All multimode fiber is not created equal

By Robert Reid

Bandwidth, reach, and cost are among the key factors you'll need to weigh.

Multimode fiber cabling is a common choice to achieve 10-Gbit/sec speeds over distances required by LAN enterprise and data center applications. But several grades of high-bandwidth laser-optimized fiber are available for use in high-speed network installations, and each with a different reach and data-rate capability. It can be challenging to select the most suitable fiber grade for a given system. It may even be necessary to mix fiber already deployed across the network with newer, higher grades.

Multimode fiber types and characteristics

Fiber type	Core/cladding (µm)	minEMBc (MHz·km)	Max. reach at 10-Gbit/sec (m)*	Cost
OM1 (legacy)	62.5/125	200	33	$$$
OM2	50/125	500	82	$
OM2+**	50/125	950	150	$$
OM3	50/125	2,000	300	$$$
OM3+**	50/125	4,700	550	$$$$

*Data based on use with 850-nm VCSEL-based serial transceivers.
**OM2+ and OM3+ are not listed in the ISO standards.

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Understanding a few characteristics of multimode fiber, as well as the basics of the standards that govern their implementation, will help you select the optimal fiber media for your 10-Gbit/sec applications.

Multimode types, selection factors

The types of multimode fiber used in today's networks include:

- 62.5/125-µm (OM1) fiber, designed to achieve 10Base and 100Base data rates, and now largely a legacy fiber;
- 50/125-µm (OM2) fiber, used to achieve 1-Gbit/sec data rates and higher; and
- 50/125-µm (OM2+, OM3, and OM3+) fiber, used to achieve 10-Gbit/sec data rates and higher. OM2+ and OM3+ fiber grades offer nearly double the bandwidth of their parent fibers ("+" represents extended-reach OM2 and OM3 fiber).

The most economical 10-Gbit/sec network channels are those that deploy 50/125-µm fiber with serial transceiver electronics. The IEEE 802.3ae 10GBase-S standard specifies that only OM3 laser-optimized fiber can support 10-Gbit/sec up to 300 meters (m). The standard recognizes that other multimode cabling systems may support that rate over varying distances. For this reason, and as data center managers look toward "futureproofing" their cabling solutions, OM3 has become the 50-µm fiber of choice for 10-Gbit/sec premises and data center applications.

The preferred Physical Medium Dependent (PMD), or transceiver, for 10-Gbit/sec fiber cabling systems is the short-wavelength (850-nm) VCSEL (vertical-cavity surface-emitting laser)-based serial modular transceiver. These low-cost electronics have captured the LAN market, are optimized and standardized for use with OM3 fiber up to 300 m, and are also compatible with OM2 fiber grades. Fiber media for these devices are optimized for the 850-nm wavelength window, but maintain a minimum bandwidth of 500 MHz·km for the 1310-nm window.

The basic factors to consider when making a fiber choice are bandwidth, reach, and cost.

- *Bandwidth* is the information-carrying capacity of the fiber. High-bandwidth fiber media allows longer-length channels, higher loss-budget margin, and greater design flexibility.

- *Reach* (length) is a site-specific physical parameter that can be used to immediately narrow your fiber options. In general, as the data rate goes up, the reach goes down. Once reach is established, you can narrow your fiber options by identifying your users' current and/or future bandwidth needs.

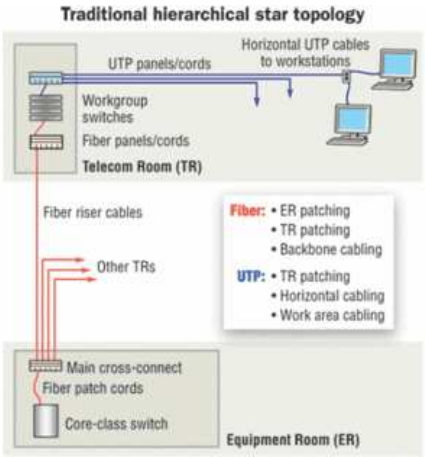
Manufacturers use the product of bandwidth times length to characterize their fibers. This is a frequency measurement normalized against the measured length. Current high-quality graded-index optical fibers have bandwidth·length products of over several hundred Megahertz·kilometers (MHz·km). For VCSEL-based systems, simulated fiber performance is determined as minimum calculated effective modal bandwidth (minEMBc). This metric is valuable for specifying 10-Gbit/sec systems and for differentiating between fiber grades.

