Fiber Optic Networking Update

Karen Dudley

Hewlett-Packard Company
Roseville Networks Division
8000 Foothills Boulevard
Roseville, CA 95678

Summary

Fiber optics is an exciting technology with great potential for networking. Declining prices and standards activity have helped increase market acceptance of fiber optics for data communications. This paper will describe the fiber optic LAN marketplace, fiber optic 802.3/Ethernet systems, Fiber Distributed Data Interface (FDDI), fiber optic MAP and HP Fiber Optic Link. The objective is to review fiber optic networking alternatives and HP's product strategy.

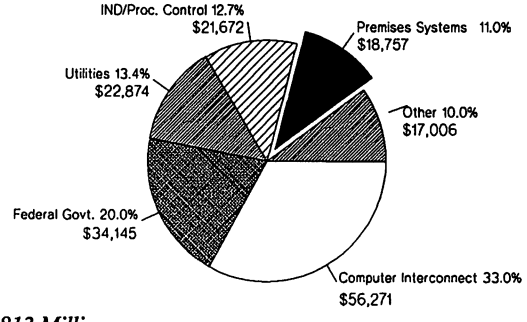
Today, fiber optics has been limited to specific applications that justify a premium price. The major network applications that require fiber today are campus backbones (distance and environmental requirements), secure environments, and harsh EMI/RFI environments such as the factory floor. Fiber is also justified for peripheral connections, especially mass storage, where large system configurability and data integrity are concerns. Very soon there will be increasing demand to use fiber for high performance workstation applications and larger capacity backbones.

The Fiber Optic LAN Marketplace

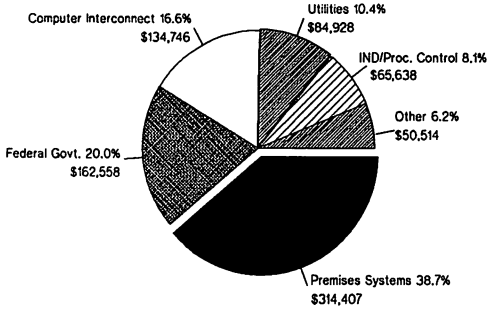
The fiber optic LAN market has not grown as quickly as industry analysts had initially predicted, but the current outlook is very promising. According to a Kessler Marketing Intelligence report, the fiber optic data communications market will grow from $171 million in 1987 to $813 million in 1992. The fastest growing application for fiber is premises systems, including local area networks, which is expected to rise from $19 million in 1987 to $314 million in 1992. Gartner Group expects steady growth in the fiber optic LAN market through 1988 and 1989, then accelerated growth as fiber based distribution systems become competitive with copper systems.

Fiber Optic Data Communications Market
Source: Kessler Marketing Intelligence

1987 Total = $171 Million



1992 Total = $813 Million



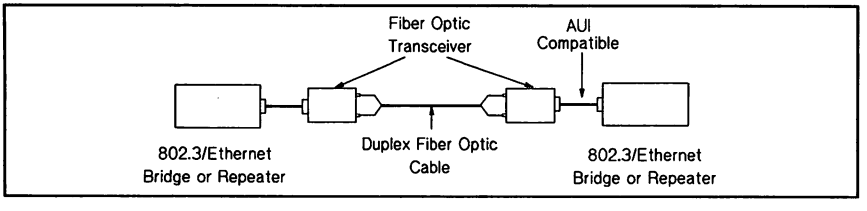
Fiber prices have dropped dramatically but high connect costs are still preventing wide-spread use of fiber optics in LAN applications. Fiber prices are now as low as 30 cents per meter depending on the fiber type, number of fibers and the quantity purchased. This is 30% lower than one year ago. Prices of other components (transceivers, connectors and electronics) have not declined as rapidly as the raw cable. Kessler Marketing Intelligence predicts further declines in fiber optic cable, transceivers and connectors by 1992.

Fiber optic LAN sales have been primarily to military and large financial institutions, where the security and reliability of fiber are worth the premium price. The key to widespread acceptance of fiber optic LANs will be standards development and continued decline in prices.

