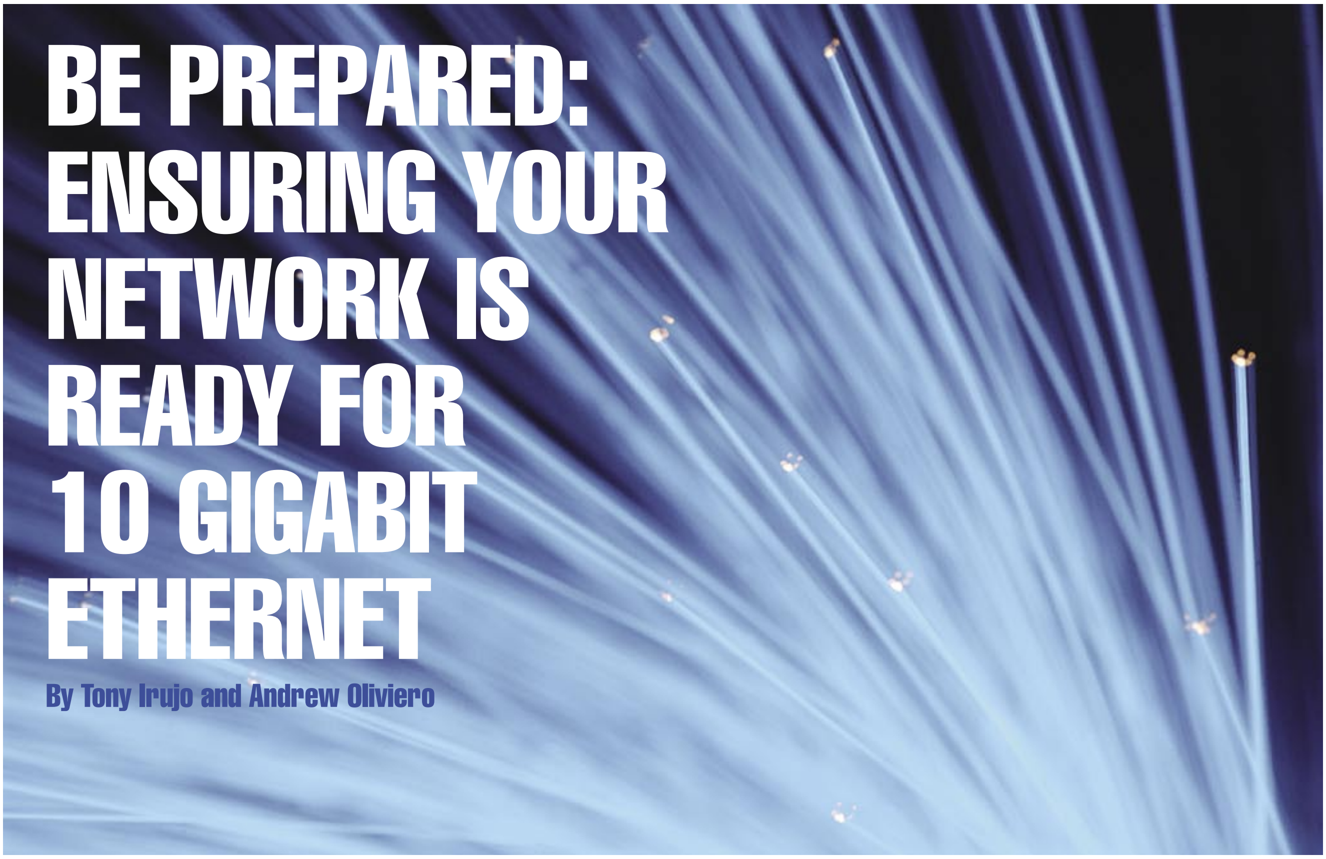

BE PREPARED: ENSURING YOUR NETWORK IS READY FOR 10 GIGABIT ETHERNET

By Tony Irujo and Andrew Oliviero

10 Gigabit Ethernet (10 Gb/s) transmission was once considered so advanced as to have no practical application in premises networks. Today, 10 Gb/s is being installed in data centers, Storage Area Networks (SANs), central offices/Internet and Local Area Networks (LANs) around the country. Many network managers are asking, "How do I prepare my network to provide the best 10 Gigabit Ethernet support for my organization?" To help answer this question, we present an overview of the system requirements of these applications and your choices in terms of optical fiber products and technology.

KNOW YOUR OPTIONS FOR 10 GIGABIT ETHERNET

Let's look at the optical fiber media and transceiver options in each application, beginning with LANs and data centers. Today's LAN installations increasingly feature a traditional hierarchal star architecture that uses 300-meter, 10 Gb/s-capable fiber building backbone cables in order to support 100-meter, 1 Gb/s-capable copper horizontal links. And data centers increasingly use 10 Gb/s-capable fiber ribbon cables to interconnect SAN and LAN equipment. The IEEE 10 Gigabit Ethernet Standard (IEEE 802.3ae) issued in 2002 identifies transceiver port types to work over singlemode and multimode fibers to support these applications.