• Cost is the final factor to consider. If you need high speed over short distances, you may be able to use less expensive grades of fiber (OM2 or OM2+) across certain links and still achieve reliable 10-Gbit/sec transmission. But if your goal is to build scalability and longer life into the network, it makes more sense to invest in higher-cost, high-bandwidth fiber (OM3 or OM3+) across the backbone and other permanent links.

TIA standards

Three sets of standards govern the most common structured cabling architectures in commercial buildings and data centers, and further support the fiber selection process:

- TIA/EIA-568-B Commercial Building Telecommunications Cabling Standard;
- TIA/EIA-569-B Commercial Building Standards for Telecommunications Pathways and Spaces; and
- TIA/EIA-942 Telecommunications Infrastructure Standard for Data Centers.



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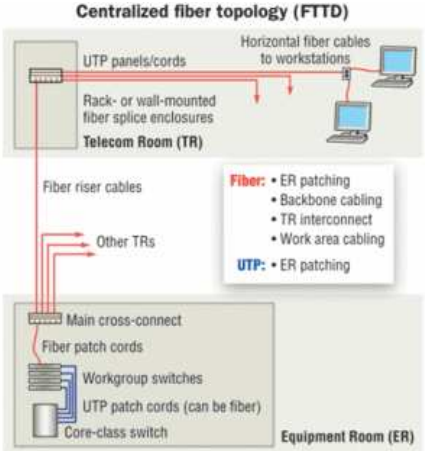
The most common enterprise architecture, the hierarchical star, uses optical fiber for backbone cabling as well as patching in the equipment room and the telecommunications room.

TIA/EIA-568-B covers structured cabling systems for commercial buildings, and between buildings in campus environments. The bulk of the standards define cabling types, distances, connectors, cable-system architectures, cable-termination standards and performance characteristics, and methods of testing installed cable. Fiber across the horizontal is specifically limited to 90 m, and maximum lengths in the backbone vary between 300 to 3,000 m, depending on the media selected. This may change in the near future, as a 300-m horizontal limit with fiber is currently being considered under this standard.



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A centralized fiber technology, or fiber-to-the-desk, includes optical fiber in the horizontal cabling runs and uses copper cabling only for equipment-room patching.

Two common network architectures are described by this standard. The hierarchical star is the most popular enterprise architecture. It consists of a main cross-connect in the equipment room with fiber backbones to remote telecommunications rooms (TRs) and copper cable in the horizontal.

Centralized fiber, or fiber-to-the-desk involves a main cross-connect in the equipment room with fiber backbones that end at user workstations. Fiber is deployed in the horizontal for applications where users (such as those deploying CAD or scientific modeling) require a high-speed connection to servers and/or storage. This is the most expensive architecture under TIA standards, although the cost of network interface cards and fixed and modular transceivers have dropped significantly in the past two years.

TIA/EIA-569-B provides requirements for spaces (rooms or areas) and pathways into and through which telecommunications equipment and media are installed. This standard, along with Addendum 5 to TIA/EIA-568-B, specifically addresses fiber to the telecom enclosure (FTTE), a third method for network deployment.

Under FTTE, electronics are typically centralized in a single TR, and fiber backbones are run to individual telecommunications enclosures (TEs) located close to the workstation. This is the lowest cost and most flexible infrastructure.

TIA/EIA-942 specifies the minimum requirements for the telecommunications infrastructure of data centers and computer rooms. This standard differs from 568-B/569-B in that it specifically recommends laser-optimized OM3 as the most reliable fiber media solution at 10-Gbits/sec.

The data center is a fiber-rich environment where fiber runs typically are less than 50 m. Storage area network (SAN) components are nearly 100% cabled with fiber media, and fiber cabling is an increasingly popular option as a high-speed server/switch interconnect.

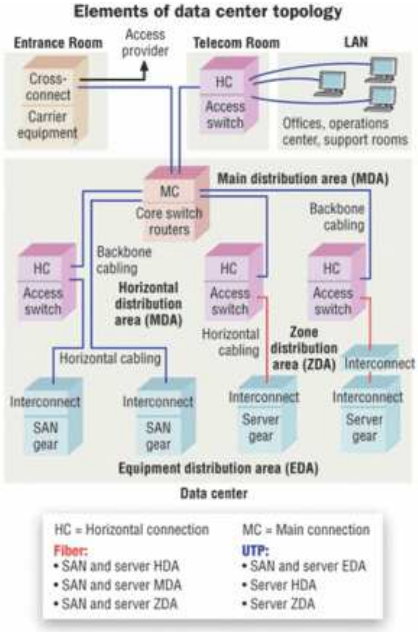
Applications for multimode

When it comes to selecting which multimode fiber is best for your network:

- Specify a high-grade fiber throughout new cabling installations to "futureproof" the investment; and
- For upgrades to existing fiber cabling, consider reach, bandwidth, and cost to identify the best options for each link.

