Asian Journal of Informationl Technology 5 (11): 1202-1205, 2006

Optical Communication in the World of Telecommunication

[1]C.I. Oriaku and [2]M.U. Onuu
[1]Department of Physics, Michael Okpara University of Agriculture,
Umudike, P.M.B.7267, Abia State, Nigeria
[2]Department of Physics, University of calabar, Calabar, Cross River State, Nigeria

Abstract: This study presents an overview of optical communication in the emerging world of telecommunication technologies. Some network approaches in achieving the potentials of the optical communication have been highlighted. Increased focus on photonics is drastically revolutionizing communication systems and is expected to form the next generation of information based technologies with optical communication base. With increased demand on bandwidth, optical network will continue to play a leading role in the future success of telecommunication which is the driving force of globalization.

Key words: Telecommunication, optical fibre communication networks, bandwidth, photonics, information revolution, globalization

INTRODUCTION

Communication has been a vital issue in the history of mankind. This operationally involves the transformation of one set of qualities (through, ideas, or events) into others that are somehow more suited for transmission or recording over a degrading medium and the recovery of estimates of the original quantities at the receiving point[1]. The newest among the kinds of communication is the optical communications. Speed, data, video and other intelligences are transmitted by means of visible and the infrared potion of the electromagnetic spectrum. Optical communication differs from radio and a microwave communication only in that wavelength employed is higher Fig. 1.

Communication itself is changing very rapidly order to cope with the incresesing demands of tommorrow technolohy. This is because the modern world requires efficient, effective and fincancially competitive communication system which would gradually out space copper lines. Though optical comminication is relatively a recent research area, it is advancing at an astonshing rapid rate[2,3]. The invention of optic fibres communication system has indeed revolutionized the worlds telecommunication technologies. Since the introduction of fibre optic communication system in the late 1980's long distance optic fibre tranmisssion speeds of 140 megabit per second for the first optical transatlanctic system to exeed 1 terabit per second[4]. That is to say that fibre optics offer a fast method of telecommunication than the coaxial line transmission system. This is because photons outspace electrons.

This information revolutions offered by optic fibre technology has important long-run inplications for society and the global ecomony. This fast and efficient means of communication has reduced the entire world to a global village. Above all it has provided the impetus for the emergence of new research areas (Semiconductor physics and non linear optics), research into the transmission of electromagnetic radiation in guilding optical media transmission system multiplexing and coding as well as complex traffic and network theory. This incresed focus on photonics is widely expected to form the next generation of information based techonolgies.

Telecommunication by optic fiber versus copper transmission lines: The communication of information over a distance by means of radio waves, optical signals or a long transmission line is known as telecommication. In 1880, Alexander Graham Bell transmitted his voice on a beam of light. His invention, the photophone only worked over short distances and in sunshine. The discoveries of optic fibres and lasers as transmission meduim has made optical telecommunication attractive, that the days of copper wires become numbered.

Optic fiber communication invoves the use of fiber optical cables as a medium for carrying information from one point to another. A typical fibre optic cable is a

Corrresponding Author: C.I. Oriaku, Department of Physics, Michael Okpara University of Agriculture, Umudike, P.M.B.7267, Abia State, Nigeria

