The Truth About Fiber in Local Area Networks

Prepared by the Fiber Optics LAN Section
of the Telecommunications Industry Association

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Introduction:

Today's high-bandwidth applications and increasing reliance on Internet-based communications are defining a new kind of network – one that needs to move large amounts of data quickly, accessibly, and reliably. To meet these emerging needs, network managers are re-evaluating their Local Area Network (LAN) infrastructures and are moving toward more robust, scalable networks. While copper cable was initially used throughout LANs over the past 20 years, optical fiber has proven itself to be a formidable alternative, offering users more bandwidth, greater reliability and lower maintenance. First displacing copper cables in the backbones and risers, research shows that users are increasingly turning to fiber for the horizontal cabling portion of their networks, a trend that is driven by ever higher transmission speeds and bandwidth needs.

Despite some of the obvious advantages of putting fiber into a LAN – greater bandwidth capacity, security, network longevity, etc. – there are a number of misconceptions that may be preventing end users from making the switch from a copper-based solution to one partially or entirely composed of fiber. The Fiber Optics LAN Section of the Telecommunications Industry Association (TIA) hopes to shed some light on the subject by debunking some of these "myths."

This white paper provides an opportunity for network managers, MIS users, installers, and others facing a decision to migrate from copper to fiber to examine a number of common concerns and hear the evidence that supports the value of fiber in LANs.

Common End-User Concerns:

- Fiber is too fragile to survive harsh conditions
- Fiber's performance capabilities are unnecessary
- Fiber is more difficult to install than copper
- Switching from copper to fiber is expensive – and not worth the trouble
- A forklift upgrade to fiber is too costly to implement
- Long-term copper users claim they don't need fiber

Fiber Is Too Fragile to Survive Harsh Conditions.

Optical fiber is not your typical kind of glass. Made of ultra-pure silica, it is an extremely strong material that has the ability to handle exposure to temperature and pressure extremes. In fact, tensile strength (resistance to pulling) of optical fiber exceeds 600,000 pounds per square inch – making it stronger than copper or steel strands of the same diameter and easily surpassing the strength requirements of today's communications applications. When cabled, glass fiber is protected and further strengthened by aramid or fiberglass yarns, a fiberglass rod, and/or an outer jacket constructed of non-conductive materials. Fiber has also demonstrated a long service life, possessing high information-carrying capacity, resistance to electromagnetic interference (EMI) and immunity to corrosion. Plus, its small size and light weight make it easier to handle in narrow duct spaces.

Fiber's Performance Capabilities Are Unnecessary.

Reliability: Fiber has proven that it can transmit information error-free over greater distances than copper and support higher data rates at the same time. If your company's LAN is experiencing bottlenecks, high error rates, slow throughput or downtime, an optical fiber solution supports a broader range of bandwidth capabilities, thus improving your network performance and decreasing downtime.

Security: Optical fiber is the most secure transmission medium, because it is immune to EMI and Radio Frequency Interference (RFI). Since fiber transmits light rather than electricity, it is not affected by the EMI from power, radio or microwave sources. Furthermore, fiber is immune to crosstalk and is extremely difficult to tap – qualities that cannot be claimed by copper. While information security has led to wide use of fiber by financial institutions and the military, it is also extremely important to the average small business and factory owner. Signal interference can pose a huge problem to factory applications and other areas with a variety of electronics if copper is their only current solution.

Equipment safety: Fiber also provides greater equipment safety. Unlike copper facilities, all-dielectric fiber cabling systems do not conduct lightning strikes or electrical currents that can damage sensitive electronic transmission equipment. In fact, optical fiber eliminates a number of performance variables (network downtime, information delivery and security, etc.) that may cause concern if your infrastructure is composed entirely of copper.

Fiber Is More Difficult to Install Than Copper.

The perception lingers that fiber is difficult to install. However, the reality is that it is just as easy, and sometimes easier, to install as copper. Since fiber is accepted as the standard choice for communications backbones, installers have become comfortable with the technology. In fact, new generation high-speed copper networks – such as Category 5, Category 5e, and the pending Category 6 Unshielded Twisted Pair (UTP) cable – require more stringent and time-consuming installation techniques than those of fiber. Compared to newer grades of copper cable, fewer regulations exist on the methods by which optical cable is pulled and terminated. In addition, there is no need to worry about the location of EMI/RFI sources during installation. Furthermore, optical fiber cables are stronger, lighter and smaller than comparable copper cable designs, and there are few routing restrictions, particularly in areas with other electrical power cables.

