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TELECOMMUNICATION FIBER OPTIC INFRASTRUCTURE WORLD-WIDE DEMAND: CASE STUDY

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ABSTRACT

Technology is often the mother of sceince. In the world of telecommunication fiber optic infrastructure has world- wide demand. They key requirement in today's world is wide bandwidth signal transmission with low delay. By the using optical fiber system we can provide enormous and unsurpassed transmission bandwidth with negligible latency. In this paper we will discuss the past, present and future aspects of fiber optics. We also discuss upcoming impact on next generation.

Index Terms- Bandwidth, Broadband, Fiber optics, Latency, Telecommunication.

I. INTRODUCTION

Fiber optics is the peer invention done by Narender Singh Kapany and Charles K. Kao. Fibre optics's rapidly increasing consumer and commercial demand is the only driven force for the wide spread of it in whole world. By the help of this technology we can convey more data through a single optical fiber over a long distances. By the help of dispersion management we can improved the transmission capacity of the optical fiber.

Optic fiber system largely replaced the radio transmission system. It is widely used for telephony, internet traffic, LANs , cable T.V etc. In optical Fiber a single silica fiber can carry hundreds of thousands of telephone channels, utilizing only a small part of the theoretical capacity.

Day by day so many new technologies emerging such as CDMA , GSM, Wi-Max,etc. Within the last 30 years, the transmission capacity of optical fibers has been increased enormously. The rise in available transmission bandwidth per fiber is even significantly faster than e.g. the increase in storage capacity of electronic memory chips, or in the increase in computation power of microprocessors.

The transmission capacity of a fiber depends on the fiber length. The longer a fiber is, the more detrimental certain effects such intermodal orchromatic dispersion are, and the lower is the achievable transmission rate.

For short distances of a few hundred meters or less (e.g. within storage area networks), it is often more convenient to utilize multimode fibers, as these are cheaper to install (for example, due to their large core areas, they are easier to splice). Depending on the transmitter technology and fiber length, they achieve data rates between a few hundred Mbit/s and ≈ 10 Gbit/s.

Single-mode fibers are typically used for longer distances of a few kilometers or more. Currently used commercial telecom systems typically transmit 10 Gbit/s or 40 Gbit/s per data channel over distances of ten kilometers or more. The newest available systems (as of 2014) reach 100 Gbit/s, and future systems may use higher data rates per channel of e.g. 160 Gbit/s. The required total capacity is usually obtained by transmitting many channels with slightly different wavelengths through fibers; this is called *wavelength division* *multiplexing* (WDM). Total data rates can be several terabits per second, sufficient for transmitting many millions of telephone channels simultaneously. Even this capacity does not reach by far the physical limit of an optical fiber. In addition, note that a fiber-optic cable can contain multiple fibers.

In conclusion, there should be no concern that technical limitations to fiber-optic data transmission could become severe in the foreseeable future. On the contrary, the fact that data transmission capacities can evolve faster than e.g. data storage and computational power, has inspired some people to predict that any transmission limitations will soon become obsolete, and large computation and storage facilities within high-capacity data networks will be extensively used, in a similar way as it has become common to use electrical power from many power stations within a large power grid. Such developments may be more severely limited by software and security issues than by the limitations of data transmission.

II. BASIC PRINCIPLES OF FIBER OPTIC

2.1 Communication

Fiber optic communication is a communication technology that uses light pulses to transfer information from one point to another through an optical fiber. The information transmitted is essentially digital information generated by telephone systems, cable television companies, and computer systems. An optical fiber is a dielectric cylindrical waveguide made from low-loss materials, usually silicon dioxide. The core of the waveguide has a refractive index a little higher than that of the outer medium (cladding), so that light pulses is guided along the axis of the fiber by total internal reflection [4]. Fiber optic communication systems consists of an optical transmitter to convert an electrical signal to an optical signal for transmission through the optical fiber, a cable containing several bundles of optical fibers, optical amplifiers to boost the power of the optical signal, and an optical receiver to reconvert the received optical signal back to the original transmitted electrical signal. Figure 1 gives a simplified description of a basic fiber optic communication system

