White Paper

Super-size your LAN with fiber

Fiber optic technology frees the Local Area Network (LAN) from the confines of a single building, allowing a LAN to extend across a campus or a metropolitan area. Read how the selection of fiber optic components affects repeaterless transmission distance and how one school district used fiber to build a more reliable and more cost effective high-speed, district-wide network. Also, read how Metropolitan Area Network (MAN) ownership may require self-assessment of network performance.

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FLUKE networks

Introduction

In the early days of enterprise networking, pre-1980 for argument's sake, the boundaries around the local area network (LAN) and wide area network (WAN) were clear. The LAN was a private, enterprise network geographically constrained by the walls of a single building. If you wanted to interconnect multiple LANs in buildings separated by hundreds of meters or across the country, you employed a service provider, or carrier, to interconnect your LANs. You paid the service provider to ferry your local LAN traffic across the public WAN to your distant LAN. The widespread deployment of fiber optic cabling has changed this picture. No longer confined by twisted pair cabling limitations, the LAN is free to extend across campuses and metropolitan areas.

A small local area network consists primarily of twisted pair cabling, jacks, patch panel, hubs, switches and servers *(see figure 1)*. The transmission characteristics of UTP twisted pair cable limit its effective distance to 100 meters. This is usually not a problem in horizontal applications, where all network devices reside on the same floor of a building, since the distance from the work area outlet to the nearest switch is typically less than 100 meters. This can be problematic in large buildings like factories, warehouses, retail stores and multi-floor office towers. And it is certainly a problem when we want to connect LANs in multiple buildings located across a campus or across town. We commonly use fiber optic cabling to overcome the unshielded twisted pair (UTP) distance limitation in these applications.

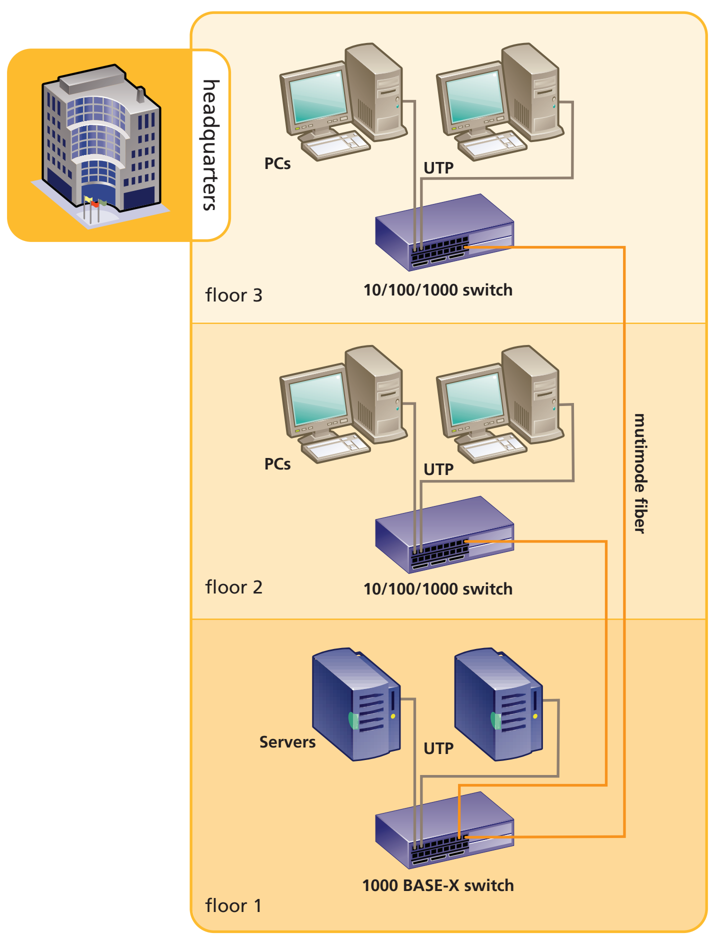


Figure 1

Determining fiber transmission distances

We can transmit data 2,000 meters or more over fiber optic cable without repeaters, making fiber an excellent choice for long distance applications. With singlemode fiber and the right optoelectronics, we can extend this repeaterless distance to 80,000 meters (50 miles) or more. There is a simple formula to determine the maximum transmission distance.

$$\boldsymbol{linklength(km)} = \frac{(availablepower - linkloss)}{lengthdependentlinkloss}$$

where

$$\boldsymbol{availablepower(dB)} = (min\ transmitpower(dBm) - min\ receivesensitivity(dBm))$$

$$\boldsymbol{linkloss(dB)} = (connectorloss(dB) + safetymargin(dB))$$

$$\boldsymbol{lengthdependentlinkloss(dB / km)} = (max\ cableattenuation(dB / km) + max\ spliceloss\ (dB / km))$$

This information is readily available from optoelectronic and fiber cable suppliers. The following table provides maximum lengths for some typical fiber optic applications using commercially available transceivers, cabling and connectors.

