Evolving Converged Optical Ethernet

Jim Archuleta
Ciena Corporation.
Challenges we hear from our R&E customers

- Must Adapt to new requirements with minimal incremental cost or disruption
- 100G readiness, availability and performance are new state of the art differentiators
- Integration of switching and transport, with the right balance of both.
- Close vendor partnership ensures success
- Services and support must flexibly support unique requirements of customers and community members

<table>
<thead>
<tr>
<th>Changing Requirements</th>
<th>Challenges</th>
<th>Needed Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Add new connectivity</td>
<td>• Capital Expenditure – minimize up front and incremental cost</td>
<td>• Adapt to Demand Uncertainty</td>
</tr>
<tr>
<td>• Support increased scale</td>
<td>• Must simplify operational complexity</td>
<td>• Quickly activate new connectivity</td>
</tr>
<tr>
<td>• Provide Higher Performance</td>
<td></td>
<td>• Continuously upgrade bandwidth</td>
</tr>
</tbody>
</table>

© Ciena Confidential and Proprietary
NextGen Optical Core Architecture Vision
Automated Photonic, OTN, and Packet Switching

10G/40G/100G Photonic Mesh
High Speed Traffic Demands at Photonic Layer
Low-Med Speed Traffic Demands at OTN Layer
Core Router Interconnect at the OTN/Packet Tunnel layer
Ciena Technology Investments for Converged Optical Ethernet

**BEST IN CLASS PHOTONICS**

Colorless Add/Drop + DIA for Mesh EROADM + TOADM for low Cost

**NextGen MODULATION**

Multi-Level, Phase, Polarization Modulation Coherent Rx - Phase & Amplitude recovery

**Multilayer Control & Automation**

Supports layer 0, 1 and 2 services
Built on G.ASON, GMPLS & OIF standards

**HYBRID SWITCHING**

OTN/Packet Switch

**PLATFORM + SERVICE FLEXIBILITY + SCALE**

OC-3/12/48/192/768
ODU0/ODU1/ODU2/ODU3, 1GE/10GE/40GE/100GE

SAOS Software

6500 2,7,14,32
5410, 5430
Ciena Adaptive Optical Engine

Coherent Technology for Scale
- Scaling to 40/100G and beyond
- Intelligent Receiver
- More bits per symbol
- Real-time access to system health

Electronic Disp Compensation for Network Simplification
- Lowering costs
- Low-cost CMOS
- No re-engineering
- 40G/100G over challenged plant
- Real time traffic optimization
- “100G with 10G planning rules”

Wavelength Agility for Service Velocity/Resilience
- Service Velocity
- Any wave, anywhere
- Directionless ROADM for optical restoration
- Coherent Rx → colorless ROADM:
  No need for tunable filters

Automation & Control Plane for OPEX Simplification
- Plug and Play + Self Healing
- Point-click wavelength provisioning
- Operational simplification
Next generation optical technology should facilitate wavelength switching in mixed fiber networks.

As wavelengths traverse different distances across a variety of fiber types, bulk optical compensation becomes insufficient.

Electronic Dynamically Compensating Optics (EDCO) brings dispersion management cost under control and increases line system flexibility.

- Real-time performance optimization on each wavelength: Improved specs.
- Greatly facilitated accommodation of mixed fiber applications.
- Enables agility and wavelength re-route capabilities with or without control plane.

Bulk optical dispersion compensation will not suffice.
ROADM Roadmap achieving Colorless drop flexibility

**Late 1990’s ROADM Node**
- Multi-degree ROADM
  - Flexible wavelength routing between WAN ports
  - Fixed channel filters for connecting client ports to specific WAN ports

**Late 2000’s Direction Independent ROADM Node (DIA)**
- Directionless ROADM
  - Flexible connection of add/drop channels to any WAN ports
  - Allows for the manual or dynamic re-routing of wavelengths under failure conditions.

**2010’s Colorless ROADM Node**
- Colorless ROADM
  - Reconfigurable to add/drop any wavelengths on any port
  - Decouples planning from deployment
  - Wavelength defrag
  - Remove human intervention
A multilayer automation and restoration control architecture

- Supports layer 0, 1 and 2 services
- Built on ITU G.ASON, IETF GMPLS and OIF standards
- Implemented across NE, EMS and OSS

Vertical Integration through Transport, Control and Management Planes
5400 Product Family: Converged Multi-service Switching and Aggregation

L2: Carrier Ethernet
- Virtual Switching
- MPLS
- Packet Control Plane
- Connection Oriented Ethernet

L1: Optical Switching/OTN
- FastMesh Control Plane
- Optical Switching
- Scalability
- High Availability

L0: WDM
- Granular OTN
- FlexiPorts
- Packet Optical Transport
- 40/100G DWDM

Scale and Convergence

5400 Family
5430: 3.6T
5410: 1.2T

© Ciena Confidential and Proprietary
Thank you
Beyond 100GbE: Coherent Networking – 3D Capacity Evolution

Three mechanisms to grow capacity

- Challenge the baud rate
- Challenge the bit/symbol
- Challenge fixed λ spacing

“Super Channels”

Polarization Diversity & OFDM

Exploit all 3Ds in order to Optimize Spectral Efficiency, Performance, Cost & Reliability