Fiber Optic 802.3/Ethernet Systems

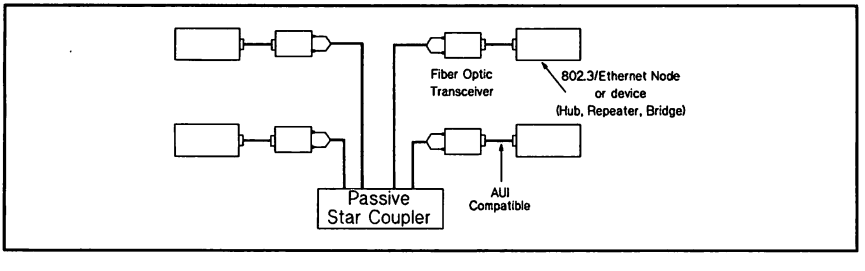
Fiber Optic 802.3/Ethernet Systems are now available from many vendors worldwide. Declining costs, simpler design and installation techniques, and standards activity are contributing to the growing acceptance of Fiber Optic Ethernet Systems. The cost for Fiber Optic Ethernet is $1,000 to $1,500 per node (approximately 25% more than a typical baseband LAN). The primary applications are for LAN backbones in harsh EMI/RFI environments and secure environments.

Fiber Optic Ethernet Systems available today include point-to-point links, passive star systems, active star systems and active ring systems. A point-to-point optical link can be configured using a pair of Ethernet optical transceivers with fiber optic cable between them. The transceivers can be connected to repeaters or bridges to create a Fiber Optic Inter-Repeater Link (FOIRL).

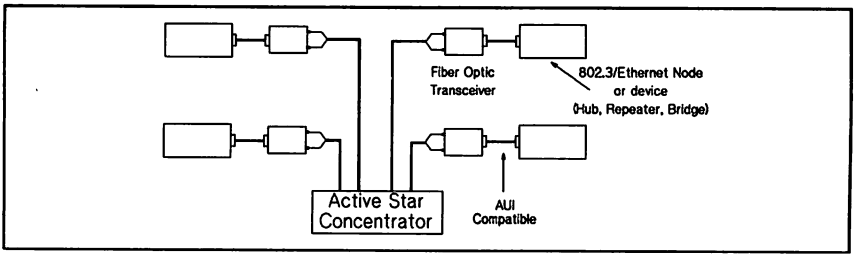


With a passive star 802.3/Ethernet system, a passive star coupler is used to provide the multiple access and broadcast functions of the CSMA/CD protocol used by 802.3/Ethernet. Fiber optic transceivers are used to connect 802.3/Ethernet nodes or devices such as multiport repeaters or bridges. The transceivers are connected to the star coupler with duplex fiber optic cable.

The use of a passive (requires no power) star coupler provides a highly reliable system where one node failure or a break in a cable effects only that node and not the entire system. The disadvantages of a passive system are imperfect collision detect and more complex design calculations (vs. an active star system). Passive systems are $300–$500 per node less than active systems.



Most active star systems consist of an Active Star concentrator with plug-in modules that connect optical transceivers. Active star systems provide better collision detection and simpler design calculations than passive star systems. Active Hubs typically include circuitry that can detect a failure in a node that would affect the network.



Another alternative for fiber optic Ethernet is an active ring configuration. Active ring systems provide a low cost implementation. Nodes are attached directly to a fiber optic ring with fiber transceivers. Adding nodes to a ring may require disconnecting the network. Node or cable failures may bring the ring down. Redundant rings can solve this problem but add cost. Rings are also more difficult to diagnose due to the lack of central electronics. When selecting a fiber optic 802.3/Ethernet System, be sure that it provides a fully compatible AUI connection to your nodes. Many are only partially compatible and this will cause connection problems in the future.

Standards Activity

The IEEE 802.3 committee has been addressing fiber optic LANs. A standard for a Fiber Optic Inter-Repeater Link (FOIRL) is complete. This standard defines the specifications for the fiber optic transceivers used in a point-to-point link.

Currently, there is an IEEE 802.3 working group evaluating fiber optic star standards. The committee is evaluating three proposals: passive star, asynchronous active star, and synchronous active star. The committee appears to be leaning towards a standard for passive stars and one for active stars. This standard should be complete by the end of 1988.

