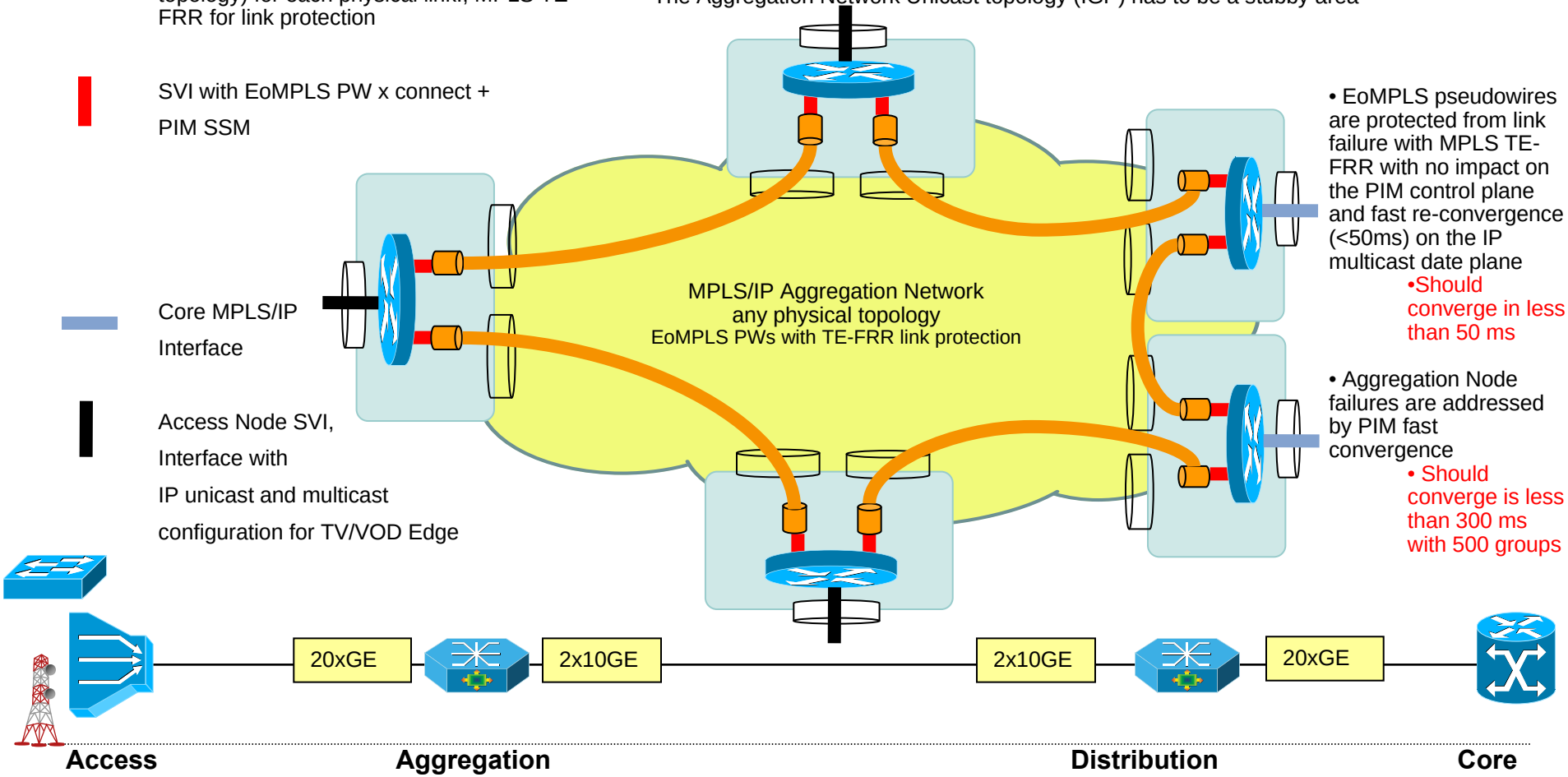
SVI with EoMPLS PW x connect + PIM SSM

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.