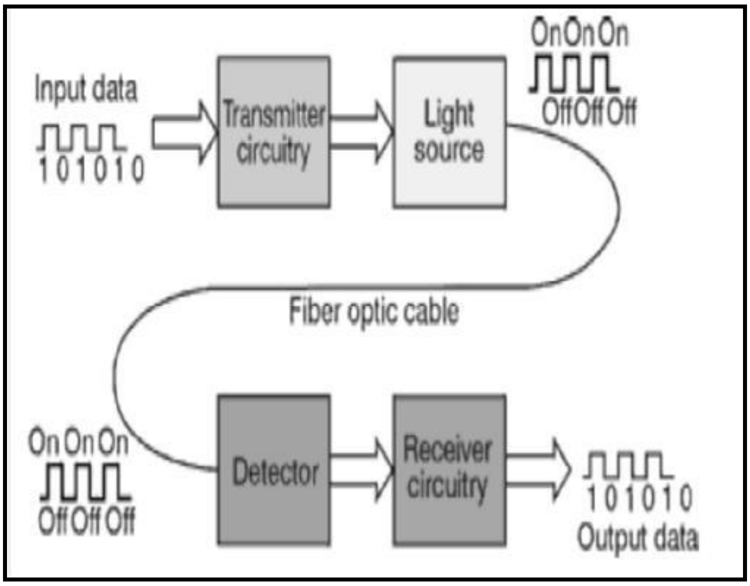

Fig.1. Basic Fiber Optic Communication System [5]

Optical fibers fall into two major categories, namely: step index optical fiber, which include single mode optical fiber and multimode optical fiber, and graded index optical fiber. Single mode step index optical fiber has a core diameter less than 10 micrometers and only allows one light path. Multimode step index optical fiber has a core diameter greater than or equal to 50 micrometers and allows several light paths, this leads to modal dispersion.

Graded index optical fibers have their core refractive index gradually decrease farther from the centre of the core, this increased refraction at the core centre slows the speed of some light rays, thereby allowing all the light rays to reach the receiver at almost the same time, thereby reducing dispersion. Figure 2 Gives a Description of the Various Optical Fiber Modes

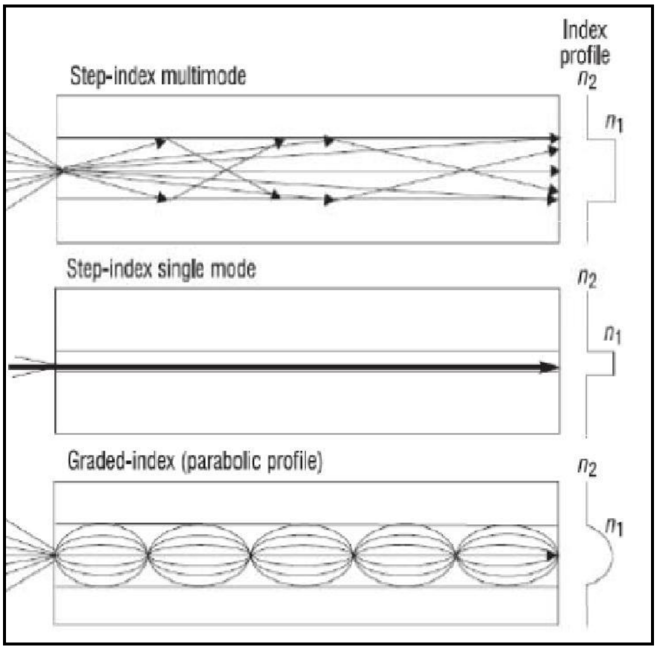

Fig.2. Optical Fiber Modes [6]

III. EVOLUTION OF FIBER OPTICS

3.1 Communication

Optical fiber was first developed in 1970 by Corning Glass Works. At the same time, GaAs semiconductor lasers were also developed for transmitting light through the fiber optic cables. The first generation fiber optic system was developed in 1975, it used GaAs semiconductor lasers, operated at a wavelength of 0.8 µm, and bit rate of 45Megabits/second with 10Km repeater spacing.

In the early 1980's, the second generation of fiber optic communication was developed, it used InGaAsP semi conductor lasers and operated at a wavelength of 1.3 µm. By 1987, these fiber optic systems were operating at bit rates of up to 1.7 Gigabits/second on single mode fiber with 50Km repeater spacing.

