CORNING

10-to-400G Structured Cabling Guide

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Scaling the Data Center to 400G

With the continued requirement for expansion and scalability in the data center, cabling infrastructures must provide reliability, manageability, and flexibility. Deployment of an optical connectivity solution allows for an infrastructure that meets these requirements for current and future data rates – all the way to 400G.

A Glance at 400G

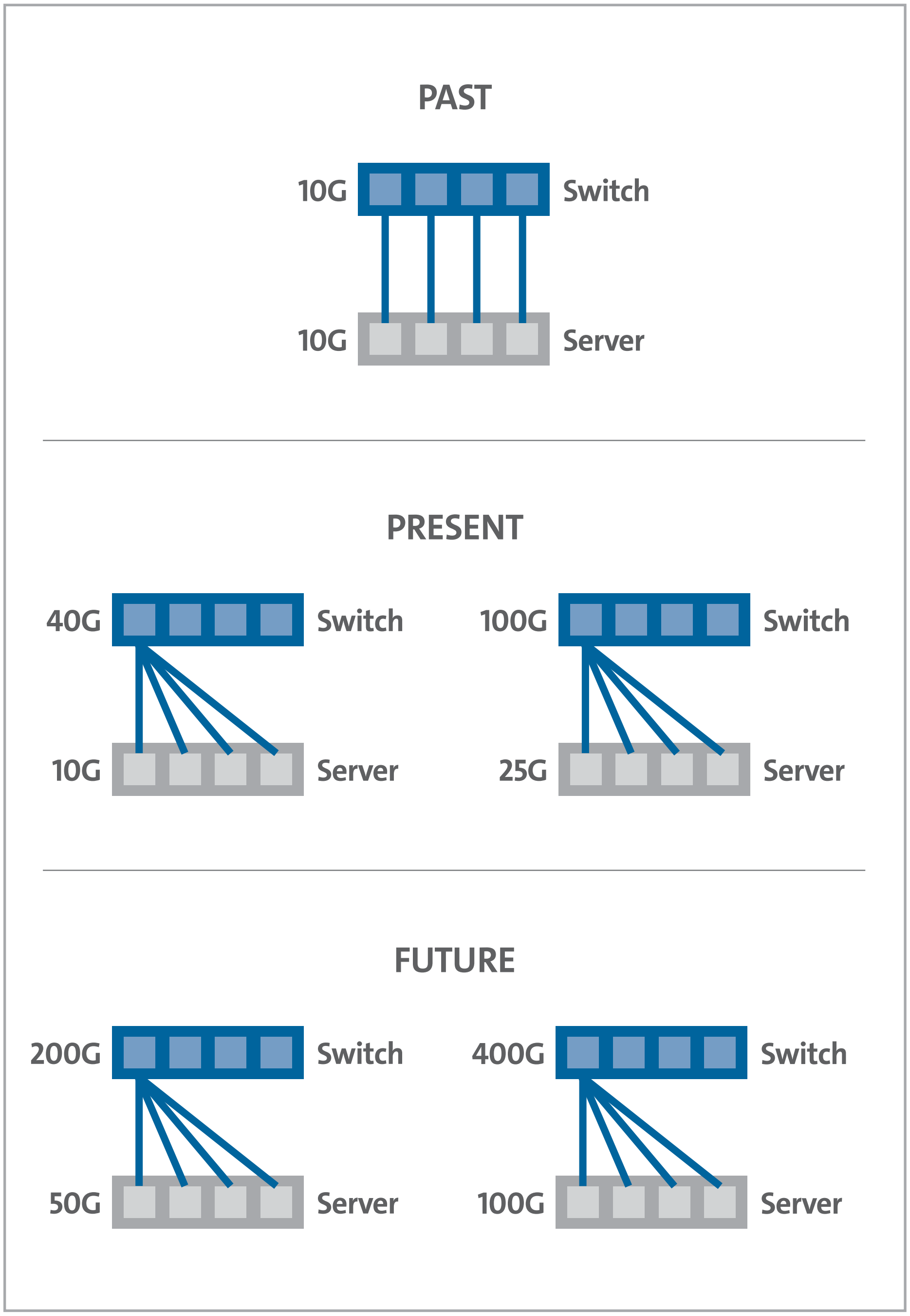

Figure 1: Data center transformation

Switching speed is always driven by the upstream server speed. As Figure 1 shows, when server speeds move from 10 to 100G, switch speeds also scale to support port disaggregation. Many networks now disaggregate the 40G ports into 4x10G ports to increase 10G port density on switches.

