Backbone Provider Bridging Networks
A Highly Scalable VLAN (Multicast) Architecture

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A Provider Bridge Scaling Solution
“Backbone Provider Bridging”

802.1ad Interfaces

Backbone Provider Bridge Network

Provider Bridge Network

PBN

Provider Bridge Network
Ethernet Service Types
MEF Ethernet Virtual Connections (EVCs)

E-LINE
Router Mesh
Pt-Pt, Like Duplex Ethernet
Any-to-any

E-TREE
Hub & Spoke
Pt-MPt, Like EPON Ethernet,
Root-to-Leaf and Leaf-to-Root

E-LAN
Multi-Site
MPt, Like VLAN,
Any-to-any
E-LINE Dominates Today

• E-LINE is a natural leased line replacement for subscribers
  – Ethernet leased lines offer high bandwidth
  – Lines provide bandwidth on demand
  – Interfaces are compatible with off the shelf Ethernet switches/routers
  – Best for router mesh

• E-LINE provides natural migration for carriers
  – Consistent with current operations model
  – Allows carrier equipment reductions
  – Bill models can follow well understood FR services
  – Current QoS models allow both traffic control and service monitoring of E-LINE service offerings
  – Service OAM models for E-LINE are relatively straightforward

• Each E-LINE service instance requires 1 S-VLAN
E-TREE Ideal For ISP Connect

• E-TREE Future Service With Great Promis
  – Useful as a multiplexed connection to an application service provider like an ISP
  – Service is unlike traditional Ethernet since leaf nodes can not talk with each other

• E-TREE has deployment issues
  – No clear billing model
    • For instance if one leaf is disconnected is the circuit down?
    • What is the distance of the tree?
  – OAM management not fully understood
  – QoS model non-existant, SLAs can only provide Best Effort
E-TREE S-VLAN Mapping

- Each E-TREE service instance requires 2 S-VLANs
- Both S-VLANs comprising an E-TREE S-VLANs are unidirectional
- The S-VLANs of and E-TREE service instance are typically on the multiplexed on the same port
Some Carriers Will Use E-LINE in Hub and Spoke Arrangement

- Hub port would usually be multiplexed to allow the multiple Pt-Pt attachments.
- Each E-LINE is a separate managed S-VLAN
- This arrangement allows use of E-LINE management, billing, and QoS
- Many more S-VLANs are required
E-LAN Many Future Applications

• E-LAN is deployed for broad connectivity in select network
  – Interconnect of multiple corporate sites
  – Multi-player gaming
  – Ubiquitous any-to-any connectivity
  – E-LAN has many future applications

• E-LAN has deployment issues
  – Deployments are very spotty
  – Unclear billing model
    • How is availability defined?
    • No definitions for QoS or performance measurement
    • What is the distance of an E-LAN
  – Unclear management models
  – Unlike existing carrier service offerings

• Each E-LAN service instance is a single S-VLAN
Prototypical Major Metro Area

- Business Subscriber Population 100K-2M
  - San Jose Yellow Pages ~100K businesses
  - The SF Bay Area lists ~1M businesses
- Large Business Sites 500-5,000
- Residential Subscriber Population 1M-20M
- Leased Line Density 10K-200K
  - Roughly 1/10 Yellow Page Listings
- Application Service Provider Sites 100-2000
  - Large APSPs sites may service residential
## Major MSA Networks

<table>
<thead>
<tr>
<th>Typical SP</th>
<th>Access</th>
<th>Business CLE</th>
<th>Small Office</th>
<th>Medium Office</th>
<th>Large Office</th>
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</thead>
<tbody>
<tr>
<td>Network Scale</td>
<td>&gt;10,000 Remotes</td>
<td>&gt;10,000 CLEs</td>
<td>&gt;500 COs</td>
<td>100-200 COs</td>
<td>10-60 COs</td>
</tr>
<tr>
<td>Metro Scale</td>
<td>&gt;4,000 Remotes</td>
<td>&gt;1,000 CLEs</td>
<td>&gt;50 COs</td>
<td>&gt;20 COs</td>
<td>&gt;4 COs</td>
</tr>
</tbody>
</table>

### Typical Metropolitan Serving Area – MSA

- MSA example shown
- ASIA/PAC more CO/MSA
- Europe less CO/MSA
Support 1,000,000 Service Instances