New generations of small connectors are also making it easier to install fiber-based systems. Small form factor (SFF) connectors have the same size footprint as traditional copper-based connectors. As a result, they help increase port density and reduce the cost of hubs and switches, lower patch-panel and enclosure costs, reduce jumper costs, and reduce connector and installation costs. Besides ease of installation, SFF connectors make fiber faster to install, as the connection time per connector is much quicker.

While SFF connectors reduce connection time, optical fiber itself is capable of supporting runs beyond the 100-meter limit for any grade of copper cabling available today. Standard 62.5-micron (μm) fiber can run effectively up to 300 meters at 100 Mbps, and 50- μm fiber can run up to 500 meters.

Testing fiber is easy, too. Since fiber cable facilities are not affected by near-end crosstalk (NEXT), and their operating performance is not affected by frequency, technicians can test runs by simply measuring the attenuation of the optical fiber link. To verify Category 5e link performance, tests must be conducted for attenuation, cable length and crosstalk. Technicians must also perform attenuation and NEXT tests across the entire frequency range of 1-100 megahertz or higher because copper-based system performance changes at different frequencies.

Transmission at different frequencies does not affect optical fiber. Once fiber works at one speed, it can be upgraded to higher protocols without sacrificing performance. Copper cables, on the other hand, may or may not be upgradeable – not just because of the cable itself, but because other components influence system performance.

In the end, fiber and cable manufacturers have made great strides to meet the demands of those interested in an easy way to deploy fiber. Technicians used to copper should no longer carry the impression that fiber is any more difficult to install – it may be different, but it certainly is not any harder than working with copper cabling.

Switching From Copper to Fiber Is Expensive – And Not Worth the Trouble.

Fiber is steadily approaching cost parity with copper, even when considering installed first costs. This is driven by several factors:

- Fiber-friendly architectures, such as TSB-72, Centralized Cabling, allow designers to leverage fiber's high bandwidth and low attenuation to accommodate longer runs (up to 300 meters). This allows MIS managers to reduce the number of active electronics in a system – the expensive part – and eliminate the need for telecommunications closets on each floor of the building. Costs associated with closets include the electronics housed within them, the loss of "real estate," the cost of temperature controls and power management.

- SFF connectors are less expensive, easier to install and have higher port densities than traditional fiber connectors.
- Use of media converters allows users to migrate incrementally from copper to fiber and utilize existing electronics by converting the signal between media.
- New standards, such as the recently ratified 100 BASE-SX, TIA/EIA-785 (http://global.ihs.com) allow users to migrate from 10 Mbps to 100 Mbps using low-cost 850 nm Light Emitting Diode (LED) based electronics instead of requiring 1300 nm lasers.

A closer look at each element of fiber installation reveals how the gap with copper costs is narrowing:

- ***Cabling component costs***: the cost for fiber and fiber-based components (cable, wall outlets, patch panels and cords, and connectors) has decreased, bringing them in parity with the cost of high-speed copper cables.
- ***Electronics costs***: the cost for fiber-based hubs, concentrators and network interface cards for fiber is falling steadily. What's more, the industry has developed architectures that allow users to install fewer electronics and reduce overall system costs and has recently issued a standard (mentioned above) that supports 100 Mbps transmission over 850 nm LEDs.
- ***No recabling costs***: because standard multimode optical fiber has proven performance at 2.5 Gbps and beyond, there is no need to pull new cable to support higher data rates or emerging protocols. Therefore, optical fiber eliminates the expense and disruption associated with pulling new cable – a concern shared by a large number of businesses that cannot afford to be offline for days at a time.
- ***Installation costs***: as technicians have become more familiar with handling fiber and because new generation UTP cabling requires more stringent installation parameters, costs to deploy either type of cabling are essentially the same today.

Also, lifetime costs of fiber are lower because:

- With fiber, there is no need to pull new cable each time you upgrade your network.
- Maintenance and downtime for fiber networks are typically less than for copper-based networks. This is because they usually use fewer electronics – thereby reducing network outages and downtime, are not subject to EMI/RFI interference, and are generally easier to troubleshoot.

The net result of these benefits is that deploying optical fiber in LANs provides measurable results and long-term value to businesses of all sizes – whether they are building a new network or incrementally upgrading an existing one. As the price of fiber components drops significantly and ease of installation continues to improve, new standards and technologies are lowering costs across the board. Accordingly, TIA has worked to address the technology needs of suppliers and end users to better support the use of fiber deeper into the LAN. For more information on standards relating to the fiber industry, please visit http://www.tiaonline.org/standards/.

