Fiber Optic Cables and Their Impact on Telecommunication Networks

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1. ABSTRACT

Beginning in 1844, telecommunication networks have developed significantly to bring us where we are now. However, until now, most of the many innovations since then have been built off the same base fromwork, the copper wire. The introduction of satellite and non-wired communication revolutionized the way we connect today. Fiber Optics will be the next leap for forward communication technologies worldwide. The new technology of Fiber Optics has begun to replace the previously built infrastructure that has been the bedrock of telecommunication for some time. This paper discusses the mechanics of Fiber Optic wires and the qualities that lead them to be an improvement upon the old standard copper-wire system architecture. It will also summarize the history of telecommunication before fiber in order to provide a knowledge base for when the paper observes some of the future possibilities Fiber Optics cables can make possible.

2. INTRODUCTION

Fiber-optic systems are a method of transmitting data. These systems work by converting electrical signals into light signals which are transmitted along with an optical fiber. The light signals are then converted at the end of the fiber back into electrical signals.[5] This allows for data to be transmitted very quickly across far distances. For this reason they form the backbone of the internet[4]. In the early stages of the internet, the internet was distributed over copper wires and satellites[4]. Then fiber optic cables proved that the internet can be distributed using light in fiber optic cables. Over the last few years they have improved the internet in many ways resulting in transmission speed and bandwidth evolving significantly [1]. In the near future, it is predicted that fiber optic systems will keep up the progress resulting in more data transfer per second and take a great role in providing infrastructure for 5G[2].

2. THE MECHANICS OF FIBER OPTICS

Fiber optic systems are a method of transmitting data. These systems work by converting electrical signals into light signals which are transmitted along an optical fiber. The light signals are then converted at the end of the fiber back into electrical signals [8] as it can be seen in Figure-1. This allows for data to be transmitted very quickly across far distances.

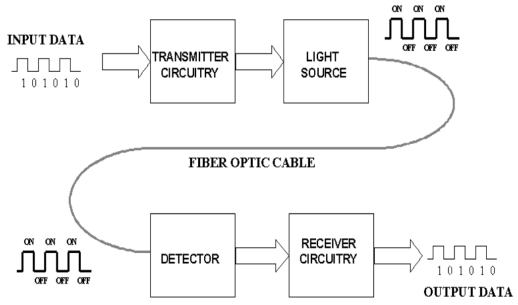

Figure-1 reproduced from reference [8]

Fiber optic cables consist of core, cladding and coating as it can be seen in Figure 2.

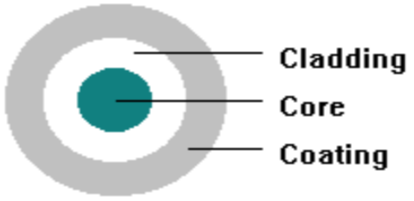

Figure-2 reproduced from reference [9]

The core is the area made up of glass and transmits the light[9]. The cladding layer causes reflection within the core and thus ensures the light wave is transmitted through the fiber[9]. The coating layer is for protection to protect the fiber from external damages[9]. Based on where the fiber optic cables are going to be used, this coating layer can be thickened. There are two types of fiber cables: single mode and multi mode[9].

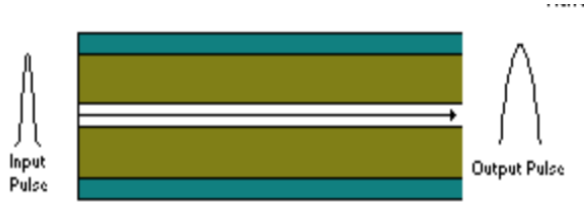

Figure-3 reproduced from reference [9]

Figure-3 shows how single mode works allowing only one light ray moving through the core.