25G server connections are starting … they will disaggregate a 100G port into 4x25G.

As the road map for switches and servers continues to increase, the ports will follow in breakouts of four – which will drive 400G.

While some data-center operations require a 400G investment today, that eventuality is still 3-4 years away for the typical enterprise data-center.

A data center's infrastructure investments can pay out in CapEx and OpEx advantages starting on day one.

Data Centers Today

The enhanced small-form-factor pluggable (SFP+) is the dominant transceiver for 1-to-10G high-density applications. As speeds have increased to 40/100G for Ethernet, 32G and beyond for Fibre Channel, and 40G and beyond for InfiniBand, the quad small-form-factor pluggable (QSFP) has become the high-density transceiver of choice because it lends itself to port disaggregation, and this is consistent as we migrate to higher speeds.

Figure 2: SFP+ Transceiver

Figure 3: QSFP Transceiver

Road Maps

Analyzing the benefits and tradeoffs of deploying structured cabling in a data center begins with the network equipment and its continuously evolving offerings from major transceiver, switch, server, and storage manufacturers. However, technology road maps clearly indicate that transmission speeds ranging from 10 to 400G are based on either 2- or 8-fiber connectivity solutions.

Solution	Reach	40G	100G	400G	800G
Duplex OM3/4	50-350 m	BiDi (150 m) SWDM4 (350 m)	VR (50 m) SR (100 m) BiDi (50 m to 1 km) SWDM4VR (50 m) SR (100 m)	To be defined	To be defined
Parallel OM3/4	50-400 m	SR4 (150 m) eSR4 (400 m)	SR4 (100 m) ESR4 (300 m) SR2 (100 m)	VR4 (50 m) SR4 (100 m) SR4.2 (100 m) SR8 (100 m)	2VR4 (50 m) 2SR4 (100 m)
Duplex SM	2-10 km	FR4 (2 km)	LR4 (10 km) CWDM4 (2 km) LR (10 km) FR (2 km)	2FR4 (2 km) LR4-6 (6 km) FR4 (2 km)	2LR4 (10 km) 2FR4 (2 km) FR8 (10 km) LR8 (2 km)
Parallel SM	500 m - 10 km	PLR4 (10 km) PLRL4 (1 km)	PSM4 (500 m) DR (500 m)	DR4 (500 m)	2DR4 (500 m) DR8 (500 m)

Note: Data represents Ethernet only.

Further reading:
http://ethernetalliance.org/roadmap/
http://fibrechannel.org/roadmap/

Transmission Types

In the traditional **serial transmission,** data is transmitted over a single pair of fibers with one fiber for transmit (Tx) and one fiber for receive (Rx) – with 1G and 10G speeds the transceiver choice was irrelevant as they all operated in the same way at the same wavelength (1x1G or 1x10G at 850 nm). As network speeds increased to 40/100G and different (proprietary) WDM techniques were introduced, the choice became more critical as some use two different wavelengths and others use four different wavelengths, rendering them inoperable with each other or with the IEEE standards-approved protocol SR4 used in parallel optics transmission.

Parallel optics transmission uses a parallel optical interface to simultaneously transmit and receive data over multiple fibers, typically used in short- to mid-reach applications. With parallel optics transmission, the 40 and 100G Ethernet interfaces are 4x10G and 4x25G channels using four fibers per direction. In other words, for 40G applications, four 10G copper traces run into the back of the QSFP transceiver, and four discrete 10G optics send light out of the front of the transceiver over eight fibers. It is this design that allows a 40G transceiver to be operated as either four discrete 10G links or one native 40G link.

