Upgrading your network to 100G or 400G? Learn how to future-proof your investment with the next generation of Cisco Optics

April 14, 2020
Pat Chou – Next Generation 100G Optics: Single-Lambda 100G

Ron Horan – Transitioning Data Center Optics from 100G to 400G

Ray Nering – QSFP-DD Optics Update
Next Generation 100G Optics: Single-Lambda 100G

Pat Chou
Product Manager, Cisco Optics
April 14, 2020
Pluggable Optics Cost Compared To Host Platform Hardware
10G Transceivers With 10km Reach: Ubiquitous

Broad Range of Applications and Markets

Campus Networks

Data Center

Service Provider Networks

> 10 million transceivers per year!
Where We’re Headed

10G

100G is the new 10G

BACK WITH CONVICTION

SEASON TWO
Reducing Optical Complexity And Module Size

Single-lambda optical interface: Forward compatible

Form Factor

Optical Interface

Single-Lambda PAM4
PAM4: Pulse Amplitude Modulation

NRZ (Binary)

PAM4 (Twice the information as NRZ)
Cisco Silicon Photonics PAM4

- High-volume CMOS Fab
- 2.5D Integration
- High volume, high yielding processes

- 1V drive (CMOS based driver)
- Enables 53Gbd PAM-4 for 100G/lambda applications
- Integrated Ge Photodetector
- World class fiber coupling solution <1dB coupling loss for TE/TM, for both O-band and C-band

Industry Standard Processes
- High performance lithography enables precise device geometries
- Low loss optical waveguide devices
Cisco Silicon Photonics: Clean Eye After SMF Propagation

Eye remains open after 10km SMF
New Product: QSFP 100G FR

- QSFP28 form factor
- 2km reach
- Data Center Application
  - Leaf-Spine connectivity
  - Same fiber and reach as CWDM4
- Upgrading to 400G
  - Provides connectivity between legacy 100G ports and new 400G ports
  - No sacrificing port bandwidth
- Standardized by 100G-Lambda MSA, IEEE P802.3cu Task Force
- Interoperates with IEEE DR (500m)
- Released December 2019
Example Application: Data Center Spine-Leaf
400G Connectivity Via Breakout

- 4x 100G ports
- QSFP28 FR
- QSFP28 FR
- QSFP28 FR
- Fully utilized 400G port
- 500m 4x Duplex Single-mode fiber
- Each 100G port fully utilized

New Host

Legacy Host

ASR9k
Incremental Upgrade to 400G

• Upgrade your network one site at a time.

• Connect new 400G sites to legacy 100G sites via 4x100G breakout.

• Fully utilize your 400G port bandwidth with 4x100G breakout.

• Re-use 100G optics in new 400G ports.
References

• Cisco Optics Blog: https://blogs.cisco.com/tag/ciscoopticsblog
• Compatibility Matrix tool: https://tmgmatrix.cisco.com/
Transitioning Data Center Optics from 100G to 400G

Ron Horan
Director, TMG Optics
April 14, 2020
Agenda

• The Increasing Need for Higher Bandwidth Optics

• Who Is Leading the Charge to 400G?

• 400G Transition Timing

• Key Factors Driving the Transition to 400G

• Where Data Centers Will Deploy 400G
The Data and Traffic Explosion
We are Seeing Growth at Unprecedented Levels

- This is driven by high bandwidth applications for business and consumer workloads
- Installed workloads and compute instances are growing at a 19% CAGR between 2016-2021
- Today, business & compute applications have the highest share
- But social networking and media streaming have the fastest growth rate
- Consumer traffic is growing 2.5x faster than business traffic
Trends in IP Traffic Growth

- Cisco believes data center traffic will triple from 2016 to 2021
  - That’s a compounded annual growth rate (CAGR) of 25%

- Equinix projects traffic growth at 51% CAGR in 2018–2022

- Either way, global data center traffic is growing at a breakneck pace
What Markets are Driving this Growth?

