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Recommended Citation

Omar, Mohammed H. 1989. "Fiber Optics Technology: A Promise for Productivity Enhancement." E.C.R.S.B. 89-14. Robins School of Business White Paper Series. University of Richmond, Richmond, Virginia.

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FIBER OPTICS TECHNOLOGY:

A PROMISE FOR PRODUCTIVITY ENHANCEMENT

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INTRODUCTION

The evolution of fiber optics during the past thirty years has led to dramatic developments in the fields of computer information systems, telecommunications, cable television, and military science. Today, fiber optical systems are widely accepted as a practical and cost efficient alternative to electrical communication systems.

Fiber optics entails the transmission of light through a medium such as glass. In contrast to electronic technology which centers around the transmission of electrons, fiber optics technology centers around the transmission of photons. Optical fiber consists of a single glass thread wrapped in a plastic casing. The center of the glass thread is made of a slightly denser glass that carries the light. Transmitting a message through optical fiber involves two main stages. First, the message is transformed into electrical signals that pass through a light emitter and become either pulses of light (digital transmission) or become a light of varying brightness (analog transmission). Second, the light signal passes through the fiber to the receiver which converts the light back into electrical signals. This paper addresses (1) the basic architecture of fiber optical systems; (2) the evolution of fiber optical systems; (3) the advantages and limitations of fiber optical systems in comparison to traditional communication systems; (4) the application of fiber optical systems; and (5) the anticipated future developments of fiber optical systems.

Architecture of Fiber Optical Systems:

Most optical communication systems consist of five primary components:

1. The original source:

The original source could either be a source that transmits electrical signals -like a computer or a terminal, or a source that transmits non-electrical messages - like voices and images. A transducer is usually used to convert a non-electrical message into electrical signals. Common examples of transducers are microphones that convert sound waves into electrical currents and video cameras that convert images into electrical current.

2. The electronic driver/ modulator:

After the non-electrical message has been converted into electrical current, the optical intensity of the source is modulated to convert the electrical current into a light signal that can travel along the glass fiber.

3. The transmission medium (the optical fiber):

The typical structure of an optical fiber consists of a single glass thread that is surrounded by a coating of glass. After the electrical current has been converted into a light signal, the light pulse is sent through the glass thread with guided energy that confines transmission to the inner fiber core.

4. The photo-detector:

The end of the glass fiber channel is attached to a photo-detector which functions as the optical receiver. The photo-detector, which is highly sensitive to weak light signals, receives the incoming light signal and converts the light pulse back into an electrical signal. The photo-detector must have a sufficient bandwidth to accommodate the bandwidth of the incoming signal.

5. The signal processing device:

The electronic amplification and signal processing device is used to convert the electrical signals into a form suitable for the end user. For

example, if the message is to be received in a voice or image form, then the signal processing device will convert the incoming electrical signals into voice or images as needed.

Evolution of Fiber Optics:

The basic idea of the transmission through light can be traced back to Alexander Graham Bell and his "photophone". This device of 1880 enabled a person's voice to be carried on a reflected beam of sun light. Experiments on the transmission of light through optical fiber were first carried out in Germany in 1930. The prototype of the present optical fiber was proposed in England in 1958.[1] However, the modern era of optical communication is considered to have originated with use of laser in 1960. Although the invention of the laser solved many of the problems associated with fiber optics, the lack of an efficient transmission channel impeded the progress of researchers until 1970 when Corning Glass Works introduced the glass fiber as a media for transmission. Yet, it was not until 1975 that the first truly efficient glass fiber was developed and optical communications became a practical alternative. By 1980, commercial manufacturers were able to mass produce low cost optical fibers and the application possibilities for optical communication systems were greatly expanded.

Advantages of Fiber Optical Systems:

Fiber optical systems now offer several advantages over traditional communication systems.