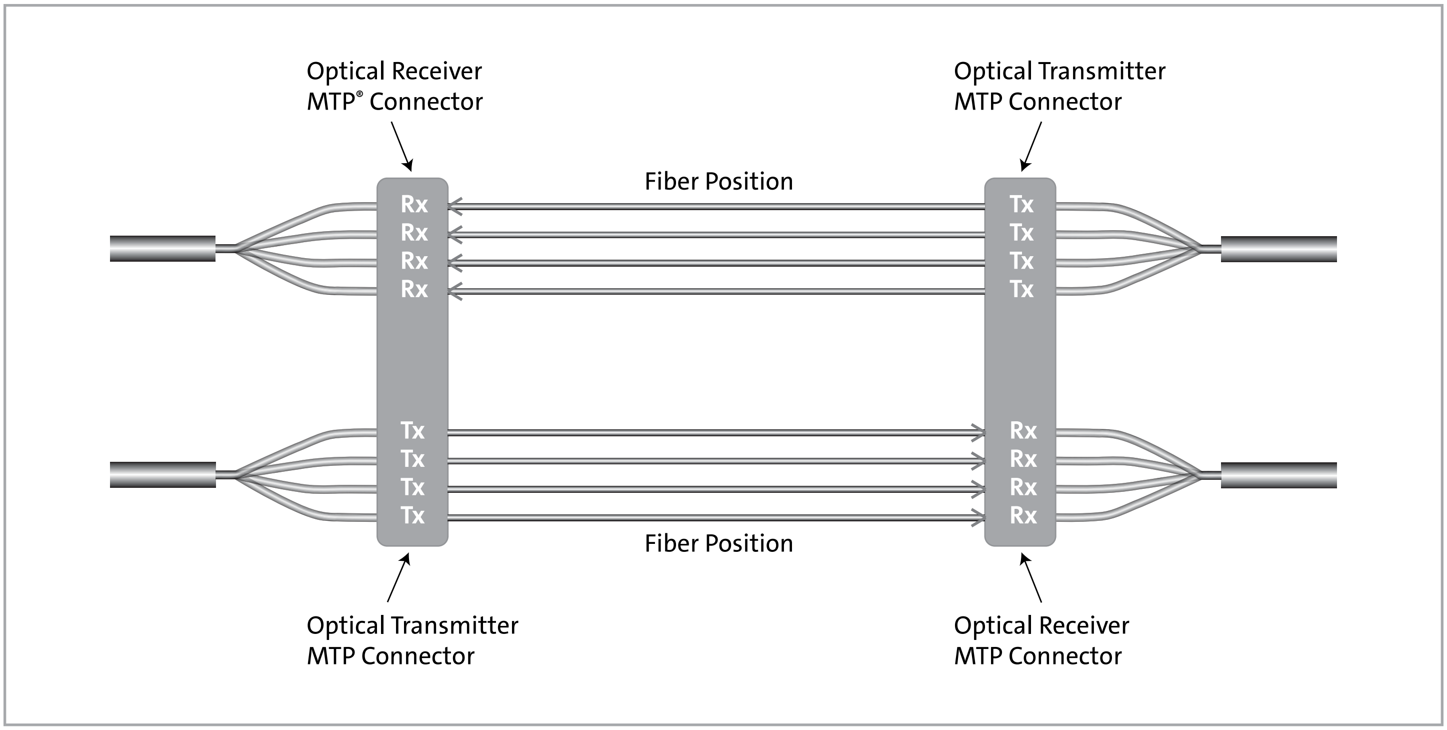

Figure 4: 40/100G Parallel Optic Transmission

Analogy: If people in cars are data packets, increasing throughput requires the addition of lanes on the highway. The speed and number of people/cars remain the same.

Wavelength-division multiplexing (WDM) transmission is a technology which multiplexes a number of optical signals onto a single fiber by using different wavelengths of laser light. This technique enables bidirectional communications over a single fiber, as well as multiplication of capacity. Typically, WDM is used in longer-reach applications where cost savings of cabling can offset the cost of more expensive transceivers.

