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The bridge to possible

Cisco Optics Applications in Optical Transport

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BRKOPT-2011

Agenda

- Why Cisco Optics?
- QSFP DD Grey optics solutions
- 400G upgrade solutions
- QSFP DD Grey optics roadmap
- Pluggable DCO WDM Overview
- Router Interconnect
- QDD vs. CFP2 vs. TXP
- Conclusion

Why Cisco Optics? Pain Free Sourcing

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Pain Free Sourcing

Breadth of portfolio

1G to 400G

Standard and non-standard devices

Breadth of suppliers

Single point of access to breadth of suppliers

High volume

>10 million transceivers shipped per year

Change Management

Manage supplier changes, requalify, secure supply

Cisco Optics Supply Chain Offers Unmatched Benefits

Supplier Management

- Ensure security of supply
- PCN/MCN management
- Audit suppliers
- Audit suppliers' critical subcomponent suppliers

Gold standard for Quality

- Validate early stage quality
- Active quality monitoring
- Ongoing quality assurance testing

Delivery

- Regional fulfillment sites
- Global service depots
- Industry leading lead times

Gartner

Cisco Supply Chain team consistently ranked in top 10 of Gartner's annual global *Supply Chain Top 25* and #1 for 2020

QSFP DD Grey optic solutions

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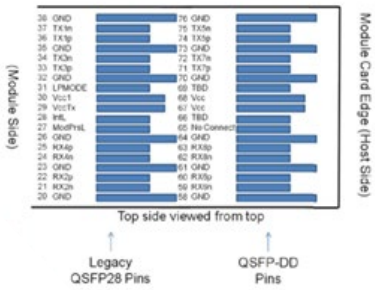
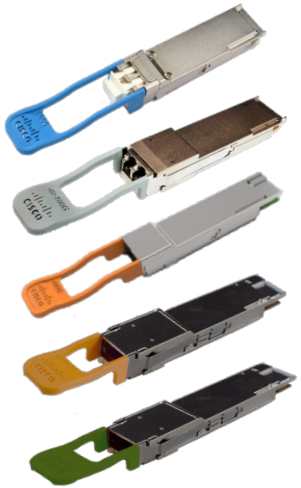
Introducing Cisco QSFP DD Portfolio



- QSFP-DD MSA has very broad industry support
- MSA has over 60 member companies
- Port is backward compatible to QSFP+, QSFP28, QSFP56
  - Ease migration to 400G
- Leverages industry cost structure and production capability of QSFP
  - Over 70M QSFP ports have been deployed to date
  - Industry has invested in roughly 40M QSFP modules
- Support 2x100G designs
- QSFP-DD will support over 20W of power dissipation
  - Supports pluggable coherent modules (ZR & ZR+)
- Broad product offering from copper cable to coherent
- Evolving to 800G in future (QSFP-DD800 MSA)

Why is Backward Compatibility Important



40G QSFP+

100G QSFP28

2x 100G QSFP-DD

200G QSFP56

400G QSFPDD

Platform with QSFP-DD Ports

Allows customers to buy the latest platforms with the latest features while managing their speed migration over time on a per port basis

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

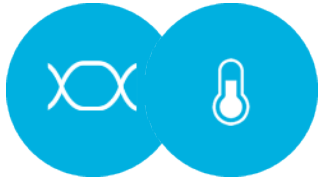
Alignment with ASIC IO (8x 50G PAM4 necessary)