• The three key markets driving growth include: Enterprise, Service Provider, and Cloud

• The Cloud market’s bandwidth growth rate is significantly faster than Enterprise or Service Provider segments

• See how the traffic growth rates were impacted by 40G, 100G, and 400G

• Cloud is driven by Hyperscale Data Center Operators (examples: Facebook, AWS, Microsoft, Google, Alibaba, etc.)
• Although trending downward, there is still a significant volume of 1G, 10G, and 40G shipping

• 100G will dominate volumes over the next 5 years

• 200G and 400G are just beginning data center deployments in what is expected to be a slow ramp
  • Hyperscale data centers are leading the transition to 200G and 400G
  • Some key hyperscale data center operators use different speeds which make the volumes look smaller but should be considered in aggregate
Key Factors Driving the Transition to 400G

- Requirement More Bandwidth – Transition will occur when applications require more bandwidth than 100G can reasonably service.

- Cost – The cost of 400G optics transceivers must dip below the cost of 4x 100G transceivers.

- Technology – PMA and PMD technology must be stable and readily available (examples: PAM4 modulation, 100G/λ signaling).

- Switch Silicon Density and Availability – Optics usage is heavily driven by the currently available switch ASICs which drive density, radix and switch chassis form factor.

- Supply Chain Readiness – Multiple optics vendors must have a stable supply chain infrastructure and be ready for HVM.

- Standardization – Standard, interoperable solutions are required before deployment begins.

The Cloud Market segment typically leads the adoption of higher speed optics by 2–3 years.
Example Data Center Topology - 100G to 400G

- **Regional Gateway / Availability Zone**: DC to DC Interconnect
  - Reach < 10km
  - Current Gen Optics: Various types
  - Next Gen Optics: Various types

- **Data Center (Core Aggregation Layer)**: Pod – Pod Interconnect
  - Reach < 2km
  - Current Gen Optics: Various types
  - Next Gen Optics: Various types

- **POD (Spine Aggregation Layer)**: Row – Row Interconnect
  - Reach < 2km
  - Current Gen Optics: Various types
  - Next Gen Optics: Various types

- **ROW (Row Aggregation Layer)**: Rack – Rack Interconnect
  - Reach < 100m
  - Current Gen Optics: Various types
  - Next Gen Optics: Various types

- **RACK**: Server – Server Interconnect
  - 4x25G DAC
  - 4x100G DAC

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Other Considerations

• MMF vs SMF at 400G
  • As optics speeds increase, MMF solutions have less reach due to increased chromatic dispersion penalties
  • SMF is less susceptible to chromatic dispersion
  • More and more data centers are choosing SMF based optics and fiber plants

• 400G-DR4 vs. 4x100G-FR1
  • While some DCs will deploy 400G-DR4 optics as a point to point solution, many others will use the 400G-DR4 in a breakout mode, typically 4x100G-FR1
  • This is significant because they are really deploying a higher density 100G solution
QSFP-DD Optics Update

Ray Nering
Product Manager, Cisco Optics
April 14, 2020
Introducing Cisco QSFP DD Portfolio

- QSFP-DD MSA has very broad industry support
- MSA has over 60 member companies
- Port is backward compatible to QSFP+, QSFP28, QSFP56
- Leverages industry cost structure and production capability of QSFP
  - More than 60M ports were deployed by end of ‘19
- Support 2x100G designs
- QSFP-DD will support over 20W of power dissipation
- Broad product offering from copper cable to coherent
Recipe for Success – Why will QSFP-DD succeed?

QSFP-DD positively checks out on all the 4 pillars necessary for a pluggable module to succeed:

- **Compatibility**
  - Alignment with ASIC IO (8x 50G PAM4 necessary)

- **Investment Protection**
  - Backwards compatibility enables smooth network transition allowing reuse of the $9B investment the industry has already made in QSFP modules

- **System Density**
  - Support network requirements for system density: 32 & 36 ports

- **Superior Performance**
  - Support necessary thermal/SI for implementation
  - All optical and copper reaches supportable incl. 400ZR
### Current 400GbE Industry Activities – not just one place!

#### Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.3bs</td>
<td>400 GbE MAC &amp; Interfaces (AUI, 200G-FR/LR4, 400G-DR4/FR8/LR8)</td>
</tr>
<tr>
<td>IEEE 802.3cd</td>
<td>100G-DR, 50G-CR (Also 50GE SMF/MMF, 200GE MMF)</td>
</tr>
<tr>
<td>IEEE 802.3ck</td>
<td>100 Gb/s SERDES Task Force</td>
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<td>IEEE 802.3cm</td>
<td>400 GbE MMF (400G-BiDi; and 400G-SR8)</td>
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<tr>
<td>IEEE 802.3cn</td>
<td>50GBASE-ER/200GBASE-ER4/400GBASE-ER8 Duplex SMF 40km Reach</td>
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<td>IEEE 802.3ct</td>
<td>100/400Gb/s Duplex SMF 80km Reach DWDM (will align to OIF 400G–ZR)</td>
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<tr>
<td>IEEE 802.3cw</td>
<td>400Gb/s Duplex SMF 80km Reach DWDM (will align to OIF-400ZR)</td>
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<tr>
<td>IEEE 802.3cu</td>
<td>100G per Lambda Task Force (100G-FR/LR, 400G-FR4/LR4)</td>
</tr>
<tr>
<td>IEEE 802.3cp</td>
<td>10/25/50G BiDi 10/20/40km</td>
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#### MSA