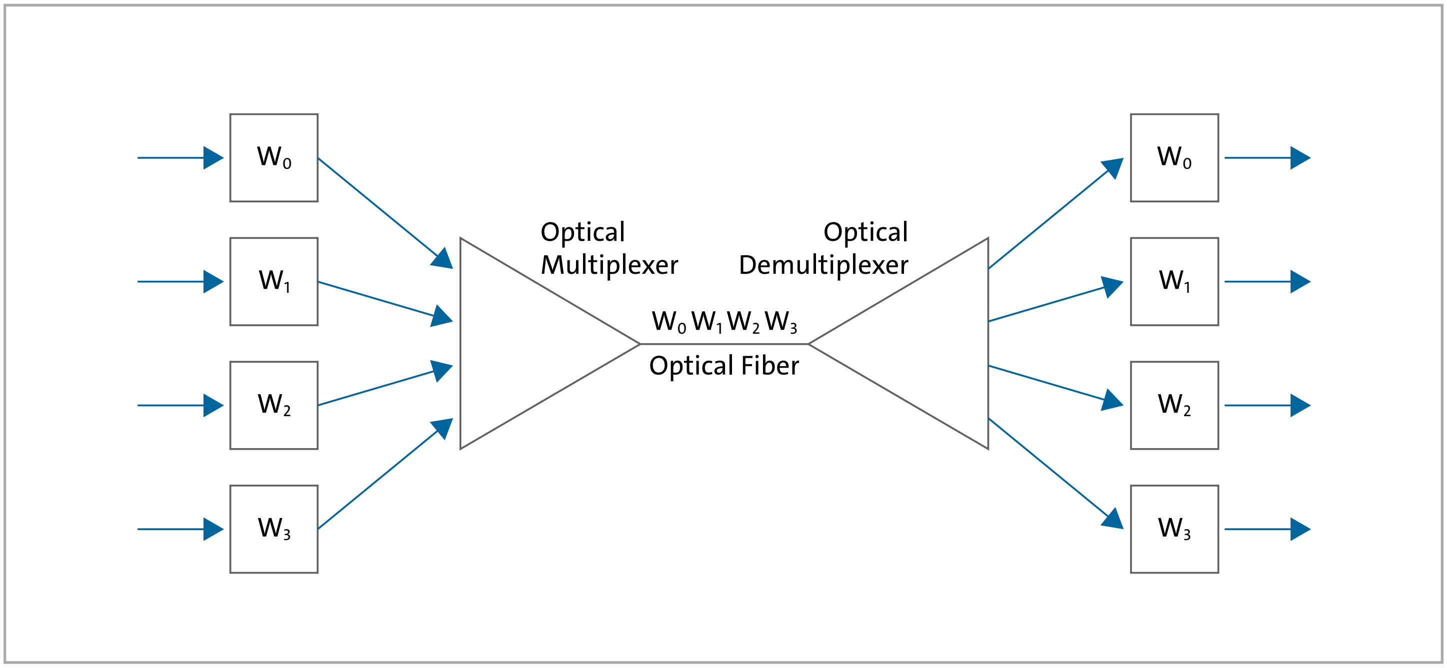

Figure 5: Wavelength-division multiplexing transmission

Analogy: If people in cars are data packets, to increase throughput, we add more people per car.

