Next-Generation Network Architecture for Integrated Wireline and Mobile SP

Vladimir Settey
Agenda

Market Trends & SP Challenges
IP NGN CE Architecture
Services Delivery Models
High Availability
Quality of Service
SLA Monitoring
Carrier Class Manageability
Market Trends and SP Challenges
Dominance of Video, Mobile and Cloud
Fundamentally Different Traffic Mix

IP traffic will increase 4X
(767 exabytes by 2014)

Source: Cisco Visual Networking Index—Forecast, 2009-2014

Exponential Growth + Evolving Traffic Mix = Complexity
Wireline Packet Transport Flow Trends

Key Challenges

**Reduce OpEx**
(50-80% of Revenue)
Make networks simple to operate

**Battle Commoditization**
Deliver rich experiences to improve customer loyalty

**Scale Profitably**
Increase ROI from CapEx investments
Main Changes in SP World

• SP revenue shifted long ago and is now under pressure of commoditization and competition
  Traditional voice and layer 1 private line → New packet based services

• Traffic and services shift to packet bring forth new opportunities:
  Emergence of new packet technologies with improved performance: IEEE (802.x), MPLS-TP, OTN, etc.
  Demand for seamless convergence of the new packet technologies and services
  Opportunity for innovative new service definitions together with challenge for increased monetization of new services

• Operational Complexity increases due to increased network and service complexity
  NMS, OAM, Capacity design, SLA monitoring and conformance, traffic steering requirements persist as before and are more complex
  New operational paradigms need to be applied to the emerging networks and services
  Older operations were simpler and streamlined to meet older network, newer operations require more intelligent networks

• Exponential increase in Video traffic due to consumer demand:
  Need for extensive upgrades with lower cost (CAPEX and OPEX)
  Need for innovations to reduce the traffic burden and optimize cost: multicast, CDN, …

• Expectation for ubiquitous Mobility:
  Expect wireline and wireless to work seamlessly, together, everywhere

• Emergence of Cloud services enabling new innovative services and operations models
  Requires applications to be aware of network
  Location services become key for efficient operation
  Virtualization introduces new challenges for network and storage
IP NGN Architecture Issues

Important back to ~ 2004

• Initially sparse customer take rates
• Business services dominating the bandwidth
• Relatively low data bandwidth usage
• Reuse of TDM (SDH/SONET) transport infrastructure
• Internet Access “Star Aggregation” traffic dominance
• Similar to centralized dial paradigm
• Subnetting and IP address pool utilization
• Conservative growth assumptions
• Availability of IP Operations Expertise

Important Today and Tomorrow

• Markets reaching saturation: BB, Mobile causing increased competition
• Consumer demand is driving businesses, new machine to machine modes emerging
• Huge data / bandwidth demand ala Video
• SONET transitioning to Ethernet
• Client-server moving to peer-peer and distributed streaming / cloud computing
• Increased Distributed Processing
• IPv6 migrations issues starting to dominate
• Fast growth expectations
• IP operation is assumed, demanding simpler Ops, better tools
IP NGN Carrier Ethernet Architecture
Proven and Tested Solution
Reduces Risk and Scales Faster

• Cisco-Validated Design: End-to-end validation to reduce risk, increase velocity

• Industry’s First MEF Network-Level Certification: Faster path to your own MEF certification

• Light Reading Experience Provider Megatests: Industry’s most comprehensive tests validate Cisco’s leading reliability and performance for video and mobility

Leading edge in the industry offering comprehensive, third-party validation and certification
# Cisco Transport Architecture Direction

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SONET/SDH</th>
<th>Optical OTN (ROADMs)</th>
<th>Electrical OTN</th>
<th>PBB-TE</th>
<th>MPLS-TP</th>
<th>IP/MPLS</th>
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<tbody>
<tr>
<td>Eline (10GE)</td>
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<td>Eline (sub 10GE)</td>
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<td>Legacy</td>
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<tr>
<td>Traffic Engineering</td>
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<tr>
<td>50ms restoration</td>
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<td>General</td>
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<tr>
<td>Multiplexing Technology</td>
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<tr>
<td>UNI processing</td>
<td>Limited</td>
<td>None</td>
<td>None</td>
<td>Typically rich</td>
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<tr>
<td>Granularity</td>
<td>VC-4</td>
<td>Lambda</td>
<td>ODU</td>
<td>Variable</td>
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</tr>
<tr>
<td>Technology Maturity</td>
<td></td>
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</tbody>
</table>

