Provider Backbone Bridges with Traffic Engineering (PBB-TE) aka PBT

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Next Gen Ethernet Wish List

Ethernet as used today is lowest cost but has several challenges:

- MAC explosions
- Service Scalability
- Customer Segregation
- Traffic engineering
- Spanning Tree challenges:
  - Stranded bandwidth
  - Poor convergence
- Security

Cost per Mbps
CAPEX
OPEX
Traffic Engineering
Resource Reservation
Dynamic Provisioning
OAM
Service Scalability
Differentiated Services
Network Resiliency
Service Flexibility
Today’s Alternatives for Carrier Ethernet

- Ethernet Challenges
  - Solve the problem by extending native Ethernet?
  - Solve the problem by adding MPLS?

Wait….

> Can a hybrid of MPLS and Ethernet capabilities produce a cost effective infrastructure?

…..YES!
MPLS Dissected: 2 separate layers

1. MPLS provides a Service Layer
   - *Revenue generating*
   - L3 VPNS (2547), L2 VPNs (PWs, VPLS)

2. 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
> 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
  • Tunnels are service agnostic
PBB-TE (Provider Backbone Transport-PBT)

- Keep your existing ethernet services.
- Keep your existing MPLS services.
- Lose your MPLS control plane costs.
- Delayer and simplify your infrastructure.
PBB-TE provides ...

Connection Oriented features
  • traffic engineering
  • Resiliency
  • QoS

> Comprehensive OAM
  • Robust toolset for monitoring and debugging

> Seamless interworking with the WAN

> Solutions to QinQ Shortcomings
  • MAC Explosions, Service Scalability etc…

...at Ethernet costs!

> Reuse existing (deployed) ethernet technology

> Eliminate flooding and spanning tree

> Fraction of the cost of MPLS enabled switches (CAPEX)

> No learning curve for your Metro operators (OPEX)
Configured PBB-TE Tunnels Concept

Configured TE Tunnels

Service and Network Management

Traffic Engineered PBB-TE Trunk
GMPLS Signaled PBB-TE Trunks

Add dynamic signaling as required. Low cost ETH devices (MTU, DSLAMs) may migrate at a slower pace. GMPLS already built in some Optical devices.

Easy migration to dynamic signaling when you are ready.
QoS and Resiliency

> PW bandwidth can be reserved from the tunnel at each end point
  • Similar to PWs today in RSVP tunnels

> Ethernet VLAN “p” bits can effectively emulate a MPLS E-LSP
  • One tunnel can provide per packet CoS
  • Can also support per packet pre-emption for resiliency

> Backup Trunks can be pre-provisioned for redundancy
  • Ethernet OAM provide fault notification in millisecond time frames
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PBB-TE OAM Key Principles

> PBB-TE reuses all the Ethernet OAM initiatives in IEEE & ITU
  • Fault detection and notification (IEEE 802.1ag)
    • OAM hierarchy (IEEE 802.1ag)
  • Service Monitoring and performance (ITU Y.17ethoam)
  • Resiliency and Protection switching (ITU G.8031)
  • Link layer discovery (IEEE 802.1ab)

> Each PBB-TE packet is self identifying
  • Ideal for in band OAM, traces and flow monitoring
    • Where did it originated from (SA MAC)
    • Where is it going (DA MAC)
    • Which maintenance level is it
    • What action/functionality does this frame represent.
  • No need to involve an unnecessary control plane
    • MPLS OAM relies on control plane
      • Determinism? Scalability?
Ethernet OAM across Metro Ethernet Networks

Customer Domain

Service Provider Domain

Operator Domain

Access Metro Core Access

Maintenance End Point

Maintenance Intermediate Point
IEEE 802.1ag - OAM Functionality

1. Continuity Check (CC)
   a) Multicast/unidirectional heartbeat
   b) Usage: Fault detection

2. Loopback – Connectivity Check
   a) Unicast bi-directional request/response
   b) Usage: Fault verification
   c) MPLS has LSP ping – but it’s implemented in control plane

3. Traceroute (i.e., Link trace)
   a) Trace nodes in path to a specified target node
   b) Usage: Fault isolation
   c) Traceroute is not available for MPLS PWs over MPLS tunnels

4. Alarm Indication Signal (AIS): Under discussion in .1ag
   a) Propagate data path fault notifications
   b) Usage: Alarm suppression

5. Discovery (not specifically supported by .1ag however Y.17ethoam supports it)
   a) Service (e.g. discover all PEs supporting common service instance)
   b) Network (e.g. discover all devices (PE and P) common to a domain)

6. Performance Monitoring (not specifically supported by .1ag however Y.17ethoam supports it)
   a) Frame Delay
   b) Frame Delay Variation
   c) Frame Loss
 Ethernet SLA Management Features

Items in **GREEN** not available in MPLS OAM

1. **Performance of Service**
   a) **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.
   b) **Frame Delay (FD)** Measurement of round trip frame delay by utilizing the OAM frames as defined in 802.1ag
   c) **Frame Delay Variation (FDV-Jitter)** Measurement of delay using time stamps of consecutive OAM frames.

2. **Availability of Service**
   a) **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.

3. **Utilization of Service**
   a) **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
   b) **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 build 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.
**PBB-TE provides ...**

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  - QoS

> Comprehensive OAM
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> Seamless interworking to the WAN

> Solutions to QinQ Shortcomings
  - MAC Explosions, Service Scalability etc…

**...at Ethernet costs!**

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PBB-TE to MPLS Interoperability
MS-PW example

Ethernet Metro

PBB-TE Tunnel
MPLS Tunnel
Virtual Forwarder

MPLS WAN

MPLS LDP or RSVP
End-to-end PW

Ethernet Metro

ATM, FR

Ethernet

VF

VF

VF

VF

VF

PBT

VF

VF

PBT

MPLS

VF

VF

VF

VF

FR/ATM Multi Segment PW

ATM, FR
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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
<table>
<thead>
<tr>
<th>Ethernet challenges</th>
<th>PBB-TE Solutions</th>
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</thead>
<tbody>
<tr>
<td>MAC table explosions</td>
<td>Forwards on Provider Mac addresses. Solves MAC explosion issues.</td>
</tr>
<tr>
<td>Service Scalability</td>
<td>VLAN+Destination MAC FIB entries provides $2^{60}$ connections.</td>
</tr>
<tr>
<td>Traffic engineering</td>
<td>Provides deterministic path selection</td>
</tr>
<tr>
<td>Spanning Tree Challenges</td>
<td>No spanning tree required. Complete route freedom for PBB-TE trunks.</td>
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<tr>
<td>- stranded bandwidth</td>
<td></td>
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<td>- poor performance</td>
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<td>Security</td>
<td>Customer transparency. Provider is unaware of customer control plane packets.</td>
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Nortel Carrier Ethernet

Carrier Grade Ethernet

PBB-TE
- Ethernet Virtual Trunks
- Traffic Determinism
- Path Engineering
- Eliminate Flooding
- Path Protection
- Path Restoration

802.1ag OAM
- Y.1730 PM
  - Comprehensive OAM
    - Fault Propagation
    - Ethernet PING
    - Trace Route
    - Connectivity Check
  - Performance Metrics
    - Delay, Jitter
    - Service or Tunnel

802.1ah (MiM) / PWE3
- Massive Service Scalability
- Customer Demarcation
- Reduce Network State
- Service/Tunnel Hierarchy

Predictable, Scalable and Manageable Ethernet Networks