Structured Cabling

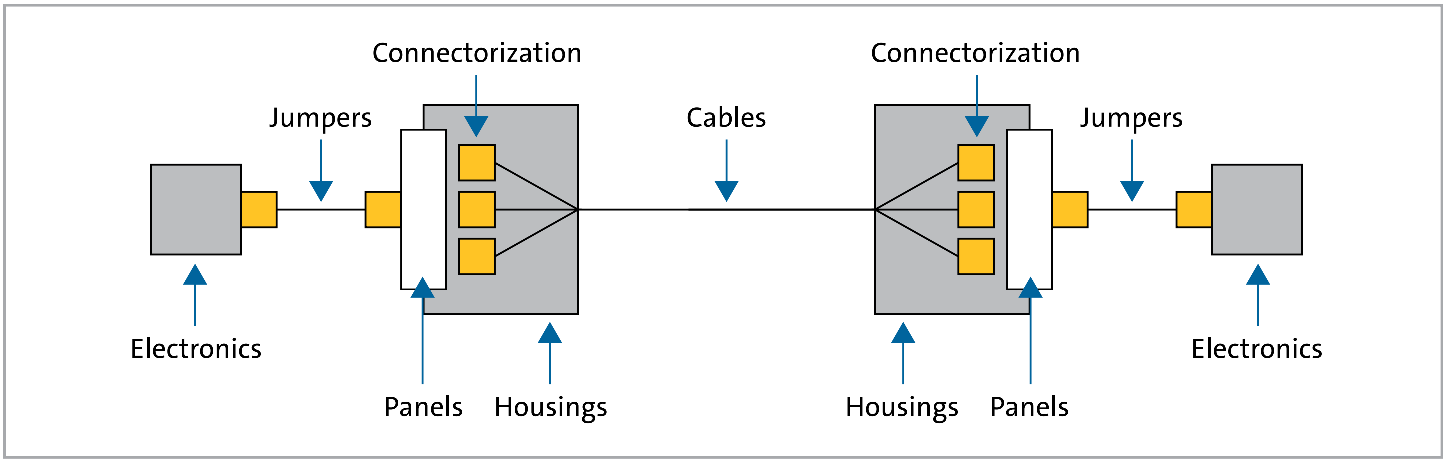

Figure 6: Structured cabling components

MTP® Connector
A connector with a QSFP footprint containing a linear array of 8 or 12 fibers.

MTP Trunk
A multifiber cable with a single outer sheath preterminated with MTP connectors on either end for backbone and horizontal networks.

MTP Jumper
Connects QSFP ports to other QSFP ports.

MTP-to-LC Harness
Breaks a QSFP port into 4 x SFP+ ports.

MTP-to-LC Module
Accepts 8-fiber trunks and presents four LC duplex connections at the front.

MTP Adapter Panel
Connects two MTP connectors together.

Port Breakout Module
Delivers the most flexible, cost-effective interconnection.

LC Jumper
Connects SFP+ ports to other SFP+ ports.

Housing

Also referred to as patch panels, these modular, single-footprint housings accept modules and adapter panels for different applications with enhanced cable management and ultra-high-density capabilities.

SFP+ Optics for 1/10G Networks

Cabling migration from 1G to 10, 40, 100, and 400G in an MTP® connector-based system is simple. Starting with 10G, an MTP cable is deployed between two 10G switches, and a module and/or an MTP panel with harness are used at the end to transition from the MTP connector to LC duplex.