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



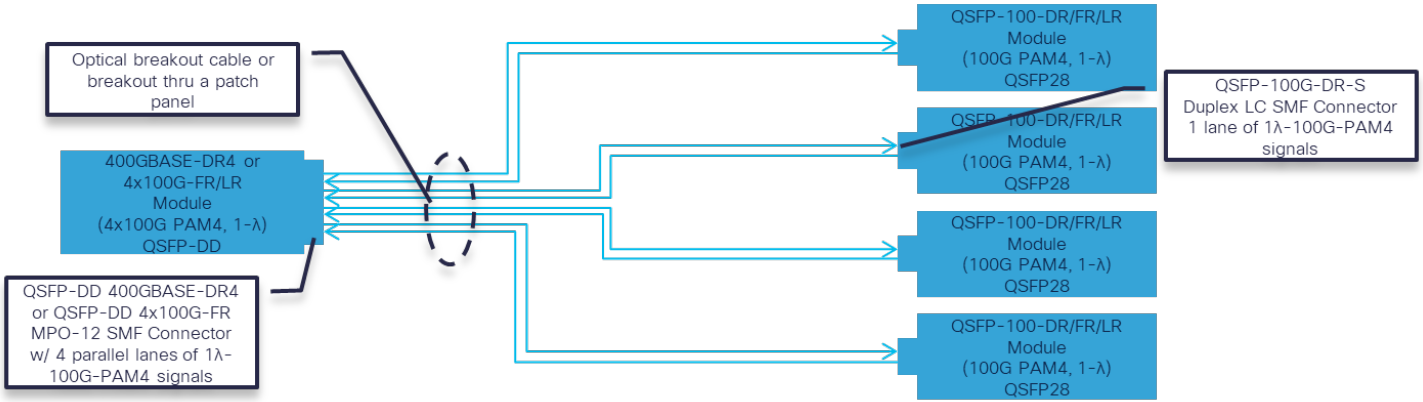
Superior Performance

Support necessary thermal/SI for implementation

All optical and copper reaches supportable incl. 400ZR

400GBASE-DR4 & 4x100G to 100GBASE-DR/FR/LR Breakout

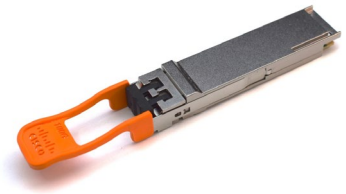
- QSFP-DD provides the industry's highest density 100G interface
- Module in breakout is a high density 100G interface for 500m, 2km or 10km reach
- MPO-12 SMF connector
- Module provides breakouts to 4 lanes of 100GE
- Three reaches: 400G-DR4 – 500m; 4X100G-FR – 2km; 4X100G-LR – 10km
- QSFP-100G-DR/FR/LR provide low cost 100G to QSFP28 port



Single-Wavelength QSFP100 Portfolio

Cisco Silicon Photonics

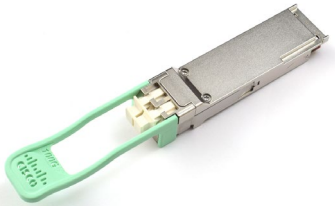
Orderable



DR (500m)

Data Center:
- Leaf switch connectivity to high density spine switch
- Nexus bundles

Orderable



FR (2km)

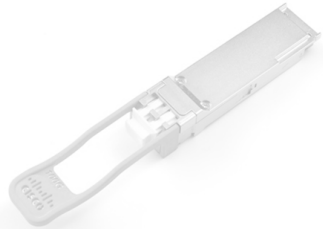
- Alternative to CWDM4
- 400G compatibility for incremental upgrade

Orderable

LR (10km)

- Alternative to LR4
- 400G compatibility for full utilization of port bandwidth

Q1 CY21



ER-Lite (25km)

- Low-cost alternative to ER4-Lite, CFP2-DCO
- Cisco Silicon Photonics performance advantage

Single-Wavelength 100G Optics

- Interoperability with 400G QSFP-DD DR4 and others
- Fully utilize 400G port bandwidth via breakout

400G Compatibility

Forward Compatibility

- Optically interoperable with future 100G form factors
- Future proofs investment in 100G network

- Single-wavelength reduces component count
- Single lane data path aligned with future single-lane 100G ports (SFP112)