Note: To compare copper and fiber costs in more detail for your installation, consult the new Cost Modeling report developed by TIA's Fiber Optics LAN Section (FOLS) and Pearson Technologies. This matrix allows you to compare the costs of legacy networks to those of fiber-to-the-desk networks. To download a copy of the model, please visit the FOLS Web site at http://www.fols.org.

A Forklift Upgrade to Fiber Is Too Costly to Implement.

Optical fiber gets the most attention when considered for new installations, as network planners can start with a clean slate. In rebuild situations, network managers have been more reluctant to use a fiber solution. While the overall cost of a fiber installation has become increasingly competitive to that of copper, some companies do not have the resources to upgrade their entire network at once. They also may only need the increased bandwidth or speed in a portion of their network, or they may have a legacy network that includes a variety of media. For these users, media conversion technology offers them a controlled migration strategy. Media converters do just what their name implies – the devices convert the signal from one type of media to another, allowing seamless links between different media and supporting incremental upgrades to fiber. Media converters also allow users to continue to use their existing electronics, leveraging their existing investment.

Many small- to medium-sized businesses take the incremental approach to network upgrading, because it makes better financial and technical sense. MIS managers at small businesses know that upgrading to a higher grade of cable – either copper or fiber – will require a substantial financial investment. Once they understand that they can bring fiber into their network on an as-needed basis, these network managers will seriously consider choosing this option for the built-in scalability.

Long-term Copper Users Claim They Don't Need Fiber.

Most growing enterprises have an increasing need for faster, more effective information transmission. As we touched on earlier, fiber users typically only need to pull cable once to support network longevity of 10-15 years, compared to the 3-5 years typically afforded by grades of copper cables. Given optical fiber's greater bandwidth capacity, network managers can consider their fiber infrastructure as a "future proofing" investment that frees them from worrying about their cabling infrastructure when making system upgrades. If your company is reaching its bandwidth limits, it may be time to consider converting your network to fiber.

Conclusion:

Most analysts agree that optical fiber ultimately will replace copper cable in all parts of the LAN. Over the near term, the migration can be attributed to the increasing level of comfort among engineers, experts, and users with optical fiber and its benefits. However, as network managers start to look at 10 Gigabit Ethernet and beyond, optical fiber will be the only medium that can support their network over 300-meter distances. This makes optical fiber the ideal choice not only for today – but also for the future.

More on the Fiber Optics LAN Section:

The Fiber Optic LAN Section (FOLS) of the Telecommunications Industry Association (TIA) is a consortium of leading fiber optic cable, component and electronics manufacturers. The FOLS focuses on educating end users and influencers about the technical advantages and affordability that optical transmission brings to local area networks and fiber-to-the-desk applications. Member companies of the FOLS include: 3M/Volition, AMP/Tyco Electronics, Corning, Leviton Voice & Data, OFS, Optek Technology, Ortronics, Panduit, and Sumitomo Electric Lightwave. Visit the FOLS at www.fols.org.

This white paper is one of several initiatives underway by the FOLS. For more information about FOLS and its activities, or to become a member of TIA and FOLS, please visit us at http://www.fols.org or contact Andy Dryden at (703) 907-7633 or adryden@tia.eia.org.

Glossary:

Attenuation The decrease in power of a signal, light beam, or lightwave, either absolutely or as a fraction of a reference value. The decrease usually occurs as a result of absorption, reflection, diffusion, scattering, deflection or dispersion from an original level and usually not as a result of geometric spreading. The loss of volume during transmission – measured in decibels.

Bandwidth The width of a communications channel. In analog communications, bandwidth is typically measured in Hertz – cycles per second. In digital communications, bandwidth is typically measured in bits per second (bps). A voice conversation in analog format is typically 3,000 Hertz, carried in a 4,000 Hertz analog channel. In digital communications, encoded in PCM, it's 64,000 bits per second.

Category 5 A Category of Performance for inside wire and cable systems. CAT 5 cables can be of various gauges, and are useful in support of applications requiring a carrier frequency of up to 100 MHz; the transmission rate achievable depends on the compression scheme employed. CAT 5 is now the most common cabling being installed for LAN connectivity. Increasingly, CAT 5 cabling is being installed for both data and voice use.

Category 5e CAT 5e is intended to be manufactured according to tight specifications in support of signaling rates of up to 200 MHz over distances of up to 100 meters. Specifications call for a tighter twist, electrical balancing between pairs, and fewer cable anomalies, such as inconsistencies in the core diameter

Category 6 A developing cabling standard for UTP and Shielded Foil Twisted Pair (SFTP) intended to support signaling rates up to 250 MHz. The SFTP version of CAT 6 comprises 4 twisted pairs separately wrapped in foil insulators and twisted around one another. The group of 4 pairs is contained in an extra insulating shield that is then contained within a flame-retardant polymer jacket.

