DATA DISTRIBUTION WITHIN A LOCAL NETWORK USING FIBER OPTICS

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ABSTRACT

With the increased use of data communications and telecommunications by major corporations, the data communications managers are finding it increasingly more difficult to interconnect their networks in a cost-effective and efficient manner.

INTRODUCTION

Although twisted-pair cable, as well as just recently the coax cable, has long been used for data transmission, especially in local networks, fiber optic cable may well supplement both in the large networks of the 1980’s. Fiber optics has historically been used only in the telecommunications industry, but because of its enormous advantages and rapid advancements in the electronics to mate with it, the capabilities of fiber optics can no longer be ignored by network planners.

Due to the weight and size of the twisted-pair and coax cables, fiber optic cable has now become a very cost-effective means for installing data networks. With typical twisted-pair and coax systems requiring space of 3/8 inch to over 3 to 4 inches in diameter in conduits, fiber optic cable offers a very cost-effective way to obtain the data-carrying capacity of tens to hundreds of twisted-pair or coax cables with a single cable in the 1/4 to 3/8 inch diameter range. Achievable bandwidths of fiber optic cables presently on the data communication market are in the range of 400 MHz to 1 GHz. With this capacity, data communication networks can be installed at a much lower cost, as well as having enormous expansion capability due to the large bandwidth of the fiber optic cable.
FIBER OPTIC OVERVIEW

Why has fiber optic technology only recently emerged in the data communication industry? The field of fiber optics dates back into the early 1950’s, where fiber optics was being used in such apparatus as the fiberscopes, used in the medical field at that time, for doing exploratory surgery. In the 1960’s, developments by Corning in low-loss fibers made it feasible for companies such as Bell Labs to install initial fiber optic telecommunications systems, like the most noted one installed in Chicago. In the 1970’s, the advancements in fiber optic technology, as well as the availability of electronics, made the use of fiber optics more feasible. As the 70’s ended, and we have now gone into the 1980’s, the cost of fiber optic cable and associated electronics has dropped significantly. These lower costs, and the availability of more electronics designed specifically for data communications, have now made the local networks realistic. Spurred by the phenomenal growth of data communications in the local area network in recent years, fiber optic local networks have made impressive advances. With the increased growth demands for high-capacity, multi-channel megabit-range communications, the technology has recently been expanded from the telecommunications area into the data communications area, and has been implemented into businesses, industry, research, and educational facilities. Fiber optics is now being used in almost every industry, such as banks, universities, research centers, military bases, government buildings, oil and chemical refineries, to name a few.

In addition to providing a flexible and expandable high-capacity data network, this technology allows for auxiliary services such as video and audio telephone to be co-resident within the same cable. Because of the exceptional bandwidth, the massive cable networks that are used in local networks can usually be replaced by a single fiber cable. Fiber optic asynchronous and synchronous modems, 20 Megabit data links, time division multiplexers, and optical computer bus extenders are now commercially available.

Fiber optic cable allows the network designer to develop systems having not only single data channels, but multiple data channels operating at data rates ranging from low speed (less than 56 Kbps) to 1, 2, and 20 Mbps, to be co-resident on one single fiber.

REALIZATION

Until recently, the network planners have not had to pay much attention to future growth because as new systems were needed, a new cable was installed between the sites. Anticipated growth was never a significant factor. Historically, it has been difficult to sell management on the growth orientation or future services that would be required. However, in many plant sites, data communications network growth has been awesome. There are many installations now where in the past new cables were just installed as needed, but ceilings are now starting to sag, and cable trays are at the point of collapsing due to the
overload. Underground ducts are filled to the point that streets are being excavated for new, larger, and incredibly expensive duct work just to house the new cables that will be required in the future. These physical limitations and the many advantages of the fiber optic cable, especially in bandwidth and small size, have made the fiber optic technology a more viable way of providing for system growth.

One major responsibility of the planner and manager is to analyze the trends of his own network. The need to install underground services may delay implementation of newly delivered systems by several months, or years. Fiber optic cabling can condense dramatically the amount of cables required, as well as providing at the same time for future expansion. For example, it is easily possible using the state-of-the-art fiber optic equipment to set up networks between several buildings supporting over 500 separate users and multiple computers, using a single fiber cable, and still have room to grow and expand in the future.

