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White Paper

Cabling Strategies for 400 Gigabit Networks

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Table of Contents

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400 Gb/s Has Arrived

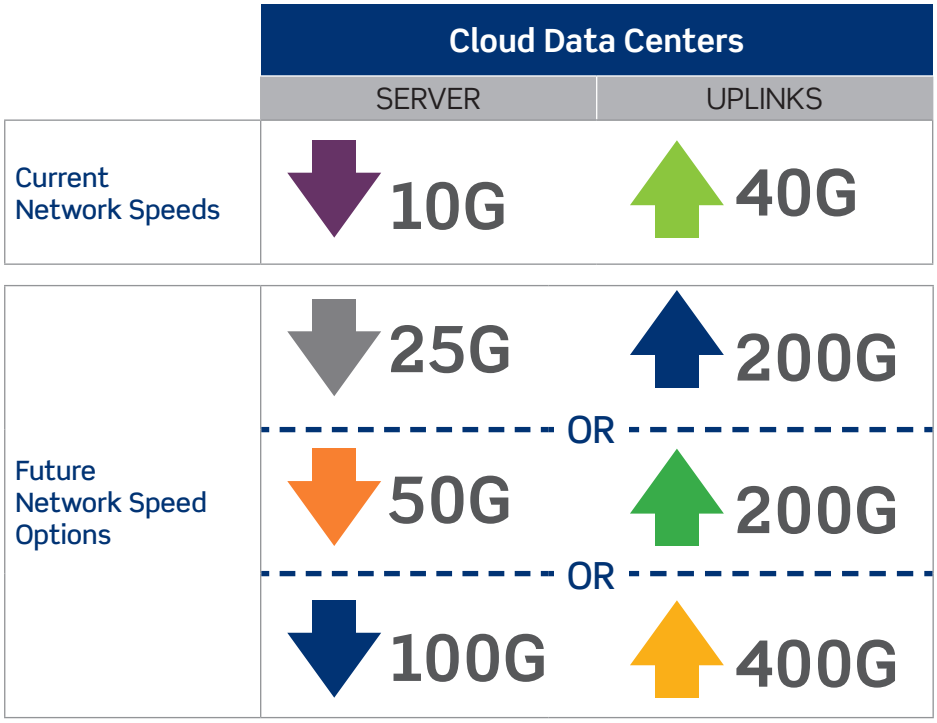
As 400 Gb/s switch options entered the market only recently — introduced by manufacturers in late 2018 and early 2019 — adoption has yet to take off. However, many expect 400 Gb/s to see real adoption in 2020, and data center market analyst Dell'Oro expects 400 Gb/s shipments to reach 15 million ports by 2023.

The draw? The new 400 Gb/s switches — based on 12.8 Tb/s chips — bring not only much faster speeds but greater network density. The ability for switches to enable high density breakout scenarios with 100 Gb/s ports translates into a lower total cost of ownership per port.

Transceiver shipments of 100 GbE have grown much faster than expected. The most popular options have been 100G-CWDM4, a single-mode two-fiber solution with a two-kilometer reach, and 100G-SR4, a 100-meter multimode solution. These options will continue to see strong adoption in the next several years, but 100 Gb/s ports are expected to peak in 2020 or 2021 and make way for 400 Gb/s switches, according to a 2019 Ethernet Switch - Data Center Five Year Forecast Report from The Dell'Oro Group.

While new 400 Gb/s switches come at a significant cost, they will likely drop in price as early adopters in the cloud service provider and telecom industries purchase more 400 Gb/s switches over the next several years. Those cloud providers continue to gobble up more of the data center space, as large players such as Amazon Web Services (AWS), Microsoft Azure, Google, and IBM are predicted to make up half of all data center servers by 2021, according to the Cisco Global Cloud Index. These data centers are moving to 100, 200, and 400 Gb/s uplinks now or in the near future.

