A COMPARATIVE ANALYSIS OF THE DIFFERENCES BETWEEN FIBER OPTIC AND COPPER CABLES IN COMMUNICATION SYSTEM

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Abstract— Fiber optic and copper cables are the two famous cables used in communication system. Selecting the appropriate cable for effective communication project can be challenging. Nevertheless, knowing the distinct properties of fiber optic and copper can be the solution. This paper provides a comparative analysis of the differences between fiber optic and copper in communication system. The analysis encompasses the security, bandwidth and distance, cost, flexibility and size, immunity and safety etc. Each cable, has its place in the design of any communication system.

Index Terms— Communication Medium, Copper Cable, Optical Fiber.

I. INTRODUCTION

Signals need a channel to follow, so that they can move from place to place. Examples of these communication mediums or channels are fiber optic and copper cables. Fiber optics, also called optical fibers, are thin strands of glass that carry pulses of light (frequently infrared light) across long distances. Fiber optic channels are usually immune to common RF interference, and can transmit incredibly high amount of data very quickly. [1]. Fiber optic chain works in the following manner. At one end, the fiber cable is connected to a transmitter. The transmitter converts the electronic pulses into light pulses and sends the optical signal through the fiber cable. At the other end, the fiber cable is plugged into a receiver which decodes the optical signal back into digital pulses. [2]. Fig. 1 shows a fiber optic cable.

Copper is a relatively soft, reddish metal that conducts heat and electricity very well. [3].

The electrical properties of copper wire create resistance and interference. The further communication signals travel the more they are weakened by the electrical properties associated with the copper cable. Electrical, resistance within the copper medium slows down the signal or flow of current. The electrical properties of copper wire are the key factors that limit communication transmission speed, and distance. [4]

There are two primary types of cables containing copper wire used for communication:

(a) Twisted Pair and
(b) Coaxial

Twisted Pair

Communication signals sent over copper wire are primarily direct electrical current (DC) which is modulated to represent a frequency. Any other electrical current near the communication wire (including other communication signals) can introduce interference and noise. Multiple communication wires within a cable bundle can induce interfering electro-magnetic currents, or "cross-talk". This happens when one signal within the cable is so strong that it introduces a magnetic field into an adjacent wire, or communication pair. Energy sources such as power transmission lines, or fluorescent lighting fixtures can cause electromagnetic interference. This interference can be minimized by twisting a pair of wires around a common axis, or by the use of metallic shielding, or both. The twisting effectively creates a magnetic shield that helps to minimize "crosstalk".Twisted pair is the ordinary copper wire that provides basic telephone services to the home and many businesses. In fact, it is referred to as "Plain Old Telephone Service" (POTS). The twisted pair is composed of two insulated copper wires twisted around one another as shown in fig. 2. The twisting is done to prevent opposing electrical currents traveling along the individual wires from interfering with each other.

Twisted copper pair, is what Alexander Bell used to make the first telephone system work and is generally the most common transmission medium used today. A broad generalization is that twisted copper pair is in fact the basis for all telecommunication technology and services today.

Coaxial Cable

Coaxial cable is a primary type of copper cable used by cable TV companies for signal distribution between the community antenna and user homes and businesses.

Coaxial cable was invented in 1929 and first used commercially in 1941. AT&T established its first cross-continental coaxial transmission system in 1940. Depending on the carrier technology used and other factors, twisted pair copper wire and optical fiber are alternatives to coaxial cable.

Coaxial cable was originally used by some traffic departments to provide communications between field controllers and the central controller in an automated traffic signal system. It was also the medium of choice for early implementation of video incident management systems used in ITS. However, with the introduction of fiber optics, the use of coaxial cable has all but been abandoned for this purpose.
Coaxial cable is still used for connecting CCTV cameras to monitors and video switchers. As the cost of using fiber optics has begun to drop, camera manufacturers are installing fiber optic transceivers in the camera. This is especially useful for preventing interference from electrical systems, or creating a secure video transmission network.[4]. The coaxial copper cable is shown in fig. 3.

