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Performance Analysis Of Secured Fiber Optics Communication Technologies In Computer Networking And Security Challenges

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Abstract *- Fiber Optics Communication is also one of the major branch which is widely used in current communication world. Due to several advantages of fiber optics communication over different conventional wired communication method it is having higher priority. Though fiber optic transmits large amount of data quickly over long distance, it is vulnerable to various security attacks. The fiber optic cable can be easily tapped. Fundamental improvements can be achieved for the entire network by increasing the optical network's performance in terms of channel capacity, data rate, and processing speed. Furthermore, the security of the optical network has an impact on the security of the entire communication system. Optical network security can be effectively protected by fiber-based methods, including all optical signal processing, optical key distribution, optical steganography, and optical chaos-based communication. Fiber-based devices do not radiate an electromagnetic signature and are immune to electromagnetic interference. To provide end to end secure fiber optic communication, a special encryption algorithm based on Advanced Encryption Standard (AES) is employed. The proposed encryption algorithm is simulated and the performance is analyzed. In this paper we are mostly dealing with the basics of fiber optics working principle, priority over other conventional communication system and role of fiber optics communication in computer networking and its vulnerabilities.*

Keywords *- Fiber optic communication, Optical Fiber Tapping, Advanced Encryption Standard, Optical Transmitter and Receiver, Optical Regenerator, Wavelength Division Multiplexing*

I. INTRODUCTION

Fiber optics is a flexible transparent fiber made up of high quality glass or plastic. Silica system is used as core material along with dopants such as Al2O3, TiO2, , GeO2, P2O5 etc. in order to increase its refractive index. Fiber optics construction consists of three parts:

I.I. Core: Thin glass center of the fiber through which light travels

I.II. Cladding : It surrounds the core and reflects the light back into the core.

I.III. Buffer coating: Final coating made up of plastic to prevent fiber from damage and moisture (Soumya et al., 2014)

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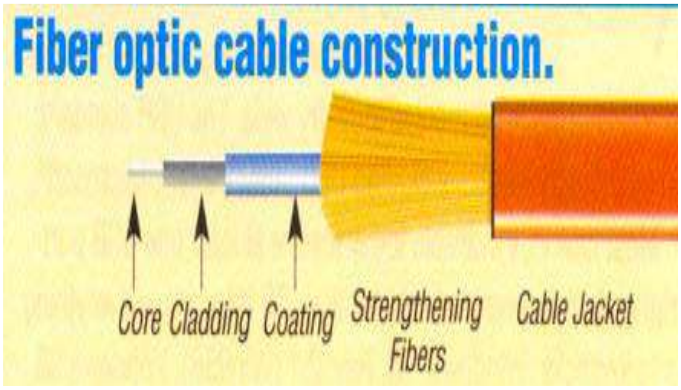

Fig. 1. Fiber Optic cable Construction.
Source: electrcalengineering123.com

The optical fiber communication technology has improved further to allow transmission of sound, image, video, data and microwaves etc., all traveling along the same fiber optics cable without electromagnetic interference from other sources. It has got immense bandwidth, high signal security, total immunity to interference and crosstalk, complete electrical isolation, very low transmission loss, very low power consumption and unique capability to transport signals over long distances (Raghavendra A.M.V et al., 2010).

Fiber Optics involves sending signals down hair-thin strands of glass or plastic fiber. The light is "guided" down the center of the fiber called the "core". The core is surrounded by a optical material called the "cladding" that traps the light in the core using an optical technique called "total internal reflection. (Bates, et al.,2001) The core and cladding are usually made of ultra-pure glass, although some fibers are all plastic or a glass core and plastic cladding. The fiber is coated with a protective plastic covering called the primary buffer coating that protects it from moisture and other damage. More protection is provided by the cable which has the fibers and strength members inside an outer covering called jacket. The light stays confined to the core because the cladding has a lower refractive index a measure of its ability to bend light. Refinements in optical fibers, along with the development of new lasers and diodes, may one day allow commercial fiber-optic networks to carry trillions of bits of data per second. Total internal refection confines light within optical fibers because the cladding has a lower refractive index, light rays reflect back into the core if they encounter the cladding at a shallow angle (Amaku et al., 2014). A ray that exceeds a certain "critical" angle escapes from the fiber.