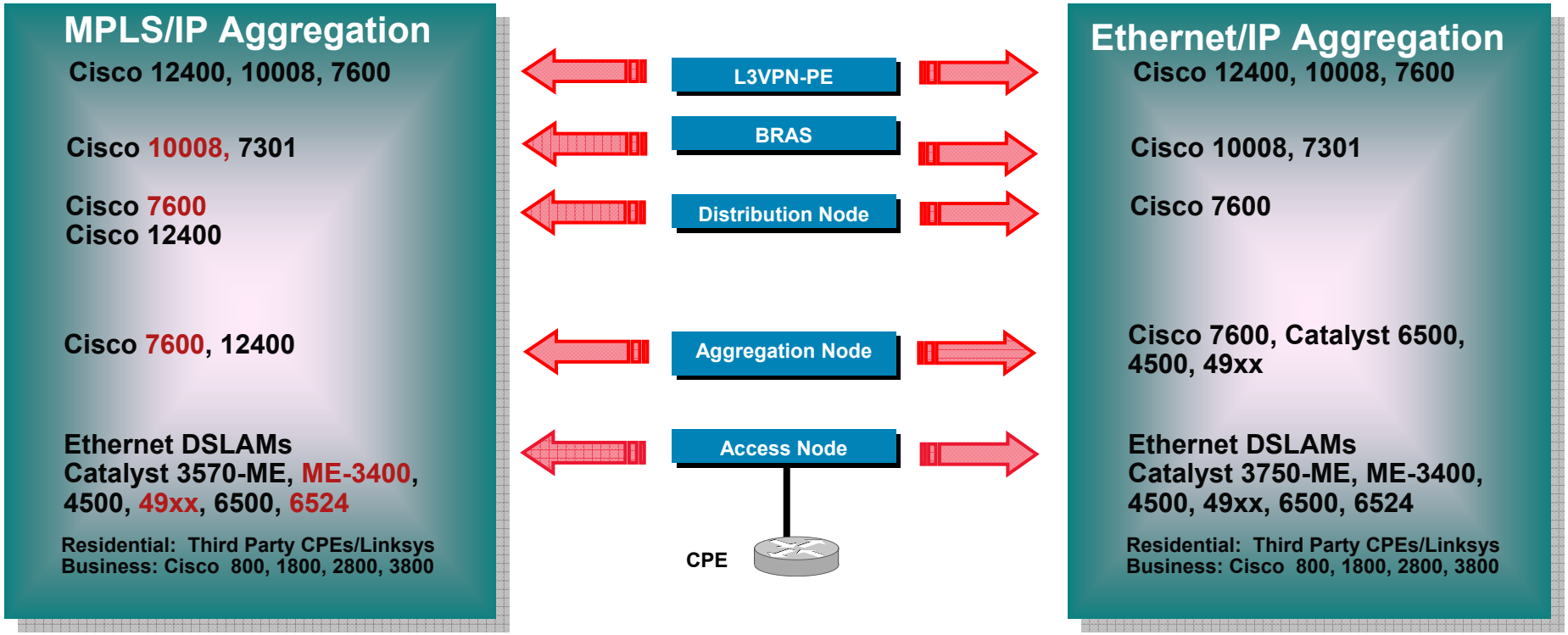
The Aggregation Network Unicast topology (IGP) has to be a stubby area