- **Cisco focuses on IP/MPLS for the Carrier Ethernet Transport architecture**

- **Cisco targets MPLS-TP for the POTS and Access Networks while supporting already Ethernet Bridged Access**

- **Statistical**

- **Typically rich**

- **Typically rich**

- **Variable**

- **Typically rich**

- **Variable**
NGN Architecture Overview

- TR-101 Functions
- MSTP/REP
- L2 Access Network
- 802.1Q NNI

- Local VLAN Significance
- Flexible service mapping
- Ethernet virtual connection infrastructure
- Security features

- IPTV Edge
- Backhaul HSI to BNG
- Triple Play Edge
- Interworking VPLS with MST/REP

- ATM/TDM backhaul over MPLS
- EoMPLS/VPLS/L3VPN
- IP Unicast/Multicast Forwarding
- Ethernet/MPLS OAM

- MPLS/IP Transport
- Transport Deployment: VPWS, VPLS

- MPLS/IPoDWDM Optical Network

- Optional Business Service Edge Node
- Optional Video Service Edge Node
- HSI Service Edge Node
- BSC/RNC

- Core Node
- Core Network IP / MPLS
- Content Network

- Mobile 2G/3G/4G Node
- Residential STB
- Business Corporate
- Residential STB
- Business Corporate
Some Words About MPLS-TP

Connection Oriented, pre-determined working path and protect path
Transport Tunnel 1:1 protection, switching triggered by in-band OAM,
Options with NMS for static provisioning, or dynamic control plane for routing and signaling

Note: The cloud represents one MPLS-TP network, e.g., it may be in aggregation or access
MPLS-TP POTS in Aggregation

Packet Optical Transport

Service Edge

Multiservice Core

OAM Subsystem

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Ethernet Virtual Connection (EVC)

- One EFP Can Match One or Multiple or Range of VLANs at a Time
- Service Instance (Ethernet Flow Point)
- EVC
- L3
- VPLS
- EoMPLS
- Local Connect (P2P)
- Local Bridging (MP)
- 802.1ah Bridging

Per Service Features
- Flexible VLAN Tag Matching
- Flexible VLAN Tag Rewrite
- H-QoS Per EFP
- Security

Flexible VLAN Tag Manipulation, Pop/Push/Translate

- VLAN Local Port Significance
- Two VLAN Tag Aware
- Flexible VLAN Tag Matching (Combination of Up to Two Tags)

Flexible L2/L3 Service Mapping, One or Groups of EFPs Can Map to Same EVC
Intelligent Services Gateway
Granular SLA with Subscriber Awareness

- 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

- Provides Policing, Access Control, Accounting, via Radius Push/Pull
  Authentication
  Logon
  Change of Authorization (Policy Push)
  L4 re-direction
  Accounting

RADIUS / AAA push/pull Per Sub/Service Accounting

Self provisioning / Selfcare
Technology Scope and Standards Alignment

**MEF**
Ethernet Services definitions, UNI, ENNI SLA and functions, compliances

**IEEE**
Building Ethernet-Access Networks: Provider Bridges 802.1ad; Backbone Bridges 802.1ah OAM: 802.1ag, 802.3ah

**IETF**
Building the Carrier Ethernet Transport and Edge: IP, MPLS, VPWS, VPLS; Enabling transport in the future Access Networks: MPLS TP, MS-PW,

**ITU**
SG15/Q12, SG13/Q3; Architecture of Ethernet Layer Networks, Services etc.—from a Transport Perspective. E2E OAM

**Broadband Forum**
DSL/FTTX/Broadband-Related Architecture and Transport Aspects (TR-101/WT145), BRAS/BNG Requirements, Ethernet Aggregation/TR-59 Evolution, Subscriber Session Handling, IPv6, Connected Home…
Service Delivery Models
## Residential and Business Services

