White Paper

Wideband Multimode Fiber – What is it and why does it make sense?

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Contents

Executive summary

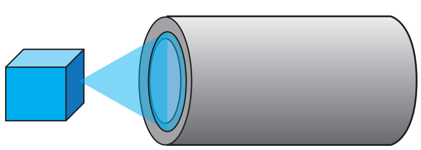
Multimode fiber (MMF) cabling is the workhorse media of local area network (LAN) backbones and data centers because it offers the lowest cost means of transporting high data rates for distances aligned with the needs of these environments. MMF has evolved from being optimized for multi-megabit per second transmission using light emitting diode (LED) light sources to being specialized to support multi-gigabit transmission using 850nm vertical cavity surface emitting laser (VCSEL) sources. Channel capacity has been multiplied through the use of parallel transmission over multiple strands of fiber. These advances have increased multimode supported data rates by an astounding factor of 40,000 — from 10 Mb/s in the late 1980s to 100 Gb/s in 2010, with 400 Gb/s in development in 2015. Today, these extraordinary rates are created from collections of 25 Gb/s lanes carried on either four or sixteen strands of fiber in each direction.

While parallel transmission is simple and effective, continuation of this trend drives higher cost into the cabling system. Wideband multimode fiber (WBMMF) enhances another means of multiplying data rates via wavelengths to increase the capacity of each fiber by at least a factor of four. This enables at least a four-fold increase in data rate for a given number of fibers (e.g. enabling 1600 Gb/s), or at least a four-fold reduction in the number of fibers for a given data rate (e.g. enabling 100 Gb/s per fiber). Optimized to support wavelengths in the 850 nm to 950 nm range, WBMMF ensures not only more efficient support for future applications to useful distances, but also complete compatibility with legacy applications, making it an ideal universal medium that supports not only the applications of the present, but also those of the future.

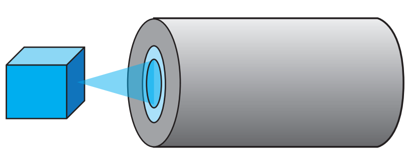
A brief history of MMF

MMF was the first fiber deployed in telecom networks in the early 1980s. With a light-carrying core diameter about six times larger than single-mode fiber, it offered a practical solution to the alignment challenges that faced designers of connectors, sources and detectors for getting light into and out of the cabling.

In the late 1980s when alignments could achieve micron (one millionth of a meter, μm) accuracy and laser diodes became available, single-mode fiber started to become widely deployed in public networks. But due to the cost advantage of easier alignment and the ability to use low-cost LED sources, MMF found a home in enterprise networks supporting a variety of applications such as private telephone switches (PBXs), data multiplexers and LANs.



Typical LED launch into 62.5μm core



Typical VCSEL launch into 50μm core

Figure 1 - Overfilling LED and underfilling VCSEL launches

During the 1990s as Ethernet and Fibre Channel applications grew in prevalence for LANs and storage area networks (SANs), MMF became the main media for backbone and other deployments requiring reaches exceeding those of copper twisted pair cabling. As data rates surpassed 100 Mb/s, LED sources gave way to a new low-cost source — the 850nm VCSEL — which could be modulated much faster. This in turn started a conversion of the MMF core diameter from 62.5 μm (i.e. OM1 cabling) to 50 μm (OM2 cabling) for two reasons:

1. The larger 62.5μm core was no longer a useful advantage with the more concentrated output of VCSELs which could efficiently couple to the smaller 50μm core as shown in Figure 1

2. The 50 μm design offered inherently higher bandwidth to better support transmission at hundreds of megabits per second

Figure 2 - LazrSPEED laser-optimized MMF

As the gigabit era dawned in the late 1990s, limitations with the bandwidth measurement techniques of that time became apparent. Originally designed to provide a bandwidth assessment that was useful for predicting performance of the fiber when used with LEDs, the measurement made with overfilling launch conditions no longer provided reliable indication for the concentrated underfilling launches of VCSELs. This led to significant advancement in bandwidth characterization via a newly standardized differential mode delay (DMD) measurement that employed many different laser launches to extract a minimum laser bandwidth. Fiber passing the new measurement became known as laser-optimized multimode fiber (LOMMF).

