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Nigerian Fiber Optic Network: Structure, Limitations, Solutions and Future Trend

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ABSTRACT

Nigeria is the most populous African country and as such the demand for telecommunication/internet services has increased tremendously. The country's communication backbone has relied on microwave communication which is economical but has great limitation in traffic capacity and poor anti-jamming capabilities. The optical fiber backbone therefore serves as the solution to the limited traffic capacity and increased demand. Optical fiber is seen as the best medium for telecommunication cable due to its speed, bandwidth and much reduced susceptibility to attenuations. This paper therefore reviews the state of fiber optics internet broadband network in Nigeria, challenges/limitation associated with deploying fiber optics technology, probable solutions and future trends. In this paper, Nigerian fiber optic network is classified into the three major categories. The optic fiber network can therefore be described as been massive with great economic viability since Nigeria has great tendency to explore the internet broadband bandwidth due to its population size.

Key words: Backbone/Backhaul, fiber optics Network, broadband

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1. INTRODUCTION

The main limitation of communication systems is its restricted information carrying capability. This information handling ability is directly proportional to the band width of the communication channel. In this twenty first century, there is the high and rapidly increasing consumer and commercial demand for more telecommunication capacity and internet services. In [1], the growth of fiber optics in Nigeria was ascertained by the level of internet penetration across the globe. In [2], the paper reviewed the ranking in information and telecommunication by African countries with Nigeria as a case study. It presented the level of ICT broadband infrastructure and possible ways of increasing broadband penetration. Fiber optic technology provides information with less attenuation, no interference and higher bandwidth capacity which is known to be better than both wireless and wired communication systems. It is of small size, low weight and low security risk. Advances in technology have ensured that data could be transmitted via a single optical fibre link through long distances by deploying wavelength division multiplexing. This is a method of transmitting signals from one point to another by sending pulses of light ray through an optical fiber. The light rays are electromagnetic waves which act as the carrier that is modulated to convey the information. It is important to state that due to high bandwidth, large immunity to electromagnetic signals and very communication distances involved, optical fibers are preferred to electrical cables. Various options have been sort as a measure of bringing optical fiber technology closer in every aspect of life via FTTx approach (where x refers to different points such as; home (FTTH), Building (FTTB), desktop (FTTD), Curb (FTTC) etc).

Basic Principles of Fiber Optic Communication

The information transmitted may be voice, video or data. It is essentially converted to a form that is compatible with the communication medium. This is achieved by converting continuous analogue signal into series of digital pulses with the use of an analogue to digital converter. The composition of the optical fiber just like a wave guide is made up of dielectric material. It composes of the core, cladding and the outer protective unit. The refractive index of the core is higher than that of the cladding. This implies that the light signal which has been converted into a pulse train can be conveyed along the fiber axis. This action is achieved by total internal reflection. The entire fiber optic system is made up

of a transmitter, the transmitting medium which is the fiber cable, amplifier to enhance the optical power of the signal, a receiver which serves as a decoder to conert the optical signal to its original form

2. METHODOLOGY

The method adopted in this work requires the use of strategic qualitative analysis using scholarly works in fiber optic communication.

Structure of Fibre Optics Network in Nigeria

Internet broadband achievement with fiber optics technology is categorised into the following;
1 The core fiber optic network
2 The backbone or backhaul; this is essentially given by internet service providers
3 The access or last mile fiber optic network. This has low deployment in Nigeria. It uses the gigabit passive optical network (GPON).

The following are the different submarine companies existing in Nigeria which make up the core fiber optic network.
1 SA-3WACS
2 Main one cable Company
3 Glo 1
4 West Africa cable system (WACS)
5 African Coast to Europe

Table -1 International submarine fiber optic connection in Nigeria [3]

S/N	Cable	Distance (km)	Date launched	Capacity (Tbps)	Landing point	Owner in Nigeria
1	SAT-3	14,350	Apr-02	0.54	Lagos	NAT COM
2	MainOne	7,000	Jul-02	4.96	Lagos	MainOne
3	Glo 1	9,800	Oct-02	2.5	Lagos	Globacom
4	WACS	14,530	May-12			
5	ACE	17,000	Dec-12	5.12	Lagos	Dolphin
	Total capacity			27.62		

3. BACKBONE FIBER OPTIC NETWORKS IN NIGERIA

The fiber optic backbone infrastructure is in existence in all the 36 state capitals of Nigeria including the Federal Capital city (Abuja). One of the major challenges of utilizing the fiber optic network is that majority of its infrastructures are situated in the urban with a few in the rural communities. Out of the 774 existing local government headquarters, only a few number are connected on the route of the primary fiber backbone. The Metropolitan networks include places like only par of Lagos, Port Harcourt and Abuja [4]. The National wholesale fiber optic networks that are operational are all owned by private investors in the countries. These investors include, Globacom Limited, MTN Group, Multilinks, Etisalat, Phase 3/Dcancom, Airtel and Main One. The Nigerian telecommunication network has failed and is no longer in use. Unfortunately the facilities are today been deployed by major private sector. The end of year report of Nigerian Communication Commission (NCC) reveals that about 80,938km length of fiber optics are deployed by Mobile GSM/CDMA and Fixed operators as at December, 2014.