<table>
<thead>
<tr>
<th>Market</th>
<th>Services</th>
<th>Access</th>
<th>SLA Type</th>
<th>SLA Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential</strong></td>
<td><strong>VoIP Telephony</strong></td>
<td>Ethernet, DSL, PON</td>
<td>Application</td>
<td>Guaranteed bandwidth, jitter, security, availability. The number of VoIP appliances, SIP URLs/PST Phone numbers, active calls, VoIP call quality</td>
</tr>
<tr>
<td><strong>VoD</strong></td>
<td></td>
<td>Ethernet, DSL, PON</td>
<td>Application</td>
<td>Guaranteed bandwidth, security, admission control, availability. The number of STBs, stream quality, content flavors, charging models.</td>
</tr>
<tr>
<td><strong>IPTV</strong></td>
<td></td>
<td>Ethernet, DSL, PON</td>
<td>Application</td>
<td>Guaranteed bandwidth, security, admission control, availability. The number of STBs, type of TV packages, S/D HD content profiles.</td>
</tr>
<tr>
<td><strong>Internet Access</strong></td>
<td><strong>E-Line</strong></td>
<td>Ethernet, DSL, PON</td>
<td>Transport</td>
<td>Dynamic access bandwidth, session/idle timeout, advertisements, post paid/prepaid (time and volume).</td>
</tr>
<tr>
<td><strong>Business</strong></td>
<td><strong>L3 VPN MPLS / Multicast</strong></td>
<td>Ethernet, DSL, PON</td>
<td>Transport</td>
<td>Access bandwidth, differentiated services support, L3 VPN topology, managed services (MPLS/Multicast VPN).</td>
</tr>
<tr>
<td><strong>E-Line</strong></td>
<td></td>
<td>Ethernet, DSL, PON</td>
<td>Transport</td>
<td>Access bandwidth, differentiated services support, transparency.</td>
</tr>
<tr>
<td><strong>E-LAN</strong></td>
<td></td>
<td>Ethernet, DSL, PON</td>
<td>Transport</td>
<td>Access bandwidth, differentiated services support, multipoint transport, transparency.</td>
</tr>
</tbody>
</table>
## Transport Services

<table>
<thead>
<tr>
<th>Market</th>
<th>Services</th>
<th>Access</th>
<th>SLA Type</th>
<th>SLA Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>Mobile RAN</td>
<td>2G TDM, 3G ATM, ATM, Ethernet/IP</td>
<td>Transport</td>
<td>Guaranteed bandwidth, delay and jitter inline with Mobile Radio Access Network requirements</td>
</tr>
<tr>
<td>HSI Wholesale</td>
<td>Ethernet, DSL, PON</td>
<td>Transport</td>
<td></td>
<td>Aggregated bandwidth on ISP level, differentiated services support, with subscriber management at ISP, with L2TP or MPLS VPN transport.</td>
</tr>
<tr>
<td>Triple Play Wholesale</td>
<td>Ethernet, DSL, PON</td>
<td>Transport</td>
<td></td>
<td>Aggregated bandwidth on ISP level, differentiated services support, transparent P2P Ethernet transport for unicast services, IP Multicast for IPTV.</td>
</tr>
<tr>
<td>Contribution Video</td>
<td>Ethernet, Video HD-SDI</td>
<td>Transport</td>
<td></td>
<td>Guaranteed bandwidth, delay, jitter and close to zero or zero packet loss.</td>
</tr>
</tbody>
</table>
Residential Services Model

Retail 3Play Services

- HSI, VoIP VLAN(s)
  - Non/Trunk UNI, N:1 or 1:1 VLAN
- VoD+IPTV, VoIP VLAN
  - N:1 VLAN
  - EoMPLS PW
  - 802.1Q, QinQ
  - MPLS/IP, IP Multicast, IP LFA, MoFRR

Retail or Wholesale 3Play Services

- HSI, VoIP VLAN(s)
  - Trunk UNI, N:1 or 1:1 VLAN
- VoD+IPTV VLAN
  - N:1 VLAN
  - EoMPLS PW
  - 802.1Q, QinQ
  - H-VPLS, IGMP snooping, CAC

Efficient Access Network

- DSL, PON, Ethernet
- Access Node
- Aggregation Node ASR9k, 7600, ME3800X
- Distribution Node ASR9k, 7600