II. REVIEW ON FIBER OPTICS TECHNIQUES

Fiber optics communication is a technology that is use to transmit signals like data, video or voice which is modulated with pulse of light that serves as an electromagnetic carrier wave send down a glass tube over a long distance with very little attenuation or loss. This modulated pulse of light propagates through the glass tube using the principle of total internal reflection (TIR). A fiber optics communication link also known as a fiber channel is a system which provides a point-to-point data connection between two points. It comprises of data transmitter consisting of a laser diode or Light Emitting Diode (LED) which convert electric signal to light, a transmission fiber in which the modulated light propagate, and a receiver which consist of a photo detector that converts light to electric signal. (S. Babani et al., 2014)

II.I. Fiber Optics Modes Types and Comparison

The modes of fiber optics mainly consists of single mode and multi mode and with different frequencies. In Fig.2. and Fig. 3. shown the basic difference between single and multimode and their structures respectively.

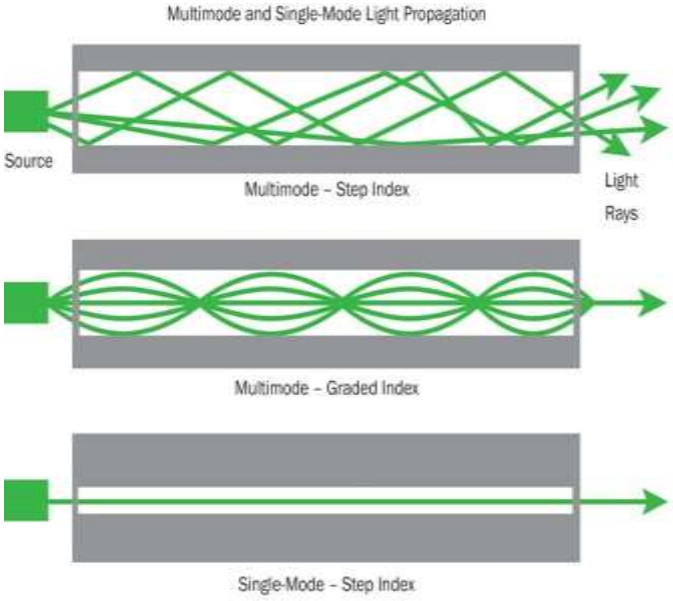

Fig. 2. Fiber Optics Mode. Source: Fiberopticshare.com

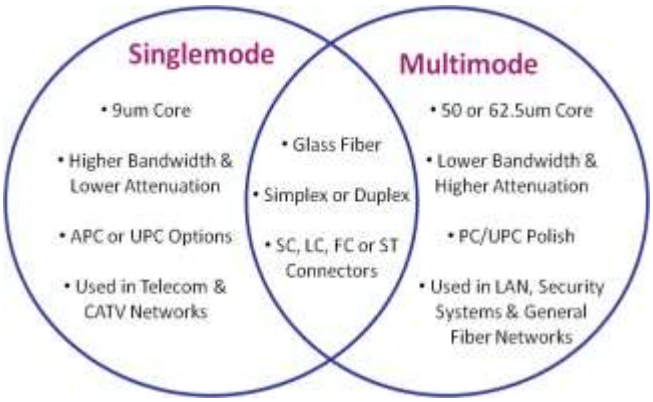

Fig. 3. Fiber Modes Comparison. Source: Cables-solution.com

II.II. Optical Transmitter and Receiver

Message signals (in form of electrical signal) are converted to optical signals and then transmitted over the optic cable either with the help of laser or Light Emitting Diodes (LED's) via optical transmitter a shown in Fig. 4. depicts block diagram of transmitter and receiver. These signals are detected by photodiodes of an optical receiver at the other side which converts the optical signals into its corresponding message signals.

