Carrier Ethernet Transport – Requirements and Multilayer Network Architecture with PBB-TE

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Packet Transport Workshop Series
Focus on Provider Ethernet Networks
Q108 – Ft. Lauderdale, FL USA
February 4, 2008
Agenda

- Motivation behind Carrier Ethernet Transport
- Requirements of Carrier Scale Networks
- Evolution of Carrier Ethernet Transport
- Multilayer Optimization
- Conclusion
TCO as a Driver for Operator Decisions
Decouple Cost and Capacity

Operator Revenues
6% p.a.

Operator Traffic
50-500% p.a.

Total Cost of Ownership per Tbips Transport
-25% p.a.

Exponentially increasing BW and flat revenues leads to cost pressures which force operators to look for the lowest network TCO
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Requirements of Carrier Scale Networks (1)

- **Predictability**
  - even under high-load conditions, for solid service delivery.
  - SDH-like behavior

- **Traffic Engineering and Service Separation**
  - Decouple client information from forwarding decision
    - Transport hierarchy
  - Free choice of paths (not necessarily shortest ones)
    - No path dependencies
  - Support of VPN and traffic separation
  - Support of Pt2Pt, Pt2MPt, MPt2Pt, MPt2MPt
Requirements of Carrier Scale Networks (2)

- **Scalability, Simplicity and Cost-Efficiency**
  - **Technological point of view**
    - Support 100,000s of clients and services and transmit their traffic, whichever the network size be, comprising the access, metro edge, metro core and backbone segments.
  - **Economical point of view:**
    - Decouple cost from capacity
      - Strong traffic increase in metro and core networks
    - Reducing Total Cost of Ownership
      - Efficient usage of resources and simple network operation
  - **Discussion points:**
    - Number of required paths/labels (1000 edge nodes)
    - Path merging to simplify/reduce number of paths
    - Swapping of labels or not?
Requirements of Carrier Scale Networks (3)

- **Quality Of Service**
  - Classical QoS guarantees
    - Bandwidth, jitter, latency, packet-loss
  - Service differentiation
    - Coexistence of time-critical, assured and best effort traffic
  - Discussion points:
    - Control of resources, need for admission control

- **Reliability**
  - Allow high availability
    - “5 nines” possible
  - Discussion points:
    - Protection and/or Restoration?
    - Reaction time: 50ms / some 100ms
Requirements of Carrier Scale Networks (4)

- **Network Management** (SDH-like behavior)
  - Fault Management
    - Fault detection, alarming, isolation, trouble shooting
  - Configuration Management
    - Static provisioning, Protocol parameter configuration
  - Accounting
  - Performance Management
    - Performance monitoring, supervision, alarming
  - Security Management
    - DDoS attacks, Distribution of security-relevant data
  - Traffic Management
    - Resource Control, Admission Control, (Dynamic) Optimization
Requirements of Carrier Scale Networks (5)

- **Mobility (Fixed Mobile Conversion)**
  - Synchronization
    - By protocol or hardware
      e.g. IEEE1588, GPS, NTP, …

- **Legacy Service**
  - Support of legacy services (e.g. TDM services)

- **Standardized Solution**
  - Not single source

- **Interoperability**
  - Between different technologies
    - Especially IP/MPLS, SDH/Sonet, Ethernet Aggregation
  - Support of interoperable end-to-end solutions
Here we are.

This may need simplification!
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The Evolution of Network Technologies
Moving towards Ethernet

- IP/MPLS
  - Classical IP/MPLS
  - L2/MPLS
  - T-MPLS

- SDH/Sonet
  - Carrier Ethernet

- Ethernet
  - Classical Ethernet
  - PBB-TE
  - PBB
  - Compound NE

- WDM/ONT
  - ROADM/PXC
  - Ethernet ADM with GFP-T/F
  - Ethernet ADM with L2 Switch
  - Integration of Ethernet/OTN
  - Integration of Ethernet functionality
Carrier Ethernet Transport Evolution

**Standard Ethernet**
- Focus: LAN Technology
- Forwarding based on Spanning Tree
- Inefficient use of resources
- Limited traffic engineering possibilities
- Very complex optimization tasks when using multiple trees
- Slow restoration upon failures (seconds)
- Flat switching hierarchy (broadcast if unknown)

**Carrier Ethernet**
- Focus: Metro Aggregation
- Metro Ethernet Forum Standardization
  - Enhanced QoS
  - Manageability, OAM
  - Improved Scalability with VLANs, Q-in-Q
  - Availability
- But still using
  - Spanning Tree
  - Slow restoration upon failures

**Carrier Ethernet Transport**
- Focus: Transport Networks
- Forwarding based on transport label, not on customer MAC address
- Establishment of virtual tunnels (paths)
- Broadcast if unknown is disabled (hierarchy)
- Centralized management or distributed control plane (e.g. GMPLS)
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IP/MPLS Transport
Network Architecture Model

Strengths

Service Awareness
Packet routing
Traffic Engineering
Robust network
(Restoration)