Large Scale Aggregation Network

- Service Aware or Transport VPWS, VPLS, MPLS/IP
- Large Scale Aggregation Network
- Ethernet UNI

Intelligent Services Edge

- HSI SEN, ASR1k
- Ethernet/MPLS NNI
- ISG Sessions
- MPLS/IP, MPLS/Multicast VPN

Multiservice Core Network

- PPP, IP, MPLS
- Video SEN, 7600
- Core Node, CRS-1
- MPLS

Enables PPPoE to IPoE migration, usage based services with service and session control, DPI and SBC

May include in future service supporting functions: Content Cache, FCC, RET, VoD CAC
• Preserve existing broadband deployment model
  NAS-Port-ID C-tag/S-Tag used as subscriber identity
  Access provisioning for HSI service and backend AAA infrastructure untouched

• Introduce Video (IPTV/VoD) as value added service

• Growing broadband subscriber base with low 3Play penetration

• Common deployment model in emerging markets
Evolution of existing architecture – L2 transport to centralized edge

Maintain centralized edge in a few large PoPs and Introduce Video by
Upgrading legacy BNG to a 3Play BNG – Single Edge
Preserve existing BNG and add Video BNG – Multi-Edge

Large subscriber base with high 3play penetration requires BNG capable of handling high session scale and high throughput due to centralization

Common deployment model
When SP is transport centric, or
Strict operational segmentation across Aggregation & Edge departments
Trunk UNI 1:1 (Non-TR101 Compliant)

- Access Nodes with 1:1 cross connects used to avoid provisioning and simplify operations
  - In some cases legacy Access Nodes may not support TR-101 functions
- All services provisioned with per subscriber VLANs and service functions offloaded to the Aggregation Node
- Aggregation to Edge L2 transport similar to the Trunk UNI, N:1 VLAN Centralized-Edge deployment model
- Not a common deployment model but seen in some dense geographies with high 3Play penetration
Non-Trunk N:1 VLAN Model

- Service Edge is distributed in the Aggregation Network - Integrated Edge Nodes
- Single Edge offers granular SLA enforcement with per-subscriber H-QOS policy for HSI/VoIP/Video services
- Efficient bandwidth utilization – Keep local traffic local, avoid bottlenecks due to backhauling
  - IPTV multicast replication close to the subscriber
  - Policy enforcement close to subscriber - No need to backhaul internet traffic that can be dropped
- Distributed architecture reduces session scale on Integrated Edge Nodes
- Intelligence in Aggregation Nodes provide benefits for other services - Traffic-Offload for Mobile RAN backhaul, Dynamic Ethernet Service Activation with RADIUS etc.
2G/3G RAN Traditional Transport

- RAN traffic via TDM/SDH Network
- All bandwidth is “nailed-up”
- All scaling must be planned for provisioning
- Separate networks for RAN and Core
Evolution of Mobile Networks

- Circuit Switched Voice/Data
- T1 Access / CHOC Core
- Integrated CTL/Data Plane

- Packet Switched Data
- ATM-IMA acc./CHOC Core
- Integrated CTL/Data Plane

- All IP Core introduced (R4)
- Separation of Data/Ctl planes (R7)
- Ethernet Transport (R5)
- Radio Ctl pushed toward NodeB
- Direct Tunnel/Flat IP introduced

- CS Domain collapsed -> VoIP
- Ctl plane fully decoupled
- Direct NodeB Connectivity

Pre Rel-99 2G GSM
Rel-99 3G UMTS
Rel 4-7 3G UMTS
Rel 8+ LTE/SAE
NGN Mobile Transport over Carrier Ethernet

- 2G/3G Legacy T1
- Ethernet Node-B/LTE
- 2G/3G Legacy T1
- Cell Site Router
- Carrier Ethernet Aggregation
- Ethernet Access
- CSR Access
- SyncE/1588v2/ACR
- PWE3 Links
- Aggregation Node
- BSC
- RNC
- Distribution Node
Mobile RAN Transport

