

# **100BASE-SX Fast Ethernet:**

**A Cost Effective Migration Path for Fiber in  
the Horizontal**

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

**February 2000**

## **Introduction**

For desktop networking, the proposed 100BASE-SX standard is the most significant development in the last year. The proposed standard defines an affordable migration strategy for 10 Mbps copper or fiber to 100 Mbps fiber, using a cabling structure that is capable of Gigabit Ethernet speeds. For the first time, those interested in investing in a fiber infrastructure will have a road map that clearly spells out how to migrate from 10BASE-FL to the future.

The draft standard defines a new Physical Media Dependent (PMD) sublayer as well as a means for implementing Auto-Negotiation. The proposed standard does not define anything new above the physical layer. It is intended for use along with the IEEE 802.3 1998 edition standard to provide a complete definition. This means that 100BASE-SX will work with, and along side of, all of the Ethernet/Fast Ethernet equipment that makes up over 80% of the premises LAN market.

## **Background**

Optical fiber has long been the preferred cabling technology for building and campus network LAN backbones. Until recently, however, the use of fiber as a cabling medium to the desktop has been confined to special environments that require the unique properties of optical fiber such as noise immunity, security, distance, high bandwidth demands (CAD/CAM, video conferencing), and immunity to electrical interference. Several factors are changing this scenario:

- The accelerating deployment of fiber based Gigabit Ethernet (GbE) in the LAN backbone.
- Uncertainty whether GbE will run on existing Category-5 twisted pair or will require an upgrade to enhanced Category-5 wiring, Category-6 wiring, or something even higher.
- Decreasing costs of optical fiber components compared to the increasing electronic costs of carrying Gigabit Ethernet over Cat 5 or Cat 5E UTP copper cabling.
- The development of a proposed 100BASE-SX standard, which uses 850 nm optoelectronics.

Most experts and users agree that fiber will eventually be the dominant cabling medium all the way through the horizontal. The only question is, when? To a certain extent it depends on whether copper can meet the demands of higher data rates with a standardized solution. Deployment of Gigabit Ethernet as a backbone technology is rapidly gaining hold in networks. Even though it's unlikely that users will need gigabit speeds to the desktop any time soon, many are outgrowing their 10 Mbps Ethernet LANs and are looking for simple, straight-forward migration paths that will allow them to upgrade their networks incrementally as needed.

Users with existing CAT-5 cable plants are waiting to see if the technology can support GbE. If it can't, they can recable with copper or install optical fiber. Category 6 (or even Category 7) UTP may only provide non-standardized solutions for a single generation of LAN speeds. Multimode fiber, which meets all current and proposed future standards, will have a useful life cycle of two or three generations of LAN optoelectronics.

For users who currently have CAT-3 installed, the question of whether to deploy twisted pair or fiber is more pressing. Many will need to upgrade to Fast (100 Mbps) Ethernet, which is beyond the capabilities of CAT-3. Should they upgrade to CAT-5, which may support only one or, perhaps, two generations of LAN speeds (100Mbps and perhaps 1Gbps)? Or, should they think long term now and deploy optical fiber?

### **New Migration Path Minimizes Recabling**

The TIA FO 2.2 committee developed the proposed 100BASE-SX standard (Project SP-4360) to meet the needs of users who want to leverage the upgradeability of optical fiber using a simple, efficient migration strategy from 10BASE-FL to higher speeds.

The proposed 100BASE-SX standard uses 850 nm wavelength optics, which provides compatibility with 10BASE-FL, while controlling costs and minimizing risk for the user. In addition, the proposed standard will provide fiber customers a means to upgrade to Fast Ethernet speeds today and install a fiber infrastructure that will support Gigabit Ethernet operation at the IEEE 802.3 distances, thus making future upgrades easy and affordable, and eliminating the need to install new cable.

