Specifying Fiber in the Horizontal

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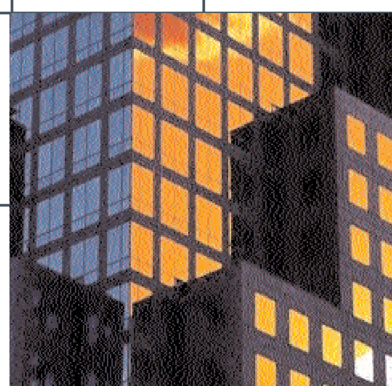

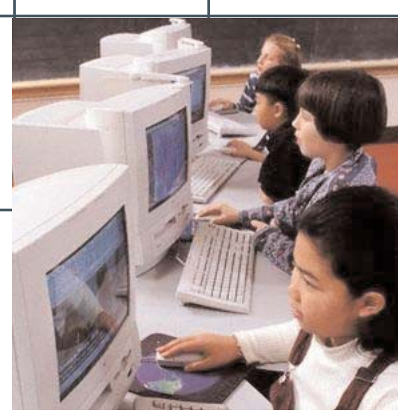

Specifying Fiber in the Horizontal

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Leading Optical Innovations

To meet the need for higher bandwidth, more end-users are installing fiber in their horizontal networks, directly to desktops or even to wireless access points. Once the end user has elected to install fiber, many questions arise: What do the standards specify for optical applications in the horizontal? How does one decide what kind of fiber should be used? What level of bandwidth support is required to sustain today's applications and those into the future? How should channel insertion loss be managed?

What's Driving the Growth? Fiber in the horizontal is a relatively small but growing application space. As shown in Figure 1, the percentage of Local Area Network (LAN) nodes that are fiber-based will double by 2007, and the LAN cabling market for fiber cable will grow at more than twice the rate of Unshielded Twisted Pair (UTP) cable (source: FTM Consulting, Inc). This growth is being driven in large part by the need for Gigabit Ethernet transmission rates and increased deployments of Fiber to the Desktop (FTTD), fiber to wireless access points, and Storage Area Networks (SANs).

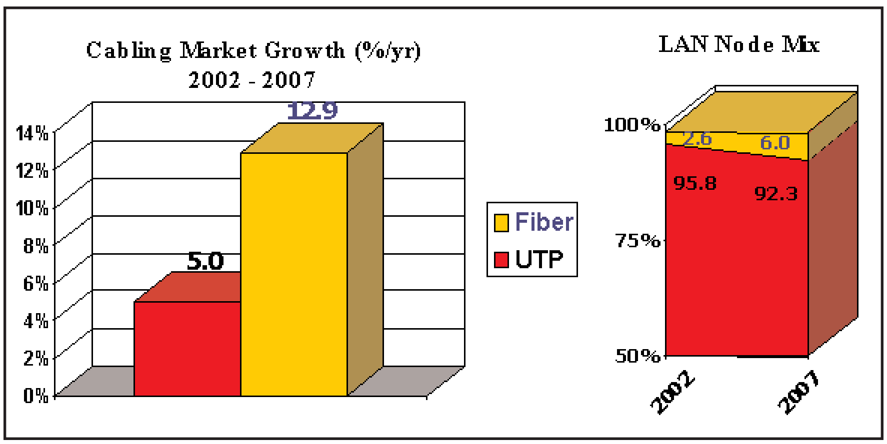

Figure 1 Projected growth of Fiber and UTP Cabling in LANs

The traditional reasons for using fiber in LANs and SANs are security, higher bandwidth, longer distances, lower bit error rates, easier testing, and stronger cable pull ratings. One new driver for FTTD is a "future-proof" upgrade path to 10 Gb/s data rates. While some fibers today can easily support 10 Gb/s to 500 meters, there is currently no UTP cable specified to support 10 Gb/s applications by any application standards body. IEEE is studying the possibility of writing a draft standard for 10 Gb/s over 100 meters of UTP. This 10GBASE-T proposal could be published as a standard by 2006. However, if published, this standard will require a new, higher bandwidth UTP cable.

Another FTTD driver can be cost. Its 300-meter + reach enables fiber to support a centralized architecture, which has one network electronics location in the basement connected to each user. UTP has a limited 100-meter reach, and thus requires electronics both in the basement *and* in the telecommunications closet (TC) on each floor of a building. If an end user installs FTTD using a centralized system, the savings in TC space can result in a lower cost system compared with UTP.