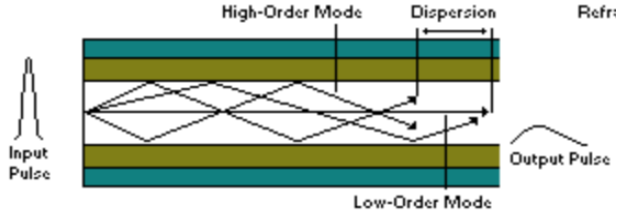

Figure-4 reproduced from reference [9]

Figure-4 is a step-index multimode fiber. It reflects different lightwaves in the reflective core and cladding[9]. It allows us to send more than one light ray at the same time and have them differentiated at the receiver[9].

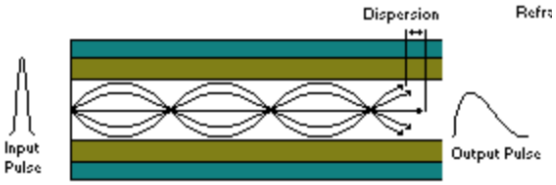

Figure-5 reproduced from reference [9]

Figure-5 shows graded-index multimode fiber that reflects light in different ways through the fiber[9]. It consists of many layers of glass that each have a lower index of reflection as we go outer[9]. This results in light rays to speed up in the outer layers and helps us to send data over long distances without light pulses overlapping at the receiver edge[9]. Since there is no distortion in single mode because of having only one light ray and having a very tiny core, it provides higher capacity then the other multimode fibers[9].

3. TELECOMMUNICATIONS BEFORE FIBER OPTICS

Telecommunications started with telegraph cables transmitted on conventional copper wires in 1844[4]. Later radio communication replaced some long-distance telegraph cables for transatlantic links[4]. Eventually copper telephone cables were added across the Atlantic further increasing connectivity. For a time satellites were beginning to replace conventional cables for data transmission across large distances. Satellites were a great choice for broadcasting as television was growing so fast[4]. Satellites also provided a much higher number of telephone circuits then all the submarine cables[4].

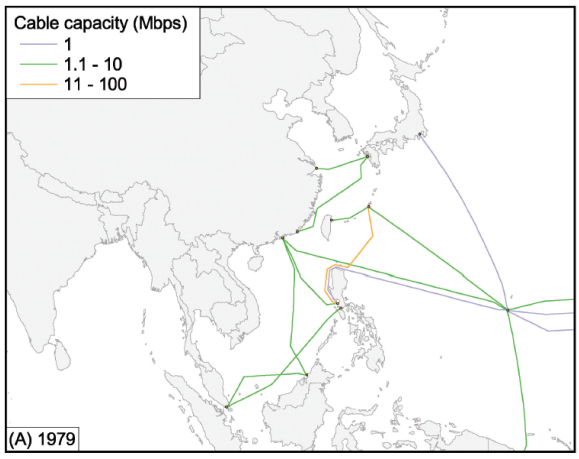

Figure-6 reproduced from reference[4]

Figure-6 shows the first submarine cables providing the internet in 1979.

Between 1965 to 1988 satellites were the best choice for telecommunication networks providing ten times the capacity than the submarine cables and at a significantly lower cost.[4]. Eventually they turn to be replaced by fiber-optic submarine cable as Fiber optics are provided to be cheaper and transmit more data faster than satellites along more concentrated corridors[4]. This allowed for much larger bandwidth along internet infrastructure increasing internet speeds available for users. It remains the main technology in use today for long-distance transmission of data[4].

4. FIBER OPTIC IMPROVEMENTS

Fiber Optic cables improve on the performance of the previous industry-standard coaxial copper wires in a variety of ways. The primary advantage is the increased bandwidth. Cat 5e Copper Unshielded Twisted Pair, one of the most commonly used copper cables, holds a maximum bandwidth of 100 Mbps. Fiber Optic cables can operate at a bandwidth of 10 Gbps or higher [1].

Fiber-optic systems can transmit data faster because they have higher bandwidths. They have higher bandwidths because they have larger frequency ranges at higher frequencies [7].