II.III. Optical Regenerator

While transmission of optical data over very large distances, degradation of signals takes place due to several losses. To resolve this problem at regular intervals the optic cable is coated with special coating of dopant. When degraded signals (in form of laser) comes in contact with this dopant, molecules of dopant gets pumped up and they themselves behave as laser thus transmitting stronger signals having characteristics similar to that of degraded signals. Fig. 4. shows the block diagram for the same (Soumya et al., 2014).

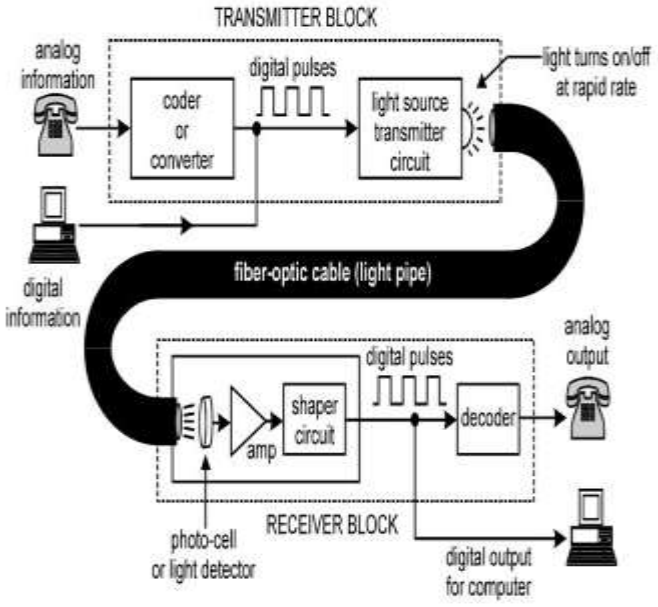

Fig. 4. Fiber Optic Communication Block Diagram

II.IV. Benefits of optical fibers Advantages of using optical fibers are listed below.

II.IV.I. Immunity to electromagnetic interference (EMI): EMI Interference is a common type of noise in ordinary wires transmission and even in coaxial cables. But fiber optics is immune to this EMI, since signals are transmitted as light instead of current.

II.IV.II. High bandwidth over long distances: Fiber optics cable has high bandwidth to carry high speed signals over longer distances than other types of cables.

II.IV.III. Data security: There are no radiated magnetic fields around optical fibers, so the electromagnetic fields are confined within the fiber, making it impossible to tap the signal being transmitted through a fiber without cutting into the fiber.

II.IV.IV. High voltage isolation: The optical fibre link provides high voltage isolation by converting electrical signals into optical signals. It can be used in high voltage floating applications, where the reference point is not at the earth potential, instead it is floating at certain high voltage.

II.IV.V. Eliminating spark hazards: Fiber optic cables do not produce sparks since they do not carry electric current. But transmitting signals electrically may be dangerous. Even tiny spark can create a big explosion in sensitive areas causing serious hindrance to data communication.

II.IV.VI. Ease of installation: Fiber cables are easier to install since they have smaller diameter, lightweight and more flexible. They can also run along the same routes as electric cables without picking up noise. (Abhijeet Badapanda et al., 2014).

III. FIBER OPTICS TECHNOLOGIES IN COMPUTER NETWORKING

The world of computing is likely to change rapidly in near future on replacing the metal wiring between components with faster, more efficient fiber-optic links. It has immense capability to transport signals having much larger information, over much longer distances and at much higher speed than the copper wire link can do. Some of the major applications of fiber optics for computer applications are listed below.

High security for transmitting sensitive government data, personal, financial and medical information, is a need of an hour and dependability for security of data globally is achieved by fiber optic communication. It provides the safest mode for transporting signals for one place to another. Benefits of this system as listed above in this paper makes it the most reliable, considering immunity from EMI (electromagnetic interference) and similar other interference makes it the most prominent of all (D.C. Agarwal, 1993).