- 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

Summary

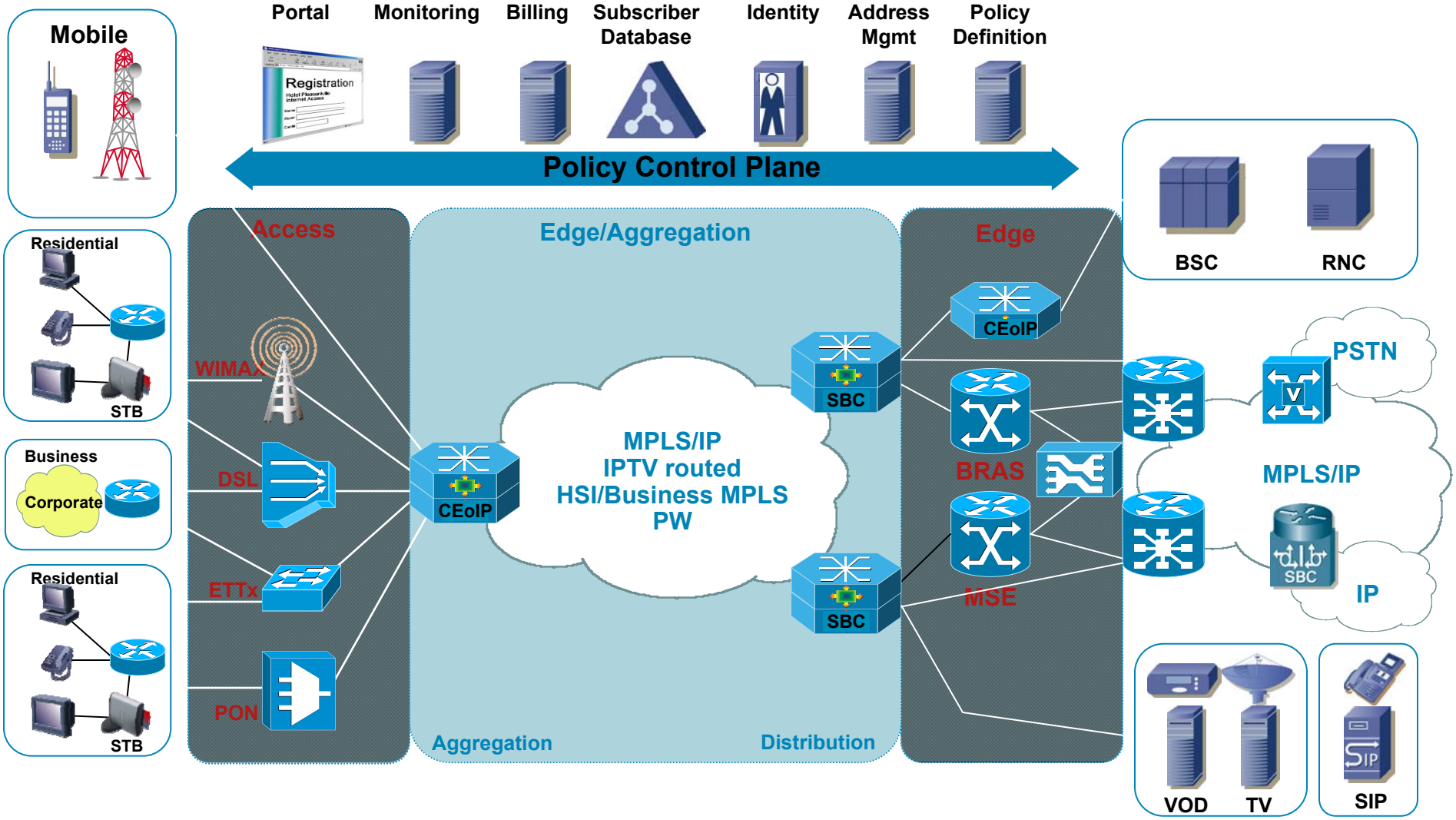
Next Generation Broadband Architecture Components



Products in Red part of CEAS1.0 !