1. BTS, ATM NodeB
   - ATM VC, TDM (SATOP, CESoPSN)
   - E1 (w/IMA)
   - AToM Pseudowire
   - BSC ATM RNC

2. BTS, ATM NodeB
   - AToM Pseudowire
   - Optional S-PE, MS-PW
   - ATM or TDM
   - BSC ATM RNC

3. IP NodeB, eNodeB
   - Ethernet Pseudowire
   - MPLS/IP, MPLS VPN for LTE IP RAN and UMTS IP RAN
   - Ethernet
   - IP RNC, SAE

4. REP
   - Ethernet
   - Ethernet
   - Ethernet

5. IP (VRF lite)
   - MPLS/IP, MPLS VPN for LTE IP RAN and UMTS IP RAN
   - Ethernet
   - IP RNC, SAE

6. Efficient Access
   - Large Scale Aggregation
     - MLPPP over SDH/SONET
     - Coexistence with Model 2

Efficient Access
- MPLS/IP or Ethernet CSG 2941
- ATM or TDM or Ethernet NNI
- ATM, TDM, Ethernet Cell Site

Large Scale Aggregation
- MLPPP over SDH/SONET
- VPWS, VPLS, MPLS/IP
- SyncE, 1588 Phase

Mobile RAN Edge
- Aggregation Node
  - 7600, ASR9k, ME-3800X

Multiservice Core
- Core Node
  - ATM, TDM, Ethernet NNI
  - RNC or BSC or SAE

2G/3G Cell Site, SyncE, 1588
- MPLS/IPoDWDM

MPLS/IGP/BFD
- VPLS/HVPLS for UMTS
- ATM RNC

BTS, ATM NodeB
- ATM VC, TDM (SATOP, CESoPSN)
- E1 (w/IMA)
- AToM Pseudowire
- BSC ATM RNC
Mobile RAN Synchronization
Wholesale Services Transport Architecture

HSI Wholesale

HSI
N:1, 1:1 VLAN

EoMPLS PW

HSI SEN

PPPoE
L2TPv2

PPPoE/IPoE
MPLS VPN

Active Line Access

HSI, VoIP, VoD, IPTV

N:1 or 1:1 VLAN

IPTV

N:1 VLAN w/ Access Node MVR

HSI/VoD/VoIP

H-VPLS+IGMP Snooping over Physical Topology

Efficient Access Network

Aggregation Node
ASR9k, 7600, ME3800X

Service Aware or Transport VPWS, VPLS, MPLS/IP

Large Scale Aggregation Network

Distribution Node
ASR9k, 7600

Intelligent Services Edge
HSI SEN, ASR1k

Multiservice Core Network

Core Node

Video SEN, 7600

DSL, PON, Ethernet
802.1ad NNI, MPLS / IP Transport

PPP, IP, MPLS

MPLS

802.1ad NNI, MPLS / IP Transport

802.1Q

SP NNI

Ethernet UNI

Ethernet/MPLS NNI

Ethernet UNI

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High Availability
Baseline Network Availability Mechanism

• **Access Mechanisms**
  - Multiple Spanning Tree (MST) or MST Access Gateway
  - Resilient Ethernet Protocol (REP)
  - LACP, Multi-Chassis LACP
  - Inter Chassis Control Protocol (ICCP)

• **IP Services and MPLS IGP:**
  - IP Fast Convergence
  - BFD
  - Multicast Fast Convergence, MoFRR

• **MPLS Services:**
  - VPLS mac-address withdrawal; MST/REP and VPLS interworking
  - Pseudowire redundancy including pseudowire status bit support
  - MPLS TE-FRR Link and Node protection with IP services, PW/VPLS
  - PW tunnel selection

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**Efficient Access**
- Access Node
  - DSL, Ethernet

**Large Scale Aggregation**
- Aggregation Node
  - Cisco 7600 with ES+

**Intelligent Edge**
- Distribution Node
  - Cisco 7600 with ES+

**Multiservice Core**
- BNG
  - MPLS/IP
  - PP, IP, MPLS
  - MPLS
Tight SLA and The Simplicity Principle

Gain (measured in reduction of msecs)

Complexity
(always impact OPEX, may impact CAPEX)

The theoretical / academic optimum

The engineering optimum

Simplicity should be the guiding rule of all Tight SLA designs
Tight SLA Technology Options

• Service Recovery = Protection (super-fast) and Restoration (fast)