<table>
<thead>
<tr>
<th>MSA</th>
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<tbody>
<tr>
<td>OIF 400G ZR</td>
<td>400G Coherent 80/120km</td>
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<tr>
<td>100G Lambda MSA</td>
<td>100G-FR, 100G-LR, 400G-FR4, 400G-LR4</td>
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<tr>
<td>400G-BiDi MSA</td>
<td>400G-SR4.2 100m Parallel MMF</td>
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<tr>
<td>QSFP-DD MSA</td>
<td>400G Form factor</td>
</tr>
<tr>
<td>OSFP MSA</td>
<td>400G Form factor</td>
</tr>
<tr>
<td>COBO</td>
<td>Embedded 400G/800G module</td>
</tr>
<tr>
<td>CWDM8 MSA</td>
<td>400G MSA for 2km and 10km</td>
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<tr>
<td>Open-Eye MSA</td>
<td>Alternative (Analog-only receivers) specs (non-interoperable)</td>
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<tr>
<td>QSFP-DD800</td>
<td>800G version of QSFP-DD</td>
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<tr>
<td>HiWire MSA</td>
<td>Standardize Active Copper Cables</td>
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</table>

*Multi-Source Agreements – new ones all the time. Not all get wide industry adoption*
QSFP56-DD 400G Roadmap

CABLES

400G Copper
- 400G Copper
- 8x50G Copper
- 400G Active Copper
- 8x50G Active Copper
- 4x100G Active Copper
- 400G AOC

3m
7m
30m

MULTIMODE OPTICS

400G SR4-BD
- Plan
400G SR8
- Plan

400G ZR/ZR+
- FCS: Q2CY20

SINGLE MODE OPTICS

400G Copper
- 400G Copper
- 8x50G Copper
- 400G Active Copper
- 8x50G Active Copper
- 4x100G Active Copper
- 400G Copper

3m
7m
30m

400G DR4
- FCS: 2HCY20
4x100G MPO (100G DR/FR interop)
- FCS: Q2CY20

4x100G FR/LR
- FCS: 2HCY20
4x100G MPO (100G FR/LR)
- FCS: Q2CY20

400G FR4
- FCS: Q2CY20
400G LC (CWDM4 technology)
- FCS: Q2CY20

400G LR8
- FCS: Q2CY20
400G LC (LAN WDM technology)
- FCS: Q1CY21

400G LR4
- FCS: Q1CY21
400G Coherent
- FCS: 2HCY20

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• QSFP28-DD optics enables high-density 100G backward compatibility with current gen100G optics

PLAN – Technology under evaluation
Cisco Nexus 400G Switch Portfolio

Nexus 3400-S
- Innovium Terralynx
- 1RU 32p 400G Switch
- 4RU 8-slot Switch

Nexus 9300 GX
- Cisco Cloud Scale GX
- 1RU 16p 400G Switch
- 1RU 28p 100G + 8p 400G Switch

Nexus 9500 GX
- Cisco Cloud Scale GX
- 16p 400G Line Card
- 8-slot GX 400G Fabric Module
- 4-slot GX 400G Fabric Module

Nexus 9500 R Series
- Broadcom Jericho 2
- 24p 400G Line Card
- 8-slot R2 400G Fabric Module

Nexus 9000 GX2, GX3
- Cisco Cloud Scale GX2 & GX3
- 1 RU 32p 400G Switch
- 2RU 64p 400G Switch
- 4RU 400G & 100G (Expandable)

ACI – On Cisco Cloud Scale ASICs. NXOS – On Cisco Cloud Scale & Merchant ASICs.