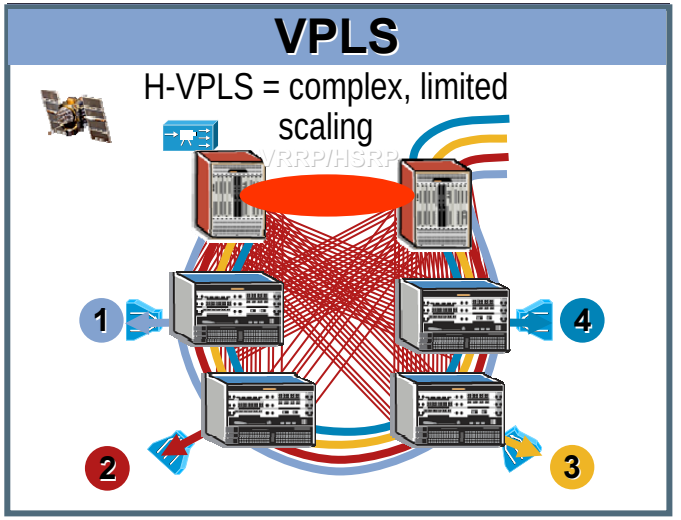
Cisco's ServiceFlex Approach

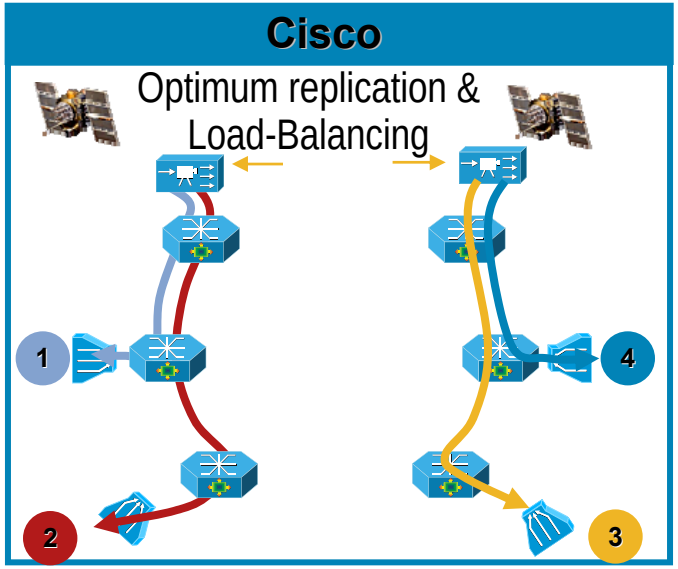
Build IP clouds, tunnel where necessary



IPTV – Benefits of Layer 3 Cloud Approach

- **H-VPLS Complexity**
  - Complex VPLS mesh & VRRP
  - Proprietary NMS required
  - Snooping troubleshooting challenges
  - Provision each user 2x – video app & network
- **L3 Cloud Optimal**
  - Provision service once at network layer
  - Proven Internet scale, any topology
  - Dynamic Load Balancing on ECMP
  - Optimized ARP & IGMP tables
  - Superior Resiliency
- **Clouds are Future Ready**
  - Ready for local content injection (P2P, ads)
  - Cisco Roadmap integrates cloud approach





Video Quality Leadership

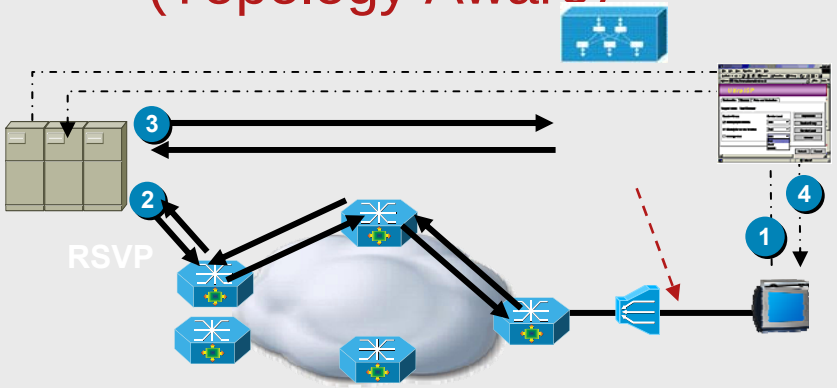
Consistent Resiliency

	Link in metro	Distr. Node	Agg Node	Source
Impact	50K	10K	100K	1M
VendorX	50ms	2-3s	~10s	>2-3s
Cisco	<1s	<1s	<1s	<1s

Integrated Video QoE Monitoring

NAM

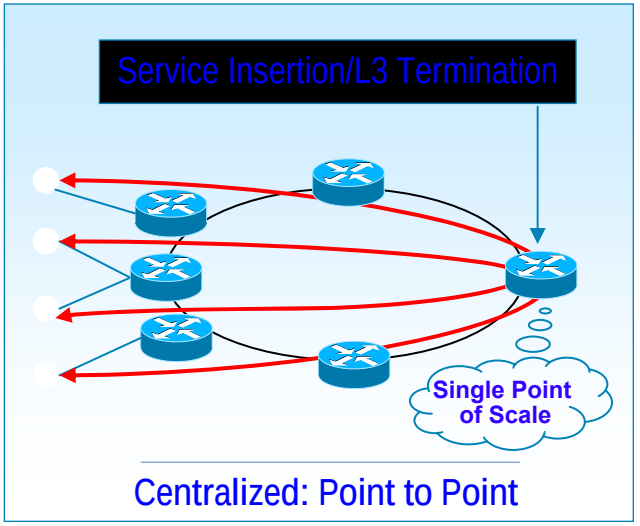
Integrated Video CAC (Topology Aware)

