Carrier Ethernet – A Wave is Building
Provider Backbone Bridges with Traffic Engineering (PBB-TE)

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Next Generation Packet Metro

**Requirements:**
- Lower Cost per Mbps
- Reduced CAPEX
- Reduced OPEX & Simplified OAM
- Higher Service
- Scalability & Flexibility
- Traffic Engineering
- Resource Reservation
- Dynamic Provisioning
- Differentiated Services
- Network Resiliency

Ethernet Interface is the obvious choice – CAPEX / OPEX

**Existing Ethernet Challenges:**

<table>
<thead>
<tr>
<th>Challenge</th>
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<tr>
<td>Overlapping addresses; Secure separation &amp; demarcation of customers &amp; provider</td>
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<tr>
<td>Service Scalability</td>
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<td>OAM equivalent or better than current provider OSS systems</td>
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<tr>
<td>Traffic Engineering &amp; QoS</td>
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<td>Carrier-grade resiliency with bandwidth efficiency</td>
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Today’s New Alternative

What if I told you QoS, Resiliency, Traffic Engineering and OAM were achievable without:

- Adding MPLS control plane
- Changing Ethernet hardware
- Building a new network

…Interested? … Nortel’s Metro Ethernet
Nortel’s Metro Ethernet Solution:
*Building Carrier Grade Ethernet*

- Ethernet Tunneling
- Deterministic Service Delivery
- QoS & Traffic Engineering
- Resiliency & Restoration

- Connectivity / Service Checks
- ITU Y.1731 Performance Metrics
- Complete Fault Management
- 802.1ag

- 802.1ah (MinM) / PWE3 Encap
- Secure Customer Separation
- Service/Tunnel Hierarchy
- Reduced Network State

Analysis of real Metro deployment models shows 40-80% savings using Ethernet vs. MPLS
Why is Nortel pursuing Ethernet

> It is rapidly becoming the link layer of choice...everywhere!
  • Far faster than we would have predicted

> Ethernet has fundamental advantages over other L1/2/3 technologies
  • Ethernet was built 30 years ago to do efficient any-to-any connectivity
    • Modifying it to do point-to-point or point-to-mp is actually subtractive

> AND ... it can be made to address carrier concerns:
  • Cost points, scalability and familiarity already built in
  • Simple and standards based solutions to meet all requirements for next generation services

Ethernet is rapidly becoming THE most complete and scalable carrier networking technology
MPLS Dissected: 2 separate layers

> MPLS provides a Service Layer
  • *Revenue generating*
  • L3 VPNS (2547), L2 VPNs (PWs, VPLS)

> MPLS also provides a Tunnel layer
  • Provides networking functionality
  • Adds significant cost to your equipment and operational complexity
  • *Can we eliminate this layer of cost? Yes!*
Extending Ethernet to de-layer your network

- Replace the MPLS Tunnel layer with an Ethernet Tunnel layer
- Extend the Ethernet capabilities to provide MPLS equivalent functionality
- We get the best of Ethernet with the best of MPLS
  - Simplicity and familiarity of Ethernet
  - Real OAM – CC, PING, TRACE, FAULT: 802.1ag
  - Common Service Layer – eliminate service gateways
  - Leverage lowest cost Ethernet forwarding components
Provider Backbone Bridge Introduction

- IEEE 802.1ah is the Provider Backbone Bridge standard under development
- Also known as Mac In Mac (MiM) encapsulation
  - Driven by Nortel and Cisco
  - Recent support by several other vendors
- PBB solves several of today’s Ethernet challenges....
PBB: Solving Current Ethernet Challenges

> Provides an ELAN, ELINE, and ETREE service

> Service Scalability
  • Up to 16 million service identifiers

> Customer Segregation
  • Clear demarcation between customer and provider domains

> Service Provisioning only at edge of the network

> Eliminates MAC explosions
  • Increased security

> Backwards compatibility built in
  • Created to inter-work with existing Ethernet technologies
> P2P traffic engineered trunks based on existing Ethernet forwarding principles
  • Reuses existing Ethernet forwarding plane

> Simple L2 networking technology
  • Tunnels can be engineered for diversity, resiliency or load spreading
  • 50 ms recovery with fast 802.1ag CFM OAM
Ethernet Becomes Connection Oriented

> Place under a Comprehensive Management system and introduce northbound auto-discovery within the network itself

> Management sets up connections, populating switch bridging tables:
  • The VLAN tag is no longer a network global: scaling issues are removed;
  • VLAN tags now used to set up per destination alternate paths
  • A range of VLANs can be used for bridging and another range for PBT

Routing Topology Sees this:

Routing sees links in its protocol. But with PBT a failure will be recovered from faster than the protocol can detect so no failure is seen to the IP and application layer.
PBB-TE: Solving Current Ethernet Challenges

