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White Paper

Navigating Cabling Options for Enterprise and Cloud Data Centers

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Table of Contents

Data centers are rapidly evolving to address rising volumes of network traffic. Faced with increasing bandwidth demand and the need to adapt and scale quickly, many organizations with small or medium data centers have moved to cloud service providers or have outsourced to colocation facilities. In addition, many large enterprise data centers with traditional three-tier architectures are changing to "flatter" leaf-spine architectures, creating lower latency and more scalable designs. As these data centers adapt, one trend has become clear: while both cloud data centers and large enterprise data centers invest heavily in next-generation network infrastructure, they deploy different types of optics and cabling systems.

For the purpose of this article, we define the size of a data center by the number of servers or switches it hosts. A cloud data center generally has upwards of 100,000 or more servers, while a large enterprise data center will has around 10,000 or more servers. Small-to-medium data centers may have 500 servers or less.

Types of Cloud Data Centers

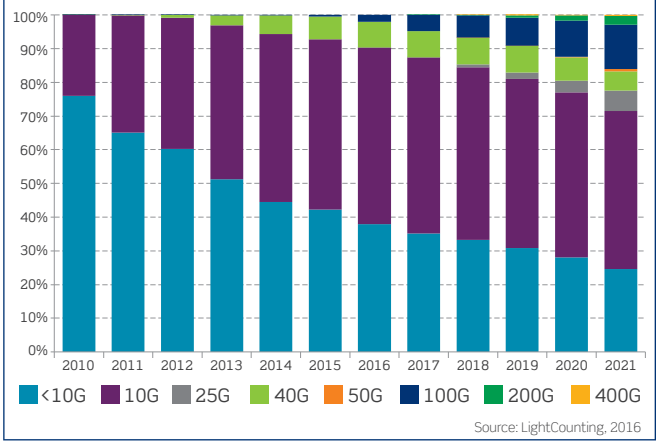
It is important to briefly recognize the four major areas of the cloud market: community, public, private, and hybrid. These segments have different requirements when it comes to bandwidth growth and how big they need to scale.

- A **community cloud** network is used exclusively by several organizations with a shared interest. It is typically hosted externally by a third party, but is sometimes hosted by an organization that is part of the community.
- A **public cloud** is the most common type of cloud infrastructure. It is for open use by a hosting company which operates the data center, with the most popular hosts being Amazon Web Services, Microsoft Azure, Google, IBM, and Salesforce.
- **Private clouds** are provisioned exclusively for a single organization. It can be externally hosted but is often internally hosted. A common example of a private cloud is a government application.
- A **hybrid cloud** is any combination of a private/community or a private/public. A good example of this is a financial organization who might use a public cloud like Salesforce for its CRM applications, while using a private cloud for its strategic assets.

Trends in Network Speeds

Today, while 10 Gb/s transceiver modules make up a large portion of the market, 100 Gb/s is starting to make a big move, as shown in **Figure 1**. 40 Gb/s transceivers will remain strong over the next several years, but the strongest growth will come from 100 Gb/s, driven by cloud environments. By 2018, eight speeds will be available on the market, including 200G and 400G. This is an unprecedented number of options that data center managers will need to evaluate and design their networks to support.