What Do the Standards Say? Let's assume now that an end user has decided to deploy FTTD. Their first step is to review the applicable standards. The ANSI TIA/EIA-568-B.1/B.3 and ISO-11801 2nd Edition standards both specify centralized cabling architectures of up to 300 meters, using 50 micron multimode, 62.5 micron multimode, or single-mode fiber. Included in these standards is 850 nm Laser Optimized 50 micron fiber (850 LO 50), as it is called in the TIA documents; the same fiber is specified as OM-3 in the ISO-11801 standard (one example of this fiber type is OFS' LaserWave™ 300 fiber).

Ethernet dominates the application standards for LAN FTTD. The IEEE 802.3 and TIA/EIA-785 standards for Ethernet and supported media types for 300-meter FTTD applications are summarized in Table 1 (specified in IEEE 802.3 unless indicated).

Data Rate	Designations	Source Type	300 meter support for FTTD?		
			62.5 Micron	50 micron	Singlemode
100 Mb/s	100BASE-SX TIA-785	850 nm LED (Lower cost)	Yes	Yes	No
	100BASE-FX	1310 nm LED	Yes	Yes	No
1 Gb/s	1000BASE-SX	850 nm Laser (Lower Cost)	Yes	Yes	No
	1000BASE-LX	1310 nm Laser	Yes	Yes	Yes
10 Gb/s	10GBASE-SR	850 nm Laser (Lower Cost)	No, only 26 meters	Yes, OM-3	No
	10GBASE-LR	1310 nm Laser	No	No	Yes
	10GBASE-LX4	1310 nm Laser (Highest cost)	Only w/ mode conditioning patch cords	Only w/ mode conditioning patch cords	Yes

Table 1 Ethernet Standards Relevant to FTTD

The choice of FTTD fiber type depends on the end user's upgrade plans. If no upgrade to 10 Gb/s is envisioned, one could use a standard 50 micron fiber having a 500 MHz-km bandwidth at 850 nm to support 100 Mb/s and 1 Gb/s up to a distance of 300 meters. However, since most end users installing FTTD typically operate bandwidth intensive networks, an upgrade to 10 Gb/s applications is likely to occur within the 10 - 20 year life of the cabling system. Thus, the 850 nm LO 50 micron fiber is the most cost-effective choice for FTTD that will protect the investment well into the future.

The next decision is to determine whether to deploy single-mode or multimode fiber. While single-mode fiber is ideal for applications up to hundreds of kilometers, it requires much more expensive laser transceivers and connectors than multimode fiber.

The key parameter for the decision-maker should be the optical system cost (the cost of the optical transceivers, cabling system components, and installation). The cost for multimode fiber based optical systems is typically 25 - 50 percent lower than for single-mode fiber based optical systems. So multimode fiber is the clear choice for FTTD.

What's the Best Fiber to Use? Next, the user must determine which type of multimode fiber to use. There are two primary types - 50 micron and 62.5 micron - and both are described by the diameter of its light-carrying core.

For today's high-speed laser based applications, 50 micron fiber has up to 10 times the bandwidth and distance capability of 62.5 micron fiber. The 850 LO 50-micron fibers such as LaserWave 300 fiber can support 100 Mb/s through 10 Gb/s up to a distance of 300 meters, allowing an end user to install a 100 Mb/s system today, and cost-effectively migrate to 1 and then 10 Gb/s in the future.

For those few who think they may require more than 10 Gb/s, 850 LO 50-micron fiber can also support the proposed 40 Gb/s speed for Ethernet to 300 meters using inexpensive 850 nm VCSELs.

Let's assume now that a designer has selected 850 nm LO 50 micron fiber for a FTTD network. To support 10 Gb/s at 300 meters, this fiber is specified by the standards to provide 2000 MHz-km of effective modal bandwidth (EMB) at 850 nm. According to both the TIA and ISO standards, this 2000 MHz-km EMB shall be assured by a measurement known as High Resolution Differential Mode Delay (HRDMD).

Specified in TIA-FOTP-220, HRDMD is a very precise measurement of the worst-case pulse spreading that can occur in a 10 Gigabit multimode fiber sys-

