Green from the Inside-out

Carrier Ethernet & 100G Optical Transport

Chris Janson
Agenda

Green from the Inside-out
Carrier Ethernet & 100G Optical Transport

- Bandwidth drivers
- Ethernet
  - Advantages and Carrier Ethernet
  - Potential of EEE
- High capacity optical transport
  - 100G
- Efficiency of the converged network
Meet the need to expand capacity

Sustained capacity demand is best met through 100G networks

Source: Infonetics
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Open the Door for New Services

Optical/Wavelength Services
Ethernet Services
Layer 3 VPN Services

Optical Infrastructure
Ethernet Infrastructure
IP/MPLS Infrastructure
Multimedia/3Play Infrastructure

Newer, smarter service challenge the network infrastructure
Network and Computing speed development pace

Network Aggregation Bandwidth Increases ~2x/12-18mos. Driven by Internet & telecom usage

Computing I/O Bandwidth Increases ~2x/2yrs. Driven by Moore’s Law

Source: Ethernet Alliance
Ethernet Advantages

<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>International standardization</td>
<td>Ethernet is the first global network access technology</td>
</tr>
<tr>
<td>Unrivaled success in enterprise</td>
<td>Access, metro, and wide-area applications</td>
</tr>
<tr>
<td>Large set of component and equipment manufacturers</td>
<td>Metro Ethernet Forum = 150+ members</td>
</tr>
<tr>
<td>→Ethernet Alliance = 100 members</td>
<td>Lowest cost per megabit</td>
</tr>
<tr>
<td></td>
<td>&gt; 7¢ per megabit for triple-speed NIC</td>
</tr>
<tr>
<td>Mature, layer 2 technology</td>
<td>Plug-and-play</td>
</tr>
</tbody>
</table>

“Ethernet over any media…any service over Ethernet”
Carrier Ethernet defined

The 5 attributes of carrier Ethernet

- Carrier Ethernet is a ubiquitous, standardized, carrier-class SERVICE defined by five attributes that distinguish Carrier Ethernet from familiar LAN based Ethernet
- It brings the compelling business benefit of the Ethernet cost model to achieve significant savings

Carrier Ethernet Attributes

- Standardized services
- Scalability
- Service management
- Reliability
- Quality of service
Transport Solution...

100G Optical Mesh

- Carry more bandwidth over existing infrastructure
  - Difficult to justify green field overbuilds

- Flexible optical networks
  - Need to lower the cost of network operation
100G + Optical Mesh
Evolution of the Client-Server Network

SONET/SDH is Managed Transport “Server” layer for existing service “clients”

IP builds over WDM

... so does Ethernet

... and ESCON, FC, I services

WDM augments SONET/SDH capacity

OTN provides the necessary Managed Transparent Service for all Transport Clients
# 100G Technology evolution

<table>
<thead>
<tr>
<th></th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modulation Format</strong></td>
<td>PM-DQPSK</td>
<td>PM-DQPSK</td>
<td>PM-QPSK w/ Coherent RX</td>
</tr>
<tr>
<td><strong>Physical Size per Channel</strong></td>
<td>5 Slots</td>
<td>5 Slots</td>
<td>4 - 2 Slots</td>
</tr>
<tr>
<td><strong>Transmission Reach</strong></td>
<td>1,000 km</td>
<td>1,000 km</td>
<td>1,500 km</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>4 Tbps (100 GHz Spacing)</td>
<td>4 Tbps (100 GHz Spacing)</td>
<td>4 – 8 Tbps (100 – 50 GHz Spacing)</td>
</tr>
<tr>
<td><strong>Physical Interface</strong></td>
<td>Single I SMF</td>
<td>Single I SMF</td>
<td>Single I SMF (Parallel optics possible)</td>
</tr>
</tbody>
</table>

*Field trial supports 10 x 10GbE only*
Agenda

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Where does Data Center power go?

- Chiller 33%
- Humidifier 3%
- CRAC 9%
- IT Equipment 30%
- PDU 5%
- UPS 18%
- Lighting 1%
- Main switchgear / Generator 1%

This data center is 30% efficient

Heat OUT

Source: APC
Energy Efficient Ethernet (EEE)

• Majority of Ethernet NIC’s operate full throttle <5% of time
• In 2005, US NIC’s consumed ~5.3 Terawatts
• Two EEE concepts:
  – Adaptive link rate: throttle network speed based on need
  – Low power idle: Send fast, put NIC to sleep quickly
• Sleep mode either slows clocks or shuts down components
  – Lower average power consumption
• Issues of link control and quick turn-on are under consideration
### Optical Transport Data Center Power Consumption

**Node 1**
- 15xGE
- 2x10G
- 2xOC-48/STM-16
- 20xFc-200

**Node 2**
- 15xGE
- 2x10G
- 2xOC-48/STM-16
- 20xFc-200

#### Comparison Table

<table>
<thead>
<tr>
<th></th>
<th>Nortel 5200</th>
<th>Cisco 15454</th>
<th>CIENA 4200</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Chassis</strong></td>
<td>4 total (2/ node)</td>
<td>4 total (2/ node)</td>
<td>2 total (1/node)</td>
</tr>
<tr>
<td><strong>Number of Wavelengths</strong></td>
<td>16</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td><strong>Power Consumed</strong></td>
<td>3290W (1645/ node)</td>
<td>3140W (1570/ node)</td>
<td>2412W (1206/ node)</td>
</tr>
</tbody>
</table>

**Average power consumption:** 2947W/ system

**Average of 12 wavelengths needed**

**Average of 245W/ wavelength needed for this traffic**
100G
100 Gbps per Wavelength Over the Same Infrastructure

• Same commons but 10 x capacity

10Gbps per λ

100Gbps per λ
Potential power savings with 100G

- 10x increase in capacity with same commons
- Industry average 245W/wavelength needed for example system
- Only two 100G wavelengths needed

Power consumption reduced by ~83% to 490 Watts

Annual power cost of 10G based system: $2323
Annual power cost of 100G based system: $386
Conclusions

• Continued growth in traffic demand comes from multiple applications and users
• These fit efficiently into a converged Ethernet-optical infrastructure
• Energy Efficient Ethernet (EEE) offers potential for huge macro-system energy savings
• High bit rate backbones offer potentially greater than 80% power savings