Current vs. Future Network Configurations



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New 400 Gb/s transceiver form factors

There are two major transceiver form factors for 400 Gb/s: QSFP-DD and OSFP. Various switch manufacturers are offering one or the other, and in some cases both. The QSFP-DD (Quad small form-factor pluggable, double density) transceiver can support up to 32 ports in a 1RU switch, and is backwards compatible to QSFP+ and QSFP28 options. The transceiver accepts LC, MPO, and CS connectors.

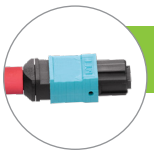
The OSFP (Octal Small Form-Factor Pluggable) can also support up to 32 ports and accepts the same connector types, and can become backwards compatible with QSFP ports with the use of an adapter. It has been designed to handle future generations, such as 800 Gb/s.

The first 400 Gb/s switches on the market come from Arista, Cisco, and Juniper. Arista 7060 top-of-rack switches offer 32 ports of 400 Gb/s in 1RU, using either QSFP-DD or OSFP transceiver options. The Cisco 3432 top-of-rack switch also offers 32 ports of 400 Gb/s in 1RU, using QSFP-DD transceivers. In addition, its 3408 switch provides a 4RU 8-slot chassis option. The Juniper QFX5220-32D 1RU Top-of-Rack switch also offers 32 ports with QSFP-DD transceivers.

Transceiver Options for 200 and 400 Gb/s

One variable yet to be resolved is the number of fiber strands used to deliver 400 Gb/s. Currently, switch manufacturers have plans for connectors with 2, 8, 16, 24, and even 32 fibers. Given how quickly the market is responding to higher speeds — and how measured standards bodies can be — some of the options introduced are proprietary or based on multisource agreements (MSAs). Between proprietary and standards-based offerings, there are now a range of options, but a few favorites are emerging.

The latest transceivers for 200 and 400 Gb/s introduce several new terms that indicate the number of channels and fiber modes: SR8, DR4, and FR4. The “SR” suffix denotes short reach (100 meter) multimode, with “8” indicating 8 optical channels. The “DR” refers to a 500-meter reach, with “4” for 4 optical channels. The “FR” denotes a 2-kilometer reach, with the “4” for 4 optical channels.

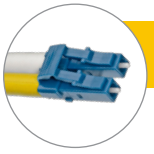


SR8 100m reach

8 optical channels (16 total MM fibers-MPO). Each channel operates at 50Gb/s.

DR4 500m reach

4 optical channels (8 total SM fibers-MPO). Each channel operates at 100Gb/s.



FR4 2km reach

4 optical channels multiplexed onto 1 pair (2 total SM fibers-LC). Each channel operates at 100Gb/s.

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With 200 Gb/s transceiver options, only two are available on the market today: 2x100-PSM4 single-mode and 2x100-SR4 multimode, as highlighted in Figure 1 below. These are proprietary options introduced by Cisco, and they both rely on 24-fiber MTP connectors. While transceiver options using two LC fibers or 8-fiber MTP connectors (1, 2, and 4 below) are defined in IEEE standards, they have not yet been introduced to the market.

Figure 1:

200G Transceivers

	200G Transceiver	STD	MFR	Form Factor	Breakout Option	Fiber Type	Distance (meters)	# of fibers	Connector
1	200G-FR4	IEEE	None	TBD	No	OS2	2,000	2	LC
2	200G-DR4	IEEE	None	TBD	Yes	OS2	500	8	12F MTP
3	**2X100-PSM4**	**Prop.**	**Cisco**	**QSFP-DD**	**Yes**	**OS2**	**500**	**24**	**24F MTP**
4	200G-SR4	IEEE	None	TBD	Yes	OM3/OM4/OM5	70/100/100	8	12F MTP
5	**2X100-SR4**	**Prop.**	**Cisco**	**QSFP-DD**	**Yes**	**OM3/OM4/OM5**	**70/100/100**	**24**	**24F MTP**
6	2x100G-CWDM4	Prop.	Cisco	QSFP-DD	Yes	OS2	2,000	4	CS