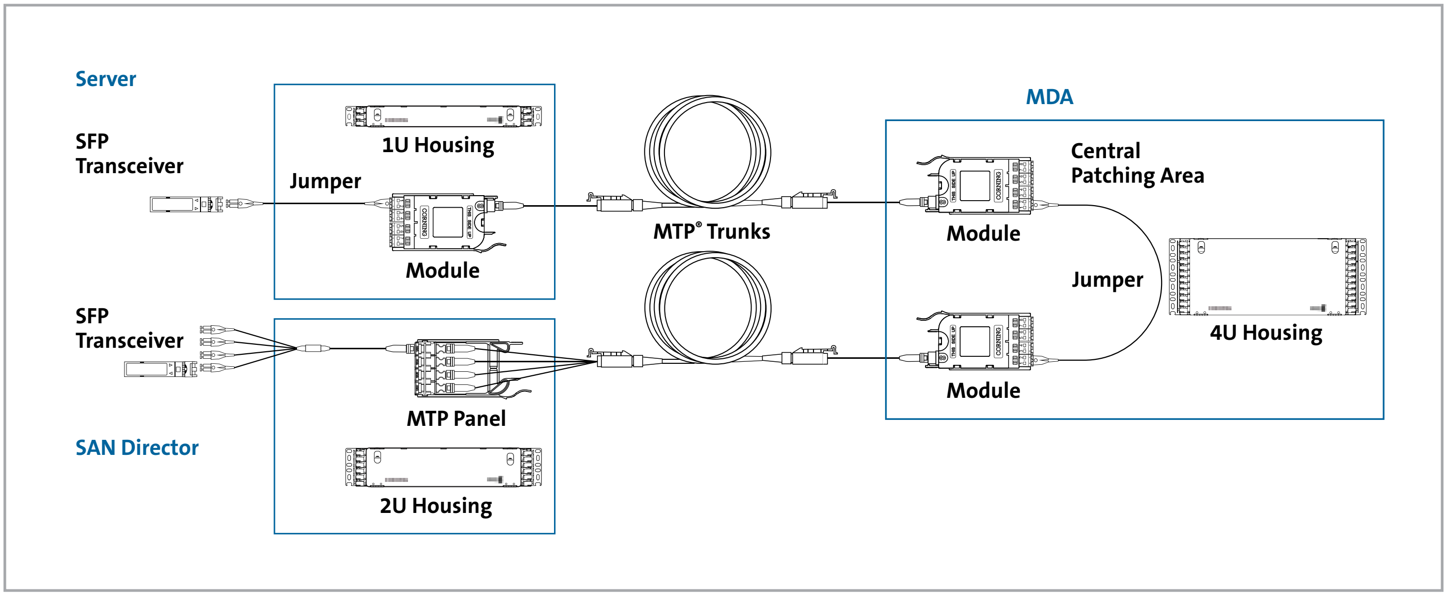

Figure 7: Structured cabling at 1/10G

Utilizing 40/100G

When the switches migrate, the module is removed and is replaced by a MTP adapter panel. Connectivity between the 40/100G switches is accomplished with an MTP jumper.

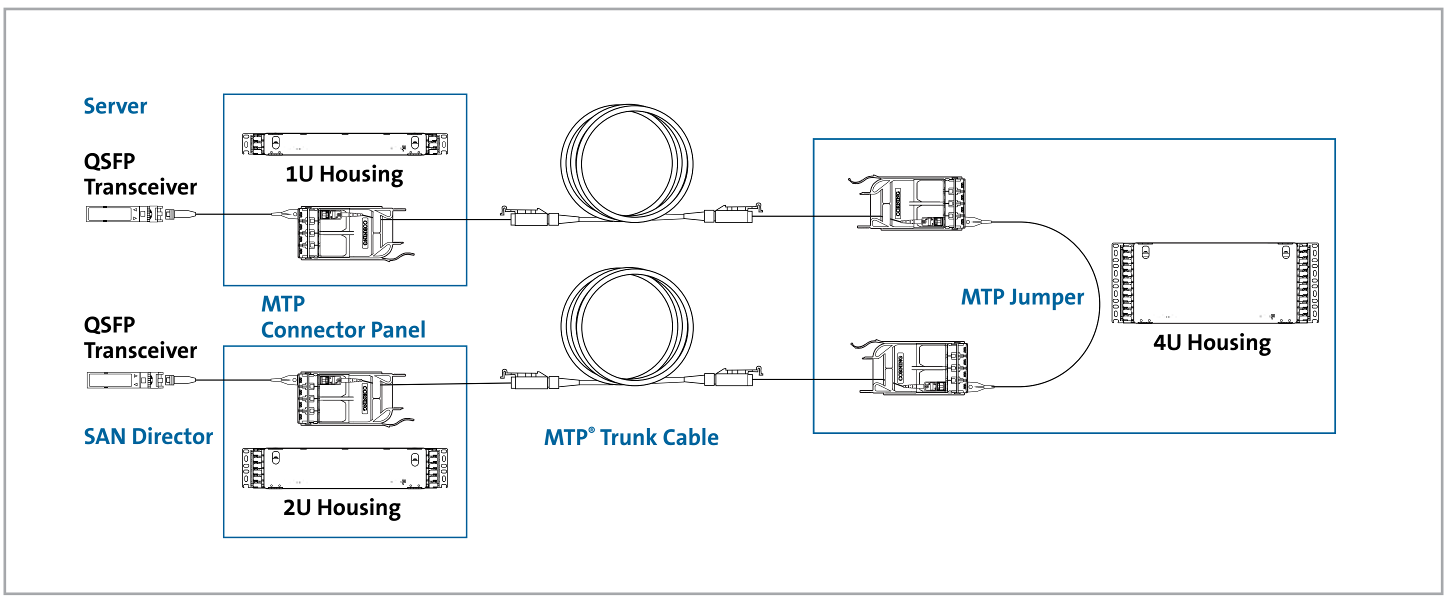

Figure 8: Structured cabling at 40/100G

The Economies of Port Breakout

Port breakout deployments have become a popular networking tool and are driving the large industry demand for parallel optics transceivers. Today, port breakout is commonly used to operate 40/100G parallel optics transceivers as four 10/25G links. Breaking out parallel ports is beneficial for multiple applications, including building large-scale spine-and-leaf networks and enabling today's high-density 10/25G networks.