Centralized Cabling A system where all network electronics reside in either the main distribution center or intermediate distribution center so that the user can be connected directly from the desktop or workgroup to the centralized network electronics. With one central location for all network electronics, maintenance is simplified, troubleshooting time is reduced and security is enhanced.

TIA/EIA TSB-72 provides a method of centralizing optical fiber connections from the cross-connect to the work area. The recognized techniques are pull-through cabling, an interconnect, or a splice in the telecommunications room. These techniques, sometimes designated as a collapsed backbone, allow a single tenant to use centralized electronics to serve multiple users.

Centralized cabling needs to be in the same building as the work area. Combined length of the horizontal, intra-building backbone, and patch cords between the TR and cross-connect to 300m (982 ft).

EMI Electromagnetic Interference. EMI happens when one device leaks so much energy that it adversely affects the operation of another device.

LED Light Emitting Diode. A semiconductor diode that emits light when a current is passed through it. In lightwave transmission systems, light-emitting diodes or lasers are used as sources of light. LEDs are used as sources for optical data link applications in which the data rates are less than about 500 Mbps and the transmission distances do not exceed a few kilometers. LEDs are also used in alphanumeric displays on calculators and computer devices.

LAN Local Area Network. A communications network connecting personal computers, workstations, printers, file servers and other devices inside a building or a campus.

Media Converters Media converters connect dissimilar cable and connectors, making it possible to mix media and speed on a network to optimize price and performance requirements -- whether extending legacy networks with the latest technology, or connecting inexpensive, lower bandwidth desktops to a state of the art fiber optic backbone.

Multimode Fiber An optical fiber designed to propagate multiple light signals through its core simultaneously.. Multimode fiber types are referred to by their core sizes (the light-carrying region of the fiber), which are measured in micrometers (1/25,000 of an inch). Multimode fibers are used in LANs as they have large numerical apertures, which allow them to be used with low cost LED light sources. While they do not have the distance capabilities of singlemode fibers, multimode fibers are more than able to meet the needs of premises applications.

62.5/125 µm multimode fiber Multimode optical fibers that have a core diameter of 62.5 µm and a cladding diameter of 125 µm. Most fiber-based networks today deploy 62.5/125 FDDI-grade multimode fiber in their backbones and risers and possibly all the way to the workstation. This grade of fiber typically has a bandwidth of 160/500 MHz•km. It is ideal for use with distances up to 300 meters (m) although some fibers are available that support distances up to 500 m.

50/125 µm multimode fiber Multimode fiber with a core that measures 50µm in diameter and a cladding of 125 µm. Compared to 62.5 µm multimode fiber, it offers higher bandwidth of 500/500 MHz•km. 50 µm fiber is becoming a popular choice for users who need to transmit high bandwidth applications over distances longer than 300 m, or who are interested in using Vertical Cavity Surface Emitting Lasers (VCSELs).

NEXT Near End Crosstalk. A type of crosstalk that occurs when signals transmitted on one pair of wires are fed back into another pair. Since at this point on the link the transmitted signal is at maximum strength and the receive signal has been attenuated, it may be difficult to maintain an acceptable ACR (Attenuation-to-Crosstalk Ratio). NEXT is particularly troublesome when a number of high-speed transmission services are supported within a single copper cable system. Shielded or screened cable systems are more desirable in addressing this problem than are unshielded varieties.

RFI Radio Frequency Interference. All computer equipment generates radio frequency signals. The FCC regulates the amount of RFI a computing device can leak past its shielding.

SFF Connectors Designed to cost less than traditional fiber connectors, SFF connectors have a footprint similar in size to the copper RJ-45-style eight-pin modular jack connectors. Because of their small size, SFF connectors can increase density and therefore reduce the cost of hubs and switches, lower patch-

	panel and enclosure costs, reduce jumper costs, and reduce connector installation costs. Six different SFF connector designs currently are available.
Tensile Strength	The greatest longitudinal tensile stress a substance can bear without tearing apart or rupturing.
UTP	Unshielded Twisted Pair. A pair of wires that is twisted so as to minimize crosstalk with other pairs of wires of the same cable (which are each twisted at a slightly different rate) but not shielded. UTP is used to maximize signal strength over a distance and minimize interference between adjacent pairs in a multi-pair cable.

Sources:

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