THE BASIC LINK

Point-to-point Link - Up until recently, many of the network designers have looked at fiber optic cable as being only a substitute for the old modem point-to-point links, as shown in Figure 1. As users became more familiar with fiber optics, they realized that the channel capacity for a fiber optic modem was much larger than that of their conventional twisted-pair type wire modems. With this increased bandwidth they were able to now set up networks where the statistical multiplexers and time division multiplexers could be more efficiently used with the fiber optic cable. Using this technology, the high-channel capacity (up to 56 Kbps) using the fiber optic modems allowed them to multiplex many lower-speed channels onto one fiber optic cable, thus alleviating the necessity for large cable bundles going between two locations.

BASIC NETWORKS

With the increased availability of the electronics using fiber optic cabling, the networks now can be realized. The basic network that has been used in data communications applications has been that of connecting the computer centers to multiple terminal locations. Figure 2 illustrates a basic network in which the computer center, located in one building, is connected to multiple terminals and printer locations in another building. Since fiber optic cable in a variety of different configurations is available, the cable no longer has to be installed in conduits or protective housing. As illustrated, the fiber optic cables now can be supplied to be aerially installed on telephone poles, or can be directly buried with rodent-proofing protections as well. With the availability of the fiber optic time division multiplexers from companies such as Canoga Data Systems, Harris Corporation, and Valtec, it is now possible to multiplex many terminals onto one single fiber optic cable,
thus eliminating the need for multiple pairs of cables going between two buildings. Locating a time division multiplexer in each of the buildings would then require only a single duplex fiber optic cable to be strung between the buildings to handle anywhere from 4 to over 1,000 terminals on the single cable. Some of the fiber optic time division multiplexer manufacturers have utilized the high bandwidth of the fiber optic cable to multiplex many highspeed channels onto one single fiber, such as the Canoga Data Systems CMX-100 multiplexer that has the ability to multiplex sixteen 56 Kbps synchronous lines onto one duplex cable. This multiplexer also has the ability to remotely locate the electrical interface on individual multiplexer channels, thus eliminating the problem in the past where the network planner, when wanting to use a multiplexer, had to locate the multiplexer near his terminal points. With the new fiber optic multiplexers, the planner now has the ability to remote the standard electrical connection to the terminal locations that he wishes, up to distances of 3 Km from the multiplexer, with readily available, off-the-shelf components. This now allows the planner not to fix the locations of terminals and other data communication equipment into certain geographically-close locations. Applications where terminals and other data communication equipment will be located a great distance from the multiplexer location can now be realized using the multiplexer as a data concentrating point.

**DISTRIBUTED DATA NETWORKS**

With the availability of only twisted-pair or coaxial types of cable, the network planner found it difficult to achieve very high data rates when setting up a distributed data network where one central computer would have the capability of addressing other remote processing centers. This type of network is very popular in large corporations and college and research facilities. In these distributed data networks there is usually a central computing center in which the main processing and storage capability of the computing center is in one location. This was the main method of data processing in large corporations until recently, when distributed processing took hold. In a distributed processing network, the trend is to locate remote processors with less capacity than the central computing center at various locations within the complex, thus eliminating the need for those wanting to use the computing facility to work with batch processing commonly employed by central computing centers. With the remote processing centers, the user now has the capability to perform his routine data processing needs. As time progressed, the network planners realized that the users using remote processors did not have the ability to tap into the large memory banks and processing capabilities of the central computer center. The trend was then to connect the remote processing centers to the central computing center. The difficulties then arose that no high-speed communication ports were available that would communicate over twisted-pair or coaxial type cable. The maximum data rates typically employed within these networks was 1 Megabit serial, which worked out to be about a 50 Kiloword type of data rate, which is typically very slow when transferring large
amounts of data. With recent advancements in fiber optic technology, high-speed optical parallel-to-serial bus extenders became available on the market from manufacturers such as Canoga Data Systems and Harris Corporation. These bus extenders provided the network planner with the ability to transmit either a 16-bit parallel word, or a 32-bit parallel word over a single fiber optic cable between processors, with data speeds in the range of one-quarter million word transfers per second, thus increasing the data transmission capacity between processors by five-fold. Now, with these products, high-speed distributed data networks can be realized, as illustrated in Figure 3. Remote processing centers, development labs, and accounting and word processing computing centers can now all be tied into one central network connected to the central computing center, and utilize its enormous memory capacity and computational capabilities.