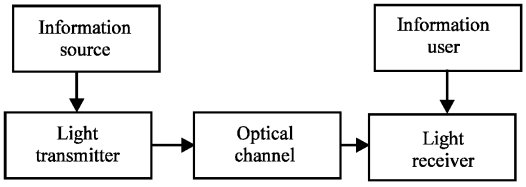

Fig 1: A typical optical communcation

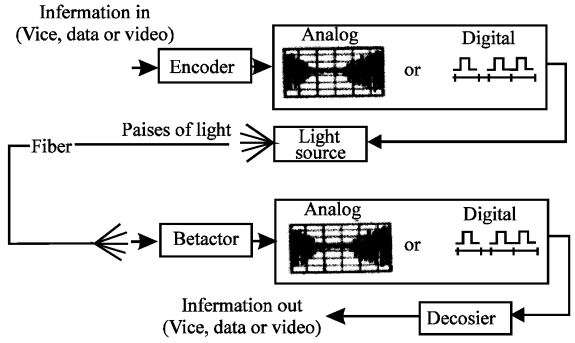

Fig. 2: Information transmission sequence in a typical optic fibre system

cylindrical dielectric waveguide that transmit light signals along its axis by the process of total internal reflection. The fiber consist of a core sorrounded by a cladding layer. For the fibre to guide the optical signal the refraction index of the core must be greater than that of the cladding so that the light can be confined to the guilding layer by to total internal reflection.

A basic optic fibre system consist of a transmiting device, which generate the light signal and fibre cable, which carrie the light and a receiver which accepts the light signal transimitted. Buy so doing data, voice, images etc are transmitted and recorded with low loss of imput signals. It was first recognised that attenuation of contemporary fibres was caused by impurities, which could be removed, rather than physical effects such as scattering. It was demostrated that optical fibre communication could be real if attenuation could be reduced below 20decibel per kilometer[5] Fig. 2.

The benefits of fibre optical communication are numerous and has many advantages over metallic-based communication system. These include:

- The fibre optic medium has low light loss. The light loss of a fibre material after the light has traveled a length L is related to the initial power coupled into the fiber, P_0 versus the power at the output and P, by the Eq.

$$\text{Loss (db/km)} = \frac{10}{\text{L (km)}} \log \frac{P_o}{P}$$

This really allows long distances between amplifiers and repeaters.

- Fiber optical system has large bandwidth, light weight and small in diameter. This indeed allows for more bandwidth for numerous subscribers. The fiber cable makes installation easy and practicable and save valuable conduit space in the environment.
- When fiber cables are run along side each other for long distance fiber cables experiences effectively no crosstalk in contrast to some types of electrical transmission lines
- Optical fiber are dielectric in nature, it can be installed in areas with Electro Magnetic Interference (EMI), including Radio Frequency Interference (RFI). Optic fibers are also ideal for areas of high lightning-strike incidence.
- Unlike metallic-based system , the dielectric nation of optic fibre makes it impossible to remove the signal being transmitted within the cable . The only way to do so is by actually accessing the fiber itself. Accessing the fibre requires intervention that is easily detectable by security surveillance. These circumstances make fiber extremely attractive to government bodies, banks and other major security concerns.

Lasers in modern optic fibre networks: Light sources for fibre optic communication act as light transmitted which conveys information (voice date video, etc) to the receiver and these light sources must be monochromatic (single frequency as possible). Most light sources are single frequency but emit light at many frequency distributed over a band or portion of spectrum, which may be quite broad.

Next, the light sources should have a light intensity output so that sufficient energy is transmitted on a fibre to overcome the losses uncovered during transmission on a fibre to overcome the losses encountered during transmission. Also the light sources must be capable of being easily modulated. Finally the devices must be small and easily coupled to fibers so that excessive coupling losses do not occur. They must also be relatively inexpensive to manufacture.

Light emitting diodes and semiconductor laser are both extensively used for these applications. Both emit narrow band light at fixed centre wavelengths as the result of the recombination of hole electron pairs in the junction area of the a diode. Each such recombination is accompanied by the release of a photon of light with a fixed energy centre that corresponds to the wavelength of light emitted and to the energy required to free a valence

electron from its parent atom in the semiconductor. Each photon contains an amount of energy that can be related to the corresponding electromagnetic frequency to the expression

$$E = h f \quad (2)$$

Where E is the energy in joules, h is the planks constant ($h = 6.625 \times 10^{-34} j^{s-1}$) and f is the frequency of light sources.

Interestingly, among these, laser light has proved the most attractive for optic fibre communication since the successful operation of a lower in 1960. Communication by laser beam has been attractive for several reasons.