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III.I. Fiber Optics for PC to PC Communication

PC to PC fiber optic communication deals with data transfer from one computer to another. An MAX 232 is employed to convert RS 232 logic from the serial port of computer to TTL logic, which is then sent to an optical transmitter circuit to transmit optical data via fiber optic cable. In fact, transmitter converts electronic information into pulses of light, a pulse represents one, while no pulse represents zero. At the receiver end, an optical receiver circuit receives data using a photo transistor and another MAX 232 again employed to convert TTL logic to RS 232 to receive data on the serial port at the receiving end of computer. Fig.3 shows block diagram of PC to PC fiber optics communication for data transfer between two PC, which can also be extended for data transfer among a set of computers in a computer network (Abhijeet Badapanda et al., 2014).

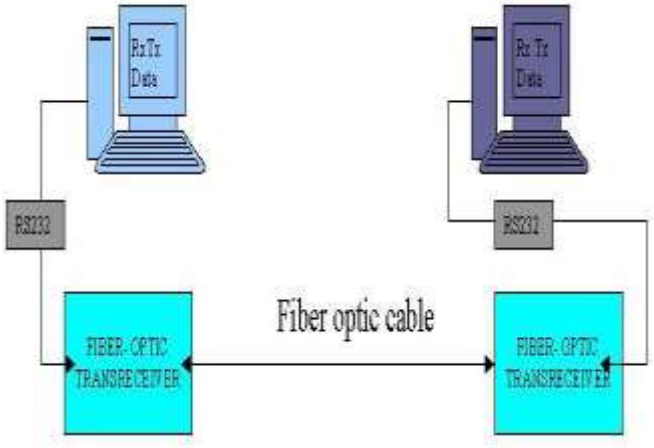

Fig. 5. Fibre optics for PC to PC Communication.
Source: FOA (Fiber Optic Association Inc.)

III.II. Fiber Optics in Computer Networking

Computer networking is defined as a network of many computers connected to each other for resource sharing, information interchange and communication purposes. By creating a computer network, devices like printers and scanners, various software, files and data that are stored in the network can be shared, as and when necessary. For example, a document can be printed on a printer from any computer connected in that network, so each computer need not require its own printer. It is established with integration of various computer hardware and software.

The common hardware devices employed in computer network are routers, hubs, switches, network gateways, network firewalls and network interface card. There are broadly two types of computer networks: Local Area Network (LAN) and Wide Area Network (WAN). A LAN is a computer network that extends to a comparatively smaller area; say to one building or group of buildings in an organization within a restricted region. Most of the LANs connect personal computers and workstations.

In a LAN, each computer has its own CPU in which it executes programs and is also capable of sharing the information with other computers in it. LAN is more significant and capable in transferring the data quickly at fast rates but the distances of transmission are limited. On the other hand, WAN enables the connectivity among many computers to transfer data in large geographical area, such as in a country or in a continent and even it can span across the world. So, offices in different countries can be interconnected through WAN. Speed of data transmission in WAN can be as low as a few Kbps or as fast as a few Gbps, depending on the technology adopted (Kurose, J.F., 2012).

Internet could also be called as largest WAN in the world, The majority of computer networks today use some type of cable to connect the computer systems and hardware that make up a network.

Most cables used in computer networks can be categorized into three groups: coaxial, twisted pair and fiber optic. Coaxial cable consists of a central conductor surrounded by insulating material, which is then surrounded by a braided metal shield and an outer plastic jacket of the cable. In coaxial cable, the central conductor wire and the braided metal shield share the same central axis.

Coaxial cable is effective at shielding data from Electro-Magnetic Interference (EMI) and is commonly used to enable a cable modem to connect to an Internet Service Provider (ISP). Twisted pair cable, which consists of multiple pairs of wires twisted around each other at specific intervals, is commonly used in computer networks. (Raghavendra A.M.V et al., 2010).