Figure 1: Transceiver Modules by Speed, Percent of Total



Source: LightCounting, 2016

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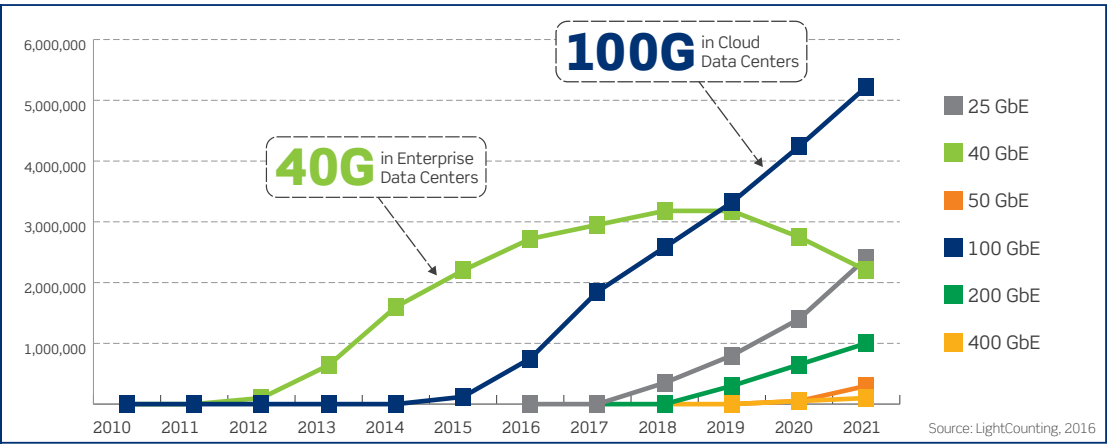
Narrowing to transceiver trends at 25 Gb/s or higher, **Figure 2** shows how 40 Gb/s adoption will begin to flatten out in the next two years. Interestingly, 25 Gb/s transceiver shipments will grow in parallel with 100 Gb/s. These two rates are related, and their parallel growth is largely the result of the 2015 IEEE802.3bm standard defining 100G-SR4, allowing for 100 Gb/s using four 25 Gb/s lanes over an 8-fiber MTP® connection.

Figure 2: Transceiver Shipments of 25 Gb/s and Greater



These 25 Gb/s lanes enable the next wave of high-speed networking, as more data center tech refreshes will include 100 Gb/s uplinks at the switch, and 25 Gb/s down to the server. The majority of these lanes — around 75 percent — will use 4-fiber or 8-fiber MPO/MTP connections for short-reach applications at 500 meters or less. Long-reach applications over single-mode largely use an LC interface over two fibers.

One other option is a 16-lane connection that delivers 25 Gb/s over each lane for 400 Gb/s transceivers (400GBASE-SR16). This option, included in IEEE 802.3bs, requires a 32-fiber MTP connector and will have the option to use OM5. It is expected to see little deployment, as the industry-wide move to single-mode will likely leapfrog this technology. **Figure 3** shows new and upcoming technologies using the 25 Gb/s lane ecosystem, along with their fiber count, connector type, and maximum reach. It is important to note that five of the eight options listed are using single-mode fiber for next generation switch port technology. In addition, there are five more solutions under development by IEEE that define a 50 Gb/s lane ecosystem, and the majority of these also rely on single-mode solutions. Since the majority of these next-generation technologies will use single-mode fiber, there will be little need to install a new multimode fiber like OM5.

Figure 3: Developing Technologies Using 25 Gb/s Lanes

Rate	Fiber Type	# Fibers	Connector	Reach	IEEE Std	Est. Release
100GBASE-SR4	OM4	8	MPO	70m	802.3bm	April-15
100GBASE-SR2	OM4	4	MPO	100m	802.3cd	Sep-18
100GBASE-DR2	OS2	4	MPO	500m	802.3cd	Sep-18
100GBASE-FR2	OS2	2	LC	2km	802.3cd	Sep-18
200GBASE-DR4	OS2	8	MPO	500m	802.3bs	Dec-17
200GBASE-FR4	OS2	2	LC	2km	802.3bs	Dec-17
400GBASE-SR16	OM4 / OM5	32	MPO	100m	802.3bs	Dec-17
400GBASE-FR8	OS2	2	LC	2km	802.3bs	Dec-17

Since the majority of these next generation technologies will use single-mode fiber, there will be **little need to install a new multimode fiber like OM5.**

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Enterprise Versus Cloud Network Trends

Current enterprise data centers primarily use 10 Gb/s switches and 1 Gb/s servers. These networks are migrating to 25 or 40 Gb/s uplinks and 10 Gb/s servers.