- The transmitted laser been is extremely directional. The directionality is determined by diffraction and is expressed by the beam divergence angle;

$$\phi \cong 1.27 \frac{\lambda_L}{D_L} \quad (3)$$

Where λ_L is the wave light of the beam and D_L is the diameter of the beam waist.

- The information carrying potential of laser beam is high. The amount of information that can be sent over an electromagnetic wave is proportional to the bandwidth of the wave.
- The region $\frac{dp}{dt}$ = constant (during modulation makes it very good for lasers to be used in fibre optic communication. Hence lasers are used for optical medium for space communication (where atmospheric interference is not a problem) and terrestrial communication links for short distances.

Optical bandwidth in optical fibre network: The primary limit on the amount of date that can be carried from point to point is the available transmission band width of medium itself. Band width is the information carrying capacity of a given. Band measured in bit per second. Two approaches

Are possible in slicing up the optical band width they include Wavelength Division Multiplexing (WDM) and Optical Time Division Multiplexing (OTDM).

Wavelength Division Multiplexing (WDM): Wave length Division Multiplexing (WDM) was first proposed division with an "optical ether" ether or Frequency Division Multiplexing (EDM), over fifteen years ago[6]. The Wave Length Division Multiplexing (WDM) allows the spectrum to be sliced up into channels with a different wave length wave length allocated to each channel as in Fig. 3 below some experiments demonstrating electrical multiplexing capability at 40 G bit 5 using speed photo receivers have been reported recently[6-8] although the bit rate the can be conveniently converted to optical domain is currently still to G bit 5^{-1}.

Figure 3 shows for example, how four different wavelength channels in a single fibre individually modulated at 10 G bit 5^{-1} each, can give the total bandwidth of 40 G bit 5^{-1}[4].

Optical Time Division Multiplexing (OTDM): Another network approach in slicing up optical bandwidth is the optical time division multiplexing (OTDM). This network approach involves all optical; interleaving and regeneration of many lower bit-rate channels, each, say at 10-40 G bit S^{-1} and all at the same wavelength, optically multiplexed to 100 $GbitS^{-1}$ and over. This is represented in Fig. 4.

The total amount of data is contained in one optical channel, transmitted serially over network and inter-leaved in time.

Impacts of optical fibre networks: the global challenge: The first transatlantic optical fibre communication system, TAT-8 was installed in 1988. It operated at 140 $MbitS^{-1}$ and used electrical generation to amplify reshape and retime the signals. In more recent years, the capacity of optical network to transmit data has increased vastly, to tens and hundreds of gigabits and is fast approaching terabit[4]. This information revolution has of course important long run implications for society and the global economy.

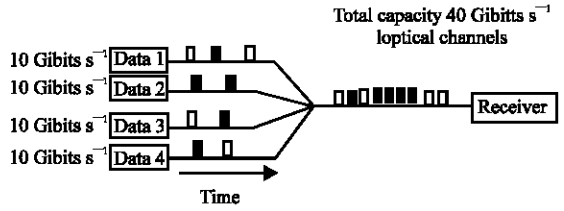

Fig. 3: Four different vauelength channels in a single fibre indviually modclulated

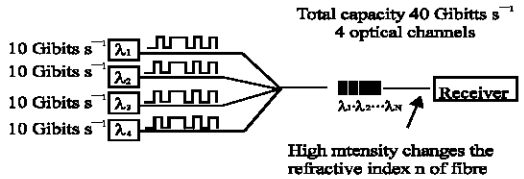

Fig. 4: Interleaving and regeneration of many lower bit-rate channels, each, say at 10-40 G bit S^{-1}

Through the application of information and fibre optical technologies, enterprises have the ability to diminish the impact of space, time and distance. Global companies can break apart business functions that were previously through to be best colleted (i.e., within the same geographic area) and spread them across the globe in a globally disarticulated labour and production process. This aspect of advanced globalization requires the existence and development of an advanced information and communication infrastructure based on a network of telecommunication, broadcasting, computers and content providers.