Fiber-optic cable transmits data via waves of light through glass as opposed to electrical current through copper wire. The main advantages of fiber-optic over twisted pair cable are distance and speed. Fiber optic cable can transmit data for hundreds of kilometers with very low transmission loss as opposed to only a few hundred meters with twisted pair cable. Similarly, it can carry multiple wavelengths of light simultaneously, which greatly increases the speed at which data can be transmitted in more secure and reliable manner. (Agrawal, G.P. 2010).

Fibre optic cables are already being used in a variety of ways, from delivering television signals at homes to transferring data between computers that are thousands of miles apart. As the computer networks are getting complex day by day, specifically for applications demanding high bandwidth and long distance of transmission, interconnections using optical fibres are indispensable choice.

III.III. Fiber Optics in Internet

The internet is a global system of interconnected computer networks that use the standard TCP/IP protocol to link several billion devices worldwide. It is a globally distributed network that consists of millions of private, public, academic, business and government switched networks, which operates without a central governing body.

The Internet carries an extensive range of information resources and an extremely large number of services, such as applications of the World Wide Web (WWW), the infrastructure to support email, internet phone, audio, video and file transfer services and networks for file sharing (Kurose et al.,, 2012). So WWW is one of the large numbers of services running on the Internet and Hyper Text Transfer Protocol (HTTP), is the main access protocol of the WWW and is the language used for information transfer. WWW browser software, such as Microsoft's Internet Explorer, Mozilla, Opera, Apple's Safari and Google chrome lets users navigate from one web page to another. (Alain Goulet et al., 2002).

The most prominent component of the internet is the Internet Protocol (IP), which provides addressing systems called IP addresses for all computers on the internet and enables internet working.

The commercialization of internet started in 1990s, but has grown to such an extent that it has virtually impacted into every aspect of modern human life, creating the so called internet revolution. Today more than one third of the world's human population has used the services of the internet. Email is one of the most important communications service available on the internet (eBay, 2014).

The internet allows computer users to remotely access other computers in the network with or without computer security. It is also widely used for social networking through face book, twitter and my space for fostering commercial and business connections through LinkedIn as well as for storing and transferring large amounts of data, whenever

necessary. Common methods of internet access by users is either by dial-up with a computer modem via telephone circuits or by wireless or by broadband over coaxial cable and fiber optic cable.

Broadband internet through fiber optic cable allows large amount of data transmitted at high speed for demanding applications like streaming and uploading online video, online gaming and multimedia applications (Stephen Shankland, 2014). As the networks of internet is expanding rapidly and getting complex day by day, demand for high quality optical fibres with high bandwidth and long distance of transmission is increasing to meet the user expectations.

IV. SECURITY VULNERABILITIES

Copper wires data transmission can be very easily tapped which was not the case in fiber optics communication few years back, until then the later was and still is to some extent considered as finest communication mode, but once an intruder has gained access to the fiber cable tapping of data is easier. For an undetected tap, intruder needs a laptop, special software, Optical Tap and an Opto-Electronic Convertor (Soumya et al., 2014).

This special software acts as a filter and allows access to specific IP address, Mac address and other sensitive information. Without actually piercing or disrupting the flow of the data, fiber optical cable can be tapped.With the help of clip-on couplers they can be bent in a precise way that forms micro-bends. These micro-bends (ripples) causes photons of light, which is carrying some data, to leak out (Kimberlie Witcher, 2005). This method is more successful for lower speed data transmission.Fig. 6. depicts this in a pictorial way.