The transceivers circled in Figure 2 below (rows 1, 2, and 5) highlight the options likely to become the most common over the next several years. Both 400G-FR4 and 400G-SR4.2, originally introduced MSA between manufacturers, are currently in development by IEEE. 400G-FR4 is being drafted under IEEE P802.3cu and is expected to be published in late 2020, while 400G-SR4.2 will be defined by IEEE P802.3cm, with a target publication date of January 2020. The 400G-SR4.2 transceiver specification created by the 400G BiDi MSA is called 400G-BD4.2. Other 400 Gb/s transceivers not mentioned on this list include interfaces under development that will reach beyond 10 kilometers.

Figure 2:

400G Transceivers

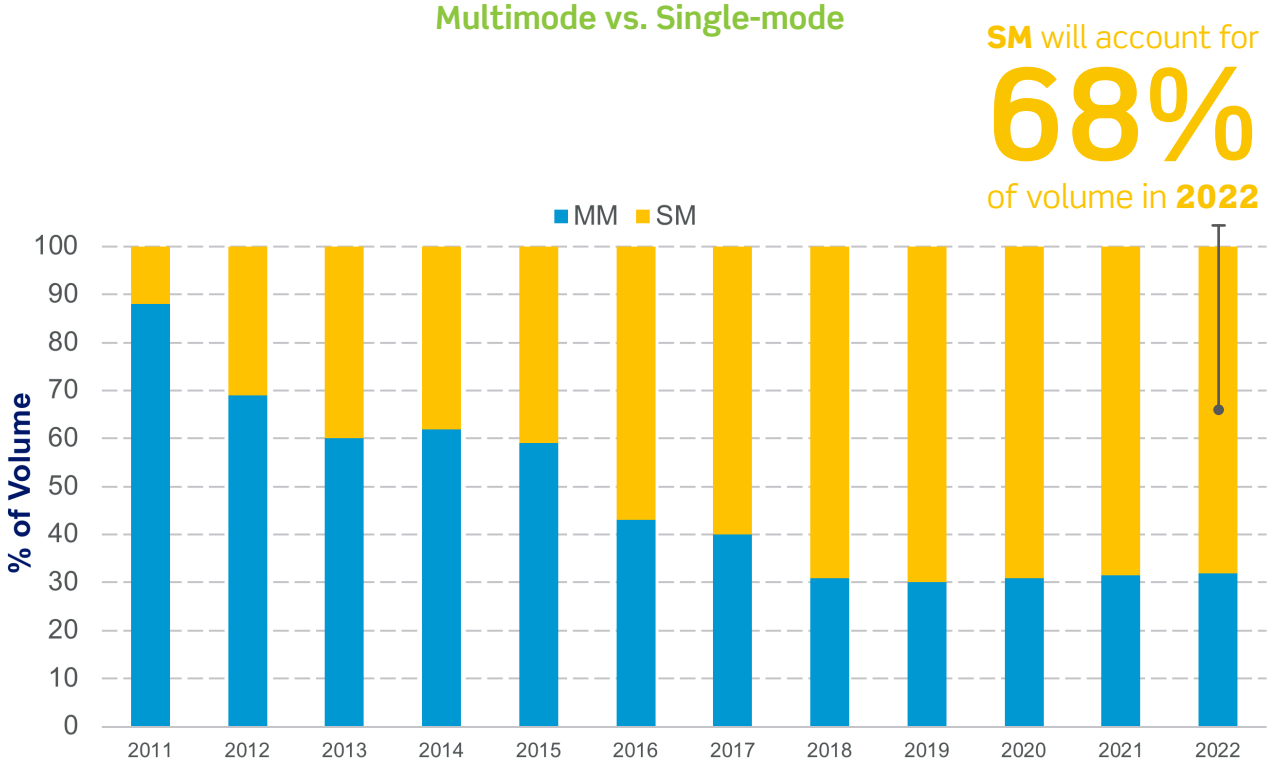
	400G Transceiver	STD	MFR	Form Factor	Breakout Option	Fiber Type	Distance (meters)	# of fibers	Connector
1	**400G-FR4**	**IEEE/ MSA**	**Arista, Cisco, Juniper**	**QSFP-DD, OSFP**	**No**	**OS2**	**2,000**	**2**	**LC**
2	**400G-DR4**	**IEEE**	**Arista, Cisco, Juniper**	**QSFP-DD, OSFP**	**Yes**	**OS2**	**500**	**8**	**12F MTP**
3	400G-XDR4 (DR4+)	Prop.	Arista, Juniper	QSFP-DD, OSFP	Yes	OS2	2,000	8	12F MTP
4	400G-SR8	IEEE	Arista	OSFP	Yes	OM3/OM4/OM5	70/100/100	16	16F/24F MTP
5	**400G-SR4.2 (BD)**	**IEEE/ MSA**	**Cisco**	**QSFP-DD**	**Yes**	**OM3/OM4/OM5**	**70/100/150**	**8**	**12F MTP**
6	400G-2FR4	Prop.	Arista	QSFP-DD	Yes	OS2	2,000	4	CS