### **100BASE-SX Overview**

The proposed 100BASE-SX standard, like 100BASE-TX, consists of two major parts: the mandatory short wavelength 100BASE-SX PMD (physical medium dependent) and an optional Auto-Negotiation implementation on fiber. The short wavelength 100BASE-SX PMD is very closely related to 100BASE-FX. The signal encoding is identical (allowing existing silicon to be used) but there are three significant differences:

- 100BASE-SX uses low cost short wavelength (850nm) optics.
- The point-to-point distance of 100BASE-SX is 300 meters over supported fiber types, more than adequate for desktop applications.
- 100BASE-SX leaves the choice of connector to the user, allowing any connector that meets the minimum specified performance.

It should be noted that 300 meters is a very conservative expectation that is likely to be exceeded. Many estimates of the installed multimode fiber base show that the majority of horizontal fiber links are 300 meters or less, so this distance should satisfy the majority of installation requirements.

There are several types of “next generation” connectors on the market, all of which should have no problem meeting the specified requirements. In practice, fiber connector compatibility has not been an issue in the horizontal because a fiber patch cord with different connectors at each end always can provide connectivity.

### **Auto-Negotiation**

Auto-Negotiation is the mechanism by which two Ethernet/Fast Ethernet ports communicate with each other during the link up phase of the connection. This capability has been around for some time in the 100BASE-TX standard. In fact, 10/100 capability is now found in Network Interface Cards (NICs), switches and even dual-speed hubs.

Auto-Negotiation works as follows: When two devices first connect, each one sends out a message (at the Auto-Negotiation level, not an Ethernet message), stating its functionality. Currently, the functionality in question is speed (10 Mbps or 100 Mbps) and mode of operation (Full Duplex or Half Duplex). The information is compared and the highest performing combination is used.

The optional Auto-Negotiation in 100BASE-SX uses essentially the same algorithms as 100BASE-TX. In 100BASE-TX, information is transmitted as a burst of up to 33 pulses (Fast Link Pulses or FLP), separated by 62.5 micro seconds ( $\mu\text{s}$ ) (nominally). The pulses are transmitted in pairs; the first pulse (always sent) is the clock pulse and the next pulse is a data pulse with the value of the bit indicated by the existence or lack of a pulse in that position. The 33<sup>rd</sup> pulse is a single clock pulse sent after the last data pulse. Therefore, 16 bits of data can be sent in a 2 ms burst; the bursts are separated by 16 ms (nominally).

Using Fast Link Pulses, two nodes can advertise their capabilities, perform a handshake and establish a link at the highest level of performance possible given their individual capabilities. If one of the nodes does not have the Auto-Negotiation option, the other node can determine whether it is 10 or 100 Mbps through the process of parallel detection. Parallel Detection monitors the link for the presence of link signaling from legacy devices that do not have Auto-Negotiation. If such link is detected, the port is activated using the speed of the detected link signaling and the Auto-Negotiation process is stopped. Auto-Negotiation process is started by a loss of link or a command from an external source, for example network management. It is completed in a few seconds.

Instead of inventing a new scheme for Auto-Negotiation on fiber, the 100BASE-X committee adapted the proven algorithm of 100BASE-TX (some parameters were changed because of the different times needed to detect carrier presence and loss in fiber versus twisted pair). This approach requires an emulation of Fast Link Pulses on fiber. Since there was no concept of a Link Pulse in 10BASE-FL (it uses a 1MHz carrier as an idle signal), one had to be invented. The approach chosen emulates a Link Pulse by a code violation of the fiber idle signal, in particular sending a pulse which is longer than the one allowed in 10BASE-FL. The 1.5  $\mu\text{s}$  pulse is too short to cause a carrier drop but long enough to be easily distinguishable from the longest pulse that can occur in the 10BASE-FL idle signal (approximately 0.6  $\mu\text{s}$ ).