1. optical fiber cables offer larger capacity than metallic cables. A standard telephone wire cable contains 900 twisted wire pairs and has a diameter of 70 millimeters. Each pair carries 24 voice channels, thus the capacity of the cable is 21,600 calls. An optical fiber cable developed for telephone applications, however has a 12.7 millimeter diameter and contains 144 fibers,

with a total capacity of 96,768 calls. The fiber cable has nearly 4.5 times as much capacity as the wire cable, and has a cross-sectional area that is 30 times smaller.[2]

2. The light weight of fiber cables makes it easier to install. The small diameter of fiber cables makes it possible to stretch them through existing conduits. Comparing equal weights of fiber cable and wire cable, the fiber cable would extend to three times the distance the wire cable would reach. The fiber cable would also have a transmission capacity 100 times that of the wire cable.

3. Fiber optic cables are cheaper to produce, cheaper to transport, and cheaper to install than wire cables. Fiber cables are made of glass, which is made of silica, a plentiful natural resource, while wire cables are made of copper, a scarce resource produced through mining.

4. Optical communication systems offer a higher degree of security than electrical communication systems. In order to tap into an optical fiber wire, the individual must tamper directly with the fiber. If the fiber is cut or damaged, the security breach is immediately detected.

5. Fiber optic cables don't generate electromagnetic interference because light rather than electricity is transmitted through the cable. Therefore, fiber optic cables can be installed close to electric power cables without concern for electromagnetic interference. Fiber cables are well suited for use in connections between computers. Being immune to interference from magnetic or electrical fields, distortion of signals will be much less than in wire cables. The Bit Error Rate (BER) for wire cables, for example, is one bit per one billion, while the BER for fiber cable is one bit per ten trillion bits.

6. Light has a bandwidth that allows the transmission of huge amounts of

data at a tremendous rate. The current experimental record for information transmission is 4 billion bits per second -about the information contained in a 30 volume encyclopedia. Utilizing the full capacity in fiber optics, the contents of the Library of Congress could be transmitted in few minutes.

7. Optical fiber is tolerant to its environment. It is non flammable and resistant to abrasion and to most corrosive substances. This makes it ideal for use in harsh environments which can affect the integrity of data transmitted through other types of media.

Limitations to Use of Fiber Cables:

Despite the numerous advantages listed above, there are certain limitations to the use of fiber optics.

1. The tools required for installing fiber optic cables are completely different from those currently used for installing wire cables. This requires purchasing new equipment and special training which leads to increasing the initial costs and prohibits some companies from adopting the fiber optics solution.

2. The interface equipments are complex and expensive. In order to make use of all the bandwidth available, the circuitry must be of high quality to ensure the most efficient transfer of signals.

3. Repairs for fiber cables are more tedious and time consuming than repairs of cable wires. If a fiber cable breaks, splices must be made or new equipment must be attached to the existing fiber channels. The splicing and connecting operations require close alignment and fine precision.[3]

4. Fiber optics need a clear path through which light can travel. In office applications, turns in the cable should be given consideration, so the light

path is not broken. This is one of the reasons that fiber optics has not been used extinsively in office environment.

5. There is a need for standards in fiber optics communications. The American National Standard Institute is finalizing a fiber optics standard, the Fiber Distributed Data Interface (FDDI).[4] The adoption of such a standard will significantly increase the application of fiber optics in local area networks.

However, it is important to remember that fiber optics is a relatively new field. Rapid progress in this technology is contributing to solutions for these problems and helping to drive the costs down.

Applications of Fiber Optics

There are variety of uses for fiber optics that will impact the futur of our society.

1. Computer communications:

The small diameter of fiber cables, its immunity to electromagnetic interference, and the security features it provides, make it suitable for computer networks. Fiber optics lend themselves very nicely to the ring and star network configurations. Currently, many companies are recognizing the benifits of fiber optic cables and are finding ways to intermix them with existing wire cables. This helps reduce the costs by using coaxial cables for short distances while taking advantage of fiber optics for linking systems that are farther apart physically. The use of fiber optics is promissing in solving the problem of slow respose time due to the slow speed of the input/output channels. This may occur to the point where the processor might take longer to complete its tasks than the input/output devices. This could lead to many new and exciting changes in the concept of the computer

as a whole.