Note: List does not include long reach (10 km) options.

It is important to note that the majority of 100, 200 and 400 Gb/s transceiver options are for single-mode networks, due to the bandwidth and distance capabilities. This trend is also partially a result of decreasing cost — as adoption by cloud companies with major purchasing power have reduced the cost of single-mode optics — and recent standards committee activities continuing to promote more single-mode options for higher speeds. As this trend continues, the market in general will find single-mode to be a more enticing option. Market research from Lightcounting forecasts that single-mode will account for 68% of transceiver volume through 2022, as shown in Figure 3.

Similarly, a Leviton customer poll from mid 2019 found that 45% said they would use existing or new multimode cabling for 40, 100, 200, or 400 Gb/s, while 55% said they would use existing or new single-mode structured cabling.

Figure 3:
Multimode vs. Single-mode



Source: LightCounting, Sept. 2017

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200 and 400 Gb/s use cases and cabling strategies

There are numerous design factors that shape the makeup of a cabling infrastructure for 200 and 400 Gb/s networks. These may include whether the data center is an enterprise or cloud provider (although in the majority of cases it will be a cloud provider moving to 400 Gb/s). Others include reach requirements and existing server speeds, and the cost per channel. Power levels can be a factor: the 400 Gigabit optics are in the 10-12 watt range, about three times that of 100 Gigabit optics. Finally, channel insertion loss budgets are an important consideration. The typical single-mode budget will be between 3.0 to 4.0 dB, while the typical OM4 budget will remain at 1.9 dB.

Looking at switch-to-switch cabling scenarios, a two-fiber single-mode channel as shown in Figure 4 below delivers 400 Gb/s in the form of 400G-FR4 and 400G-FR8, using QSFP-DD or OSFP transceivers. This is a very versatile cabling design, as it can also support 10, 40, 100, and 200 Gb/s, using or reusing a backbone of 24-fiber MTP trunk cabling. Leviton was the first to introduce this cable configuration in 2010, initially over multimode for 100 Gb/s networks

Figure 4:

400G: Switch-to-Switch Use Case

2-fiber Single-Mode Configuration (10/40/100/200/400G) with 400G FR4

The configuration in Figure 5 can also use the same cabling to support 10 through 400 Gb/s over single-mode, supporting 400G-DR4 or 400G-XDR4. This configuration delivers 400 Gb/s over 4 pairs using short wavelength multiplexing. Once again, the 24-fiber backbone connections are present, and use conversion cassettes to break into 8-fiber array cords to the transceivers. This approach allows for 100% fiber utilization.