• Must be able to support E-LINE service for leased line replacement for entire MSA
  – This is the way Ethernet is entering the markets
  – The objective is 200K E-LINE instances
• Must support E-LINE for APSP to Subscribers
  – Not all service providers will allow E-TREE because of deployment problems
  – The objective of an additional 200K E-LINE is adequate for transition until E-TREE
  – Requirements for around 10K E-TREE instances
  – Requires 20K S-VLANs
• Must support E-LAN for APSP and B-B
  – Advanced peer applications
  – Number of service instances speculative, however could be large
• Totals
  – 200K E-LINE S-VLANs for leased line replacement
  – 200K E-LINE S-VLANs for APSP
  – 20K E-TREE S-VLANs
  – ? E-LAN Service Instances
• Designing Into A Corner Will Not Instill Confidence In Future
  – Set Objectives to at least 1,000,000 service instances E-LINE, E-TREE, E-LAN
  – E-LAN service will eventually become important for coupling small groups
  – Allow E-TREE and E-LAN service scaling to at least 100,000 for future growth
Large Service Address Space Needed

• Carriers need to separate the service address space to allow administration of networks
  – Allocation address blocks to offices
  – Merging network elements

• The address space usually needs to be 10-100 times larger than the number of services supported

• Should have an address space around $2^{24}$
New Project for Backbone Provider Bridge

802.1ad Interfaces

Backbone Provider Bridge Network

Provider Bridge Network

PBN

Provider Bridge Network
Possible Directions
Backbone Provider Bridge Model

Provider Bridge Relays

Backbone Bridge Relays

Backbone Bridge Interfaces

Provider Bridge Interfaces
Backbone Provider Bridge Network

- **PB**: Provider Bridge (as defined by 802.1ad)
- **BB PB**: Backbone Provider Bridge Edge
- **BB**: Backbone Provider Bridge
Backbone Provider Bridging Principles

- BBN encapsulates PBN frame with BBN header
- BBN header consists of
  a) Service Instance identifier
     - Identifies the BBN service instance of the PBN flow
     - Requires $2^{20}$ bits to identify 1M services
  b) Site Connectivity identifier
     - Identifies a B-VLAN (or tunnel) that is used to transport the BBN service instance
     - Site connectivity (i.e., tunnel/domain) can be point-to-point or multi-point in nature
  c) Backbone POP Address
     Addresses POP within Site Connectivity
- PBN service instances (S-VLANs) map to BBN service instances
  - PBN service instances are local to the PBN
  - BBN service instances are local to the BBN
Terminology

• IEEE 802.1ad Terminology
  – C-TAG  Customer VLAN TAG
  – C-VLAN  Customer VLAN
  – C-VID  Customer VLAN ID
  – S-TAG  Service VLAN TAG
  – S-VLAN  Service VLAN
  – S-VID  Service VLAN ID

• Additional Backbone Provider Bridge Terminology
  – ES-VID  Extended Service VLAN ID
  – B-VLAN  Backbone VLAN (tunnel)
  – B-VID  Backbone VLAN ID (tunnel)
  – B-MCB  Backbone Multicast Domain
  – B-TAG  Backbone TAG Field
  – B-MAC  Backbone MAC Address
BBN Provides Multi-Point B-VLANs Between PBNs

- Each B-VLAN carries many S-VLANs
- S-VLANs may be carried on a subset of a B-VLAN (i.e. all P-P S-VLANs could be carried on a single MP B-VLAN providing connection to all end points.)

- **BB PB**: Backbone Provider Bridge Edge
Backbone Frame Format

PB Frame Format

- MAC DA
- MAC SA
- Provider
- S-TAG
- C-tag
- Payload
- FCS

BBN Frame Format

- B-MAC DA
- B-MAC SA
- B-TAG

BBN Frame Header

- MAC DA
- MAC SA
- S-TAG
- Payload
- BBN FCS

Provider S-TAG
Basic Backbone Forwarding
Basic Back Backbone Operation

• Frames from PBN are encapsuled with BBN header
  – S-VID maps from/to provisioned ES-VID
  – DA B-MAC from provisioned ES-VID table
• Forwarding through BBN may occur as in 802.1D Bridge
• At destination BBN header is de-encapsuled
But E-LAN/E-TREE Are Flooded

- These are filtered at BB POP based on ES-VID lookup, but still
- Add to the basic picture the B-VID tunnel
  - This tunnel may have many service instances multiplexed since the ES-VID separates the service instances
- Change mapping for E-LAN and E-LINE to use a B-VID (for a B-VLAN) with the correct backbone connectivity
- Solution allows E-LINE scaling to Millions, but E-LAN and E-TREE are limited to 4K instances
- Not bad, but we could go further
Multicast Relay Scaling
Backbone Provider Bridging

802.1ad Interfaces

Backbone Provider Bridge Network (BBN)

Provider Bridge Network

PBN

Provider Bridge Network
Terminology

• IEEE 802.1ad Terminology
  – C-TAG       Customer VLAN TAG
  – C-VLAN      Customer VLAN
  – C-VID       Customer VLAN ID
  – S-TAG       Service VLAN TAG
  – S-VLAN      Service VLAN
  – S-VID       Service VLAN ID