Fig. 1: Fiber optic cable [5]

Fig. 2: Twisted pair cable [6]

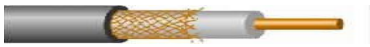

Fig. 3 Coaxial copper cable [7]

II. ADVANTAGES OF FIBER OPTIC OVER COPPER

There are many advantages in using Fiber optic instead of copper cable. Some of the advantages are:

A. Security
Fiber is the MOST secure network: for example, it is quite possible to attach to a copper line in order to hack into the system, however, fiber connectivity is made out of glass and the only way to penetrate the system is to break it, which will cause the whole system to go down and in turn would alert you that you have been hacked – rare disruption of connectivity.[8]
Your data is safe with fiber cable. It doesn't radiate signals and is extremely difficult to tap. If the cable is tapped, it's very easy to monitor because the cable leaks light, causing the entire system to fail. If an attempt is made to break the physical security of your fiber system, you will know it. [10]
An optical-time domain reflectometer will easily locate the location of a tap on fiber cabling [9].

B. Bandwidth and Distance
Fiber provides more bandwidth than copper and has standardized performance up to 10 Gbps and beyond. More bandwidth means fiber can carry more information with greater fidelity than copper wire. [10]
Whether you use optical fiber or copper, there will be a loss in signal strength as the length of the cable increases. This loss is called attenuation and is measured in decibels (dB).
For example:
The maximum allowed industry standard of attenuation for multi-mode fiber over a 100 meter distance is 0.15 dB. The fiber loses only 3% of its original signal strength over 100 meters. Also the attenuation of fiber doesn't change as bandwidth increases or decreases.
Meanwhile, the maximum allowed industry standard of attenuation for category 6A cable over 100 meters at 100 MHz is 20.9 dB which is a 94% loss in signal strength.
The fact of the matter is that fiber can retain a higher bandwidth over greater distances than comparable copper cabling. [9]. Copper cable has very limited bandwidth over distance as shown in table 1.

Table 1. : Bandwidth over distance [11].

	Distance	Bandwidth	Voice Channels
Copper	2.5 km	1.5 Mb/s	24
Fiber	200 km	2.5 Gb/s	32, 000 +

C. Reliability
The optical fibers are made from silicon glass which does not undergo any chemical reaction or corrosion. It is not affected by external radiation. Further due to its negligible attenuation and dispersion, optical fiber communication has high reliability. [12].

D. Lightweight
An optical cable weighs less than a comparable wire cable. [3]

E. Non-flammable
Fiber is a dielectric, which means that there is no electrical current that flows through it. Copper, on the other hand does carry a current and could cause a fire concern if it is old or worn. [9].

F. Ease of Maintenance
Since reliability of optical fiber is no longer a problem, so it reduces expenditure on its maintenance time and cost. [12].

G. Immunity
Optical fiber is immune to electromagnetic energy because it is a dielectric (not able to conduct electric current). Copper cabling, if not installed properly is vulnerable to the effects of EMI, such as undesirable responses, degradation, or complete system failure. [9]. Fiber provides extremely reliable data transmission. It's completely immune to many environmental factors that affect copper cable. The core is made of glass, which is an insulator, so no electric current can flow through. It's immune to electromagnetic interference and radio-frequency interference (EMI/RFI), crosstalk, impedance problems, and more. You can run fiber cable next to industrial equipment without worry. Fiber is also less

susceptible to temperature fluctuations than copper and can be submerged in water. [10]

H. Cost

Fiber cable is actually less expensive than copper, but don't forget the expensive electronics that it requires. [9]. Fiber cable costs significantly less than copper cable for the same transmission capacity. [12]

III. DISADVANTAGES

- Optical fiber cables have limited bend radius (about 30 mm). So, if they are bent more, it might lead to some signal loss. But recently, bend resistant fibers have been introduced which have higher tolerance to bending. [12]
- Fiber splicing is a complicated procedure and requires skilled manpower to achieve. If it is not done properly, there will be performance degradation. [12]
- After the installation and also during trouble shooting, the fiber cores need to be tested using testing equipment like OTDR. But these equipment are quite expensive to procure, and if rented, the charges for testing each core could be considerable. [12].
- Physical vibration will show up as signal noise. [13]
- Gamma radiation comes from space and is always present. It can be thought of as a high-energy X-ray. Gamma radiation can cause some types of glass to emit light (causing interference) and also gamma radiation can cause glass to discolor and hence attenuate the signal. In normal situations these effects are minimal. [12]
- There are outdoor fiber cables but they need to be shielded well. This shielding makes them less agile/flexible to run in all the places and it increases the cost of cables as well. [12]

CONCLUSION

A performance comparison between fiber optic and copper cabling system is presented. It was shown that each cabling system has advantages and disadvantages. Which channel is best depends upon the purpose of the communications system, the desired end results and the designer's circumstances.

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