CONNECTING AT THE SPEED OF LIGHT

Coherent Optical Solutions for Data Center Interconnections

OPTINET 2019

JUNE 13, 2019
The World Has Moved to the Cloud

Billions of Smart Phones

Millions of Servers in the Cloud

Hyper-scale Datacenter Era
Network Coherent Requirements are Expanding

Coherent technology already in majority of network; moving towards data center and access networks
Data Center Traffic Patterns and Trends

- **Bandwidth doubling/year**
- **Driven by video, artificial intelligence, and machine learning**

**Intra-datacenter Bandwidth Growth**

- **Google**
- **Facebook**

**Switch Port Transition**

400G passes 100G bandwidth in 2022

- **Dell’Oro Group**
Coherent Gets Smaller and Smaller

100G MSA

100G CFP

200G CFP2

400G QSFP-DD/OSFP

DSP
ASIC

E-mux

Modulator

CRX

DRV

3D Stacking

Coherent: Ideal for Electro-Photonic Integration

COHERENT TRANSCEIVER

Many optical functions
High speed drivers and TIAs
High speed ADC and DACs
High speed analog interconnects
Advanced DSP
Equalization of imperfections
Optical Interconnect Trends

Moving to shorter reach as data rates increase

Direct Detect (DD)

Coherent Solutions

Embedded Solutions

0.5km 2km 10km 80km 300km 1000km

Intra DC Campus Edge/ZR Metro LH/ULH
Moving into the Data Center: Coherent Advances

- ≥400G Sweet Spot for Coherent
  - Similar complexity as PAM4
  - Move complexity to Electronic domain
  - Add Pol and Phase for 4x capacity
  - Efficient EQ for non-perfect optics
  - Power of 800G <18W

- Enabling Technology Advances
  - Silicon Photonics
  - Multilevel with DSP being introduced at 400G
  - Advanced miniaturization/integration (co-packaging)
  - 2.5D and 3D stacking
Standardization Momentum on Coherent

**Data Center**
- Intra D/C 800G/1.6T MSA?
- Coherent focused

**Carrier**
- OIF 400ZR
  - 80-120km
- ITU 200G/400G
  - 80km, 450km

**Cable/MSO**
- Open ROADM
  - 100G/200G/300G/400G
- CableLabs
  - 100G & 200G

**Network Rates**
- 100G
- 200G
- 400G
- 800G/1.6T
50Tbps Switch with Co-packaged Optics

Switch-to-Optics Options

- Pluggable Optics
- On-board Optics
- Co-packaged Optics

Socket

Substrate (110x110mm²)

3.2-Tb/s chiplet set

Rx in

Tx out

Lasers (4λ) in

8-ch TIA

PIC

32-ch ADC/DAC/EQ

8-ch driver
50Tbps Switch with Co-packaged Optics Saves Power and Space

<table>
<thead>
<tr>
<th>Switch IO Bandwidth</th>
<th>Lane Speed</th>
<th>Type of Pluggables</th>
<th>Number of Ports</th>
<th>Line-card Height</th>
<th>ASIC Core Power</th>
<th>SERDES and Retimer Power</th>
<th>Optics PMD Power</th>
<th>Total Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.6Tb/s</td>
<td>100Gb/s</td>
<td>400G DR4/FR4</td>
<td>64</td>
<td>2RU</td>
<td>400W*</td>
<td>340W*</td>
<td>500W</td>
<td>1240W</td>
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<tr>
<td>51.2Tb/s</td>
<td>100Gb/s</td>
<td>400G DR4/FR4</td>
<td>128</td>
<td>2+RU</td>
<td>560W*</td>
<td>480W*</td>
<td>860W</td>
<td>1900W</td>
</tr>
</tbody>
</table>

100% Reduction

15-20% Reduction

Courtesy of Luxtera

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Conclusion

• Coherent optical technology moving toward shorter reaches
• Standardization momentum towards coherent, especially ≥ 400G
• Miniaturization of optics/electronics required for 400ZR as well as intra-data center links
Thank You