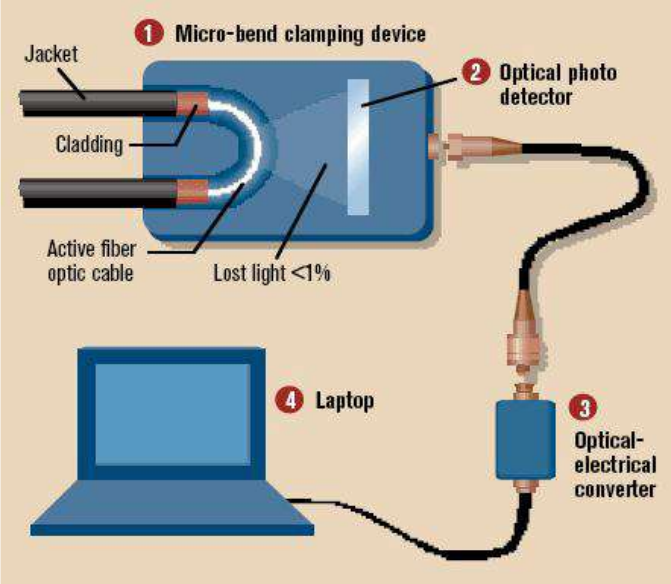

Fig. 6. Optical Electro Converter

The second method is the non-touching tapping method. In this additional light is injected into the fiber plant which analyze the optical signals by gauging certain interactions between the two. In absence of physical-layer optical signal protection the other end data user would never be able to identify that his/her data is being intercepted·

IV.I. Counter Measures

IV.I.I. Physical layer

To check all these sorts of tapping, the best way is physical layer security system. It provides a roadmap and brings attention to this system ssecurityvulnerabilities.

IV.I.II. Encryption

- One of the most reliable for secure data transmission since older times is 'encryption'. It is a technique for transforming information in such a way that it becomes unreadable (NI Standards, 1999).
- It basically translates normal text into cipher text. This method keeps a check that data is unreadable to intruders.
- Three methods to encrypt our data.

Hashing: In this method a unique, fixed length for a data is set. As each "hash" is unique to a data set, so any minor changes to that data would be easily tracked.

Symmetric: It is also known as private key cryptography. Here a 'single key' is used to encrypt and decrypt the data set so the d1ata remains secure.

Asymmetric: It is also known as public key cryptography. Here separate keys are used for encryption and decryption. This method is more secure.

IV.I.III. A special optical security

It has been developed which is protocol independent. In this, if data is intercepted the intruder will not be able to gain access to captured data and data will be rerouted to a backup system (Soumya et al., 2014).

V. TESTING FOR THE VARIOUS LOSSES

Testing is used to evaluate the performance of fiber optic components, cable plants and systems. As the components like fiber, connectors, splices, LED or laser sources, detectors and receivers are being developed, testing confirms their performance specifications and helps understand how they will work together. Designers of fiber optic cable plants and networks depend on these specifications to determine if networks will work for the planned applications. Perhaps the most important test is insertion loss of an installed fiber optic cable plant performed with a light Source and Power Meter (LSPM) or optical Loss Test Set (OLTS) which is required by all international standards to ensure the cable plant is within the loss budget before acceptance of the installation.

After fiber optic cables are installed, spliced and terminated, they must be tested. For every fiber optic cable plant, there is the need to test for continuity and polarity, end-to-end insertion loss and then troubleshoot any problems. If it's a long outside plant cable with intermediate splices, there is need to verify the individual splices with an Optical Time Domain Reflectometers (OTDR) test, this is about the only way to make sure that each splice is good. Designers may also be interested in testing transmitter and receiver power, as power is the measurement that tells whether the system is operating properly (Amaku et al., 2014). The importance of the appropriate tools to perform the various tests and compare the test results with appropriate typical results acceptable for splice and insertions losses.

V.I. The Testing Tools

• Source and power meter, optical loss test set (OLTS) or test kit with proper equipment adapters for the cable plant you are testing.

• Reference test cables that match the cables to be tested and mating adapters, including hybrids if needed

• Fiber Tracer or Visual Fault Locator

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• Cleaning materials - lint free cleaning wipes and pure alcohol

• OTDR with launch and/or receive cables for outside plant jobs and troubleshooting.