The third generation of fiber optic communication operating at a wavelength of 1.55 µm was developed in 1990. These systems were operating at a bit rate of up to 2.5 Gigabits/second on a single longitudinal mode fiber with 100Km repeater spacing.

The fourth generation of fiber optic systems made use of optical amplifiers as a replacement for repeaters, and utilized wavelength division multiplexing (WDM) to increase data rates. By 1996, transmission of over 11,300Km at a data rate of 5Gigabits/second had been demonstrated using submarine cables [7].

The fifth generation fiber optic communication systems use the Dense Wave Division Multiplexing (DWDM) to further increase data rates. Also, the concept of optical solitons, which are pulses that can preserve their shape by counteracting the negative effects of dispersion, is also being explored. Figure 3 shows the evolution of fiber optic communication.

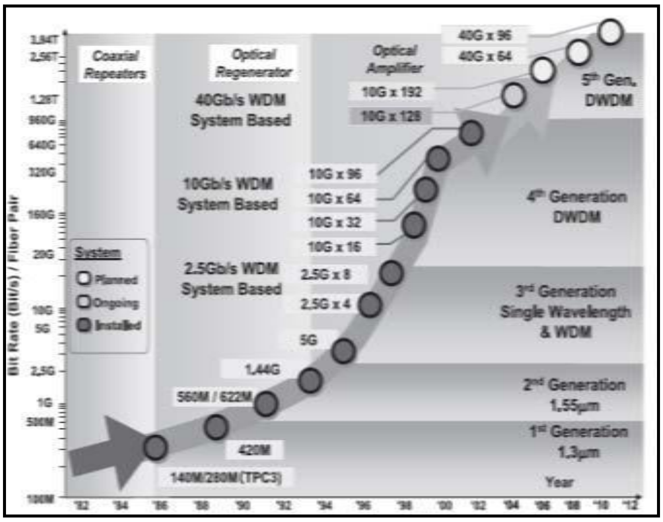

Fig.3. Generations of Fiber Optics Communication [8]

IV. FUTURE TRENDS IN FIBER OPTICS

4.1 Communication

Fiber optics communication is definitely the future of data communication. The evolution of fiber optic communication has been driven by advancement in technology and increased demand for fiber optic communication. It is expected to continue into the future, with the development of new and more advanced communication technology. Below are some of the envisioned future trends in fiber optic communication.

4.2 All Optical Communication Networks

An all fiber optic communication is envisioned which will be completely in the optical domain, giving rise to an all optical communication network. In such networks, all signals will be processed in the optical domain, without any form of electrical manipulation. Presently, processing and switching of signals take place in the electrical domain, optical signals must first be converted to electrical signal before they can be processed, and routed to their destination. After the processing and routing, the signals are then re-converted to optical signals, which are transmitted over long distances to their destination. This optical to electrical conversion, and vice versa, results in added latency on the network and thus is a limitation to achieving very high data rates.

Another benefit of all optical networks is that there will not be any need to replace the electronics when data rate increases, since all signal processing and routing occurs in the optical domain [9]. However, before this can become a reality, difficulties in optical routing, and wavelength switching has to be solved. Research is currently ongoing to find an effective solution to these difficulties.

4.3 Multi – Terabit Optical Networks

Dense Wave Division Multiplexing (DWDM) paves the way for multi-terabit transmission. The world-wide need for increased bandwidth availability has led to the interest in developing multi-terabit optical networks. Presently, four terabit networks using 40Gb/s data rate combined with 100 DWDM channels exists. Researchers are looking at achieving even higher bandwidth with 100Gb/s. With the continuous reduction in the cost of fiber optic components, the availability of much greater bandwidth in the future is possible.

4.4 Intelligent Optical Transmission Network

Presently, traditional optical networks are not able to adapt to the rapid growth of online data services due to the unpredictability of dynamic allocation of bandwidth, traditional optical networks rely mainly on manual configuration of network connectivity, which is time consuming, and unable to fully adapt to the demands of the modern network. Intelligent optical network is a future trend in optical network development [2], and will have the following applications: traffic engineering, dynamic resource route allocation, special control protocols for network management, scalable signaling capabilities, bandwidth on demand, wavelength rental, wavelength wholesale, differentiated services for a variety of Quality of Service levels, and so on. It will take some time before the intelligent optical network can be applied to all levels of the network, it will first be applied in long-haul networks, and gradually be applied to the network edge [10].