Other than the different physical form, the timing of the Fiber Fast Link Pulses (or Fiber Link Negotiation Pulses - FNLP in 100BASE-SX lingo) is identical to the 100BASE-TX parameters. This enables a one-to-one correspondence between twisted pair and fiber link pulses which in turn maximizes compatibility, eases the conversion from one media to the other, and allows use of existing proven twisted pair circuitry for fiber.

### **Proposed Standard Lowers Barriers to Fiber Deployment**

Three issues have limited the wide-scale deployment of fiber in the horizontal – cost, backward and forward compatibility of fiber standards, and compatibility with copper. The proposed 100BASE-SX standard goes a long way towards providing solutions.

## **Cost**

Optical fiber traditionally has been viewed as an inherently more expensive option than copper. Today, several factors are bringing the installed first costs of the two media closer together.

- The cost of horizontal multimode fiber cable is now comparable to the cost of enhanced twisted pair and is lower than CAT-6 twisted pair.
- Pulling fiber cables now costs less than pulling copper because there are fewer regulatory restrictions regarding fiber cable placement. For example, special conduits or spacing considerations when running next to power lines. The introduction of a new generation of connectors, such as the MT-RJ (AMP), the Volition (3M), and the LC (Lucent) connectors, also make fiber connection quick and easy. These connectors are small (RJ45 footprint) and can be assembled in the same time as the RJ45.
- 100BASE-SX uses short wavelength optics which are significantly less expensive than the long wavelength optics used in 100BASE-FX. In fact the optical drivers and receivers used in 100BASE-SX are the same components used in 10BASE-FL.

Optoelectronic devices are the major cost component of a 100BASE-FX fiber media interface, typically accounting for about 50% of the total system cost. Since the cost of 100 Mbps short wavelength electro-optics is roughly 1/3 of the cost of long wavelength optoelectronics, this and other cost savings result in a total product cost that is approximately 30% lower.

Because 100BASE-SX (without Auto-Negotiation) uses existing silicon designed for 100BASE-FX, users should expect stand-alone SX devices (for example a media converter) to be priced roughly half way between a 10BASE-FL and a 100BASE-FX media converter. In other words, a 100 Mbps SX device will cost roughly 50% more than a 10 Mbps device. When devices implementing Auto-Negotiation become available, the price will most likely not change. In absolute terms, the end-user is likely to pay \$50-\$100 more for an auto-negotiating 10/100 SX fiber port than for an auto-negotiating 10/100 twisted pair 10/100 TX port. As volume rises, the price differential will decrease. If deployment of fiber to the desktop doubles each year (which is possible given the very low 1%-2% current penetration), users can expect a per-port premium of only \$25-\$50 for fiber in a few years.

## **Backward and Forward Compatibility of Fiber Standards**

One of the important features of the 100BASE-TX (100 Mbps twisted pair) standard is its backwards compatibility with 10BASE-T (10 Mbps) and forward compatibility with 1000BASE-T (1 Gbps). This feature (referred to as Auto-Negotiation or 10/100) allows a node to establish the highest performance link (speed and duplex) with its remote partner.

Auto-Negotiation allows users to upgrade networks incrementally, rather than in a single expensive and disruptive step. For example, if the user upgrades to a 10/100 switch, the switch can support the existing 10BASE-T nodes at 10 Mbps. When a node is upgraded to 100 Mbps 100BASE-TX, the switch automatically adapts to the higher speed. The process can be also done in reverse. The user can equip his new PCs or workstations with 10/100 NICs and install them in an existing 10 Mbps environment. When the hubs or switches are upgraded to 100 Mbps, the end nodes automatically take advantage of the higher bandwidth.

Until the development of 100BASE-SX, users with installed fiber could not implement Auto-Negotiation because the 10 Mbps standard (10BASE-FL) operates at a short wavelength (850 nm) while the 100 Mbps standard (100BASE-FX) operates at a long wavelength (1300 nm). The 1 Gbps standard supports both long (1000BASE-LX) and short wavelengths (1000BASE-SX). Because different wavelengths were used at 10 Mbps and 100 Mbps, there was a basic physical layer incompatibility that prevented any communication (including Auto-Negotiation) between 10BASE-FL and 100BASE-FX nodes.