For the last two decades, researchers have been intrigued with the concept of using light beams for computing. Recently, Bell Labs developed an optical transistor capable of controlling light beams in the same way that transistors control electrical current. The idea of a digital optical computer is not a dream anymore.

2. **Long distance communications:**

Land-based fiber optics networks are expanding rapidly. Communication companies in the U.S. are joining businesses that own rights of way -railway and pipe line companies- to install extensive networks. AT&T fiber optics routes now stretch over 10,000 miles. The speed at which optical networks are replacing wire cables is dependent on the geography. Progress in the U.S is slower than in Europe. AT&T for example have an existing network of more than 800 million miles of cable wires, the replacement of which will take tens of years. In Britain, however, BTI wants at least fifty percent of its long distance network on fiber optics by 1990.

In addition to competing with wire cables, fiber optics is also competing with satellites. A group of communication companies led by America's AT&T, the French ministry of telecommunications, and BTI of Britain will soon finish laying the first optical cable accross the Atlantic. It will cost $325 million to build, and will run for 4,200 miles -from Tuckerton, New Jersy to Widemouth, England, and Penmarch, France. By 1989, a $593 million fiber optic network will connect California to Asia, and by 1990 four other transatlantic fiber cables will be in place.[5]

3. **Telephone Cable Networks:**

The smaller diameter of the fiber cable and the increased capacity it offers will improve sound and picture quality tremendously. Also, a single

line could be installed into home for use in all communications rather than installing seperate lines for telephone and cable televesion hookups. Eventually this could lead to a telecommunication system that will provide the services required for the entire family vedio libraries and video data services.

While the technology is currently available for these systems, the steps to link individual homes to optical fibers may still be quite distant. The cost is still very high and additional services are needed to make the connections cost effective. In addition, television cable and phone companies have not shared good relations in the past, and until they can coordinate their works, it is unlikely that fiber optics will make the final step into the consumers homes.

4. **Medical applications:**

Another area where fiber optics is beginning to gain attention is the medical field. Fiber optics are used now to perform certain types of procedures during surgery. The compact size of fiber and its clarity and accuracy in transmitting data make it convenient for delicate surgical procedures. Fiber optic sensors are being developed that can get to places man has been unable to reach such as monitoring the blood flow inside a vein. Another application under development is the the introduction of tracers into the body which target malignant tumors, using fiber optics the tracers can be located. Sensors which can detect chemicals such as oxygen and glucose will be used to determine a patient's lung capability and monitor diabetes mellitis accordingly. The accuracy and reproducibility with which these sensors will operate is certain to advance the science of medicine as we know it.[6]

5. **Testing for pollution:**

The standard testing procedures for ground water and toxic waste sites involved digging test wells to extract samples and send them to laboratories for analysis. However, many of the chemicals tested are volatile and their characteristics are often lost during transportation leading to inaccurate results. Fiber optics are being used to send pulses of light through ground water at toxic waste sites . A sensor will detect changes in color or changes in wave length characteristics due to presence of pollutants. Such optical sensors can be placed in areas designated as waste sites and can be used indifinitely without the problems of the current systems.

6. **Military applications:**

As mentioned earlier, fiber optics are immune from electromagnetic and radio interference, and are thus immune from the current techniques used in eavesdropping. The implications for the military are astounding when compared with the complexity of the currently used equipment. Various branches of the military have used fiber optics to improve communication systems, command control link on ships and aircraft, data links for satellite earth stations, and transmission lines for tactical command posts.

Conclusion

Fiber optics is a technology that is still in its infancy, but have the potential to be one of this century's greatest accomplishments. It has numerous advantages over the current copper wiring system. The enormous capacity of fiber optic cables led some to think of the situation as a solution waiting for a problem. The increasing need for faster and more reliable communications coupled with the expanded use of natural languages, voice, and image transmission, will certainly create the demand for fiber optics.

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