HP Product Strategy

Today HP references a Fiber Optic Transceiver for use with the HP 10Mbps to 10Mbps LAN Bridge and HP Repeater Kit. This solution provides a fiber optic Inter-Repeater Link to extend a baseband coax LAN between buildings.

In addition, HP is currently testing a Fiber Hub to provide a fiber optic 802.3 backbone to connect StarLAN, StarLAN 10 or ThinLAN subnets. Wiring recommendations from consultants such as Gartner Group are focusing on the use of fiber backbones with unshielded twisted-pair to the desk.

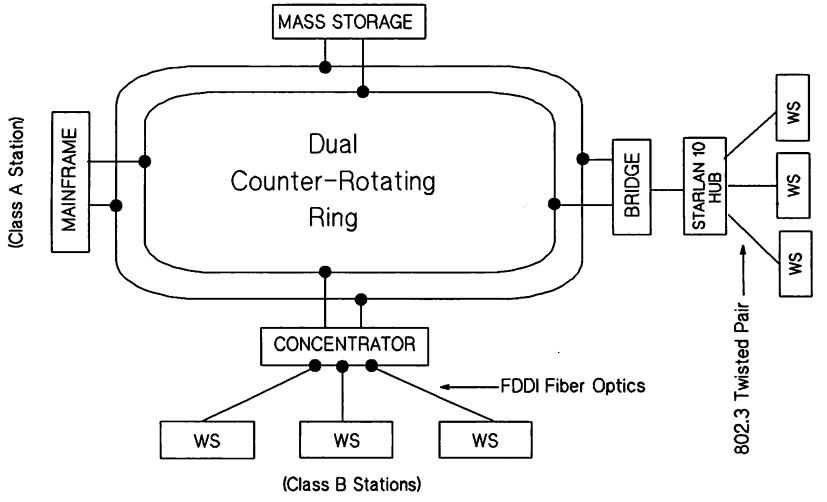
Fiber Distributed Data Interface

FDDI, being developed by the American National Standards Institute (ANSI) committee X3T9.5, is a counter-rotating token ring LAN with a data rate of 100Mbps. FDDI will support 500 dual attached stations linked by 100 km of duplex cable. A single station can support either a host computer or a subnetwork of hundreds of users.

The FDDI network consists of two independent 100Mbps rings – the primary and the secondary. The dual ring approach allows many different uses and configurations while providing redundancy and the ability to reconfigure the network under fault conditions. An FDDI ring has two basic station types: the class A station which connects to both the primary and secondary rings, and the class B station, which connects to either the primary or secondary ring but not to both. Class B stations require less hardware and are less expensive than class A stations and they can be easily isolated if a link fails. However, class A stations continue to operate in a reconfigured ring (under fault conditions).

FDDI also provides for hubs or wiring concentrators. With the use of hubs, the FDDI ring may be configured to look like a series of star networks or a branched tree network similar to a broadband network topology.

The FDDI Network

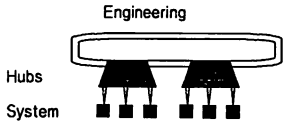
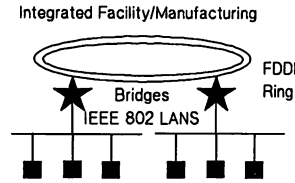
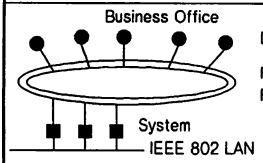


FDDI Applications

The original FDDI network was intended to be a high-performance backend network. Backend networks provide connections between computers and their high-speed peripherals or between computers in multiple processor environments. However, transport protocols and chips needed to efficiently support the long high-speed transfers typical of a backend network are still under development. Therefore, FDDI will first be used as an 802 network backbone, and to connect high-performance workstations.

FDDI will provide a high-performance backbone network to link together lower speed local area baseband networks (802.3, 802.4, 802.5) to support a greater number of stations and larger geographical distances. FDDI is ideal for this application due to its high performance, size, and compatibility with low performance standards such as 802.3 and 802.5. The FDDI MAC protocol provides a superset of the services required by the IEEE 802.2 logical link control. This simplifies the task of bridging FDDI to IEEE 802 networks. The initial FDDI specification is for data only networks and thus does not provide a complete multi-purpose backbone that is available with broadband today. New high-performance workstations and real-time imaging applications will drive the requirement for direct connection to FDDI LANs.