BROAD-BAND NETWORKS

With the use of fiber optic cable and the increasing availability of the electronics to utilize the high bandwidth of this cable, the network planner now has the ability to form multi-building data networks. With the use of the new fiber optic time division multiplexers that have the ability to remote the electrical interfaces to that multiplexer, so that the multiplexer acts as a central concentrating hub, the network planner can now connect multiple buildings within one hub, utilizing only a single fiber cable from the hub to the computing center. These capabilities of the new fiber optic TDM’s make networks such as shown in Figure 4 realistic. The remoting capability of each channel of the time division multiplexer, as well as each channel having the ability to handle 56 Kbps synchronous data, allows networks to be established where a single fiber optic channel is extended from the hub to a remote building. A statistical multiplexer connected to the fiber optic modem at the remote end of the fiber optic link can be used to concentrate multiple terminals (from 4 to 250 terminals) onto one 56 Kbps channel. At the same time, remote processors can use the 56 Kbps channels, as well, to do remote downline processing to the central computing center located great distances away.

Since the size of the fiber optic cable is so small, the cable can be installed into considerably smaller areas. The size of a 10-fiber fiber optic cable, allowing for five independent, full-duplex channels, is less than 3/8 inch in diameter. Therefore, multiple channels going from the central hub to remote buildings can now be realized using the same space as previously occupied by one single coaxial cable. In addition, the use of satellite networks is becoming more popular.

The fiber optic system, with its high data capacity, now allows the user to connect directly from the computing center using fiber optic cable and modems or multiplexers to the 56 Kbps channels that are used by the RCA 56 Plus, American Satellite, and AT&T’s DDS 56 Kbps networks. Therefore, very large network complexes can be established
connecting multiple buildings, as well as satellite networks into one common fiber optic network.

**NOT FOR ALL**

As encouraging as is the availability of the many electronic systems utilizing the high bandwidth capacity of fiber optics, it is still not the ultimate solution in networking. There is a great deal of discussion lately in networking about establishing bus networks similar to the Ethernet and Hyper-channel networks. Fiber optics, at present, does not lend itself easily to networks like this. There are presently available optical T’s and stars that can be used to construct a bus configuration network, but the cost of the T’s and the extensive loss going through these couplers still is a defeating factor in the use of fiber optics in a multi-tap-off type of bus network. There is a great deal of research going into the development of these taps and T’s which show a great deal of promise, but at present to form a bus network with fiber optics would be extremely expensive, although in certain cases it may be advantageous due to the enormous bandwidth that can be achieved, and the total noise elimination and security aspects of the fiber cable.

**CONCLUSION**

As has been shown, fiber optics has expanded out of the laboratory-type environment and the initial experimental type of systems, such as that installed by Bell Labs in Chicago, so that realistic telecommunications and data communications networks now can be achieved. Many systems have now been installed using fiber optics, and future systems, such as the Northeast Corridor Telecommunication Network, which will be put in by Bell operating companies from Boston to Washington, D.C. (611 miles), and data networks initially being installed by major corporations, now give the network planner an alternative method for connecting up his networks, with the availability of future expansion at very little cost to him.

**References**

3. Harris Corporation Technical Brief ISS-5088
4. Canoga Data Systems Data Sheets CMX-100, CBE-100, CRS-100, CSY-100, CCL-200.
FIGURE 1 - POINT-TO-POINT LINK

FIGURE 2 - TERMINAL NETWORK
FIGURE 3 - INTRA-BUILDING DISTRIBUTED DATA NETWORK

FIGURE 4 - MULTI-BUILDING DATA AND SATELLITE NETWORK