V.II. Optical Power Measurement

The most basic fiber optic measurement is optical power from the end of a fiber. This measurement is the basis for loss measurements as well as the power from a source or presented at a receiver. Typically both transmitters and receivers have receptacles for fiber optic connectors, so measuring the power of a transmitter is done by attaching a test cable to the source and measuring the power at the other end. For receivers, one disconnects the cable attached to the receiver receptacle and measures the output with the meter. (Ochie Romero, The Fiber Optic Association, Inc. (C)1999-2008). While Optical Power Meters are the primary power measurement instrument, Optical Loss Test Sets (OLTSs) and Optical Time Domain Reflectometers (OTDRs) also measure power in testing loss.

Optical power is based on the heating power of the light, and some optical lab instruments actually measure the heat when light is absorbed in a detector. While this may work for high power lasers, these detectors are not sensitive enough for the low power levels typical for fiber optic communication systems.

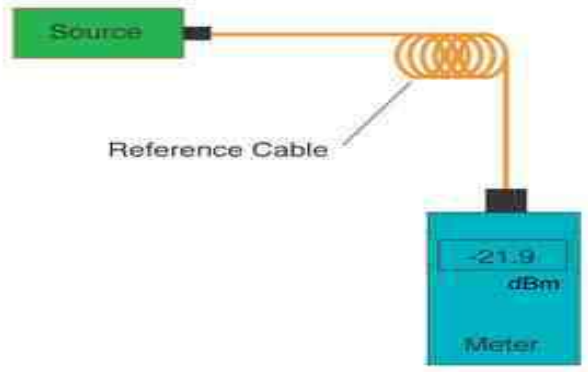

Fig. 7. Optical Power Meter . Source (FOA)

V.III. Visual Tracing

Continuity checking with a visual fiber tracer makes certain the fibers are not broken and to trace a path of a fiber from one end to another through many connections, verifying duplex connector polarity for example. It looks like a flashlight or a pen-like instrument with a light bulb or LED source that mates to a fiber optic connector.

Attach the fiber to test to the visual tracer and look at the other end of the fiber to see the light transmitted through the core of the fiber. If there is no light at the end, one has to go back to intermediate connections to find the bad section of the cable. A good example of how it can save time and money is testing fiber on a reel before it is pulled to make sure it hasn't been damaged during shipment. For testing, visual tracers help also identify the next fiber to be tested for loss with the test kit.

When connecting cables at patch panels, the visual tracer is used to make sure each connection is the right two fibers! And to make certain the proper fibers are connected to the transmitter and receiver, use the visual tracer in place of the transmitter and your eye instead of the receiver (Amaku et al., 2014).

Fig. 8. Visual Tracer. Source (FOA)

V.IV. Visual Fault Location

A higher power version of the fiber tracer called a Visual Fault Locator (VFL) uses a visible laser that can also find faults. The red laser light is powerful enough for continuity checking or to trace fibers for several kilometers, identify splices in splice trays and show breaks in fibers or high loss connectors.

We can actually see the loss of light at a fiber break by the bright red light from the VFL through the jacket of many yellow or orange simplex cables (excepting black or gray jackets, of course.). Its most important use is finding faults in short cables or near the connector where Optical Time Domain Reflectometers (OTDRs) cannot find them. (Amaku et al., 2014) .

Fig. 9. Visual Fault Locator Source: (FOA)

This gadget can also be used to visually verify and optimize mechanical splices or prepolished-splice type fiber optic connectors. By visually minimizing the light lost can get the lowest loss splice. No other method will assure the high yield with those connectors. Loss of a cable is the difference between the power coupled into the cable at the transmitter end and what comes out at the receiver end.

Testing for loss (also called "insertion loss") requires measuring the optical power lost in a cable (including fiber attenuation, connector loss and splice loss) with a fiber optic Light Source and Power Meter (LSPM) or Optical Loss Test Test (OLTS.) Loss testing is done at wavelengths appropriate for the fiber and its usage.