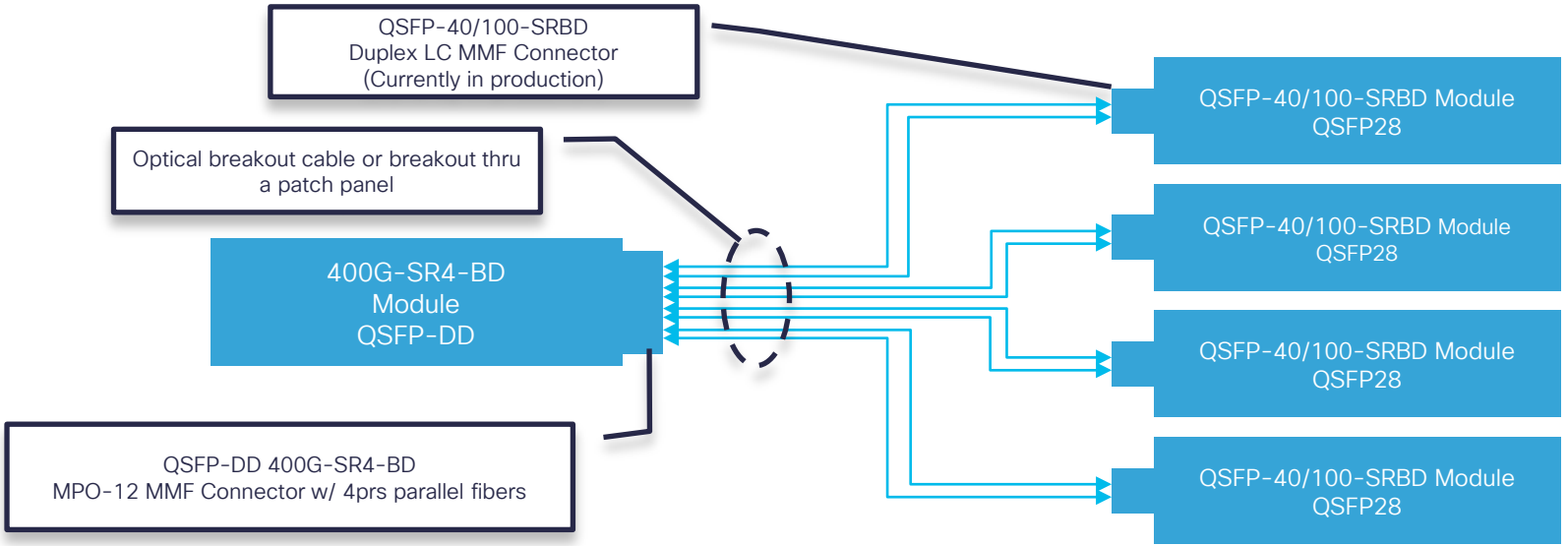
Manufacturability For Low Cost

Cisco Silicon Photonics

- Leverages Cisco investment in optics technology
- ER-Lite 25km reach is Cisco value-add

400G MMF Solution (QDD-400G-SR4-BD)

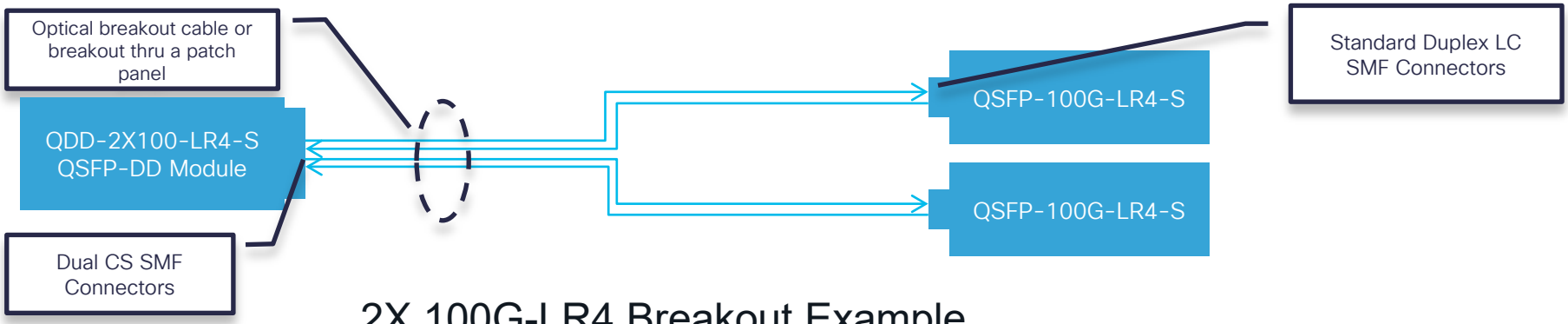
- Provides 400GE connectivity over 4 prs. of MMF
  - Same cable infrastructure as 100G-SR4
- Ease speed migration from 100G to 400G with 4x 100G breakouts
- Reach target is 100m



2X100G QSFP-DD to 100G QSFP28 Breakout

- QSFP-DD 2X100G Modules connect legacy 100G modules to QSFP-DD ports
- Available in for the most common legacy module types
- Higher density 100G connectivity

Module Type	Optical Connector
2X 100G-LR4	Dual Duplex CS Connector
2X 100G-CWDM4	Dual Duplex CS Connector
2X 100G-SR4	MMF MPO-24 Connector