• IP/MPLS fast convergence baseline has improved dramatically
  IGP Fast Convergence (FC) broke the barrier of <200msec restoration time
  Powerful and simple baseline tool for all L2 and L3 services, covering multiple failures
  Combined with BGP PIC* ensures fast convergence for IP/IPVPN service edge
  It is simple – a built-in property of the IP/MPLS network

• Protection with IP Fast ReRoute (IP FRR)
  Tool to improve on IGP FC for some topologies (e.g. two-plane designs)
  Provides local protection with <50msec recovery

• Protection with MPLS TE FRR
  Local Link and Node Protection for deterministic <50msec recovery
  Seamless service restoration (make-before-break)
  Applies to all transit MPLS link and node failures
IGP Fast Convergence (IPFC)

- Enabled by IGP fast topology updates and distributed computation
  - Optimized SPF calculation
  - Optimized RIB and FIB calculation
  - Optimized FIB distribution to the forwarding plane (e.g. linecards)

- IGP FC always matters
  - BGP next-hop, IPTV PIM-SSM source availability, VOD services
  - MPLS pseudowires leverage IP FC
  - MPLS TE topology and resource information
  - Catastrophic events

- No impact on the network stability
- Works out of the box on Cisco devices
  - 200-500 ms convergence
- Years of experience with large SP networks deployments
- Operational simplicity is achieved!
Tight SLA for L3 Services

- Leverage IP/MPLS infrastructure tight-SLA technologies
  IGP Fast Convergence
  MPLS TE FRR
  IP FRR Loop Free Alternative (LFA)

- Optimize L3 PE forwarding plane for fast convergence
  BGP Prefix Independent Convergence
  IP Multicast PIM Fast Convergence
  Multicast only Fast ReRoute (MoFRR)
IP / optical integration enables the capability:

To identify degraded link using optical data (per-FEC BER)

Start protection (i.e. by signaling to the IGP) before traffic starts failing, achieving hitless protection in many cases
IPTV Service Delivery

• **Simplified Operations**
  IGMP/PIM only required, no snooping necessary in Aggregation network; snooping contained in DSLAM
  Single point of L3 termination for IP/TV (no VRRP required)
  No overlay topology

• **Optimal and Scalable Forwarding**
  SSM multicast distribution model for optimal tree creation under all conditions
  Dynamic load balancing on equal cost paths (!!)
  Optimized ARP and IGMP tables through distribution
  Flexible content injection, including localized content
  Same topology for unicast and multicast (!!)
  Scales in terms of network nodes and subscribers in any topology due to distributed L3
  Allows for on-path CAC

• **Resiliency**
  Consistent convergence in all failure cases: Source-, Node-, Link-Failure.
  Anycast-Source model for enhanced redundancy
  SSM security and address-space efficiency proven architecture in many 3Play production networks today

• **Future Ready**
  Possibility to add/distribute video monitoring and error concealment techniques easily
### Multicast Transport Options

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Native IP Multicast</th>
<th>P2MP MPLS TE</th>
<th>Multicast LDP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Convergence</strong></td>
<td>&lt; 1s (100ms)</td>
<td>~ 50ms</td>
<td>&lt; 1s (~ 50ms with TE FRR LP)</td>
</tr>
<tr>
<td></td>
<td>link and node failures</td>
<td>link failures only</td>
<td></td>
</tr>
<tr>
<td><strong>Offload Routing</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>IGP metric engineering</td>
<td></td>
<td>IGP metric engineering</td>
</tr>
<tr>
<td><strong>Path Separation</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>MoFRR or MTR</td>
<td></td>
<td>MoFRR or MTR</td>
</tr>
<tr>
<td><strong>CAC and BW Reservation</strong></td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>RSVP</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scalable MP2MP Multicast VPN</strong></td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Typical Application</strong></td>
<td>Secondary Distribution TV</td>
<td>Contribution TV</td>
<td>Enterprise VPN</td>
</tr>
</tbody>
</table>
Resilient Ethernet Protocol

- REP guarantees there is no connectivity between two edge ports on a segment
- A REP segment is a chain of ports connected to each other and configured with a segment ID
- When all interfaces in the segment are UP, the alternate port is blocking
- When a link or switch failure occurs on the segment, then blocked port goes forwarding
- Available on ME3400, 4500, 7600
REP Edge No Neighbor