- Service Scalability: 2-60\textsuperscript{th} tunnel scalability
- Customer Segregation: Full segregation in P2P model
- Traffic engineering: End to End TE with QoS, With 50 ms recovery
- Spanning Tree challenges:
  - Stranded bandwidth
  - Poor convergence
  - Disable STP, No blocked links, fast .1ag OAM for convergence
- MAC explosions: Eliminates MAC Explosions
- Security: Customer BPDUs are transparently switched
Carrier Ethernet Switching (PBB-TE)
CAPEX Advantages

3 independent studies show Ethernet (PBB/PBT) to be less expensive than MPLS

• Nortel: Analyzed actual metro deployment for Tier 1 SP and an MSO comparing MPLS/VPLS to PBB/PBT based on list price.
  RESULT: 40%-80% savings depending on vendor and specific network modeling

• Siemens: Analyzed generic residential service offering
  RESULT: Positive ROI in 14 months for $12M invested in metro deployment compared with 24 months for MPLS
  
  Siemens Laurent Levy presentation at MPLS World Congress Feb ’07

• Light Reading: PBT and the Future of Carrier Ethernet Services
  “PBT could enable carriers to reduce the cost of metro transport networks by replacing IP/MPLS with lower cost Ethernet”
Carrier Ethernet Switching (PBB-TE)
OPEX Advantages

> PBB-TE fits the current operations model in the metro
  • Ethernet switching and SONET / SDH skill sets map very closely to PBB-TE
  • Current Metro Operators can be transitioned easily to PBB / PBT
  • You don’t need to pay for a CCIE to run a PBB/PBT network

> Simpler to setup and maintain
  • Carrier Ethernet eliminates a complete network layer (the MPLS shim) relative to MPLS / VPLS
  • Fewer moving parts - less to setup or have something go wrong
    • No IGP (OSPF, IS-IS, EIGRP)
    • No Tunnel Label Signaling (RSVP-TE, LDP-DU)
    • No Service Label Signaling (E-LDP, BGP)
    • No requirement to string PWE3 together to build a service (VPLS)

> Easier to Troubleshoot
  • Better, more feature rich tools. 802.1ah, Y.1731 vs. LSP-PING, VCCV, BFD
  • The PBB-TE packets self-describe. You always know where it came from and where it’s going from the trace.
Ethernet OAM across Metro Ethernet Networks

- Customer Domain
- Provider Domain
- Operator Domain

Maintenance End Point
Maintenance Intermediate Point
IEEE 802.1ag - OAM Functionality

- **Continuity Check (CC)**
  - Multicast/unidirectional heartbeat
  - Usage: Fault detection
- **Loopback – Connectivity Check**
  - Unicast bi-directional request/response
  - Usage: Fault verification
  - MPLS has LSP ping – but its implemented in control plane
- **Traceroute (i.e., Link trace)**
  - Trace nodes in path to a specified target node
  - Usage: Fault Isolation
  - Traceroute is not available for MPLS PWs over MPLS tunnels
- **Alarm Indication Signal (AIS): Under discussion in .1ag**
  - Propagate data path fault notifications
  - Usage: Alarm suppression
- **Discovery** (not specifically supported by .1ag however Y.17ethoam supports it)
  - Service (e.g. discover all PEs supporting common service instance)
  - Network (e.g. discover all devices (PE and P) common to a domain)
- **Performance Monitoring** (not specifically supported by .1ag however Y.17ethoam supports it)
  - Frame Delay
  - Frame Delay Variation
  - Frame Loss

Items in **GREEN** are not available in MPLS OAM
Ethernet SLA Management Features
Items in GREEN not available in MPLS OAM

> **Performance of Service**
> - **Frame Loss Ratio (FLR)** parameter is the number of service frames marked green on a per {VID, P, CoS} basis that are delivered by the Provider network versus the total sent.
> - **Frame Delay (FD)** Measurement of round trip frame delay by utilizing the OAM frames as defined in 802.1ag
> - **Frame Delay Variation (FDV-Jitter)** Measurement of delay using time stamps of consecutive OAM frames.

> **Availability of Service**
> - **AoS** is currently defined in Y.17ethoam as the amount of time that the PoS (i.e., FLR, FD, FDV for a given service) is satisfied versus the overall period of time in service.

**Utilization of Service**
- **UOS** is a proposed parameter derived from the OUTOCTETS count on a per {VID, P, CoS} basis. The counter is read periodically (e.g., every second) and binned to some intermediate value (e.g., 1 minute), when an average utilization metric can be calculated
- Usage: Tracks bandwidth usage over time, fault detection,
G.8031 (Ethernet Protection Switching)

ITU SG15/Q9

> Dataplane coordination of Protection Switching

> Designed for physical links, equally applicable to PBB-TE trunks

> Synchronizes Protection Switching state at both ends of a path
  • PS type (1+1, 1:1, m:n etc.)
  • 50ms
  • Administrative state (what is working, manual switch etc.)
  • Administrative control (force switch, revertive/non-revertive etc.)