• Additional Backbone Provider Bridge Terminology
  – ES-VID      Extended Service VLAN ID
  – B-VLAN      Backbone VLAN (tunnel)
  – B-VID       Backbone VLAN ID (tunnel)
  – B-MCD       Backbone Multicast Domain
  – B-TAG       Backbone TAG Field
  – B-MAC       Backbone MAC Address
A Simple Backbone Provider Bridge Network

- **PB**: Provider Bridge (as defined by 802.1ad)
- **BB PB**: Backbone Provider Bridge Edge
- **BB**: Backbone Provider Bridge
Simple BBN Principles

- BB PB edge encapsulates received PBN frames with BBN header
- BBN header includes
  - **Extended Service VLAN Identifier (ES-VID)**
    - Identifies the S-VLAN associated with the PBN S-VIDs on the BBN
    - Must be large enough to support millions of S-VLANs
  - **Backbone VLAN Identifier (B-VID)**
    - Identifies a backbone VLAN (B-VLAN or tunnel) that is used to transport the S-VLANs over the BBN
    - A B-VLAN(tunnel) can be point-to-point or multi-point in nature
    - The B-VID must have a large enough address space to support all available multi-point tunnels among BB bridges
  - **Backbone POP Address**
    - Addresses POP within Site Connectivity
Use Hierarchical Architecture to Scale BBN size

- Support of B-VLANs (i.e., multicast) with large number of bridges is challenging
  - frame replicators to large number of points limit performance
- Hierarchy of BB bridges creates small multicast domains
  - each domain has a small number of bridges, which limits number of multi-point tunnels and number of replications
A Two Layer Hierarchical BBN

- **PB**: Provider Bridge (as defined by 802.1ad)
- **BB PB**: Backbone Provider Bridge Edge
- **BB**: Backbone Provider Bridge
- **BB BB**: Backbone Provider Bridge Layer Edge
Hierarchical BBN Principles

• **BB PB edge**
  – Encapsulates received PBN frame with BBN header
    • swaps S-VID to/from a much large ES-VID
    • Creates a B-VID from the ES-VID
  – De-encapsulates frames to be transmitted to the PBN by stripping the BBN header
    • Swaps the ES-VID to a S-VID for the PBN
    • Removes the final B-VID
  – Both S-VID and ES-VID identify the S-VLAN carried through the PBNs and BBN

• **BB BB layer edge bridge**
  – swaps the B-VID to a new B-VID based on the ES-VID
    • The new B-VID allow transport over the current BBN multicast domain (MC-DOM)
  – source route addressing (with Backbone Connectivity identifier stacking) can also be used to avoid the need for table lookups and B-VID swapping at layer boundaries
  – The ES-VID is the same throughout the BBN
  – The ES-VID is swapped with the S-VID at the BB-PB edge
  – B-VID must be large enough to address all possible multi-point tunnels within a given layer domain (e.g., 12 bits is enough to support 12 BB bridges in a layer. More bits are required for more bridges).

• **Scalability**
  – Hierarchical BBN can have as many layers as required
Backbone Provider Bridge PAR

• Allows scaling Provider Bridge networks to support a large population of users
• May use reuse much of 802.1Q bridge technology
• Recommend a new standard to allow removing bridge functions which are not important to Backbone Provider Bridge
PAR Title

• Standard for Local and Metropolitan Area Networks – Virtual Bridged Metropolitan Backbone Provider Networks
PAR Scope

• To develop bridge protocols and architecture, compatible and interoperable with Provider Bridged(1) Network protocols and equipment allowing interconnection of multiple Provider Bridged Networks in such a way as to extend the Customer MAC Service Instances provided by these networks between the multiple Provider Bridged Networks, to allow scaling to at least $2^{20}$ Service Virtual LANs, and to support management of the Customer MAC Service Instances.

-1-IEEE Std. 802.1ad
Purpose

• This standard will enable a Service Provider to scale the number of Service Virtual LANs in a Provider Network by interconnecting many independent Provider Bridged (IEEE Std. 802.1ad) Networks while interconnecting the Service Virtual LANs provided by these Provider Bridged Networks, and provide for interoperability and consistent management.
Objectives

– interconnect Provider Bridge Networks in a manner that allow scaling of the Carrier Bridged Network to support at least $2^{20}$ S-VLANs
– support at least $2^{16}$ multipoint S-VLANs
– interconnect at least 256 Provider Bridged Networks
– provide rapid distribution of S-VLAN tags
– provide rapid healing of network failures without interruption of service to unaffected S-VLANs