On singlemode fiber, this standard supports 1300 nm- and 1550 nm-based MAN/WAN/LAN applications for distances from 10 - 40 kilometers (km). It also includes two short-reach multimode fiber solutions. The first uses low-cost 850 nm serial Vertical Cavity Surface Emitting Lasers (VCSELs) to support backbone and equipment room connections to 300 meters (m) over 50 μm laser-optimized multimode fiber (also known as OM3 fiber). This option also supports conventional 62.5 and 50 μm fiber to 26 m and 82 m, respectively.

The second option for multimode, which is more expensive, uses 1300 nm-based Coarse Wavelength Division Multiplexing (CWDM) transceivers over conventional 62.5 μm and 50 μm multimode fibers to reach 300 m. As outlined by the standard, this second option requires the use of mode-conditioning patch cords that could cost as much as $300 each.

These specific CWDM transceivers utilize four separate wavelengths in a bulky, expensive package. In order to address the high cost and size constraints of CWDM transceivers, the IEEE 802.3aq working group is developing an alternate standard for a transceiver to support 10 Gb/s over conventional multimode fiber that fits in a small form factor. This new standard, referred to as 10GBase-LRM, is expected to be published in late 2006 and will support 220m over conventional multimode fibers using a 1300 nm serial transceiver incorporating EDC (Electronic Dispersion Compensation) technology and mode-conditioning patch cords. These transceivers are projected to be slightly less expensive than the CWDM transceiver but still higher in cost than an 850 nm serial transceiver.

In Storage Area Network (SAN) applications (where U.S. infrastructure revenue is increasing at a rate of over 50 percent per year), Fibre Channel, which is the leading standards organization, published its ANSI T11.2 10-Gb/s standard in 2002. Fibre Channel, like Ethernet, includes the 850 nm serial VCSEL solution for 10 Gb/s up to 300m on 50 µm laser-optimized multimode fiber (OM3).

In central office applications, the increased use of 10 Gb/s (OC-192) transmission, DWDM, and routing systems is driving the trend toward low-cost 10 Gb/s interconnects. The Optical Internetworking Forum (OIF) is a group of more than 360 companies that established an interoperability agreement for a low-cost 10 Gb/s OC-192 central office interconnect solution. OIF recognized the cost benefit of the 850 nm serial solution over OM3 fiber, and included it in the 10 Gb/s standard VSR-4.0 for OC-192 interface, published in 2001.

SELECTING THE BEST FIBER GRADE

The conventional and lowest cost choice for supporting bandwidth increases in LANs, SANs, central offices, and data centers has been multimode fiber. In fact, 850nm multimode-based GBIC ports comprise more than 80 percent of all LAN 1 Gb/s optical ports. The advantages of multimode versus singlemode fiber systems include lower costs for transceivers, connectors, and connector installation.

Once a multimode system has been selected, the next choice to be made is whether to use 50-µm or 62.5-µm fiber, the two types of multimode products that can be used in these applications. For 10 Gb/s systems, 50 µm laser-optimized multimode fiber (OM3) is the clear choice. It offers significant bandwidth and reach advantages for the most common applications, while preserving the low system cost advantages of 850 nm-based multimode fiber. And for those who are more familiar with 62.5 µm fiber, it's helpful to know that 50 µm fiber uses the same connectors and installation techniques as 62.5.

The most cost-effective solution for 10 Gb/s transmission and beyond is OM3 fibers that have been designed and manufactured specifically for VCSEL transmission. These are available in various performance grades, all featuring a Differential Mode Delay (DMD)-controlled core that helps ensure 10 Gb/s support with low-cost 850 nm serial applications up to their rated distances. These fibers also support 1 Gb/s operation, and their 50-micron core size couples sufficient power from LED sources to support legacy applications like Ethernet, Token Ring, FDDI, and Fast Ethernet for virtually all in-building networks and most campus networks.

The common OM3 grade of laser-optimized fiber provides 10 Gb/s transmission with low cost 850 nm serial applications for distances up to 300 meters. For longer distances (large building backbones, medium-length campus backbones, etc.) and more sensitive power budget applications (e.g., data center equipment interconnects) the preferred fiber option is a higher performance laser-optimized fiber that supports 10 Gb/s Ethernet, Fibre Channel, and OIF applications to 550 meters or more using low-cost 850 nm VCSELs. The key to the performance of these fibers is a manufacturing process that produces a fiber with almost no DMD and 4,700 MHz-km of effective modal bandwidth (EMB), more than double the IEEE requirement for 10 Gb/s 300 meter support.

FINDING THE LOWEST COSTS – AND AVOIDING THE HIDDEN ONES

OFS Laboratories (formerly part of Lucent Technologies' Bell Labs) has examined the cost of various 10 Gb/s alternatives to determine the lowest cost solution. It studied the optical sub-system cost (riser fiber cables, patch cords, connectors, transceivers and installation) of outfitting a 15-story building with a 1 Gb/s riser and then upgrading it to 10 Gb/s a few years later. The study considered the following cabling scenarios: singlemode fiber, standard multimode fiber, and laser-optimized 50-µm multimode (OM) fiber.