Since the birth of optical fibre technologies, the emerging applications have been on the increase. This is taking into account that the world is largely regarded now as a global village just because of the level of efficiency that information processing has reached[9]. Optical fibre technologies has led to the inventions such as Public Data Networking (PDN), Electronic Mail services, computer Networking System (CNS), Cellular Mobile Telephone Services (CMTS), Video Broadcasting System (VBS), international networking (Internet), teleconferencing and video conferencing etc. These have made a remarkable impact in the wide world. Today a sizable number of African countries have already made progress in their internet links that have put then on the global connectivity roadmap. Databases are now easily and quickly accessed every where. News, sports, educational programs and other shows could now be viewed on real time on a large screen at homes, offices and work places. Learning and research is no longer a difficult task with the web options, E-commerce E-shaping, E banking E-governance etc are now realities.

The future of optical networks in telecommunications: Fiber optics is a medium for carrying information from one point to another in the form of light. Unlike the copper transmission lines, fiber optics is not electrical in nature. Because of this optical fiber systems have many advantages over metallic based communication systems. The application of optical fibre technologies has produced radical new developments in information and communications technologies. This increased focus on photonics is drastically revolutionizing the communication system and is widely expected to form the next generation of information based technologies. The optical fibre technologies have given us the internet world wide web E-banking, E-mail services, Mobile communication network and other technologies that have fueled the information revolution.

The future battles for bandwidth may pose a big challenge to physicists and engineers. The bandwidth in the optical domain unlike almost any other part of the radio and microwave spectrum in up for grabs[4]. There are numerous new optical devices and an enormous transmission capacity. Yet the best way of using the bandwidth, whether through WDM or OTDM is far from clear.

It is clear, in view of this that physicists and engineers working in the field of photonics face a big challenge to continue to design new networks that carry the information as far and as fast as possible and can process it flexibly quickly and reliably. It is believed that as bandwidth demands increase rapidly with technological advances in photonics, fibre optical network will continue to play a role in the future success of telecommunication-which is the driving force of globalization.

REFERENCES

1. Pierre Lafrance, 1990. Prentice-Hall, lnc. London, pp: 3.
2. Kaminow, I.P. and T.L. Koch, 1997. Optical fiber telecommunications, vols 111A and Academic.
3. Lagesse, P., 1998. Photonic Technologies in Europe (Ed. De scamps). Telenor. (The matic issues from ACTS from ACTS: http://: www.inforwin .org.)
4. Bayvel Polina, 2000. Future high-capacity optical telecommunication networks. Phil. Trans. R. Soc. London. A., 358: 303-329.
5. Hecht and Jeff, 1999. City of light, the story of fiber Optics, Oxford University press, New York, (ISBN 0195108183).
6. Hill, G.R., 1988. A wavelength-routing approach to optical communication network. BT Tech. J., pp: 6-24.
7. Hurm, V., 1998. 40 G bit/s, 1.55 km monolithic integrated G a As based PIN-HEMT photoactive. In proc. 24th Eur. Conf. optical communication (ECO C 98), Madrid, 3: 119-121.
8. Yoenaga Matsuura, K., A. Kuwahara, S. Yoneyama, Y. Miyamoto, k. Hagimoto and K. Noguchi, 1998. Dispersions Compensation-Free 40 Gbit S^{-1}*4 Channel WDM Transmission Experiment Using Zero-Dispersion-Flattened Transmission line. In proc. Optical fiber conf. OFC 98, Dallas, PD 20.
9. Kolawole, I.B., 1998. Physical, Communication and Society, A Paper Presented in the 21st Annual Conference of the Nigeria Ninstitute of Physics Held at Ogun State University, Ago Iwoye, Nigeria, pp: 23-29.