2X 100G-LR4 Breakout Example

400G upgrade solutions

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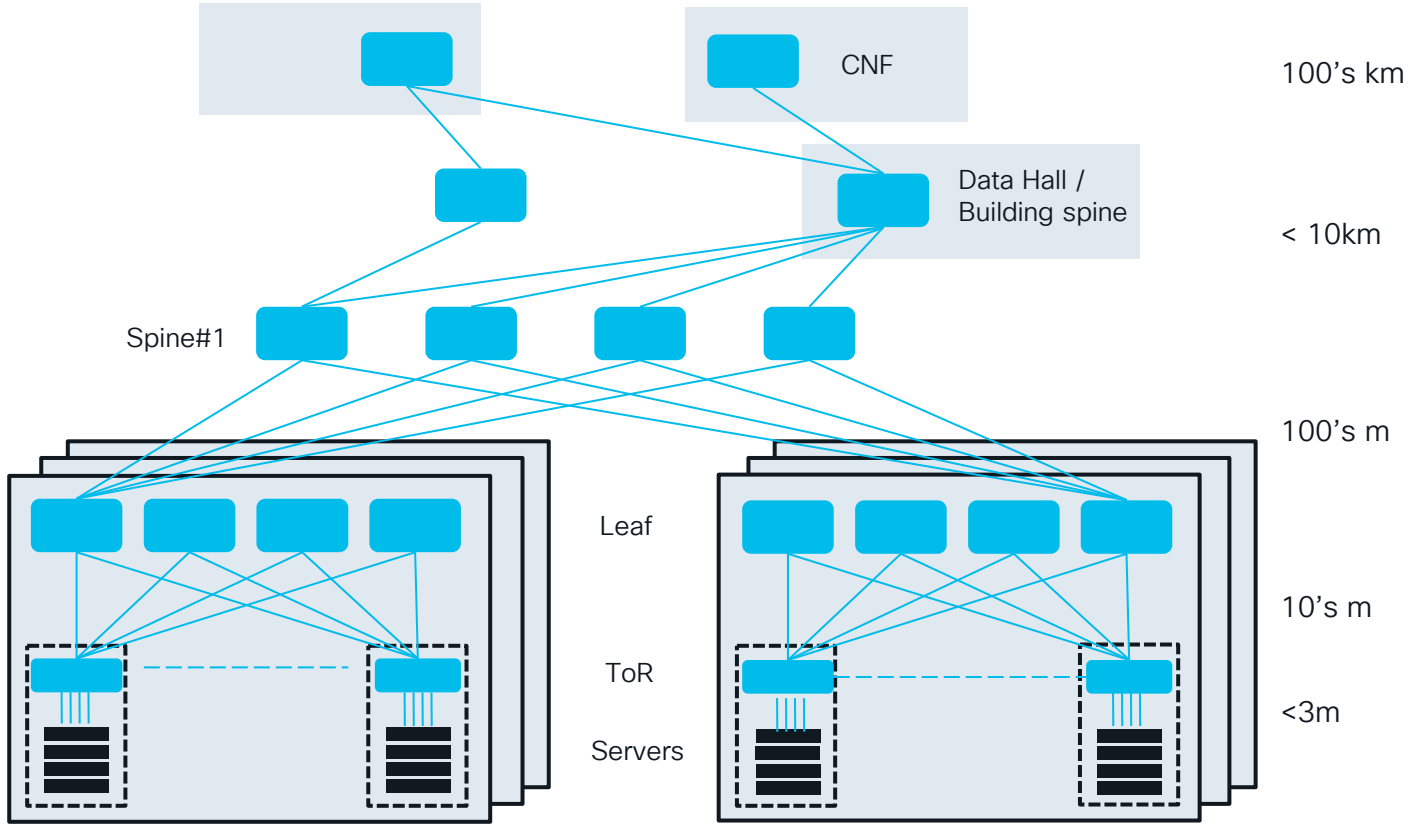
DC Topology – Scale

Today	Next Gen
100G-DCO	400G-ZR/ZR+
100G-LR4	400G-LR4 400G-FR4
100G-CWDM4 100G-PSM4	400G-FR4 400G-DR4
100G-AOC 100G-BiDi	400G-AOC 400G-SR8 400G-SR4.2
100G-CR4 4x25G-CR	400G-CR8 8x50G-CR



How to Transition from 100G to 400G Optics

400G optics on both ends of the link

Reach	Optic today	Next Gen	Media
100m MMF	100G SR4	400G SR4.2	Parallel fiber; supports breakout
500m SMF	100G PSM4	400G DR4 (500m) 4x100G FR (2km)	Parallel fiber; supports breakout
500m/2km SMF	100G SM-SR 100G CWDM4	400G FR4	Duplex fiber, no breakout
10km SMF	100G LR4	400G LR4	Duplex fiber, no breakout
80km SMF	100G DCO	400G ZR	Duplex fiber, no breakout
<30m	100G AOC	400G AOC	
<3m	100G DAC	400G DAC	

Cisco's portfolio of QSFP-DD modules makes it easy to upgrade to 400G in many cases with the current fiber infrastructure

Upgrading only one end of the link to QSFP-DD?