Figure 5:

400G: Switch-to-Switch Use Case

8-fiber SM Configuration (10/40/100/200/400G) with DR4

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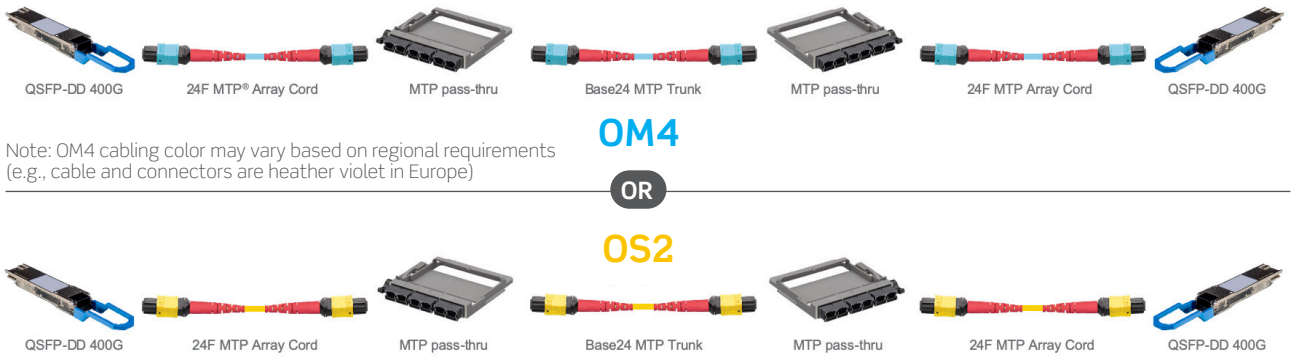
Two designs for supporting both 200 Gb/s and 400 Gb/s can be found in Figure 6 — one using multimode and one using single-mode. The multimode configuration supports 400G-SR8 or 2x100SR4, over either 16 or 24 fibers as allowed by IEEE standards. The single-mode version supports 2x100PSM4. All of these scenarios require a 24-fiber MPO/MTP® connection at the transceiver, and only require a passthrough MPO/MTP adapter to the backbone cabling. Once again, the 24-fiber backbone creates flexibility in the network design.

Figure 6:

200 or 400G: Switch-to-Switch Use Case

16/24-fiber SM or MM Channel Configuration (200/400G) with SR8 or 2x100



Breakout Use Cases

While there are many scenarios for breaking out channels, the following are currently the most common examples. When breaking 400 Gb/s down to four 100 Gb/s channels when using 400G-DR4 or 400G-XDR4 single-mode, the Figure 7 configuration breaks out to duplex LCs to QSFP28 transceivers at the server.

Figure 7:

400G to 4x100G Breakout Use Case

8-fiber Single-Mode Channel Breakout Configuration with 400G-DR4/XDR4

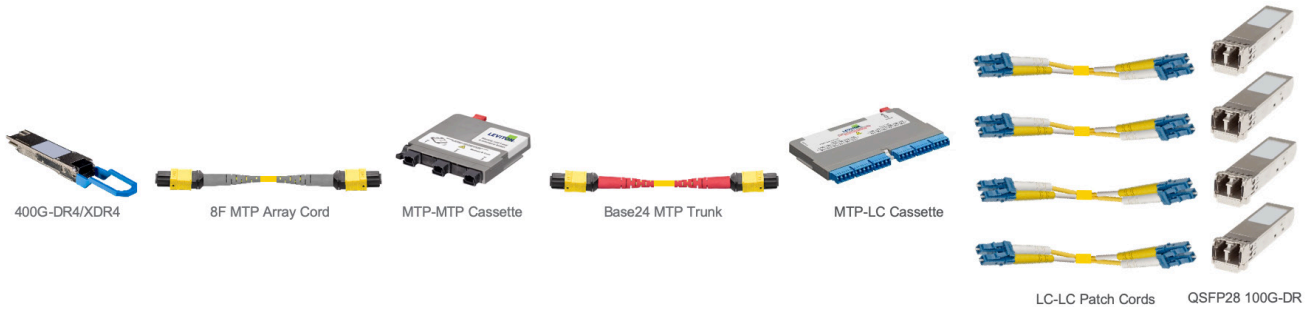


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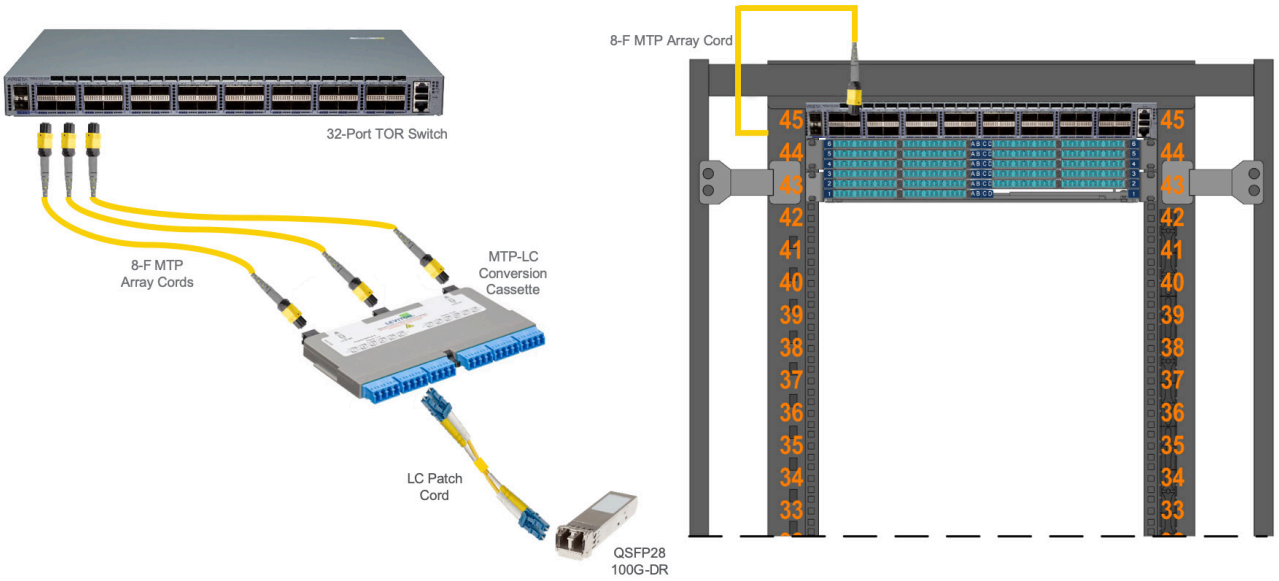
Figure 8 shows breaking out 400 Gb/s to 100 Gb/s from a 32-port Top-of-Rack (ToR) switch. In this configuration, 8-fiber array cords connect in the back of MTP-LC cassettes, and break out to 100 Gb/s transceivers at the server. This set-up takes up two rack units to support 128 100 Gb/s ports.

Figure 8:

Patching Solution for ToR with 100G Breakout Use Case

128 x 100G Ports, 2RU of Rack Space



The Figure 9 breakout is used for a 200 Gb/s network introduced by Cisco. The channel uses 2x100-PSM4 transceivers at the switch that requires a 24-fiber MPO/MTP connection. This example retains the 24-fiber MTP backbone trunking, and breaks out to eight 25 Gb/s SFP28 transceivers over duplex LC patch cords. This is an attractive option to lower the cost of 25 Gb/s lanes. Cisco also introduced the same option for multimode using 2x100-SR4 transceivers, which also converts a 24-fiber channel into 8 duplex fiber channels.