Why port breakout? The first and most obvious benefit of running a 10G network over parallel ports is the density that can be achieved over a single switch line card. High-density SFP+ switch line cards are typically offered in a maximum of 48 ports. However, today you can purchase a high-density QSFP line card with 36 ports. If that line card is operated in breakout mode, each of the 40G ports can now be used as four discrete 10G ports, tripling the line card capacity to 144 10G ports on a single line card.

In addition to space savings, always critical in the data center environment, there are economic savings in both CapEx and OpEx. When it comes to CapEx, savings come through the reduction in the "cost per port to deploy" previously mentioned.
OpEx savings are achieved through:

- Reduced power from fewer line cards, chassis, and transceivers
- Improved cooling costs
- Decreased chassis maintenance and spares
- Increased density/less data center real estate

Not to mention the improved ease when it comes to network migration. Operators only need to execute higher speeds at the other end of the link – rather than a complete upgrade of all devices.

As parallel optic transceivers operate over 8 fibers, it is important to consider how to design the data center structured cabling to support breakout mode applications. Recommended designs include solutions using Base-8 MTP® connectivity for the optical infrastructure to optimize fiber utilization and port mapping. As shown below in Figures 9a, 9b, and 9c, deploying connectivity with an 8-fiber MTP connector interface allows a simple and optimized solution to break out to four LC duplex ports for patching to 10G equipment ports.

Figures 9a and 9b depict structured cabling designs where a dedicated cabling backbone is installed between the equipment with 40/100G and 10/25G ports. Figure 9a is useful when all four of the 10/25G ports are colocated in a single equipment unit, whereas the layout shown in Figure 9b is helpful with the jumpers from the structured cabling needed to reach different equipment ports within a cabinet. Figure 9c, however, offers the most flexibility for the data center structured cabling by breaking out the 40G (MTP) ports into LC duplex ports at a cross-connect location. With a cross-connect implementation in a central patching area, any 10/25G breakout port from the 40/100G switch can be patched to any piece of equipment requiring a 10/25G link.

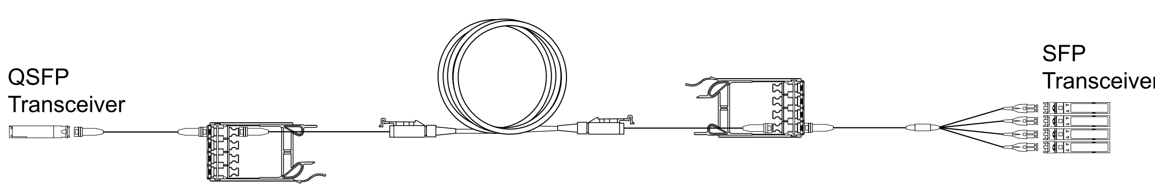

Figure 9a: System design options for port breakout applications using a panel and harness

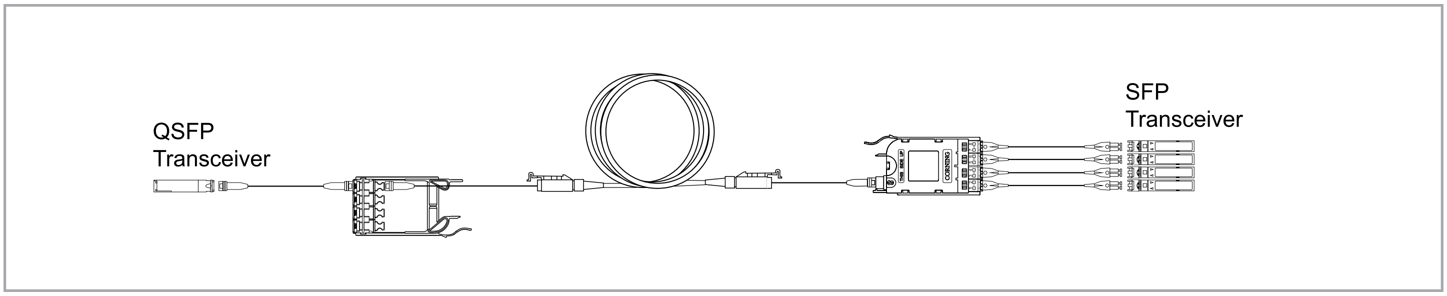

Figure 9b: System design options for port breakout applications using a connector module and jumpers