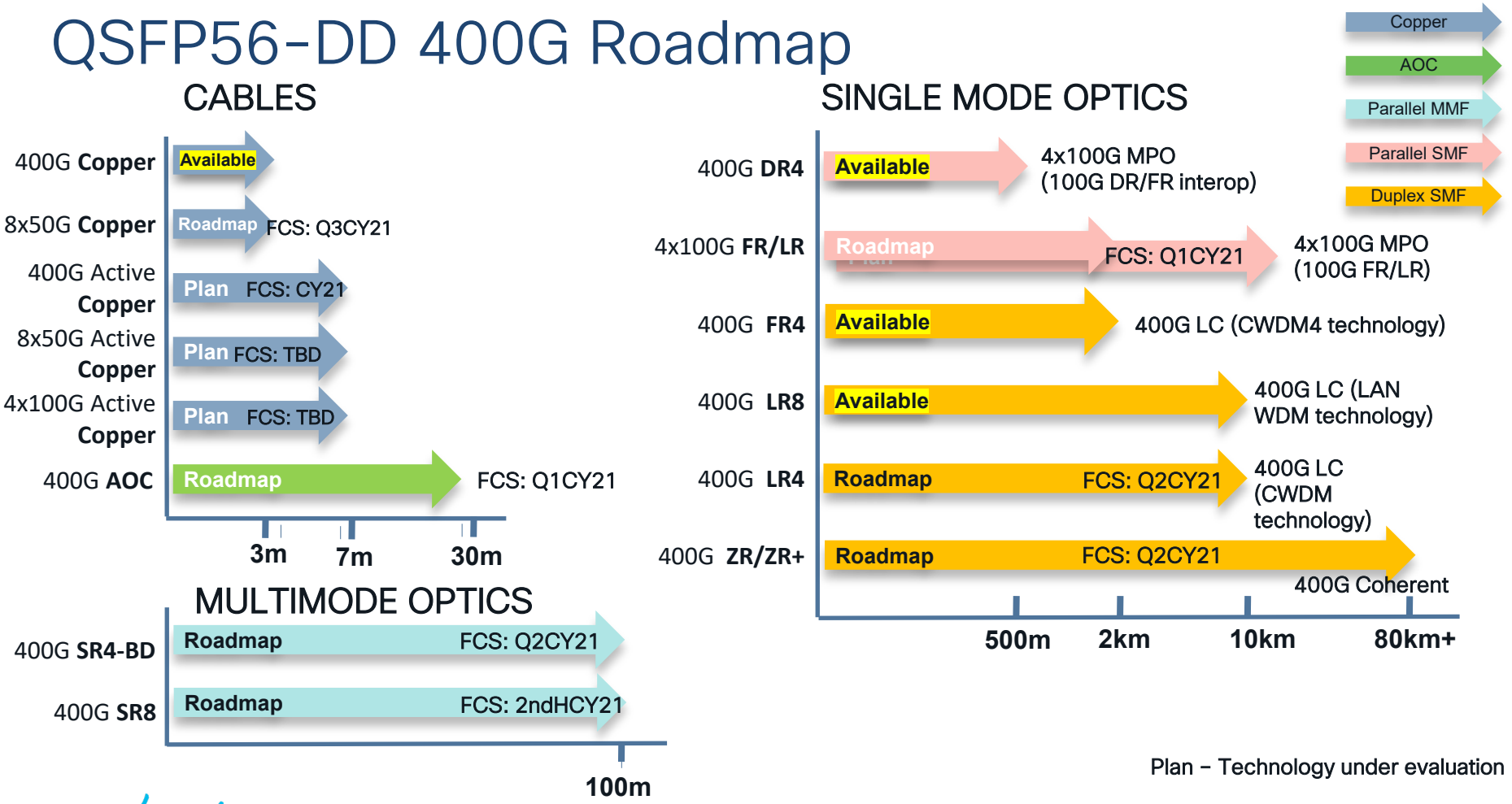
QSFP-DD breakout options provide backwards optical compatibility to QSFP28

Reach	QSFP 100G end	QSFP-DD end	
100m MMF	100G SR4	2x100G SR4	Connect up to TWO 100G-SR4 modules to a QSFP-DD port with a QDD-2X100-SR4-S module
2km SMF	100G CWDM4	2x100G CWDM4	Connect up to TWO 100G-CWDM4 modules to a QSFP-DD port with QDD-2X100-CWDM4-S modules
10km SMF	100G LR4	2x100G LR4	Connect up TWO 100G-LR4 modules to a QSFP-DD port with QDD-2x100-LR4-S modules
500m	100G-DR	400G DR4 (500m)	Connect up to FOUR 100G-DR modules to a QSFP-DD port with QDD-400G-DR4-S modules
2km SMF	100G FR	4x100G FR (2km)	Connect up to FOUR 100G-FR modules to a QSFP-DD port withQDD-4x100G-FR-S modules
10km SMF	100G LR	4x100G LR	Connect up to FOUR 100G-LR modules to a QSFP-DD port with QDD-4x100G-LR-S modules
100m MMF	100G BiDi	400G SR4.2	Connect up to FOUR 100G-BiDi modules to a QSFP-DD port with QDD-400G-SR4-BD

Cisco's portfolio of QSFP-DD modules provides efficient connectivity solutions between platforms for almost any interface