	Example 1	Example 2	Example 3	Example 4	Example 5
Transceiver type	10BASE-FL	10BASE-FL	1000BASE-LX	1000BASE-LX	1000BASE-LX
Wavelength	850 nm	1300 nm	1310 nm	1550 nm	1550 nm
Transmit power (min)	-19 dBm	-19 dBm	-5 dBm	-5 dBm	+1 dBm
Receive sensitivity (min)	-29.5 dBm	-29.5 dBm	-24 dBm	-24 dBm	-36 dBm
Available power	10.5 dB	10.5 dB	19 dB	19 dB	37 dB
Connector loss [1]	3 dB	3 dB	1.5 dB	1.5 dB	1.5 dB
Safety margin [2]	0 dB	0 dB	3 dB	3 dB	3 dB
Fiber type	62.5 MMF	62.5 MMF	Singlemode	Singlemode	Singlemode
Cable attenuation	3.75 dB/km	1.5 dB/km	0.4 dB/km	0.3 dB/km	0.25 dB/km
Slice loss [3]	0	0	0.05 dB/km	0.05 dB/km	0.05 dB/km
Link length	2.0 km 1.2 mi	5.0 km 3.1 mi	32.2 km 20 mi	41.4 km 35.7 mi	108.3 km 67.3 mi

[1] Assumes connectors with max loss of 0.75dB/connection
[2] For future repairs and unexpected factors
[3] Assumes 1 splice of 0.30dB every 6000 meters

Campus-wide LANs

Fiber optic technology liberates the LAN, allowing it to break out of the building to encompass a campus environment. By selecting the appropriate optoelectronics (switches, media converters), cabling (multimode, singlemode), connections (mechanical, fusion), and ensuring that everything is properly installed, we can easily construct extended LANs interconnecting multiple buildings on a campus. We can also employ fiber technology within a building for vertical applications. Due to the cost of optical transceivers, it is uncommon to deploy fiber to the desktop. We usually deploy UTP in horizontal applications to the work area and desktop *(see figure 2)*.