4.5 Ultra – Long Haul Optical Transmission

In the area of ultra-long haul optical transmission, the limitations imposed due to imperfections in the transmission medium are subject for research. Cancellation of dispersion effect has prompted researchers to study the potential benefits of soliton propagation. More understanding of the interactions between the electromagnetic light wave and the transmission medium is necessary to proceed towards an infrastructure with the most favorable conditions for a light pulse to propagate [11].

4.6 Improvements in Laser Technology

Another future trend will be the extension of present semiconductor lasers to a wider variety of lasing wavelengths [12]. Shorter wavelength lasers with very high output powers are of interest in some high density optical applications. Presently, laser sources which are spectrally shaped through chirp managing to compensate for chromatic dispersion are available. Chirp managing means that the laser is controlled such that it undergoes a sudden change in its wavelength when firing a pulse, such that the chromatic dispersion experienced by the pulse is reduced. There is need to develop instruments to be used to characterize such lasers. Also, single mode tunable lasers are of great importance for future coherent optical systems. These tunable lasers lase in a single longitudinal mode that can be tuned to a range of different frequencies.

4.7 Laser Neural Network Nodes

The laser neural network is an effective option for the realization of optical network nodes. A dedicated hardware configuration working in the optical domain and the use of ultra-fast photonic sections is expected to further improve the capacity and speed of telecommunication networks [12]. As optical networks become more complex in the future, the use of optical laser neural nodes can be an effective solution.

4.8 Polymer Optic Fibers

Polymer optical fibers offer many benefits when compared to other data communication solutions such as copper cables, wireless communication systems, and glass fiber. In comparison with glass optical fibers, polymer optical fibers provide an easy and less expensive processing of optical signals, and are more flexible for plug interconnections [13]. The use of polymer optical fibers as the transmission media for aircrafts is presently under research by different Research and Development groups due to its benefits. The German Aerospace Center have concluded that “the use of Polymer Optical Fibers multimedia fibers appears to be possible for future aircraft applications [14]. Also, in the future, polymer optical fibers will likely displace copper cables for the last mile connection from the telecommunication company's last distribution box and the served end consumer [15]. The future Gigabit Polymer Optical Fiber standard will be based on Tomlinson-HarashimaPrecoding,Multilevel PAM Modulation, and Multilevel Coset Coding Modulation.

4.9 High – Altitude Platforms

Presently, optical inter satellite links and orbit-to-ground links exists [16], the latter suffering from unfavorable weather conditions [17]. Current research explores optical communication to and from high altitude platforms. High altitude platforms are airships situated above the clouds at heights of 16 to 25Km, where the unfavorable atmospheric impact on a laser beam is less severe than directly above the ground [18]. As shown in figure 4, optical links between high-altitude platforms, satellites and ground stations are expected to serve as broadband back-haul communication channels, if a high-altitude platform functions as a data relay station.

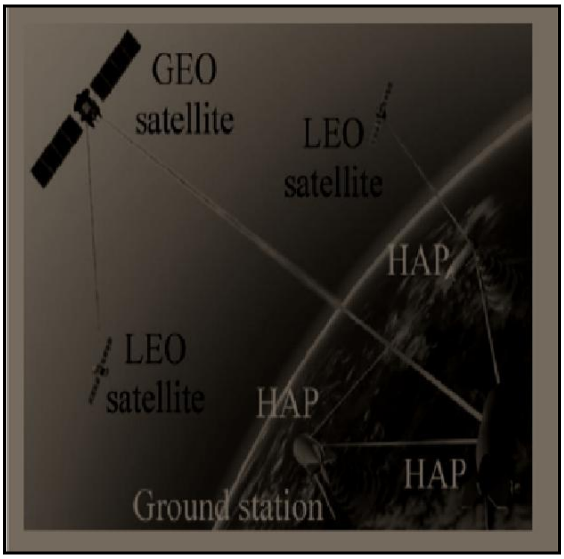

Fig.4. Laser Communication Scenarios from HAPs [4]

4.10 Improvements in Optical Transmitter/Receiver

4.10.1 Technology

In fiber optics communication, it is important to achieve high quality transmission even for optical signals with distorted waveform and low signal to noise ratio during transmission. Research is ongoing to develop optical transceivers adopting new and advanced modulation technology, with excellent chromatic dispersion and Optical Signal to Noise Ratio (OSNR) tolerance, which will be suitable for ultra-long haul communication systems. Also, better error correction codes, which are more efficient than the present BCH concatenated codes are envisioned to be available in the nearest future.

