Carrier Ethernet

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Some key technology trends

- **Fibre**
  - Can pull/blow in long sections (few kms) of cable without splicing
  - Encourages ‘fibre rich’ infrastructure

- **SFP/XFP**
  - Increasing functionality to include section management
  - Wavelength flexible in future
    - Passive DWDM (no transponders)

- **ASICs**
  - Increasing basic functionality
  - Moving into network processor space
  - However, functionality must be stable
  - *Ethernet*

- **Multi-core generic processors**
  - Increased processing rate
  - Moving into network processor space
  - Able to perform application aware (XML) routing
Why Ethernet is interesting for carriers

Ethernet Services

- Increasingly customers have an Ethernet interface
  - Large market demand for a WAN service to look like
    - CAT5 or fibre Ethernet cable
    - CAT5/fibre connecting to an Ethernet LAN
  - Can and are delivered using existing carrier technologies
    - SONET/SDH, MPLS, and ATM

Ethernet Technology

- Lowest cost per Gbit/s switching equipment
- Very large hardware volumes compared to carrier equipment
- No secondary encapsulation
- Convergence between datacentre architecture and network architecture
  - “XML routing”
  - Large interconnectivity problem

But:
Current Ethernet technology cannot easily support Ethernet services
What marks out ‘carrier’ requirements

- Equipment practise standards
  - e.g. NEBS
- DC (-48V) power supply
- Redundant cards with hitless switching
- In service software upgrade (ISSU)
- Rules on fans and air flow

- Scaling of protocols
  - Broadcast unknown
  - Spanning tree
  - Client bridge transparency
  - QoS
  - Plus need for security
- Scaling of development/capital costs
- Scaling of operational costs

Chasing these may defeat the point of the exercise

Leads to reuse of existing carrier technologies for Ethernet services

Key factors which determine the viability of Ethernet technology to deliver Ethernet services
Scaling of costs

- Fixed costs
  - “The bearing of a child takes nine months, no matter how many women are assigned.”
  - The size of the fixed costs normally depends on the ultimate scale
- Complexity costs
  - “First, even a subtle defect shows itself as a local failure of some kind. In fact it often has system-wide ramifications, usually nonobvious. Any attempt to fix it with minimum effort will repair the local and obvious, but unless the structure is pure or the documentation very fine, the far-reaching effects of the repair will be overlooked.”
- “Conceptual integrity is the most important consideration in system design.”

Quotes from “The Mythical Man-Month”, Frederick Brooks
Scalability of Development/Capital Cost

- The more obvious
  - Large amount of development are fixed costs independent of the scale of deployment
  - The law of large numbers in traffic aggregation
    - Expected performance improves with large numbers
  - Switching costs grow more than linearly with number of ports/end points
  - Broadcast unknown and bridge learning doesn’t scale
  - STP eliminates an ever greater proportion of capacity with size of topology

- The more subtle
  - The need for backwards compatibility with existing deployment
    - Additional not replacements features
    - Square law increase in feature interactions
  - Conflicting and evolving requirements from customers
    - Requirements can even move faster that time needed to implement ‘universal’ networks
  - The law of small numbers in traffic aggregation
    - Unexpected performance improves with small numbers
Scalability of operational cost

• Scale 1
  – All in one place
    • One person/team designs, plans, installs and maintains network

• Scale 2
  – Enterprise
    • One team designs, plans, installs and maintains network
    • Team may be dispersed
    • Some remote operations

• Scale 3
  – Carrier
    • Separate teams design, plan, install, and maintain network
    • ‘Handover’ between teams
    • Integral remote operations

• Time to deploy greatly increases with each scale
  – And this is much more than installation time
  – “gestation time”

• Equipment/component functionality
  – Scale 1 and 2 tend to like equipment/components with lots of functional options
  – Scale 3 tends to like equipment/components with prescribed functionality only

• Managing through ‘events’
  – Scale 1 and 2 can maintain stability through ‘executive’ action
  – Scale 3 needs to meet pre agreed commercial SLAs
Specific ‘carrier’ requirements

• Minimal interaction between user (client network) protocols and carrier protocols
  – Service transparency
  – Feature independency

• Alternatives to spanning tree and bridge learning
  – Control of forwarding
  – Network resilience and service protection

• OAM protocols from reliable remote monitoring

• Integration with operational support systems

• Control of customer service parameters
  – QoS
    • Throughput
    • Latency
  – Availability