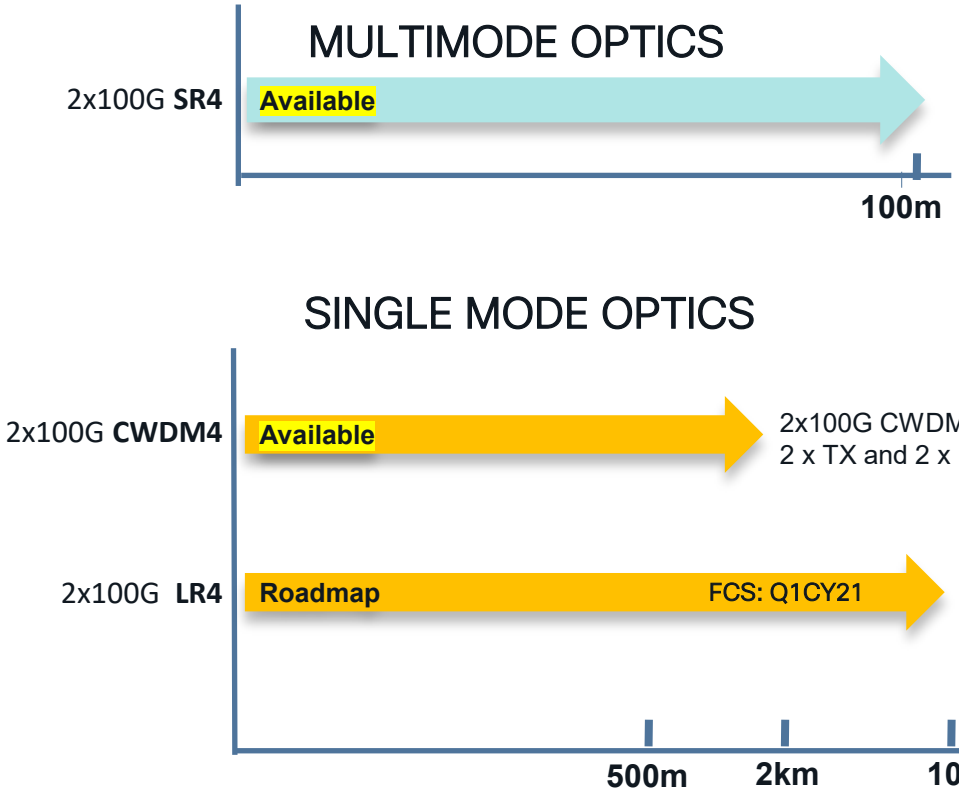
QSFP DD Grey optics roadmap

QSFP56-DD 400G Roadmap



Plan – Technology under evaluation

QSFP28-DD 2x100G Programs



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

Optics support

- Compatibility matrix (platform to optics): https://tmgmatrix.cisco.com/
- Interoperability matrix (optics to optics): https://tmgmatrix.cisco.com/iop
- Cisco Optics Blog Site: https://blogs.cisco.com/tag/ciscooptics
- Transceiver Datasheets: https://www.cisco.com/c/en/us/products/interfaces-modules/transceiver-modules/index.html

Pluggable DCO WDM Overview

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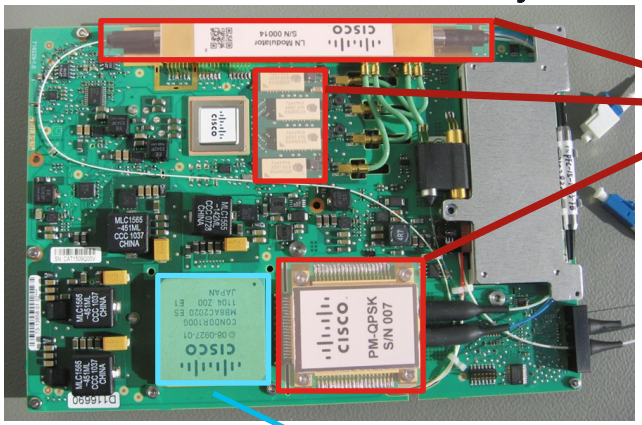
What is a DCO transceiver ?
DCO = Digital Coherent Optic

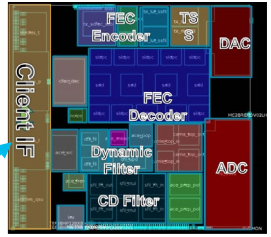
Cisco 100G Transponder line card for 300x300mm layouts



150W

Discrete Photonic Elements

Digital Signal Processor



28nm

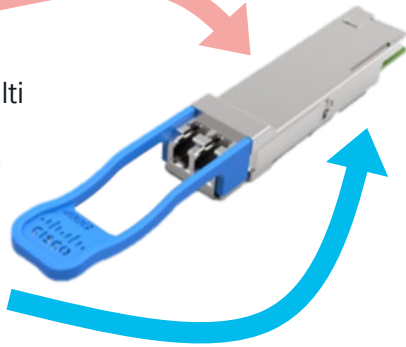
Silicon Photonics Integration
Advanced packaging Integration