Cloud networks have operated at 40 Gb/s uplinks and 10 Gb/s at the server for the past several years. As pointed out earlier, these networks will move to 100 Gb/s uplinks and 25 Gb/s at the server. We can also expect future migrations to 200 and 400 Gb/s uplinks and 50 and 100 Gb/s at the server. When comparing optical fiber systems for these higher speeds, cloud service providers are increasingly adopting single-mode over multimode systems.

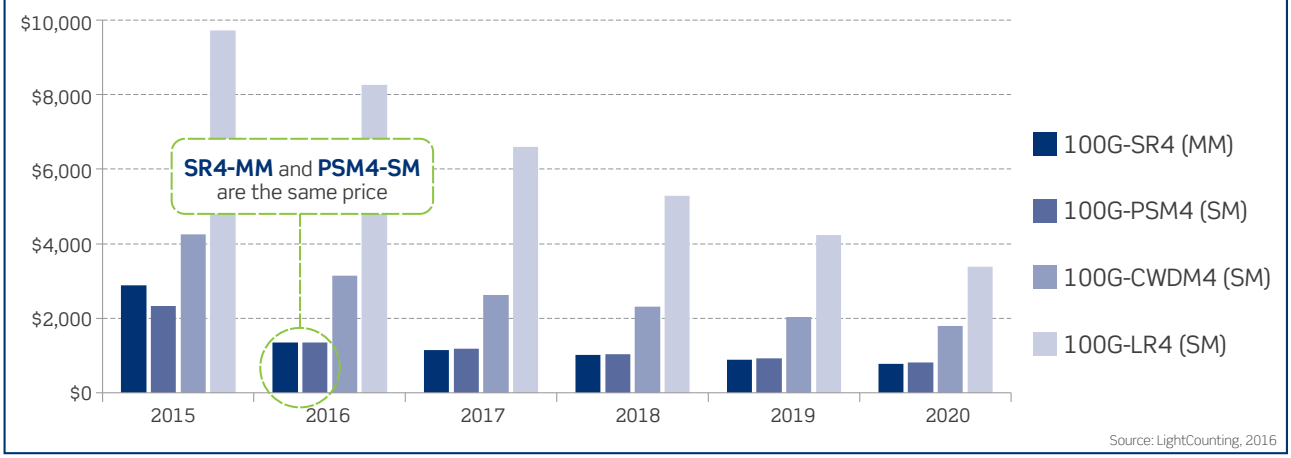
In 2016, Microsoft Azure, a market leader in cloud services, moved the vast majority of its data center fiber cabling to single-mode. In fact, Microsoft is now 99 percent single-mode, using parallel single-mode with MTP® connections more than any other fiber type. Also, Facebook has undergone efforts to shorten their data center cable links to 500 meters or less. Actions like these from companies with such major purchasing power have reduced the cost of single-mode optics to the point where the cost for 100 Gb/s single-mode optics dropped tenfold over the past two years, bringing it in line with multimode fiber.

Current vs. Future Network Configurations

	Enterprise Data Centers		Cloud Data Centers	
	SERVER	UPLINKS	SERVER	UPLINKS
Current Network Speeds	1G	10G	10G	40G
Future Network Speed Options	10G	40G	25G	100G
	OR		OR	
	10G	25G	50G	200G
			OR	
			100G	400G

As this trend continues, the market in general will find single-mode a more enticing option. For example, 100G-PSM4 single-mode technology, created in 2014 by a multi-source agreement group, is currently the same price as 100G-SR4 multimode transceivers, as shown in the **Figure 4** below. PSM4 transceivers were specifically designed as a low-cost option for 500 meters or less, using an 8-fiber MPO/MTP connection. Just as important, the price for long-reach single-mode solutions such as 100G-LR4 has dropped and will continue to drop over the next several years.