- Enhancement to REP introduced in latest Ethernet Access Node releases
- Allows interconnection of REP segments with STP/VPLS domains
Pseudowire Redundancy

- T-LDP PW Status TLV:
  - 0x00000000 – PW forwarding (clear all failures)
  - 0x00000001 – PW Not Forwarding
  - 0x00000002 - Local AC (ingress) Receive Fault
  - 0x00000004 - Local AC (egress) Transmit Fault
  - 0x00000008 - Local PSN-facing PW (ingress) RX Fault
  - 0x00000010 - Local PSN-facing PW (egress) TX Fault
  - 0x00000020 - PW Forwarding Standby (NEW Status Bit)
  - 0x00000040 – Request SO to this PW (New Status Bit)*

- Two modes of operation
  - Independent Mode: Each side signals its separate state (forwarding/standby)
  - Master/Slave Mode: One Master imposes the PW state onto slaves

- Works across single segment and multisegment PWs
Aggregation Redundancy
Active/Active Aggregation Node Redundancy

- Natural” load balancing between BRASs
- Behavior can be influenced with PADI-delay
- Terminating two pseudowires into VFI/Bridge
- Learning can be disabled + Static mac-address entries + IGMP Snooping

Gateway for VoD/IP/TV

PPPoe Sessions

EoMPLS PW

VLAN 10

VLAN 10

PPPoE Sessions

Access  Aggregation  Distribution  BNG

20xGE  2x10GE  2x10GE  20xGE
Pseudowire Redundancy (Two-Way)

- Failures within MPLS network are protected by IP FC, IP FRR, MPLS FRR
- Failures of Ethernet Attachment Circuits or PE handled by two-way PW redundancy (Note: both sides of the PW are protected)
- Inter-Chassis Communication Protocol (ICCP) for synchronization of redundancy state control for LACP and PW redundancy

ICCP = Inter-Chassis Control Protocol
LACP = Link Aggregation Control Protocol
Aggregation Redundancy
Active/Backup Aggregation Node Redundancy (FlexLink)

Pseudowire connecting the Aggregation nodes

Aggregation Node VRRP/HSRP

Gateway for VoD/IP/TV

VLAN 10

EoMPLS PW

BNG

PPPoE Load Sharing

Access

Aggregation

Distribution

BNG

20xGE

2x10GE

2x10GE

20xGE

FlexLink
Quality of Service
Scalable Hierarchical QoS

- 4 layers H-QOS for MEF and TR-101 compliant SLA applications
- Ingress and egress H-QOS with hierarchical shaping
- Shared H-QoS policy applied across multiple EVCs – allows for bundled SLAs
- Dual Priority scheduling with priority propagation for minimum latency and jitter (Voice+Video)
- Flexible & granular classification: Full Layer 2, Full Layer 3/4 IPv4, IPv6 (even for L2 services)
CAC: RSVP over DiffServ

Aggregation Node Admission Control Functions
- RSVP receiver proxy configured on the N:1 VLAN SVIs or subinterface for Video Services.
- RSVP local policies used to allocate bandwidth pools per access node based on ACLs matching the access subnet and per Application ID used to differentiate different VoD content distributors.

Aggregation Network Admission Control Models
- Each Node in the Aggregation Network runs RSVP over DiffServ. VoD Bandwidth pools are assigned to each Aggregation Network Interface.
- VoD delivery and admission control path determined by IGP. RSVP fast local repair in case of failure. IGP based recovery for VoD streams.

1. STB HTTP GET(URL) requests VoD stream
2. RSVP PATH, VoD stream BW
3. RSVP PATH, VoD stream BW
4. RSVP RESV, VoD stream BW
5. RSVP RESV, VoD stream BW
6. HTTP 200 OK (Response to SETUP (URL))

Efficient Access
- Access Node
- DSL, PON, Ethernet

Large Scale Aggregation
- Aggregation Node
- MPLS or IP
- RSVP Receiver Proxy

VoD Servers and Middleware
- Distribution Node
- IP
- RSVP Node
- RSVP Node
CAC: RSVP Aggregation over MPLS TE

**Aggregation Node Admission Control Functions**
- RSVP receiver proxy configured on the N:1 VLAN SVIs or subinterface for Video Services.
- RSVP local policies used to allocate bandwidth pools per access node based on ACLs matching the access subnet and per Application ID used to differentiate different VoD content distributors.