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** Roadmap, to be IC’ed
Cisco 400G Router Portfolio

- **NCS5500**
  - Jericho 2
  - NC57-24DD (24x400GE LC)
  - NC57-18DD-SE (18x400GE LC)

- **Series 8000**
  - Cisco Silicon One
    - 8201 (24x 400GE + 12x 100GE)
    - 8202 (12x 400GE + 60x 100GE)
    - 36x 400GE LC

- **ASR9K**
  - Cisco Light Speed Plus
    - A9K-20HG-FLEX-SE/TER (5x 400GE + 15x 100G)
    - A9K-8HG-FLEX-SE/TR (2x 400GE + 6x 100GE)

Redefining the Economics of the Internet
400GBASE-DR4 to 100GBASE-DR Breakout

- 400GBASE-DR4 provides 4 lanes of 1λ-100G-PAM4 (100GBASE-DR) optical signal with a reach of 500m
- 4x 100G-FR provides 4 lanes of 1λ-100G-PAM4 (100G-FR) optical signal extended to 2km
- Module will use an MPO-12 SMF connector
- 400GBASE-DR4 can be used for high density 100G interface with breakout QSFP-100G-DR/FR module
- QSFP-100G-DR/FR will provide low cost 100G to any QSFP28 port
- QSFP-DD provides the industry’s highest density 100G interface
400G MMF Solution
(IEEE 400GBASE-SR4.2, 400G BiDi MSA)

400G-SR4-BD

- Provides 400G connectivity over 4 prs. of MMF
  - Can be used for platform speed migration from 100G to 400G
  - Same cable infrastructure as 100G-SR4
- Reach target is 100m
- Can also for 100G breakout to QSFP-40/100G-SRBD

*Wavelengths indicated are nominal to indicate VCSEL based PMD
2X100G QSFP-DD to 100G QSFP28 Breakout

- QSFP-DD 2X100G Modules provide the ability to connect legacy 100G modules to QSFP-DD ports
- Available in 2X 100G-LR4, 2X 100G-CWDM4, 2X 100G-PSM4 or 2X 100G-SR4 modules

<table>
<thead>
<tr>
<th>Module Type</th>
<th>Optical Connector</th>
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<tbody>
<tr>
<td>2X 100G-LR4</td>
<td>Dual Duplex CS Connector</td>
</tr>
<tr>
<td>2X 100G-CWDM4</td>
<td>Dual Duplex CS Connector</td>
</tr>
<tr>
<td>2X 100G-SR4</td>
<td>MMF MPO-24 Connector</td>
</tr>
</tbody>
</table>

2X 100G-LR4 Breakout Example
400G ZR

QDD-400G-ZR-S
- OIF 400G-ZR compliant
- Mapping to 400GZR Frame
- 400G 16QAM
- C-FEC 15%
- 2400ps/nm (80 km)
- C-Band tunability
- Pout: -10dBm min
- Muxponder capable
- <16W
- 2ndHCY20

QDD-400G-ER1-S
- OIF 400G-ZR compliant
- Mapping to 400GZR Frame
- 400G 16QAM
- C-FEC 15%
- CD 1200ps/nm (40km)
- Fixed wavelength
- Pout: -9dBm min
- Muxponder capable
- <16W
- 2ndHCY20

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<th>OSNR Sensitivity</th>
<th>FEC</th>
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<th>Target Power Disp (W)</th>
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<td>1200</td>
<td>N/A</td>
<td>-9</td>
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* Engineered Link
400G ZR+

QDD-400G-ZRP-S
- OIF 400G-ZR compliant
- Mapping to 400GZR
- 400G 16QAM
- O-FEC 15%
- C-Band tunability
- Pout: -10dBm min
- Muxponder capable
  - 2x200G
  - 4x100G
- <20W
- 2ndHCY20

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<th>OSNR Sensitivity (dB)</th>
<th>FEC</th>
<th>Pout (dBm)</th>
<th>Target Power Disp (W)</th>
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</table>
The Cisco difference

- **Breadth of portfolio**
  QSFP-DD solutions to easily migrate to 400G

- **Unmatched Optics Expertise**
  Cisco optics set the standard that all others will be measured by

- **Technical expertise & Industry thought leadership**
  Switch, Router, Optics, Silicon photonics and leadership with SR, EVPN etc. technologies.

- **World class service**
  Renown Cisco TAC experience

- **End-to-End Architecture**
  Cisco optics for all networking applications

- **Innovative Business Model**
  Subscription based SIA, RTU Licenses