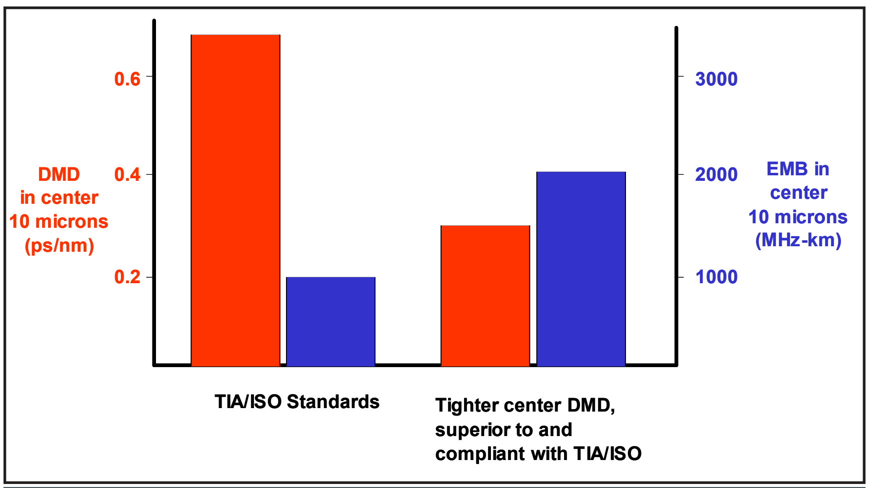

Figure 2 Comparison of tighter center DMD specifications and TIA/ISO DMD specifications. (Worst-case)

tem. Lower pulse spreading translates into higher bandwidth, so the goal is to minimize DMD.
To ensure the 2000 MHz-km EMB, the TIA and ISO standards specify the maximum DMD allowed to limit the pulse spreading at each point across the core. A comparison of the ISO and TIA specifications is shown in Figure 2.

How Do You Manage Channel Insertion Loss?

Channel insertion loss is the total optical loss, from end to end of an optical link, of the cable plus connections and splices. Gigabit and Ten Gigabit Ethernet and Fibre Channel applications have very tight channel insertion loss budgets of about 2.5 dB.

For a TIA compliant FTTD link having a cross connect in the equipment room, an interconnect in the TC, and connection at the desktop outlet, four connections are required. In a 300 meter link about 1 dB will be consumed by the cable, leaving only 1.5 dB for the connections, and less than 0.4 dB per connection for the four-connection example. One way to minimize connection loss is to use a fiber with very tight dimensional specifications.

Since the primary cause of connection loss is the offset of the two mated fiber cores, the two key specifications are core to cladding offset (also known as Core/Clad Concentricity Error), and cladding diameter. Superior specifications can reduce worst-case connection loss by up to 0.5 dB per connection.

In our four-connection example, 2 dB of connection loss in addition to the 1.5 dB worst case typical of four good quality connections could reduce the maximum 10 Gigabit Ethernet reach by up to 60 meters. A comparison of superior and typical examples of these specifications and their effect on connection loss can be dramatic, as shown in Figure 3.

Specification	Superior	Typical
Cladding diameter	125 ± 1 µm	125 ± 2 µm
Core/cladding concentricity error (offset)	= 1.5 µm	= 3.0 µm

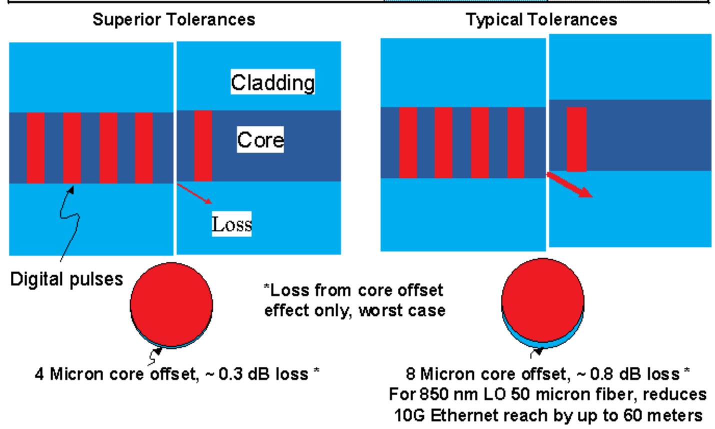

Figure 3 Effect of superior vs. typical core location tolerances on connection insertion loss

Summary The best fiber choice for most FTTD horizontal installations boils down to two scenarios. In one, those who never anticipate a need for 10 Gb/s applications use standard or laser certified 50 micron fiber with a 500 MHz-km bandwidth specification, for cost-effective 100 Mb/s through 1 Gb/s system up to the 300 meters specified for centralized cabling.

The second scenario, which is true for most FTTD installations, there is the possibility of a 10 Gb/s upgrade over the lifetime of the cabling system and the need is for maximum performance. This leads one to select 850 nm laser optimized 50 micron fiber with 2000 MHz-km of EMB that has superior DMD specifications in the core center. In either case, a fiber with superior core location tolerances should be specified to minimize channel insertion loss, and maximize system reach and reliability.

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