Because 100BASE-SX uses short wavelength and Auto-Negotiation, it is backward compatible with 10BASE-FL and forward compatible with 1000BASE-SX, although 100BASE-SX does not currently have the Auto-Negotiation option.

As in the case of twisted pair, backwards compatibility and Auto-Negotiation allow an incremental migration to higher speed networks and extend the useful lifetime of legacy networking equipment. .

### **Compatibility with Twisted Pair**

Twisted pair is by far the dominant horizontal cabling technology and will remain so for the near term, even if the fiber to the desktop market doubles every year, it will take it more than six years to have a comparable installed base. For fiber-based networks to be successful they must support a mixed environment and allow a step-wise migration from twisted pair to fiber.

Media converters offer a partial solution to the problem. As the name implies, a (twisted pair to fiber) media converter converts a 10BASE-T or 100BASE-TX signal into its fiber equivalent (10BASE-FL or 100BASE-FX) and vice versa. For example, it allows a 100Mbps twisted pair switch to become a 100 Mbps fiber switch on a port by port basis.

The Auto-Negotiation of 100BASE-SX allows users to incrementally migrate from twisted pair to fiber; allows them to retain equipment (hubs, switches, routers, NICs etc.) with 10BASE-T and 100BASE-TX interfaces; and lets them take advantage of the low cost of devices with twisted pair interfaces.

During the next few years, until fiber becomes the media of choice, media conversion will be the mainstream solution for providing fiber connectivity in a twisted-pair dominated environment. 100BASE-SX allows a fully transparent conversion between twisted pair and fiber, maintaining all the features of 100BASE-TX, including Auto-Negotiation.

### **Market Forces Driving Standards Development**

When the existing fiber standards were written, there was little market demand for fiber in the horizontal. However, as speeds and expectations have increased, network managers have been confronted with an installed copper network that is not capable of supporting the desired speeds. Due to its inherent bandwidth and immunity to interference, optical fiber is the obvious choice for this new network.

Based on input from their customers, members of the TIA Fiber Optics LAN Section recognized the need for an optical fiber based network with a migration path from Ethernet to Fast Ethernet and formed the Short Wavelength Fast Ethernet Alliance (SWLA) in March 1998.

Interest in the proposed standard has been strong. The SWLA comprises more than 25 companies, including: 3M, Allied Telesyn International, Allayer, AMD, AMP, BATM, Berk-Tek, Belden Wire & Cable, Commscope, Connectronix, Corning, Digi/Milan, Honeywell, IMC Networks, Jet Networks, LANCAST, Lucent Technologies, Micro Linear, Microcosm, Mitel Semiconductor, Ortronics, Siecor, SpecTran, Sumitomo Electric Lightwave, Sundance Technologies, Telecom Design Technologies and Transition Networks.

Several SWLA members have already introduced pre-standard products with more under development. Interoperability among these products was demonstrated in 1998 at the Networld +Interop show in Atlanta. Currently, at least two companies are marketing 100BASE-TX to 100BASE-SX media converters that includes the optional Auto-Negotiation feature and several commercial silicon manufacturers have auto-negotiating dual speed chips available (100BASE-SX without Auto-Negotiation existing 100BASE-FX silicon can be used). This will drive cost further down and increase market penetration.

The development of the standard has proceeded at a rapid rate. The first ballot for the proposed 100BASE-SX standard, SP-4360, was completed by the FO 2.2 committee at the end of February 1999. At this point, no significant technical issues with the proposal remain. The committee sent out the draft standard out for a final ballot in December of 1999, with ratification expected in the second quarter 2000. Once the draft is ratified, it will be published as Std TIA/EIA-785.

For more information on the draft 100BASE-SX standard or to learn about the Fiber Optics LAN Section and its activities, please visit us at [www.fols.org](http://www.fols.org).