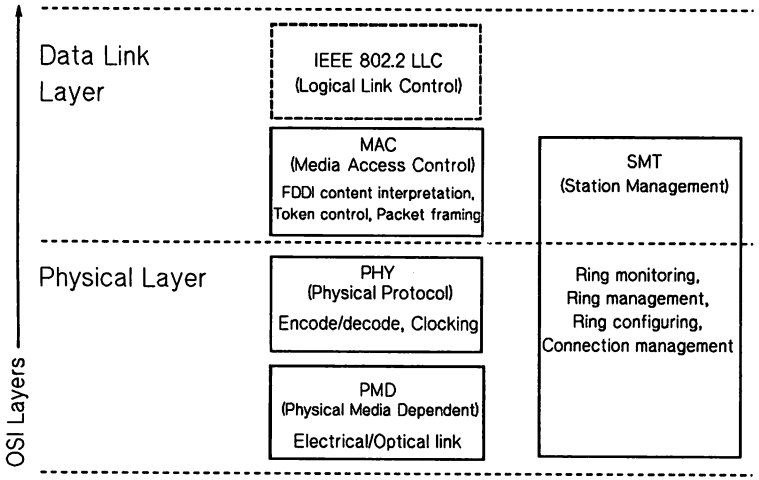
Customer Requirements

HP Solutions Fit	Type of Customer	Desired Topology	Customer Competitive Advantage
	Aerospace & Government & Universities	Workstation LAN	Performance
	Aerospace & Government & World-wide Manufacturers	Backbone	Integration
	Financial Institutions	Backend LAN	Security

Standards Activity

FDDI is being developed in accordance with the International Standard's Organization OSI model. FDDI represents the two lowest layers–Physical and Data Link–of the seven layer OSI framework.

FDDI Relationship to OSI Model



The PHY and MAC sections of the standard are complete. The PMD, which deals with optical connector standards is out for review. The SMT has the most technical work left to complete. HP is taking a very active role in contributing to the standard development. The initial FDDI standard is not expected to be complete until early 1989.

FDDI-II is a proposed follow-on to the original FDDI specification that adds circuit switching capability, thus expanding the applications of FDDI to include voice and video as well as data. FDDI-II uses a "slotted-ring" format. With this format, the 100Mbps capacity of the FDDI ring is divided into 16 channels. If FDDI-II works as envisioned, data, voice and some video signals could coexist in a single network. FDDI-II could solve many of the needs of factories, and provide a unified voice and data network for use in offices. FDDI-II standard work is still preliminary and a final standard is not expected for two to three years. A similar effort under IEEE 802.6 is also underway. It is expected that 802.6 will be positioned for public network applications and FDDI will be positioned for local area network applications.

FDDI Players

Over 50 vendors have supported FDDI standard development. Major system vendors include HP, Digital, IBM, Unisys, AT&T, Sun, and Apollo. Independent LAN vendors include Artel, Proteon, Fibercom, Fibronics, and NSC.

Fibronics, Fibercom, and NEC are the first vendors to announce FDDI products. Proteon and Artel have announced upgrades to current products when FDDI is available. Fibronics is the only vendor shipping a product today. Fibronics has a VME based system with a bridge to 802.3 Ethernet that sells for $36,800 per node. Prices are expected to drop to $25,000 per node once AMD integrated chips are available. Fibercom has announced an FDDI to Ethernet or token ring bridge that will be available mid 1989 and sell for $25,000. Integrated workstation products are expected late 1989 for approximately $10,000 per node.

HP Product Strategy

FDDI will play an important role for high bandwidth data backbones and high-performance workstation LANs. HP is contributing to the FDDI standard in the areas of fiber technology and networking. HP plans to use FDDI technology in future LAN products. Once the FDDI standard is complete, it will play an important role in multi-vendor networking.