Due to the change in structure and components, the resulting wires are much lighter, smaller, and more malleable, increasing the ease of installation. Fiber optic cables are preferred in installations that require tighter turns and coils. The aerospace industry has been incorporating fiber optics to encompass a large amount of the wiring within planes and spacecraft, in order to reduce the size and weight of the vehicles[1].

Another significant advantage of fiber optic communication compared to copper wires is that, according to Nicole Unger and Oliver Gough, in "copper cable the signal has to be repeated or amplified to restore its power and remove the noise at quite short intervals (100 m-2 km), fiber optic cable can cover much longer distances without a drop in signal strength, thus requiring a considerably less frequent regeneration of the signal (repeaters distances of 200 km are common)."[6] This makes it significantly cheaper for the transport of information over very long distances since more of the system can just be relatively simple fiber optic cables instead of signal regeneration equipment.. Additionally fiber optic cables are less prone to electromagnetic interference than copper ones which when paired with their smaller size allows them to be installed in convenient locations[6].

5. THE FUTURE OF FIBER OPTICS

As we have mentioned previously fiber-optic transmission capacity has been increasing significantly from 2.5 Gb/s in 1989 to 32Tb/s in 2019[2]. In the next few years fiber-optic transmission systems are expected to grow to offer us more capacity and wider application space [2]. As can be seen from Figure-7, in 2022 fiber-optic cables' transmission capacity is expected to be 64Tb/s. These developments in fiber-optic cable technology will help the launch of fifth-generation wireless technology in more common words 5G in 2020 [2]. 5G will be offering us enhanced mobile broadband, ultra-reliable with low latency communications and between massive machine types communications such as Internet of Things, self-driving cars, etc[2].

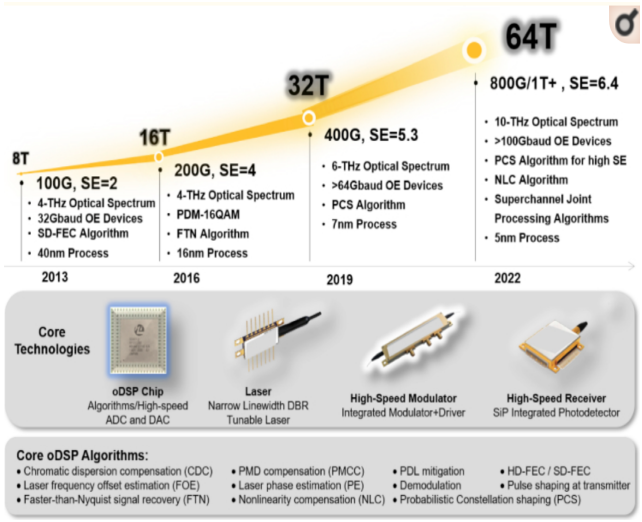

Figure-7 reproduced from [2]

Although 5G is a very important use of fiber-optic cables in the near future, fiber-optic cables won't be limited only by 5G. With the invention of polymer optical fibers which are less expensive and more flexible for plug interconnections, these are assumed to be used in future aircraft and spacecraft [3].

6. CONCLUSION

In conclusion, telecommunication networks have had a long journey starting in 1844 with copper cables and followed by satellite internet[4] and now will improve yet again with Fiber-Optic cables. We have gone in depth into how the technology operates by turning electrical inputs into light pulses for transmission and then receiving and decoding the responses back into electrical data, drastically increasing the amount of information that can be transmitted at a time. We compared Fiber's ability with copper to under several criteria including and found it had a much larger bandwidth to transmit data, it is more resistant to data loss, and it is much lighter and more maneuverable, allowing for more difficult installations to be possible. Due to the immense performance improvements they provide, they have become the backbone of the internet today. The integration of this new technology has led to increased speeds of communication across the world and allowed new innovations in aerospace, Internet of Things, and self driving cars. As Fiber Optic cables continue to be installed on local networks in addition to the investment already made in data centers and network cores, the way we communicate will continue to evolve and improve to keep us better connected.

7. REFERENCES

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