Figure 4: Estimated Prices for 100 Gb/s Transceivers



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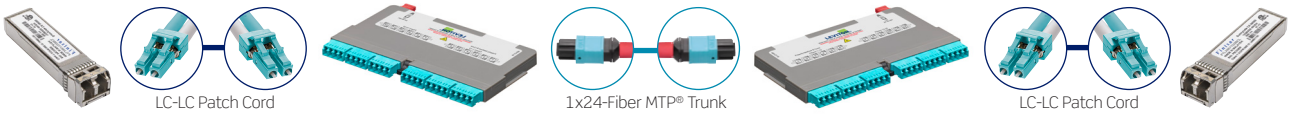
Flexible Enterprise Network Migration

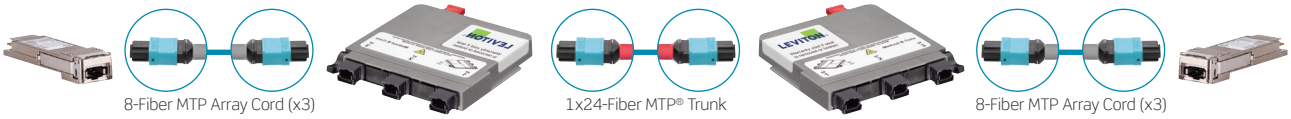
The majority of enterprise data centers already have multimode cabling installed, and 85% of these optic links are 150 meters or less. As mentioned earlier, most of today's enterprise data center applications use 1 Gb/s down to the server, with 10 Gb/s uplinks. With over 12 different 40 Gb/s transceiver options and 10 different 100 Gb/s transceiver options available on the market, infrastructure engineers must design their networks to be flexible and able to support any of these potential topologies. Below are some ideal migration paths for enterprise data centers to take advantage of existing multimode cabling while moving to 10, 40, and 100 Gb/s in the future.

Multimode 10 or 40 Gb/s Duplex Channel



Using a 24-fiber trunk cable backbone and LC patching, data centers can support 1 and 10 Gb/s in SFP+ form factors. This exact cabling design — including trunks, cassettes, and patch cords — also supports 40 Gb/s when using Wave Division Multiplexing (WDM) technology, such as Cisco or Arista QSFP+ 40 Gb/s Bi-Directional (BiDi) transceivers.

Multimode 40G-SR4 or 100G-SR4 Channel

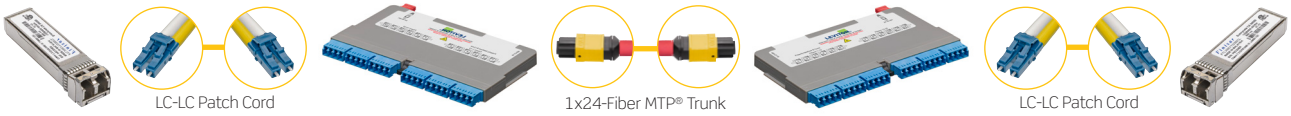


When migrating to a 40GBASE-SR4 or 100G-SR4 switch port, one only needs to make a simple change at the patching environment. The same 24-fiber backbone stays in place, and the MTP-LC cassettes are swapped out for MTP-MTP conversion cassettes that break out to three 8-fiber MTP ports. This provides 100 percent fiber utilization and creates a higher return on cabling investment. It is an ideal strategy that minimizes costly and time-consuming "rip-and-replace" upgrades to trunk cables. The allowable link distances shorten to the 70-meter range over OM4 fiber. This distance still covers the majority of connections in an enterprise data center application.

Flexible Cloud Provider Network Migration

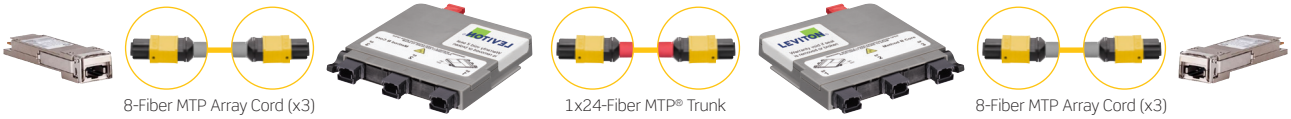
As mentioned earlier, most cloud data centers are already using single-mode or are planning to move to single-mode soon. Around 97 percent of single-mode links for these data centers are 350 meters or less. Based on this fact, there will be little need for a minimally extended multimode reach over OM5. The following cabling designs prepare networks for next-generation speeds while minimizing a rip-and-replace approach. Again, with so many transceiver options available and more on the horizon, data center managers should design their networks with the flexibility to support a range of upgrades and new technology.