4.11 Improvement in Optical Amplification Technology

Erbium Doped Fiber Amplifier (EDFA) is one of the critical technologies used in optical fiber communication systems. In the future, better technologies to enhance EDFA performance will be developed. In order to increase the gain bandwidth of EDFA, better gain equalization technology for high accuracy optical amplification will be developed. Also, in order to achieve a higher output power, and a lower noise figure, high power pumping lasers that possess excellent optical amplification characteristics with outputs of more than +20dBm, and very low noise figure are envisioned to exist in the nearest future.

4.12 Advancement in Network Configuration of Optical

4.12.1 Submarine Systems

In order to improve the flexibility of network configuration in optical submarine communication systems, it is expected that the development of a technology for configuring the mesh network will be a step in the right direction. As shown in figure 5, while a ring network joins stations along a single ring, a mesh network connects stations directly. Presently, most large scale optical submarine systems adopt the ring configuration. By adopting the optical add/drop multiplexing technology that branches signals in the wavelength domain, it is possible to realize mesh network configuration that directly inter-connects the stations. Research is ongoing, and in the future such network configuration will be common.

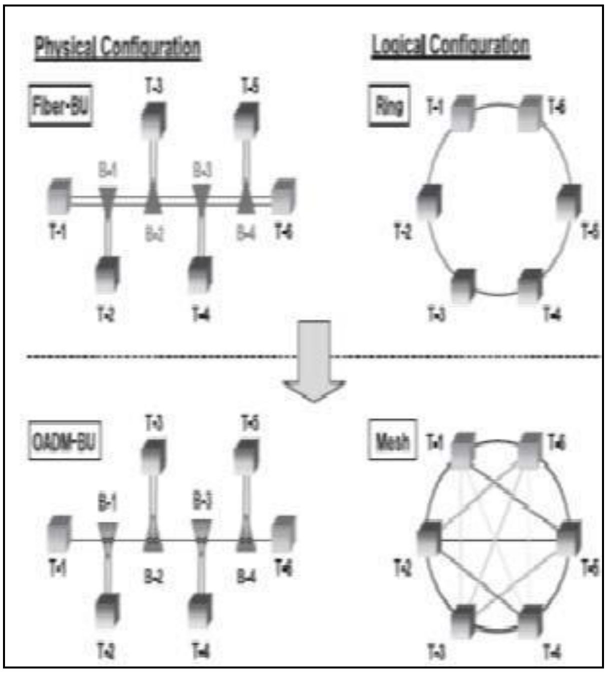

Fig.5. Optical Network Configurations [8]

4.13 Improvement in WDM Technology

Research is ongoing on how to extend the wavelength range over which wave division multiplexing systems can operate. Presently, the wavelength window (C band) ranges from 1.53-1.57µm. Dry fiber which has a low loss window promises an extension of the range to 1.30 – 1.65 µm. Also, developments in optical filtering technology for wave division multiplexing are envisioned in the future.

4.14 Improvements in Glass Fiber Design and Component

4.14.1 Miniaturization

Presently, various impurities are added or removed from the glass fiber to change its light transmitting characteristics. The result is that the speed with which light passes along a glass fiber can be controlled, thus allowing for the production of customized glass fibers to meet the specific traffic engineering requirement of a given route. This trend is anticipated to continue in the future, in order to produce more reliable and effective glass fibers. Also, the miniaturization of optical fiber communication components is another trend that is most likely to continue in the future.

V. CONCLUSION

Optical Communication industry is an ever demanding one, the growth experienced by the industry has been enormous this past decade. Recently we have so many fields where optical communication is showing outstanding performance. There is still much work to be done to support the need for faster data rates, advanced switching techniques and more intelligent network architectures that can automatically change dynamically in response to traffic patterns and at the same time be cost efficient. The trend is expected to continue in the future as breakthroughs already attained in the laboratory will be extended to practical deployment thereby leading to a new generation in fiber optics communications.

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