The following three examples describe common applications of multimode fiber for 10-Gbit/sec performance across various channel lengths and network architectures.

Example 1: Upgrading an existing hierarchical star architecture. A network solution originally built to support 100-Mbit/sec Ethernet at the workstation (1-Gbit/sec-capable fiber in the backbone with copper to the desk) needs to be upgraded to run 10-Gbit/sec fiber to several new high-end workstations. The backbone is made up of 30-m lengths of OM2 multimode fiber. The horizontal runs use 50 m of Category 5e copper to the desk.



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Data centers are fiber-rich environments in both their local area networks and their strorage area networks. The TIA-942 standard addresses cabling issues within the data center.

Which fiber choice(s) would be best for this application?

Starting with the backbone, OM2 fiber can carry 10-Gbit/sec up to 82 m, so the 30-m backbone links would not need to be replaced. Over the horizontal to the high-end stations, all four 50-µm fiber grades (OM2, OM2+, OM3, and OM3+) have the necessary reach to achieve 10-Gbits/sec at 50 m. With cost as the differentiating factor, OM2 would be the most cost-effective choice. At longer reaches, more expensive OM2+ or OM3 grades would be necessary to achieve 10-Gbit/sec.Under this architecture, OM3+ is a cost-prohibitive choice at any length.

A common design option under this architecture, and fiber-to-the-desk, is to mix different grades of 50-µm fiber to leverage existing fiber investments. Mixing fiber links does not impact 10-Gbit/sec performance across the channel, but it does affect reach. Specifically, the 10GBase-S standard channel length of 300 m over OM3 is shortened by a predictable amount for each link of OM2 or OM2+ fiber in the channel. *(The exact method for calculating adjusted reach is outlined in a technical reference document, TR25, at www.panduit.com.)*

Example 2: Installing a new FTTE system. A new six-story building is being constructed, and a network must be installed that can support the speed and bandwidth of users over the next 10 to 15 years, starting with immediate 10-Gbit/sec capability. An FTTE architecture is selected for the new network, with permanent links of about 100 m that extend from the main equipment room to the telecommunications enclosures located on each floor at or near the workstations.

Which fiber choice(s) would be best for this application?

At a reach of 100 meters, OM2+ is the most cost-effective fiber choice and will carry 10-Gbits/sec reliably across a 100-m link. (The shorter reach of OM2 at 10-Gbit/sec limits its application here.) OM3 is required for links that extend more than 150 m, and has the added value of twice the bandwidth of OM2+ at slightly higher cost.

Example 3: Enhancing a data center. Short horizontal channels (up to 60 m) are being added to the SAN side of the data center to facilitate a buildout of 2-Gbit/sec Fibre Channel switches and storage hardware. It is desired to "futureproof" this solution for growth to 10-Gbit/sec Fibre Channel.

Which fiber choice(s) would be best for this application?

For data rates up to 10 Gbits/sec, OM3 is the first fiber to consider because it is specifically recommended under TIA-942. By using OM3 as the fiber standard throughout the data center, the system gains the design flexibility to deploy large numbers of connections in each channel. Such OM3 systems also can support both very long-reach channels and existing OM2 fiber applications throughout the network. But cabling links in the data center can be

short (< 50 m), so OM2+ fiber can be used and/or existing runs of OM2 fiber may be repurposed as less-expensive solutions than OM3. (It is worth noting that OM2+ extended-reach fiber is not listed in the ISO standard and may not support next-generation services.)

For "futureproofing" the data center beyond 10 Gbits/sec, OM3 or OM3+ fiber are expected to be required. Recently, several manufacturers have begun to move beyond current IEEE 10-Gbit/sec standards and work on defining two-fiber coarse wavelength division multiplexing (CWDM) transceivers to carry signals at speeds of 40 Gbits/sec and potentially 100 Gbits/sec. One of the design goals is to repurpose OM3 fiber for use with a 40-Gbit/sec CWDM serial multimode PMD, but OM3+ may be required for use with a 100-Gbit/sec serial multimode PMD.

Strength training

Selecting the best fiber type is a much easier process once you know the strengths of each multimode grade as well as the options for installing them under the applicable standards. Whether you are upgrading your network or futureproofing the performance of a new data center, these guidelines will help you design flexible, scalable, and cost-effective multimode fiber infrastructures.

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