• Datacentre port costs or simple reuse of datacentre equipment
Provider Bridging (PB)
IEEE 802.1(Q)ad

- S-Tag very similar to C-Tag
  - Additional drop eligibility indicate
  - Different Ethertype
- Bridge operation essentially the same as VLAN bridge learning
  - Issues on uniqueness of MAC addresses
  - Issues with the scaling of flooding
- Options and issues with handling client STP
- Class based QoS model
- So many deployments use a ‘2-port S-VLAN bridge’
  - No bridge learning
  - Forms pt-pt connections
    - May be traffic engineered
    - eg assigned bandwidth QoS model
  - 12bit VLAN tag is very limited to large scale networks
  - Swapping VLAN tag value is not intended in the standard and creates its own issues
Provider Backbone Bridging (PBB)
IEEE 802.1(Q)ah

- Adds a full new MAC header
  - All client fields and protocols are fully transparent
- Client header wrapped with a 24 bit service instance ID
  - Normally be mapped to client S-Vid
  - Client flooding restricted to service instance
- Provider Backbone Bridge Network (PBBN) uses standard bridge protocols
  - MSTP
  - Bridge learning
    - MAC addresses are internal to B layer
    - Limits scalability of PBBN
- Class based QoS model only
PBB – Traffic Engineering (PBB-TE)
IEEE 802.1Qay

- Identical encapsulation to PBB
- Handling of client MAC layer identical to PBB
- In the PBBN
  - Turn off spanning
  - Disable flooding and bridge learning
  - Place entries in the forwarding table from external control/management plane
  - Can use GMPLS control plane
- Forms pt-pt or pt-mpt connection
  - Traffic engineering QoS model
- ‘Default drop’ forwarding is inherently secure
- 1:1 path protection
- Essentially unlimited scalability
Connectivity Fault Management (CFM)
IEEE 802.1(Q)ag

Continuity check message (CCM) - multicast heart beat (unicast in PBB-TE)
Loopback message – unicast ‘ping’ (no loopback of user traffic)
Traceroute message – multicast message with unicast parameter, unicast response
## Carrier Bridging – PB, PBB, and PBB-TE

<table>
<thead>
<tr>
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<th>OAM (IEEE802.1ag)</th>
<th>Transparency</th>
<th>Scalability and Efficiency</th>
<th>Bandwidth Control</th>
<th>Service Protection</th>
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<td>(S-VLAN) (IEEE802.1ad)</td>
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<td>Interacts with 'client' bridge protocols</td>
<td>Limited number of S-VLANs</td>
<td>Not consistent with mpt-mpt provider bridge network (PBN)</td>
<td>Spanning tree gives local protection in the PBN</td>
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<td>Large number of service instances</td>
<td>Provider network creates pt-pt or pt-mpt tunnels across PBBN</td>
<td>End to end protection across the PBBN</td>
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Note: Many vendors and operators have used S-VLANs in a ‘2-port’ mode to achieve more transparent pt-pt services with bandwidth control. This still has scalability and other compatibility issues.
Shortest Path Bridging (SPB)
Shortest Path Backbone Bridging (SPBB)
IEEE 802.1Q(aq)

- Currently active in IEEE802.1
- Alternative to spanning tree using link state routing protocol
  - IS-IS proposed protocol
  - Automatic discovery of topology and I-Sid service instances
- Each source is the head of its own shortest path optimised tree
  - SPB: source identified by VLAN-id
  - SPBB: source identified by B-MAC address
- Additionally, SPB/SPBB is an automatic solution for
  - Multicast registration
  - Allocation of VLAN-ids
- Loop prevention and mitigation
  - Loop prevention protocol and mechanism
    - Forwarding blocked until neighbours have identical network view
  - Optional loop mitigation alternative (need for TTL mechanism??)
- Highly complimentary addition to PBB and PBB-TE
  - SPBB is a form of control plane for PBB-TE
    - eg SPBB equal cost load sharing equivalent to PBB-TE protection
  - Possible to bandwidth manage each SPB/SPBB source tree equivalent to PBB-TE
Summary

• Ethernet services are well established
  – Currently use wide variety of technology except Ethernet technology
• ASIC based datacentre cost point of forwarding makes Ethernet technology attractive to carriers
  – Need to add carrier requirements without losing cost point of forwarding
• IEEE802.1 has new standards for carrier Ethernet technology
  – PB, PBB, PBB-TE, CFM
  – SPB, SPBB is work in progress
Thank You

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