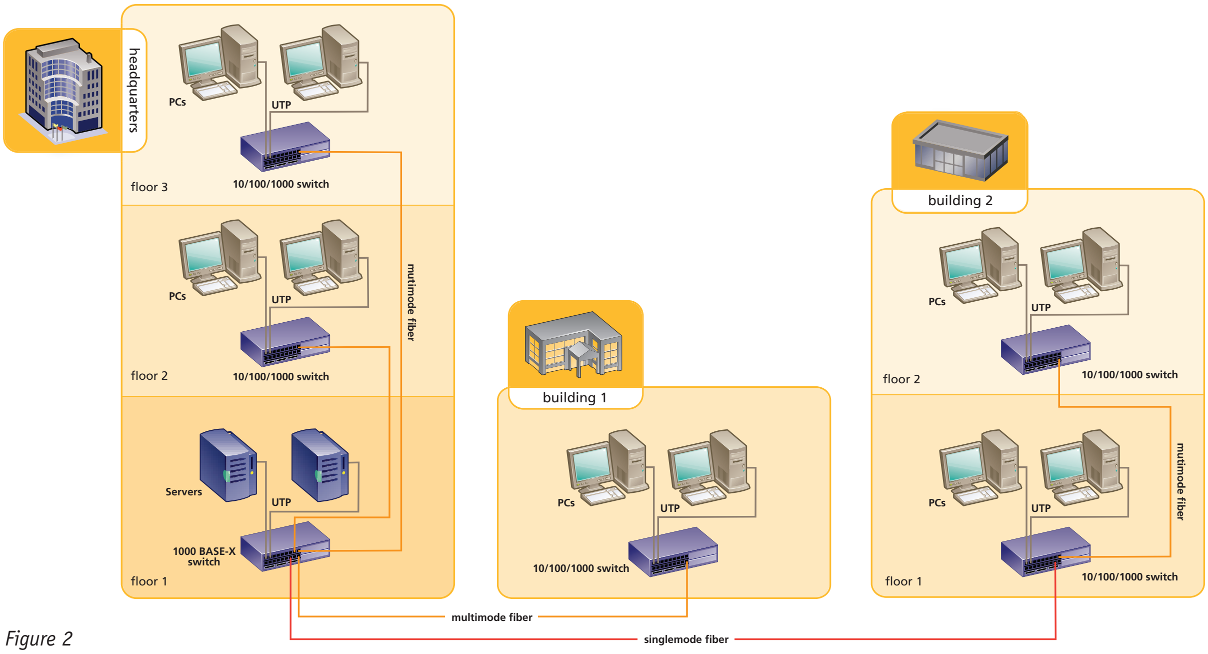


Figure 2

Metro area LANs

Beginning in the 1980s, municipal, state and regional utilities (e.g., power, gas, and water) upgraded their facilities by installing fiber cabling throughout their rights-of-way. They installed more fiber than they needed at the time, leaving some fiber "dark" for future use. Today an enterprise network owner can lease this dark fiber to extend his LAN across a metropolitan area. He can transform his LAN into a metropolitan area network (MAN), with fiber interconnecting buildings more than 50 miles apart *(see figure 3)*. For many large enterprises, building and maintaining a MAN is more cost effective than employing a WAN carrier or service provider to interconnect their LANs. A MAN also facilitates communication between switches using high-speed 100 Mbps or Gigabit Ethernet without LAN/WAN protocol conversion.

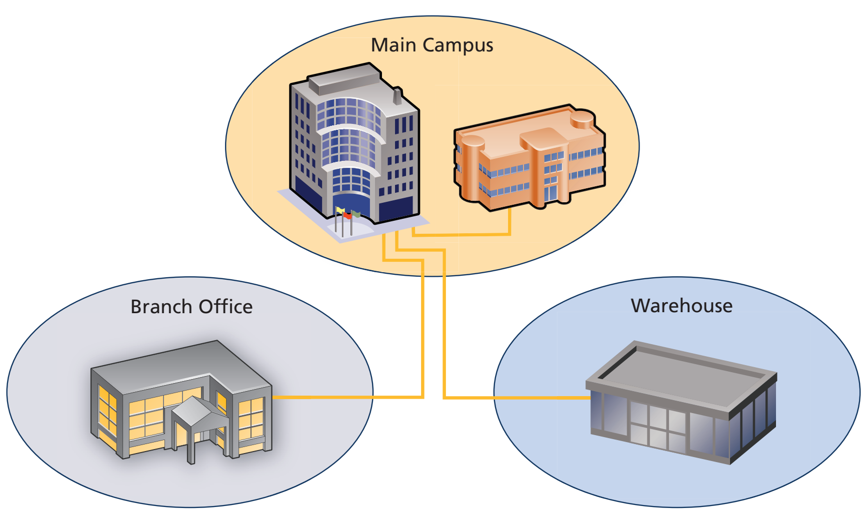


Figure 3

Monitoring and troubleshooting fiber links

An enterprise network owner who builds a fiber-based MAN for his private use will need to take on some of the network maintenance tasks traditionally performed by the WAN service provider. One such task is monitoring and troubleshooting the performance of the fiber links. A service provider defines link performance in a service level agreement (SLA). An SLA specifies, in measurable terms, the services that the network service provider will furnish, including expected performance. Performance metrics quantify end-user perceptions of service performance. Typical performance metrics include throughput, latency and frame loss. In the absence of a WAN service provider, the enterprise network owner will need to draft an internal SLA and self-access network performance. Testing and monitoring solutions are available to assist in these tasks.

Summary

Enterprise network owners are taking advantage of fiber optic technology to extend their LANs, from relatively limited geographic areas into campus-wide networks. By leasing dark fiber and selecting the appropriate optoelectronics, network owners can further extend these networks to span a metropolitan area with buildings located more than 50 miles away. In such cases, these enterprises may take on some of the monitoring and troubleshooting tasks traditionally performed by WAN carriers or service providers. Even with this added responsibility, many enterprise network owners prefer fiber optic-based Ethernet MANs to traditional LAN/WAN architectures.