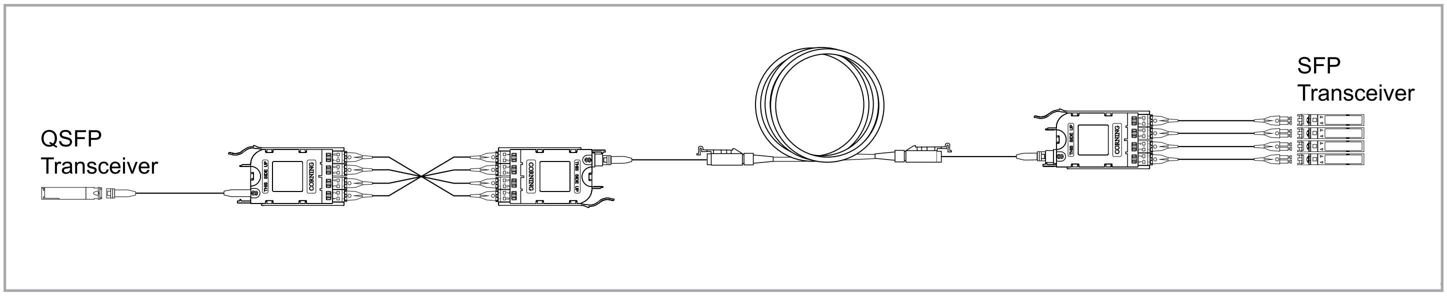

Figure 9c: System design options for port breakout applications

Scaling the Data Center to 400G and Beyond

Data center applications, networks, and optical transceivers are evolving very quickly. The timeline for migration is different for every data center, depending on technology needs, budget, size, and organizational priority. Educating yourself on 100/400G and even 800G, evaluating your current cabling infrastructure, and beginning plans for implementation will ensure a smooth, trouble-free migration. We will be here to help you with every step.

Glossary of Terms

Base-2	Data center backbone and horizontal structured cabling using 2 fibers
Base-8	Data center backbone and horizontal structured cabling using 8 fibers
Bidirectional (BiDi)	Proprietary network transmission protocol using 2x20G lanes at two different wavelengths
CapEx	Capital expenditures, the costs of the materials to build the business or network
Cross-Connect	Structured cabling where jumpers attach to different cabling hardware to link network devices together
CWDM	Coarse wavelength division multiplexing
Direct Connect	Direct connection between two network devices using a jumper or harness
DR	Data center reach
eSR	Extended short reach
FR	Fiber reach
IEEE	Institute of Electrical and Electronics Engineers
Interconnect	Structured cabling hardware used to connect backbone or horizontal cables
Line Card	Multiple line cards are installed in Chassis to provide higher density networks than individual switches
LR	Long reach
LRL	Mid reach
Migration	Increase of network speed, i.e. from 10 to 40G
OpEx	Operating expenditures, the costs to run the business or network
Parallel Optics	Network transmission protocol using 8 (SR4), 16 (SR8), 20 (SR10), or 32(SR16) fiber pairs
PLR	Parallel long reach
PMD	Physical media dependent
PSM	Parallel single-mode
Port Breakout	Breaks 40/100G ports into 4x10/25G ports
Port Disaggregation	Breaks 40/100G ports into 4x10/25G ports
QSFP	Quad small-form-factor pluggable, a type of transceiver
Serial	Network transmission protocol using a single pair of fibers
Server	Network device that hosts the different applications used across the network
SFP+	Small-form-factor pluggable, a type of receiver

Glossary of Terms (continued)

Spine and Leaf	Two-tier network comprising of spine switches and leaf switches
SR	Short reach
Storage	Network device that records and stores data
Structured Cabling	A series of cabling components to connect network devices
SWDM	Short wavelength division multiplexing
Switch	Network device that transmits application data from the servers across the network
Transceiver	Optical transmitter and receiver used in switches and servers to connect to the network
UNIV (Universal)	Proprietary network transmission protocol using 4x10G lanes at four different wavelengths
WDM	Wavelength division multiplexing

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