> Primary utility for maintenance operations…
Compared to MPLS OAM?

> MPLS OAM Challenges
  • The packet label + the signaled FEC tells you the tunnel
    • You can’t look at a trace and know where a packet came from or where it’s going
    • OAM tools must engage control resources to perform basic forwarding plane OAM functions
  • These problems are compounded by:
    • Penultimate Hop Popping
    • ECMP

> 802.1ag has built in levels of hierarchy to allow independent management over different parts of the network.

> 802.1ag has a clear addressing scheme unlike MPLS LSP OAM.

> 802.1ag does not require “helper” from higher layers to perform the OAM functions unlike MPLS LSP OAM.
Maximizing your existing Ethernet H/W

> Many Ethernet switches are “Independent VLAN Learning” (IVL)
  • IVL switches do a full 60 bit lookup (VLAN/DA tuple)

> PBB-TE changes the semantics of a VLAN/DA tuple without changing the hardware:
  • To identify a PBB-TE trunk
    • Connection id is the 12 bit VLAN ID and 96 bit source/destination MACs
  • For forwarding
    • 60 bit VLAN ID and destination address

Same forwarding plane = no new h/w costs
PBB-TE Forwarding - simple and scalable.

> PBB-TE tackles the challenges of today’s Ethernet
  > P2P forwarding eliminates the need to flood MAC addresses
  > No need for conventional loop avoidance mechanisms
  > Turn off Spanning Tree Protocols
  > Select paths based on constraints important to the services and the network
  > The Destination MAC is based on a Provider MAC address
  > No customer MAC learning
  > Eliminates MAC explosions

> Scalability
  > Forwards on a 60 bit address (VLAN+Destination MAC)
  > Only the combination of VID and MAC needs to be unique
  > Supports $2^{60}$ connections

> We are still just forwarding Ethernet frames!
In Summary: PBB-TE Key Principles

> Ethernet based point-to-point trunking technology
  • Adds deterministic, connection oriented behavior to Ethernet

> Flexible
  • Can be configured via a management system or dynamically signaled

> Efficient
  • Reuses the existing ethernet forwarding plane
  • No changes to Ethernet hardware
  • Lowest encapsulation overhead

> Robust
  • Leverages existing ethernet OAM standards (IEEE 802.1ag)
  • Leverages Ethernet protection switching (ITU SG15/Q9 g.8031)

> Deployable
  • Initially targeted for metropolitan ethernet networks,
  • Supports MPLS and ethernet services natively and can seamlessly interwork with MPLS tunnels in the WAN
Enterprise Requirements and Challenges

**who is responsible for what?**

<table>
<thead>
<tr>
<th>Head-office Campus</th>
<th>Service Provider 1</th>
<th>Service Provider 2</th>
<th>Service Provider 3</th>
<th>Branch Site Production Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Control</td>
<td>Service Provider Control</td>
<td>Enterprise Control</td>
<td></td>
<td></td>
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</tbody>
</table>

> Enterprises is responsible for the service up to the network demarc
  - No good end to end view is possible
  - Failures in the Service Provider network are seldom reported to the Enterprise

> Service Provider asks you to trust that the network is reliable
  - its the SP who is responsible for protecting your service
  - Is that enough?

Can we change the relationship and dependencies?
PBB-TE
An Enterprise perspective

> Move the intelligence from the SP edge, to the Enterprise edge with PBB-TE

> PBB-TE enables the enterprise to control end-to-end resiliency
  • 50ms protection switching
  • Regardless of SP technology or current capabilities

> Enterprise can negotiate the cheapest point to point service (e.g. vlan, leased line) from any service provider
  • Transport and technology agnostic decision

> Service Provider offers
  • Basic service
  • Bandwidth guarantees only

Protection from any failure

End to end PBT trunks
Riding an Ethernet Wave
leverage the best of Ethernet!

> Ethernet performance monitoring built in with ITU Y.1731
  • Trunk delay, delay variation, availability

> Proactively monitor your trunks and your SLAs
PBB/PBT/OAM Quick Standards Update

> Standards:
  - IEEE 802.1ah (PBB) expected to be ratified in 2Q07
    - Cisco is co-editor
  - PBB-TE (aka PBT) expecting IEEE PAR status in March
    - Unanimous vote of 33-0-3 to progress work
  - IEEE 802.1ag – sponsor ballot, expect ratification in 2Q07
  - ITU Y.1731 – ratified

> MEF Certification Update
  - MEF 9 (UNI Services) – MES8600, ESU 1800/1850, April 3, 2006
  - MEF 14 (Traffic Management) – MERS8600, ESU 1800/1850, Dec 18 2006
> BUSINESS MADE SIMPLE

THANK YOU