Real-world example

Academy School District 20 consists of more than thirty sites scattered across northern Colorado Springs, Colorado. This public school district includes administration buildings, elementary schools, middle schools and high schools. Some of the schools are located on the grounds of the U.S. Air Force Academy. Each site operates its own 10/100 Ethernet LAN. The total number of nodes district wide is approaching 10,000. Prior to 2002, the district connected each local LAN to the central datacenter via 11 Mbps point-to-point wireless links and T-1 connections. Desiring a higher performance, more reliable, and more cost effective network, the district deployed a fiber optic network in 2002. Today the district has connected nearly every site to the central datacenter via one of three, 1000BASE-LX singlemode fiber optic rings. The self-healing ring architecture provides path redundancy in case of a cable break. A layer 3 Gigabit switch connects each site to the appropriate ring. The district owns and maintains the singlemode fiber they use within the rings. The fiber is currently used for data transmission and will eventually be used for telephone service. By significantly reducing the cost of phone service paid to the local exchange carrier, the district estimates they will save more than $250,000 annually for phone service alone, making for a very attractive return on their initial $500,000 investment.

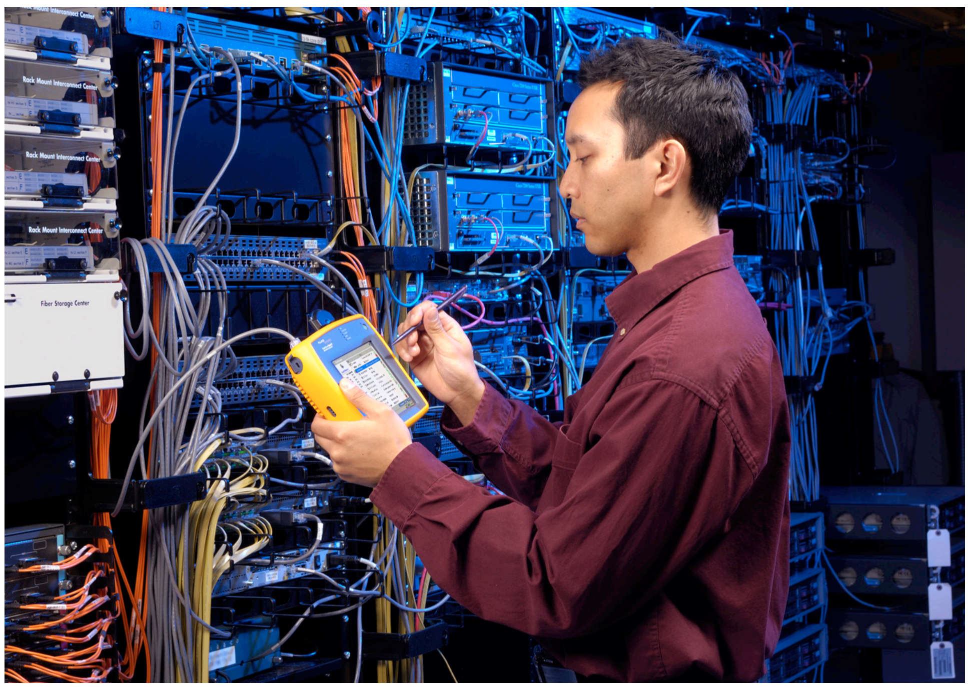
The district has been very satisfied with the performance of the network. “The fiber infrastructure is much more stable than point-to-point wireless,” said Abe Lomax, one of four engineers responsible for network deployment and management. “Service was not interrupted during the one occasion when the fiber cable was cut.”

The high-speed district-wide network enables centralized IT services including network access control, email, internet access, software distribution, patch management, and much more. Future applications may include video conferencing and on-line test administration. By employing long-haul singlemode fiber optic rings, the extended LAN is ready to support Academy School District 20’s IT goals - today and into the future.

Solution to measure link performance

The Fluke Networks EtherScope™ Series II Network Assistant features RFC 2544-based tests for measuring Ethernet link performance and validating SLA compliance. IETF RFC 2544 provides a standard testing methodology for measuring link performance, either to verify a successful service turn up or to monitor and troubleshoot links post deployment.
The handheld EtherScope Series II can test live LAN, MAN and WAN links at rates up to 1000 Mbps. It can test both twisted pair and fiber optic links via a built-in 10/100/Gig RJ-45 port and a pluggable 1000BASE-X Gig fiber SFP port. The EtherScope Series II also excels at LAN troubleshooting, including 802.11 Wi-Fi networks.

For more information on EtherScope, visit **www.flukenetworks.com/etherscope**.



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