Generally multimode fiber is tested at 850 nm and optionally at 1300 nm with LED sources. Singlemode fiber is tested at 1310 nm and optionally at 1550 nm with laser sources. The measured loss is compared to the estimated loss calculated for the link, called a "loss budget."

The insertion loss measurement is made by mating the cable being tested to known good reference cables with a calibrated launch power that becomes the "0 dB" loss reference. Reference cable is used for the following reasons.

a) It is needed to measure the output power of a source for calibration of “0” loss.

b) In order to measure the loss of the connectors, it is required to mate them to a similar, known good, connector.

c)Testing with reference cables on each end simulates a cable plant with patchcords connecting to transmission equipment (Amaku et al., 2014).

Fig. 10. Light Source and Power Meter. Source: FOA

In addition to a power meter, there is the need for a test source. The test source should match the fiber type (generally LED for MM or laser for SM) and wavelength (850, 1300, 1550 nm) that will be used on the fiber optic cable that is being tested (Amaku et al., 2014).

VI. CONCLUSION

Computer network that links two or more computers or communicating devices separated by a geographical distance. The communications channels of moderate-to-high speed data rates. Optic fiber remains the most reliable connectivity medium in computer networking base on it’s resistive capability to signal attenuations and electromagnetic interference. In this paper, we have analysed that optical communication is the best data transmitting system till date with some security vulnerabilities viz. intruders tapping data via micro bends of fiber but this can be handled by creating awareness in the field of encrypting our data and being up to date about the emerging technologies. The internet also allows computer users to remotely access other computers in the network with or without computer security. The world of computing is likely to change rapidly in near future on replacing the metal wiring between components with faster, more efficient fiber-optic links.

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REFETRENCES

[1] Soumya, Shivangi Singh. (2014). Fiber Optics Communication In Computer Networking And Security. International Journal of Electrical, Electronics and Data Communication, 2(3), 62-64.
[2] D.C. Agarwal. (1993). Fiber Optic Communication, New Delhi: Wheeler Publishing, second edition.
[3] Kimberlie Witcher. (2005). Fiber optics and its security. Vulnerabilities. SANS Institute, Version 1.4c.
[4] N.I. of Standards and Technology (1999). Data Encryption Standards (DES), Processing standards publication.
[5] Abhijeet Badapanda, M K Badapanda. (2014). Optical fibers for computer applications. International Journal of Engineering and Innovative Technology, 4(5), 169-175.
[6] Raghavendra A.M.V, Srinivasas Rao B.V. (2010)., Fiber Optics Based Parallel Computer Architecture. International Journal of Scientific & Engineering Research, 1(2), 1-10.
[7] Stephen Shankland. (2014), Fast Fiber Optic Broadband Spreads Across Developed World. Retrieved from http://www.cnet.com/news.
[8] eBay (2014). How to connect a computer network with fiber optic cables published by eBay. Retrieved from from http://www.ebay.com.
[9] S. Babani, A. A. Bature, M. I. Faruk, N. K. Dankadai. (2014). Comparative Study Between Fiber Optic And Copper In Communication Link. International Journal of Technical Research and Applications, 2(2), 59-63.
[10] Agrawal, G.P. (2010). Fiber-optic communication systems. John Wiley & Sons. 222 (2010).
[11] Amaku Amaku, Raphael E.Watti, John Joshua. (2014). Optic Fiber as a Reliable Medium for Metropolitan Area Networking (MAN) Connectivity. International Journal of Engineering and Technology Volume 4 No. 9,542-547.
[12] Kurose, J.F., and Ross, K. W., (2012). Computer Networking: A Top-Down Approach. Pearson Addison-Wesley, Fifth Edition.
[13] Bates, Regis J (2001). Optical Switching and Networking Handbook.Ochie Romero. (FOA). Reference Guide To Fiber Optics: The Fiber Optic Association, Inc