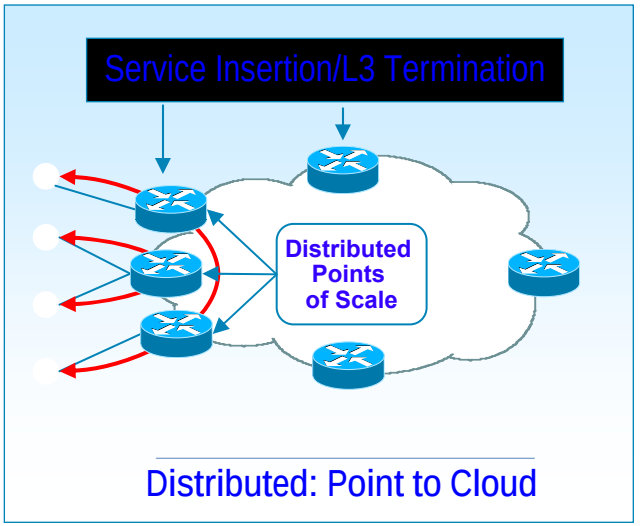


Fast Channel Change Error Repair w/ SA STBs

Future Path to Distributed Services
Drivers for more clouds and less circuits

- Reduction of CAPEX and OPEX
  - Single provisioning point for all services (L2/L3)
  - Common converged infrastructure
  - Bandwidth Efficiency
- Scale
  - Integration & Distribution = Scale
- Enhanced resiliency
  - Automated rerouting, no need for interbox redundancy (VRRP)
  - Evolution to zero-loss video failover (0 ms)
- Monitoring, control, billing of future services
  - Video 2.0: P2P legal distribution model
  - Local content injection
- However SP Org. structures will be diverse
  - Cisco supports circuit and cloud models
  - Organizational consolidation may lead to acceptance for cloud network configuration
  - Trend started in challengers and some ILECs followed