The first standard LOMMF offered reliable bandwidth of at least 2000 MHz*km at 850 nm, four times higher than the overfilled bandwidth of OM2. Dubbed OM3 and shown in Figure 2, it ushered in the age of 10 Gb/s transmission in the early 2000s. By the late 2000s OM4 arrived, offering at least 4700 MHz*km in anticipation of 25 Gb/s per lane applications that are now being developed or delivered to the market as 25G Ethernet (25GBASE-SR), 100G Ethernet (100GBASE-SR4), and 400G Ethernet (400GBASE-SR16). For SANs, Fibre Channel applications track these advancements with 8GFC, 16GFC, 32GFC, and 128GFC (4x32GFC). Today, OM3 and OM4 are the primary fiber media for Ethernet and Fibre Channel applications.

The role of fiber connectors

The first widely deployed fiber connector for multimode applications was the ST, featuring a 2.5mm-diameter cylindrical ferrule with a bayonet-style attachment mechanism in a single-fiber form factor. The SC connector, with its push-pull mechanism and ability to be clipped together to form two-fiber "duplex" connections, displaced the ST during the 1990s. A variety of small-form-factor duplex connectors followed that doubled connection density. Of these, the "duplex" LC connector emerged during the early 2000s as the predominant form. Featuring a 1.25mm-diameter ferrule and a familiar tab-style latching mechanism, the LC remains the predominant connector today. All of these connector types can be seen in Figure 3.

While the evolution of duplex connectors was underway, array connectors were also emerging. First deployed in public networks to facilitate the joining of ribbon fiber structures having eight to twelve fibers per ribbon, the MPO shown in Figure 4 found great utility during the past decade as a means to rapidly deploy cabling into data centers. The compact form of the MPO, featuring a rectangular ferrule, allows a dozen or more fibers to be terminated in a plug occupying just the space of a duplex LC. The MPO's high density enables installation of pre-terminated high-strand-count cables that eliminate the time consuming process of installing connectors on site. Typically plugged into the back of a fan-out cassette that presents LCs at its front, the MPO is now increasingly deployed directly at the front of patch panels in support of parallel applications like 40GBASE-SR4.

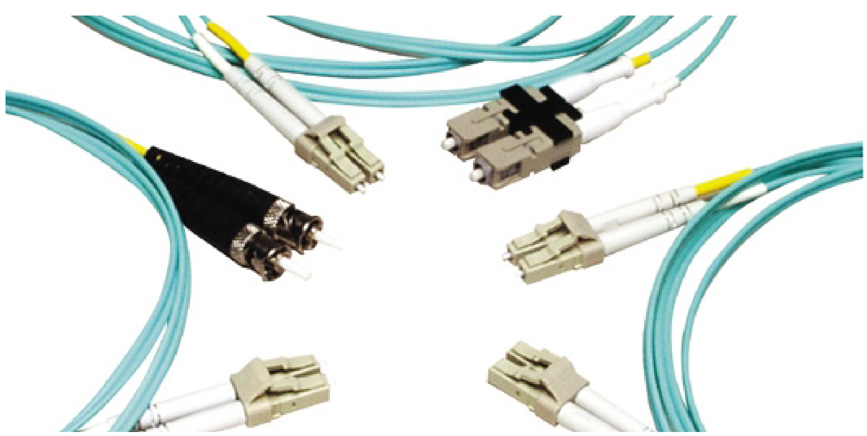


Figure 3 - ST, duplex SC and duplex LC connectors

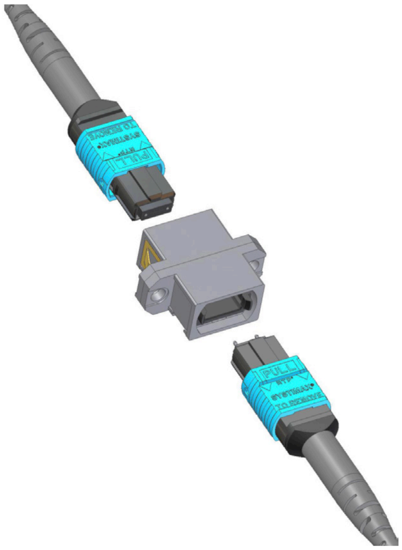


Figure 4: MPO connectors and adapter

In preparation for the deployment of 400GBASE-SR16, a new array connector known as the MPO-16 is being standardized. As the name implies, the MPO-16 increases the number of fibers per row from twelve to sixteen. Not only is it the perfect match for "-SR16", it also offers a simpler, more efficient match-up for cabling supporting applications having four lanes in each direction, such as 40GE, 100GE and 128GFC. Look for this connector to play a major role in the evolution of pre-term cabling in the coming decade.