PIC with Multi Chip Packaging

Moore's Law

7nm

QSFP-DD 400G DCO



15W

Coherent 400G Product variants

- 3 Mechanical format will be available on the market:
  - CFP2 DCO
  - QSFP-DD
  - O-SFP
- CFP2 DCO is a larger form factor that allows to integrate a Mini-EDFA in the Optical Frontend. CFP2 DCO key different will be Tx Power about 0dBm that will allow full compatibility with current MCS Optical Add/Drop structure
- QSFP-DD and OSFP shows smaller footprint but QSFP-DD is smaller providing moreover full back-compatibility with QSFP+ and QSFP28.
- Cisco will productize QSFP-DD and CFP2-DCO
- Cisco proved that QSFP-DD, even with small power envelop can support maximum scale number in term of ports per RU

What are the Cisco 400G DCO variants ?

400GE, 4x100GE

400G

-10dBm Passive Fixed Filter

P2P metro line system

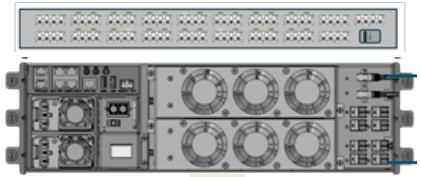
120km

400GE, 4x100GE

openZR+
Improved FEC performance

100G/200G/300G/400G

-10dBm Passive Fixed Filter



P2P line system for long haul

1500km

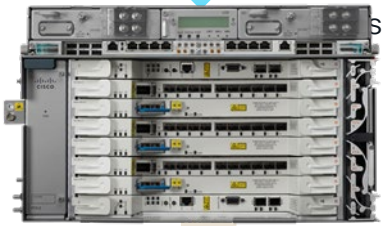
400GE, 4x 100GE/OTU4, 40x 10GE/OTU2/OTU2e/STM64/16GFC

Open ROADM
Improved FEC performance

100G/200G/300G/400G

+1dBm

Contention-less
Direction-les
s



Brown-field line system

1500km

Router Interconnect

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Remote Routers – Symmetric solution

- In case of symmetric 400G routers interconnect multiple option can be considered:
- Assuming a WDM system in the middle 3 major use cases are possible

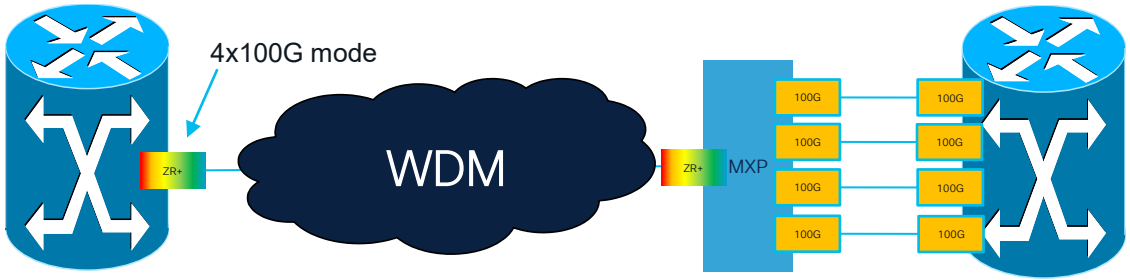
1. WDM ZR/ZR+ optics embedded on the router
   a) Sub case 1: Cisco WDM system
   b) Sub case 2: Third part WDM system

2. 400GE Interconnection with a 400GE capable TXP

3. 4x100GE fan out with a 100GE capable TXP

Remote Routers – Asymmetric solution

- The best option to interconnect a 400G router to a legacy 100G router is leverage on 400G ZR+ optics embedded in the router (also ZR is OK if distance is less than 120km)
- Router 400G port is configured as 4x 100G fanout mode as ZR+ pluggable will transport those 100GE streams onto a single wavelength at 400G
- On the remote location an interoperable Muxponder will break out 4 individual 100G interfaces to the 100G router



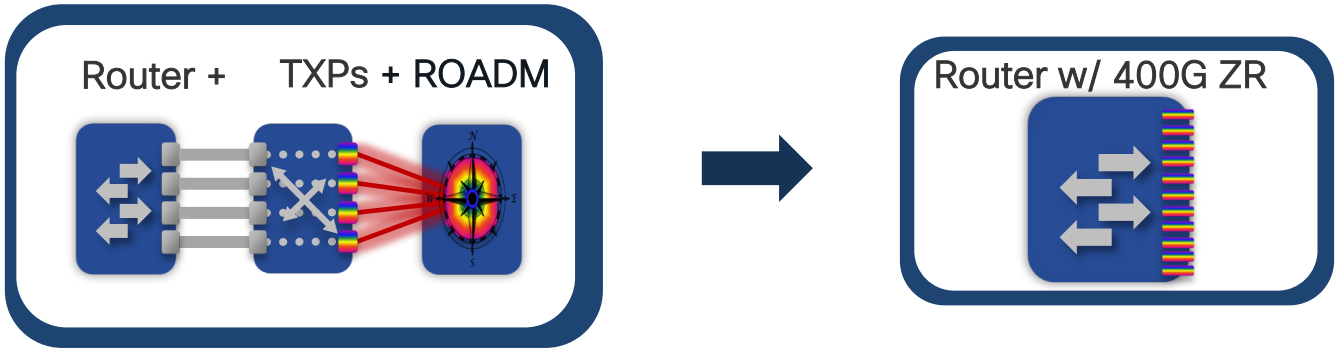
All the variant of 100G clients are available pending the selected Muxponder