Cost efficient
2.5Gbps, 10Gbps, 40Gbps, 100Gbps

Layer 2 Emulation / Tunneling

Subscriber/Service
Residential
IP, Voice, Video
Business
L1/L2/L3 VPN Leased Line, E-Line

Access
Aggregation
Edge
Core

Layer 2 / Carrier Ethernet Transport

LER
LSR
LSR

DSLAM
Access Switch

GPON FTTH
Metro DWDM
Core DWDM

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Carrier Ethernet Transport
Network Architecture Model

Service Awareness
- Packet routing
- Traffic Engineering
- Robust network (Restoration)

Packet switching
- Traffic Engineering
- Robust network

Native layer 2
- Predictable behavior

Carrier Grade OAM

Cost efficient
- 2.5Gbps, 10Gbps, 40Gbps, 100Gbps
Carrier Ethernet Transport
Network Architecture Model

Subscriber/Service
- Residential
  - IP, Voice, Video
- Business
  - L1/L2/L3 VPN
  - Leased Line, E-Line

Access
- DSLAM
- Access Switch

Aggregation
- Metro DWDM

Edge
- LER
- LSR

Core
- Layer 3 / IP
  - LER
  - LSR

Layer 2 / Carrier Ethernet Transport
- GPON FTTH
- Metro DWDM
- Core DWDM

Service Awareness
- Packet routing
- Traffic Engineering
- Robust network
- (Restoration)

Packet switching
- Traffic Engineering
- Robust network

Native layer 2
- Predictable behavior

Carrier Grade OAM
- Cost efficient
- 2.5Gbps, 10Gbps, 40Gbps, 100Gbps

Native transport
- of business services on the lowest possible layer
- dependent on service requirements and cost

Optimal mix
- of intermediate grooming and routing and transparent bypass
  (Ethernet + WDM)

Functionality only where needed
- Minimize intermediate routing - offload routers

Optimal mix of intermediate grooming and routing and transparent bypass (Ethernet + WDM)
CAPEX Benefit with Carrier Ethernet Transport

Operational Cost/ Efficiency $/Mbps

- **Service layer:** L3/IP
- **Packet based layer:** L2/Ethernet
- **Optical layer:** L1/WDM

Total cost of ownership is reduced by optimized usage of L1 and L2 technologies.
CAPEX Reduction - A Real Case Study: Multilayer Network Optimization

Combining Multilayer Optimization with Carrier Ethernet Transport maximizes total savings.

The effect of Multilayer Optimization

The effect of Carrier Ethernet Transport

opaque optimized scenario 1 optimized scenario 2
**OPEX Benefit with Carrier Ethernet Transport**

Terabit core router
- Power consumption of 13kW
- 723 kg chassis fully configured

Source: NSN analysis

Power consumption (in kW) for 100Gig

Router: 1
Switch: 0.5
SDH: 0.2
ROADM: 0.04

Router: 0.6
Switch: 0.2
ROADM: 0.01

Future

• Features / sophisticated
• Backward compatibility
### Carrier Ethernet Transport

**Network Architecture Model**

<table>
<thead>
<tr>
<th>Service</th>
<th>Access</th>
<th>Aggregation</th>
<th>IP/Aggregation</th>
<th>Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>3Play FTTH</td>
<td>CES</td>
<td>3P-PE</td>
<td>IP Edge</td>
<td>Application</td>
</tr>
<tr>
<td>3Play VDSL</td>
<td>Customer IP Service</td>
<td>BRAS</td>
<td>IP/MPLS</td>
<td>Routing</td>
</tr>
<tr>
<td>CIS</td>
<td>DSLAM</td>
<td>Carrier Ethernet</td>
<td>Optical Transport</td>
<td></td>
</tr>
<tr>
<td>Customer IP Service</td>
<td>Ethernet</td>
<td>DWDM Metro</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CES</td>
<td>Customer Ethernet Service</td>
<td>Carrier Ethernet Transport</td>
<td>DWDM Core</td>
<td></td>
</tr>
<tr>
<td>COS</td>
<td>Customer Optical Service</td>
<td></td>
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</tbody>
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OIF OPTICAL INTERNETWORKING FORUM
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PBB-TE - The New Innovative Transport Solution

What is PBB-TE:

Connection-Oriented Ethernet
- Allows carriers to engineer and provision deterministic, protected and secured connection-oriented trunks and services within the Ethernet networks.

PBB-TE Benefits:

CAPEX Savings
- Ethernet platforms have a cost advantage vs IP/MPLS
- Simple vs. complicated protocols of higher layers

OPEX Savings
- Flat architecture is simple to manage and provision
- SDH like look and feel
- Carrier-grade network management
- Costly IP/MPLS expertise not needed

PBB-TE Applications:

Metro Aggregation
- Business and Residential Services

Core Transport
- Native end-to-end transport of layer 2 services
- Backhauling of mobile and fixed services
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Questions, Answers, Discussion?

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