Introducing WBMMF

OM3 and OM4 provide very high laser-optimized modal bandwidth at 850 nm, the predominant wavelength of multimode applications. But to provide equivalent performance over a range of wavelengths needed to support low-cost wavelength division multiplexing (WDM) requires a new fiber specification because the modal bandwidth of OM3 and OM4 can diminish quickly when operated at wavelengths other than 850 nm, making them less than ideal for supporting lane rates above 10 Gb/s per wavelength. Recognizing that the chromatic bandwidth of fiber improves as wavelength increases above 850 nm, and that proprietary applications like Cisco's 40G-SR-BD (40 Gb/s using bi-directional transmission per fiber) employ 850nm and 900nm VCSELs, leads to a fiber specification starting at 850 nm and moving towards longer wavelengths.

Figure 5 - WDM concept showing four wavelengths

Low-cost WDM requires a nominal separation between wavelengths of about 30 nm. In order to well support at least four wavelengths, as depicted in Figure 5, leads to a necessary wavelength range (including guard band) of 100 nm spanning from 850 nm to 950 nm.

In October 2014 CommScope partnered with several fiber, transceiver and systems companies to initiate a standards project in the Telecommunications Industry Association (TIA) to create a new standard for fiber having the effective total bandwidth of OM4 across this target wavelength range. Because the specification retains the performance of OM4 at 850 nm, this wideband MMF will continue to support and comply with the requirements of existing applications while also enhancing and extending support for low-cost VCSEL-based WDM applications in the future. By providing high bandwidth at longer wavelengths, this fiber also provides a means to well transmit signals from faster VCSELs, opening the door to 50 Gb/s lane rates and beyond. Clearly, this fiber can not only reduce the number of fibers used for parallel applications as shown in Figure 6, but when combined with the well established parallel transmission technologies, can enable higher data rates such as 800 and 1600 Gb/s Ethernet.

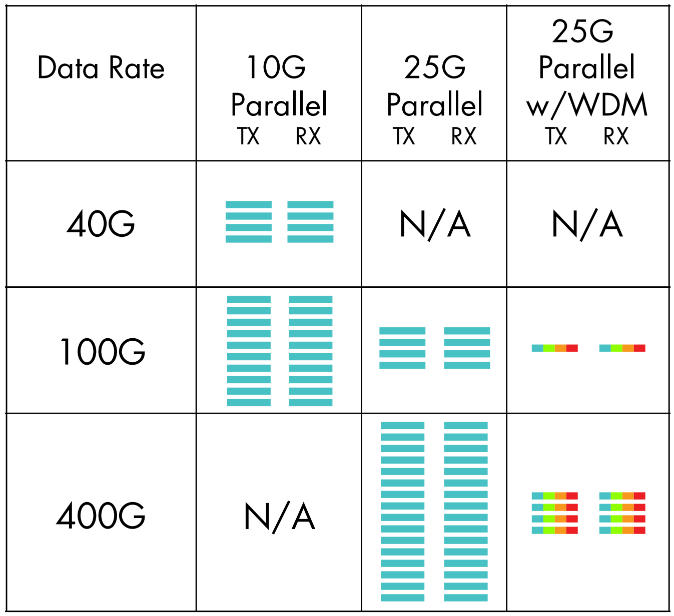


Figure 6 - Technology roadmap for parallel and WDM

A technological progression that takes MMF capability from 10Mb/s to potentially 1600Gb/s — a 160,000-fold increase — while never swaying from the low-cost paradigm that has been its hallmark for decades is a remarkable feat.

From application speeds to fiber capability, CommScope is playing a key role in this amazing technological advancement, looking beyond present limitations to envision and drive the development of more capable multimode solutions in the future, from laser optimization of OM3 and OM4 to wide-band MMF. Complementing our existing LazrSPEED 300 (OM3) fiber and LazrSPEED 550 (OM4) fiber, we now introduce LazrSPEED 550 WideBand with the capacity to take your network well into the future.

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