Today HP offers a proprietary fiber optic connection for mass storage. HP Fiber Optic Link was developed specifically to solve problems inherent in using traditional copper media for large system configurations. HP Fiber Optic Link employs a simplified data transport protocol that is partially supported in custom VLSI, in order to maintain the data throughput required for backend communication. HP Fiber Optic Link will remain HP's fiber solution for the back-end until similar multivendor transport protocols and VLSI support circuits are developed for FDDI.

Fiber Optic MAP

The opportunity for fiber in factory applications exists where there are specific environmental problems such as nuclear power plants and process plants. The factory floor environment is susceptible to high electrical noise and interference. Fiber offers immunity to noise and complete electrical isolation of connected stations. Fiber will also provide a secure system for Aerospace and military equipment production.

There are a number of vendors producing fiber optic modems that conform to MAP standards but there is no real groundswell of support for fiber optic MAP today in the US. Contrasting the situation today in the US is the increasing support of fiber in the factory in Japan and Europe. Japanese manufacturers interviewed by Advanced Manufacturing Research indicated that they see the next manufacturing advance coming from the use of advanced communications to interconnect devices on the

factory floor. To the Japanese, factory networking means working with fiber optics on the factory floor. A factory automation company has been formed by four companies (NTT, Tateishi Electric Machinery, Mitsubishi, Rayon and Sumitomo Denko) to develop fiber optic factory networks that conform to MAP).

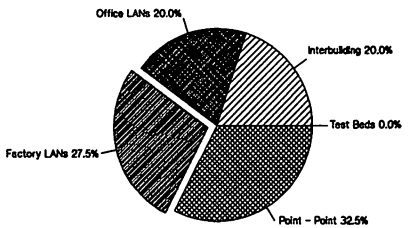
Standards Activity

A fiber optic MAP specification (802.4H) has been developed and is included in the appendix of the MAP 3.0 specification. This specification allows all topology options compatible with token passing bus Media Access Control layer. This includes linear passive bus, fiber optic passive star, fiber optic active bus, and fiber optic active star. The number of acceptable topologies included in this standard raises questions about the interoperability of different vendor's solutions.

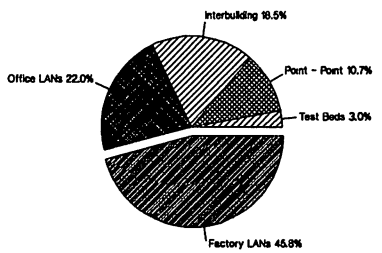
MAP/TOP Users Group Survey

A fiber optic survey was presented by Carl Morris (Chairman of the MAP/TOP Fiber Optics Special Interest Groups at the September 1988 MAP/TOP Users Group meeting. This was a survey of North American MAP/TOP Users Group. Approximately 1700 surveys were sent out and 195 were returned. Twenty percent of the survey respondents are using fiber today and 86% plan to use fiber in the future.

A. Today: 20% Using Fiber



B. Future: 86% Plan to use Fiber (Timeframe 88-90)



HP Product Strategy

HP is monitoring the 802.4H standards activity and the market for fiber optic MAP. The number of 802.4H topology options is a concern and HP will be evaluating the alternatives to help customers choose the best implementation. HP MAP products have been designed to accomodate Fiber Optic modems.

Wiring System Recommendations

Wiring systems are a very strategic hardware investment. The wiring system for a building or campus is very expensive and should last the life of the installation (10-20 years). Today, fiber optics is appropriate for specific applications that justify a premium price. While most end user applications today may not require fiber optics, you should consider running fiber for future use in new installations.

A cost effective strategy is to run "dark fiber" (currently inactive fiber) in campus or building backbones. This strategy provides bandwidth insurance at a reasonable cost. (See below for fiber optic cable specifications.) Fiber should not be run to the work area unless there is a specific requirement for security or applications that will require bandwidth greater than 10 Mbps. In general, multi-mode fiber optic backbones and unshielded twisted-pair horizontals will meet most users' requirements for the next 10 years.

Fiber Optic Specifications

The following fiber optic specifications will ensure that fiber optic pairs pulled today will support future standards such as FDDI.

- 62.5/125 micron fiber
- 500 MHz *km modal bandwidth
- cable attenuation $\leq$2.5 db/km

In general, HP recommends that ST connectors be used. FDDI will specify a new connector which is similar to the ST connector but provides the duplex connection required for FDDI.