Figure 9:

200G to 8x25G Breakout Use Case

24-fiber Single-Mode Channel B/O configuration with 2x100-PSM4

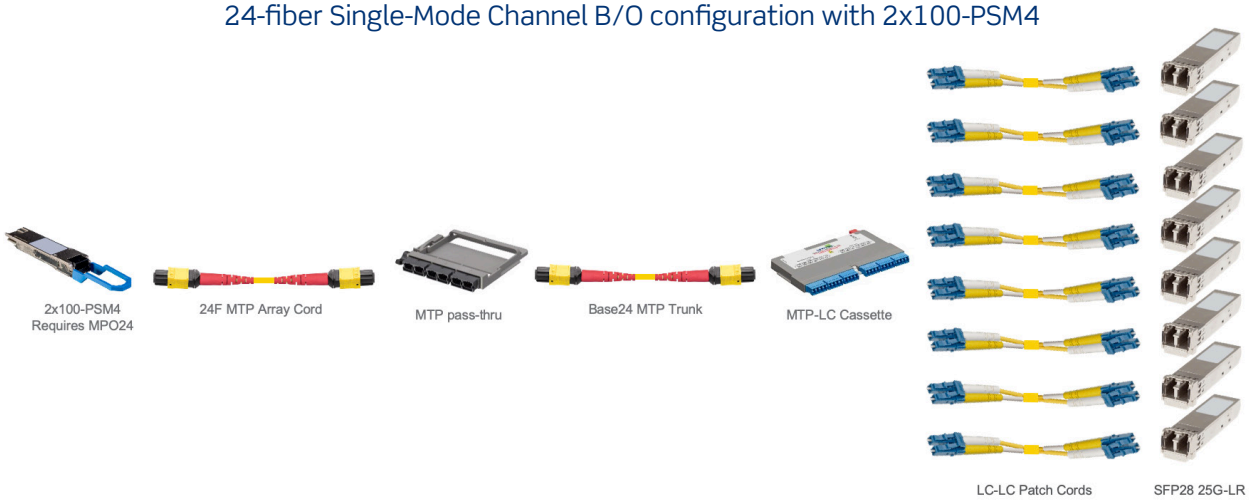


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Figure 10 shows a four-fiber single-mode channel using a new high density CS connector interface. The CS connector is a small push pull plug with two LC type ferrules. Its small size allows two CS connectors to fit in a standard LC duplex footprint or into a QSFP-DD transceiver port. Based on its inclusion in the QSFP-DD MSA, the TIA is currently developing a standard for the CS connector. This option creates 2x100G channels for OSFP transceivers, and then breaks out to duplex LCs to QSFP28 transceivers at the server.

Figure 10:

200G to 2x100G Breakout Use Case

24-fiber Single-Mode Channel B/O configuration with 2x100-PSM4

Choosing a forward-looking migration path

With so many transceiver options for 100, 200, and 400 Gb/s in both single-mode and multimode, it is important to plan for a cabling design that can handle multiple tech refreshes. Leviton's single-mode and multimode cabling systems not only meet current bandwidth requirements, but also provide the flexibility needed to meet future network demands, including 100G, 400G, and beyond. These systems include high density patching, solutions for fast deployment, and customizable trunks and cable assemblies that give data center managers the exact solution they need, delivered fast.

The Opt-X™ Unity Fiber Migration System is a single, simple connectivity solution that reduces cost and saves time by reusing the fiber backbone. This makes it easy to migrate from 10 to 40, 100, 200 and 400 Gb/s networks while increasing the frequency of tech refreshes, reducing labor and minimizing network downtime. The system components are available in multimode and single-mode systems (OM3/OM4/OS2), and feature industry-leading 24-fiber MTP® connectors.

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Today's networks must be fast and reliable, with the flexibility to handle ever-increasing data demands. Leviton can help expand your network possibilities and prepare you for the future. Our end-to-end cabling systems feature robust construction that reduces downtime, and performance that exceeds standards. We offer quick-ship make-to-order solutions from our US and UK factories. We even invent new products for customers when the product they need is not available. All of this adds up to the **highest return** on **infrastructure investment**.

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