Table 1 shows the relative costs

associated with each of these alternatives. In each of these examples, it is evident that the cost of the optical modules exceeds the cost of the cabling system plus installation.

The LO (OM3) 50-micron fiber solution uses a laser-optimized 50 μm multimode fiber cabling system with low-cost 850 nm VCSEL optical modules for the 1 Gb/s system (1000Base-SX) and can be upgraded to 10 Gb/s operation using 10GBase-SR ports. No cabling system upgrade is required. This can provide the lowest life-cycle cost.

The Std MM 1G to SM 10G system assumes a conventional 50 μm or 62.5 μm multimode fiber cabling system is installed. 850 nm optical modules are used for 1 Gb/s. In this case, we examined the impact of using singlemode fiber as the cabling upgrade path to support 10 Gb/s with 1310 nm (10GBase-LR) optical modules. Clearly, this is more expensive since the 1310 nm 10 Gb/s ports are more expensive than the 850 nm (10GBase-SR) version.

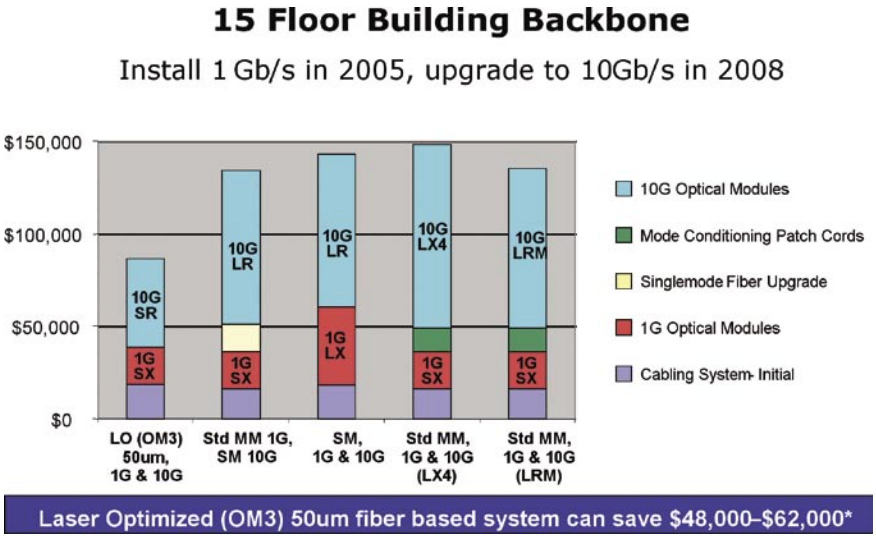

Table 1 - Optical System Cost Comparison
*** Depending on the actual configuration used**

The SM 1G to SM 10G system example examines the cost of using singlemode cabling to support 1 Gb/s (1000Base-LX) and, later, 10 Gb/s using 1310 nm optical modules. This is more expensive because more costly 1310 nm ports are also used for 1 Gb/s operation.

The Standard MM 1G to 10G solution assumes a conventional 50 or 62.5 μm cabling system with 850 nm optical modules used for 1 Gb/s. A cabling

upgrade in the form of mode-conditioning patch cords is installed per the requirement in the IEEE standard, and costly 1310 CWDM (10GBase-LX4) optical modules are used for 10 Gb/s. As can be seen, the cost of these electronics combined with the need for a costly mode-conditioning patch cord upgrade makes this option more expensive than the OM3 option.

An alternative solution (currently under development in IEEE) for Standard MM 1G to 10G involves use of a 1310 nm optical module with built-in Electronic Dispersion Compensation (10GBase-LRM). The cost of this optical module could be close to that of 10GBase-LR modules used on singlemode fiber, since it will use similar 1300 nm technology. The IEEE standard will require mode conditioning patch cords with standard multimode fiber.

As can be seen from these cost comparisons, the 50 μm laser-optimized OM3 fiber cabling system allows the use of the lowest cost electronics and patch cords, thereby helping to reduce the total sub-system costs by as much as $62,000, depending on the actual configuration used. Building owners should also consider the cost advantages of re-cabling their conventional multimode fiber infrastructure with 50 μm laser-optimized OM3 fiber cabling to take advantage of the lowest cost upgrade path of electronics.

Finally, in order to ensure the highest network reliability and performance, designers are encouraged to look closely at the specifications of their cabling systems. Choosing specifications that exceed the standard can provide power budget headroom, which can prove useful in improving the reliability of the network, and providing the ability to use higher loss MT-style connectors, additional interconnects or connections. Specifically, a designer should chose very low cable attenuation, tight fiber geometry and fiber DMD that is measured and specified to the center of the core. ■

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