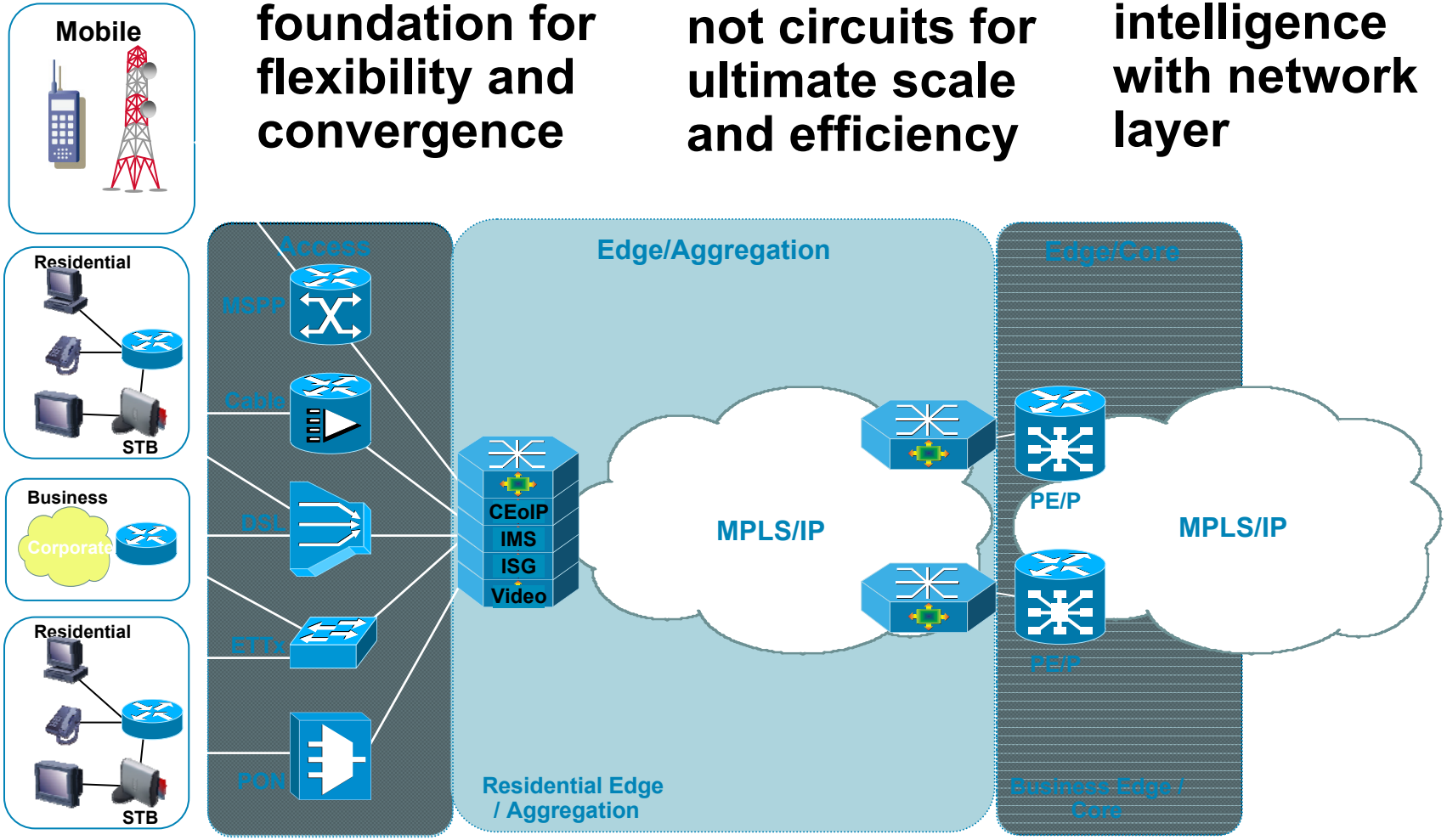


Distributed Residential Services Edge
Target Architecture Overview

Carrier Ethernet foundation for flexibility and convergence

Build Clouds, not circuits for ultimate scale and efficiency

Integrate SEF intelligence with network layer



Summary

- Cisco's Vision is "all services to all screens"
- Step one on this journey is to get Foundation IPTV Delivery right
- Two fundamental service categories that Cisco recommends to be treated differently
  - Transport Defined Services (TDS): Internet Access, Business/Wholesale Services
  - Managed Applications Services (MAS) : Video, (Voice)
- Cisco IP Multicast is key technology for efficient delivery of IPTV
- To deliver on expected user experience for MAS
  - Need CAC + per-service QoS with 10^{-6} loss for video
  - Need Layer 3 distributed edge for efficient transport, consistent resiliency, to enable path-based CAC
- Cisco's IP NGN Service Optimized Network Layer can provide this solution solution today
- Cisco has also tested several different architecture models end-to-end
  - Carrier Ethernet Aggregation System 1.0
  - Flexibility to work with any architecture that fits your needs and leverages already-deployed infrastructure components

Meet the Experts
IP NGN Architectures and Technologies

- Oliver Boehmer
  Network Consulting Engineer

- Moustafa Kattan
  Consulting Systems Engineer

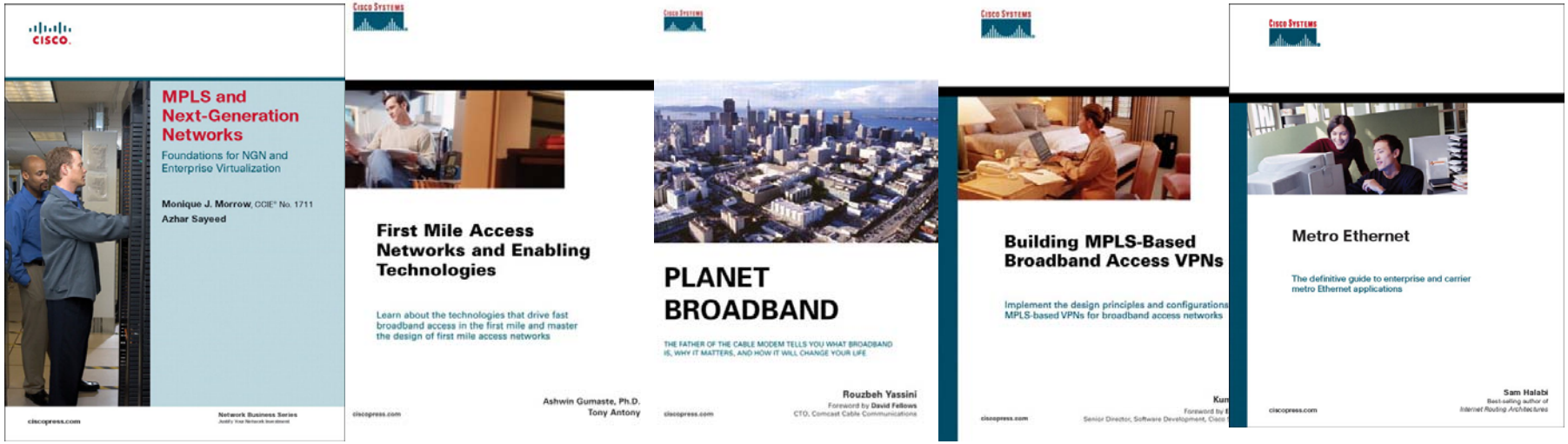
- Yves Hertoghs
  Distinguished System Engineer

- Ed Draiss
  Product Manager

Recommended Reading

BRKBBA -3002

- Metro Ethernet
- Planet Broadband
- Building MPLS-Based Broadband Access VPNs
- First Mile Access Networks and Enabling Technologies
- MPLS and Next-Generation Networks



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