**Aggregation Network Admission Control Models**
- MPLS TE Bandwidth Tunnel from Each Distribution Node to each Aggregation Node, configured with VOD allocated bandwidth for the specific Aggregation Node.
- Distribution Nodes implement RSVP Aggregation (from VoD servers) in the target MPLS TE bandwidth tunnel.

1. STB HTTP GET(2URL) requests VoD stream
2. RSVP PATH, VoD stream BW
3. RSVP PATH, VoD stream BW
4. RSVP RESV, VoD stream BW
5. RSVP RESV, VoD stream BW
6. HTTP 200 OK (Response to SETUP (2URL))

RSVP Aggregation CAC

**Efficient Access**
- DSL, PON, Ethernet

**Large Scale Aggregation**
- RSVP De-Aggregator and RSVP Receiver Proxy
- RSVP Aggregator
- RSVP Aggregator over MPLS TE tunnels: admits VOD request again the TE bandwidth

**VoD Servers and Middleware**
- RSVP Node
TV Broadcast CAC on the Access Node

**Multicast CAC Models**
- IP Multicast or VPLS IGMP snooping CAC options on the Access Node:
  - Single Mroute state limits
  - Multiple Mroute state limits
  - Cost factor Mroute state limits

**Single 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

**Multiple Mroute state limits**
- 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

**Cost factor Mroute state limits**
- Enables bandwidth CAC control per TV bundles or content providers
- Enables global bandwidth CAC control per stream types

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**Diagram:**
- Access UNI
- Multicast VPN/PIM
- Access UNI
- VPLS
- IGMP snooping
- Efficient Access Network
- Aggregation Node
- Large Scale Aggregation Network
- Service or Transport VPWS, VPLS, MPLS/IP
- Intelligent Services Edge
- Video SEN
- Business SEN
- Core Node
- HSI SEN
- Large Scale Aggregation Network
- Service or Transport VPWS, VPLS, MPLS/IP
- Intelligent Services Edge
- Video SEN
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**Networks and Protocols:**
- DSL, PON, Ethernet, 2G/3G
- 802.1ad NNI, MPLS/IP Transport
- PPP, IP, MPLS
- MPLS

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SLA Monitoring
Ethernet OAM Standards and Building Blocks
Experience Provider Benefits
- Rapidly isolate and troubleshoot network fault-domains
- Ability to offer premium SLAs to residential and business customers
  - Reduces customer churn

Customer Experience
- Improved video experience
- Reduced out-of-service times
Carrier Class Manageability
Active Network Abstraction At-A-Glance

Foundation
- Abstract VNE model and mediation layer
- Distributed scale, carrier class, HA
- Telnet, web service and SNMP APIs
- SDK and developer support
- Sun/Solaris server; Windows client
- Customizable, configurable
- NB Event, Alarm & Ticket notifications
- Solution integrations with provisioning, inventory and performance systems

Element Management
- NE and topology auto-discovery
- NE Physical & Logical Inventory
- Network Topology
- Event, alarm and user-TCA management
- Configuration support (script builder)
- 200+ built-in configuration scripts
- NE configuration archiving
- NE Image management
- Security: authentication, RBAC
- 50+ device families, 300+ NE-types

Network and Service Management
- MPLS, CE, IPRAN/MToP support
- Service discovery, network & service maps
- Service fault management & troubleshooting
- Graphical fault visualization
- Complete CE and MToP service activation
- Activation “Point & Click” GUI or via NB API
- Topology-based root cause
- Service impact analysis
- Graphical workflow builder

Deployed at top service providers in the Americas, Europe, Australia and Asia
IP NGN Summary

- IP Expertise
- Industry Leading Converged Architecture
- Integrated and Consistent Service Delivery
- Carrier Class Reliability

- Unprecedented Scale for IP Video and Mobility
- End-to-End High Availability
- Increased Agility to Monetize Services
- Network Availability SLAs
Thank you.