- Two Muxponder solution are planned to be interoperable with ZR+:
  1. NCS 2000 1.2T Muxponder Line Card (Titano6 program) – Q2CY2021 Rel 12.2
  2. NCS 1004 OTN-Xponder Line card (Bo program)
     1. Q1CY2021 IOS-XR 7.3.x (ZR)
     2. Q3CY2021 IOS-XR 7.4.x (ZR+)

QDD vs. CFP2 vs. TXP

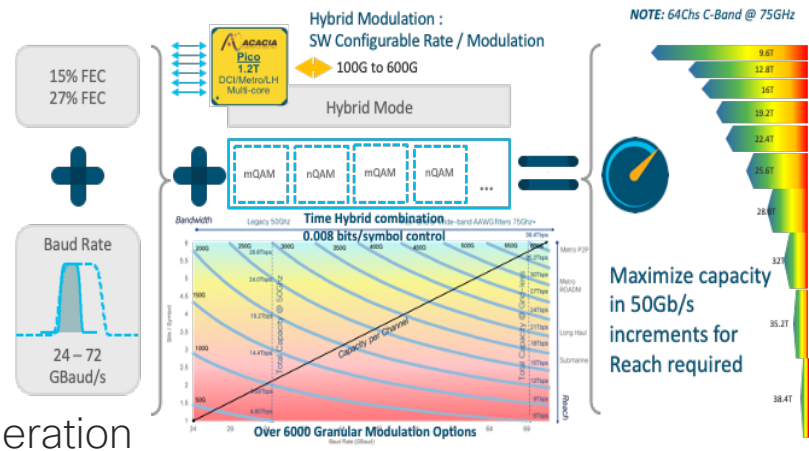
DCO vs. TXP

- If the Routers supports DCO capable the choice is intuitively to use the pluggables in place of a TXP
  - Much better Density (no need of external TXP shelf)
  - Better power consumption
  - Cost optimized solution (no need of 2 client optics, the connection cable, the transponder electronics etc.)



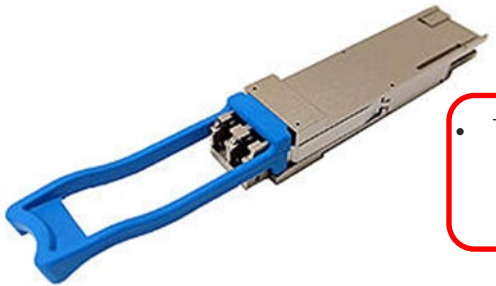
BUT.....

TXPs use cases



- There are still use cases when TXPs will be needed:
  - Submarine Applications
  - ULH network where there is no space for regeneration
  - The flexibility and the performance benefits that high-end optics mounted on the TXPs can not be matched by the DCO pluggable due to the power constraint driven by specific real-estate
- A second case is when there is not a match between the router capacity and the lambda capacity on the WDM system
  - Typical use case when one router has 400G WDM DCO and the router on the other side is 100G capable
  - A Muxponder on one side interoperating with direct wavelength from the router is expected

What about QDD vs CFP2



- TX Power Range:
  - -10 dBm,(ZR or ZR+ w/o Nyquist Shaping)
  - ~13dBm (ZR+ w/Nyquist shaping)

- TX Power Range:
  - -10 to +1dBm (SW Configurable)

- The 10dB of delta Tx Power will have a deep implication about which Add/Drop structure can be supported:
  - Unamplified passive coupler, MCS and CCOFS:
    - They require high input power and so **CFP2 DCO** shall be used
    - CFP2 DCO is compatible with any existing ADD/drop config
  - Amplified Passive coupler, Passive AWG
    - System can tolerate low Input Power and so **QDD DCO** shall be used

“Cisco is now all-in when it comes to the optics business.”

Optical technology has become an increasingly larger percentage of a communications system’s bill of materials, and the purchase gives Cisco more direct control of those costs.

Andrew Schmitt

Founder and Directing Analyst, Cignal AI

The bridge to possible

Thank you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