Router Optics Evolution and Market Trends

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February 7th, 2017
Agenda

• Router Optics vs. Transport Optics
• Router Optics Evolution
• 100G Optics Status and Challenges
• Higher 100G Density Considerations
• Router Optics Market Trends
Router Optics vs. Transport Optics

Technology

Transport Optics

- Long haul and high speed DWDM transmission
- CDC-F ROADM
- Reliable, high performance, mesh networks

Router Optics

- High density, small form factor
- Lower power, lower cost
- Point to point, grey optics
Router Optics vs. Transport Optics

Architecture

**Traditional Network Architecture**
- Separate packet and transport
- Short reach grey optics connection in between
- Interop with different generation grey optics

**Converged Network Architecture**
- Integrated DWDM on router
  - Data plane integration
  - Metro or shorter distance focus
  - Density mismatch: colored vs. grey optics
Diverse Router Optics Requirements
Router Optics Evolution for 100G and Beyond

OSFP vs. QSFP-DD, similar to CFP4 vs. QSFP28?
Router Optics Challenges

• **Router capacity vs. optical module form factor**
  - Router ASIC capacity development outpaces optics bandwidth
  - Higher optical module data rates vs. smaller form factor
  - Physical size, power consumption, cooling, fiber management

• **Fiber Savings Requirements**
  - BiDi module
  - Short reach WDM
  - Ultra long distance support

• **Different temperature range requirements**
  - Industrial temperature module for 100G and beyond

• **Higher Density 100G/200G/400G integrated DWDM**
Different application requirements drive multiple QSFP28 modules
100G Router Interface Application Issues:
MMF Short Reach Interop

Issues:
- MMF Short Reach
- Interop

Investment Protection vs. Better Cost, Higher Density, Lower Power

- CFP2 SR10 MTP-24
- CFP SR10 MTP-24
- CFP4 SR4 MTP-12
- QSFP28 SR4 MTP-12

Field Deployment
Interoperation
New Deployment

- Mechanical Adaptor
- With/Without FEC
100G Router Interface Application Issues: ER4 Support and Interop

- CFP2 ER4
- QSFP28 ER4Lite
- QSFP28 eLR4

Field Deployment

New Deployment

Interoperation

- 4WDM MSA
- FEC on host card
- Without FEC support 20~25km
- With FEC support 40km

QSFP28 ER4Lite is coming in 2017
100G Router Interface Application Issues: ZR Support and Interop

Interoperation

- Coherent 100G
- Both end with PAM4

QSFP28 ZR PAM4
Need special optical node
With amplifier and CD compensation

CFP2 DCO

10G to 100G Migration: Support ZR Distance
100G Router Interface Application Issues:
Industrial Temp Support

- SFP+
  I-Temp

- XFP
  I-Temp

- When?
  - Within 2017

- CFP4

- QSFP28
  Higher power consumption
  4.5W ~ 5.5W

10G to 100G Migration: Support Industrial Temp Applications
Router 10G Optics Challenges

- ZR distance with BiDi optics module
  - Pluggable filter
  - Attached circulator

- Ultra long span 10G transmission
  - External pizza box with transponder and single channel optical amp

- Beyond ZR Tunable SFP+
  - Power limitation, dispersion limitation
  - I-Temp tunable SFP+?

- Very high density 10G interface on core and edge router
  - Satellite solution
  - Breakout cable

10G is Still Going Strong
Higher Density 100G Interface Design Options on Router

- What’s next beyond QSFP28 100G?
- Market timing for Nx100G module?
- QSFP-DD or OSFP?
- Any market for 2x100G?
- New 100G module to support Nx100G.

<table>
<thead>
<tr>
<th>Data Rate</th>
<th>Form Factor</th>
<th>Electrical Interface</th>
<th>Optical Lane</th>
<th>Interoperation with 100G</th>
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<tbody>
<tr>
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<td>QSFP28-DD OSFP</td>
<td>8x25G NRZ</td>
<td>2x4x25G NRZ</td>
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<td>QSFP56 OSFP</td>
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Router 400G Optics Interfaces

• IEEE 400G standard to be finalized in 2017
• Packet processor ASIC is already available
• First generation optical module is coming
• Time to market vs. density/cost improvement
• Reduce fiber management complexity
• Keep 400G clear-channel end to end

Reduced LAG with 400G
Improved optical spectrum efficiency

Router 400G Optics Coming
Router Integrated DWDM Interfaces

- Metro market focus
- Open for non carrier market
- CAPEX/OPEX saving
- More reliable: full visibility for transport layer, FRR
- Fast service activation: Provision wavelengths for 100G router interfaces
- Common 100G EFEC enables interoperability among routers
Router Optics Trends

• 100G is quickly becoming the new 10G
• ASIC and Optics dictate router HW performance and cost
• Routers getting closer to wireless equipment
• Client side optics and line side optics boundary is blurring
• Shorter distance and low cost WDM is coming