Single-Mode Migration: 2-Fiber Channels for 10G, 40G, 100G, 200G, or 400G



When using 10G solutions today, you can deploy a 24-fiber backbone trunking solution that will carry through multiple upgrades in the future. While duplex LC connections to SFP+ transceivers are the typical form factor for 10G data rates, there are 40G optics available today — and 100G solutions in the future — that can be supported by an LC interface. By selecting the right family of transceivers, you can use the cabling system below to support a range of optics, including 40GBASE-LR4/LRL4 and Arista 40G Universal QSFP+ options, as well as 100GBASE-LR4/LRL4 in CFP2/CPAK or QSFP28 form factors. The same infrastructure will support 100G-FR2, 200G-FR4, and 400G-FR8 in the future.

Single-Mode Migration: 8-Fiber Channels for 40G, 100G, 200G, or 400G



If data center managers want to take advantage of low-cost PSM4 optics mentioned earlier, they can migrate to 8 fibers per switch port. Upgrading from the previous 2-fiber channel means replacing MTP-LC cassettes with MTP-MTP cassettes that break into three 8-fiber ports. The same 24-fiber trunk stays in place. For 40G speeds, this design supports 40GBASE-PLRL4 and 4x10G-LR/IR in the QSFP+ form factor. For 100G, it will support 100G-PSM4, and it will support future applications of 200G-DR4 and 400G-DR4.

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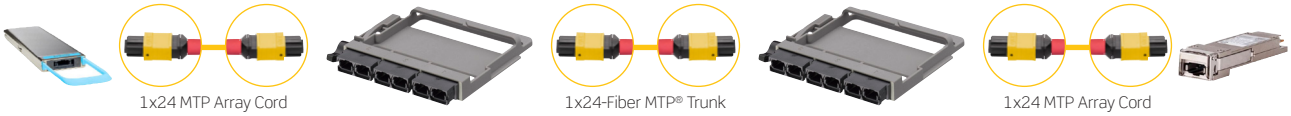
Single-Mode Migration: 20-Fiber Channels for 100G



One other option for delivering 100G is through the 10G ecosystem, creating 100G using 10 lanes of 10G. This design — using the same 24-fiber trunk but swapping in MTP passthrough cassettes and extending 20-fiber connections to the equipment — supports Cisco CPAK 10x10G-LR modules.

While a 24-fiber backbone is used in all the channels above, it is not required to support next-generation upgrades; 12-fiber MTP trunk cables are also available. However, the 24-fiber solution is a key piece in establishing the most flexibility when migrating to 400G.

Smart Migration Requires Forward-Thinking Cabling Systems

Regardless of the type or size of the data center, IT managers are looking for cabling systems that can weather multiple generations of tech upgrades with minimal disruption, dark fibers, or changes. 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.

To ensure these cabling systems address future network demands and upgrades, Leviton uses advanced testing equipment and manufacturing practices. These include interferometers to measure end face geometry, with 100% testing of process capability and standards under IEC-61755, including Apex offset, radius of curvature, and fiber protrusion. Leviton also uses high-precision laser cleavers, critical for creating consistent, high-quality terminations and ensuring performance at higher speeds. And Leviton performs multi-channel testing on single-mode solutions, ensuring there are no microbending issues.

Leviton infrastructure experts understand the evolution of the data center environment and the latest network technology. Leviton works closely with leading equipment manufacturers, is active in all next-generation standard developments, and can advise customers on their best possible migration strategy.

Learn more at Leviton.com/datacenter.

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