Table -2 Fiber optics deployment in Nigeria (in Km) 2014

GSM CDMA and fixed telephone operators	Terrestrial fiber optics (km)	Submarine fiber optics (km)
MTN	19.200	0
GLO	10,869	9,800
AIRTEL	6,314	23
EMTS (Etisalat)	4,300	0
MULTILINKS	5,789	0
VISAFONE	43	0
MTIN-FIXED	12,518	6,682
21st CENTURY	5000	1
IpNX	400	424
TOTAL	64,433	16,930

The backhaul/backbone fiber optic networks are mainly managed by the telecommunication companies to ensure quality and sufficient network performance. The NCC initiated a fiber optic Backbone Network infrastructure to establish connection between the rural and urban areas. This can be achieved by creating ownership option, pricing strategy, deployment strategy and establishing of community communication centers to increase the capacity of ICT and spur economic development. Today some villages have fiber network access most especially in the northern region of the country. This was a huge success due to the use of the facilities of power holding company of Nigeria. This can be achieved by providing efficient connectivity, reliable network and sufficient data storage sevicies. Technologies like the

dense wavelength division multiplexing may be deployed to improve throughputs of fiber optic network. DWDM is currently applied in optical transmission where over 96 wavelengths can be merged together in one fiber for transmission and separated with a demultiplxer. Transmission rates for fiber channels are progressively increasing into the Tetra bits/s rates.

4. LIMITATIONS AND PROBABLE SOLUTIONS

Nigeria is still struggling with a lot of challenges in her bid to efficiently implement fiber optic networks in the country. This is because, the country is yet to meet its said target of 120,000 kilometres of metropolitan fiber network interconnected across the country to achieve its goal of pervasive broad bond penetration. There is some level of limited distribution of fiber optic network to all parts of the country since all he landing point for optic fiber network is in Lagos. The deployment of the required infrastructure for effective distribution across the country is a major challenge. In [5], a severity index analysis was performed to investigate the categories of problems faced with optical fiber communication in Nigeria. A major setback in Nigeria's ICT world is that only 17% of our rural communities are seen to have internet facilities when compared to the 79% of urban cities. Some of the core limitations include;

- **Right to access:** The administrative exercise involved to have the right to access is cumbersome and expensive and most times there is inconsistency of the policies which could result to random taxations from all levels of Government. The government should look into this and try to harmonize the charges so fiber optics network can work efficiently in Nigeria.
- **Unplanned settlement**: It is important to put into consideration the documentation, position and existence of telecommunication facilities when roads are being constructed and maintained. It is necessary that trained personnel are deployed to ensure the existing facilities are not destroyed and network access is not limited.
- **Theft and Destruction of cables**: In Nigeria, theft and destruction of optic fibers have discouraged massive deployment of fiber cables for network operations. Although these actions is more pronounced with metallic cables than fiber optics. The relevant security agencies must be given autonomy to combat crimes of this nature. The required penalties should be enforced for defaulters.
- **Poor intervention by the Government** due to collapse of Nitel, government has very poor involvement in ensuring that optical fiber infrastructure is made available at all grass root level. Government should ensure private stake holders provide the relevant amenities for effective communication process.
- **Fragility:** the main component of a fiber optic cable is glass, which make them more fragile than electrical wires. The root cause of fiber cut incidence and its negative impact is investigated while giving probable solution to this menace. It is also important to note that chemicals and gaseous substances can react with fiber made of glass, this requires great expertise when deployed underground.
- **Difficulty of Installation:** optical fiber cables are very fragile and as such they can be damaged very easily either during construction or installation process. Splicing is a major challenge when it comes to fiber cables. It is known that attenuation and dispersion are increased as transmission distance getting longer. This is because, light signal can be lost or interfered with in the form of attenuation or dispersion, so additional components such as EDFA can be added to reduce these negative effects.
- **Erosion and other natural problems:** Natural disaster contributes 0.35% to total fault count attributed to fiber cut [6]. Some of these natural causes include; erosion, floors and force majeure as well heavy current from floor waters which was away some of the fiber cable.
- **High cost compared to copper cable**: it is more expensive to install fiber optics cable when compared to copper cables. This is due to the fact that extra care is given when installing fiber cables. This eventually leads to extra cost in handling the cables. However other technological approaches which include passive optical network and fiber to the end user can be deployed to create room for enhanced subscriber broadband access.
- **Local geography:** the topology of the land will affect the technical architecture of the fiber infrastructure. A large part of the capital cost for laying fiber is attributed to construction cost, soil type, cable routing etc. The large land mass of the nation means that every region and state has a unique topological profile.
- **Unwillingness of service operators to share backbone infrastructure.** If all the stakeholders are willing to cooperate and share backbone facilities, estimated cost of deploying fiber optics cable will reduce thereby creating more investment opportunities.

5. RECOMMENDED WAYS TO REMEDIATE THE CHALLENGES OF USING OPTICAL FIBRE NETWORKS

Proper Planning

In order to ensure effective optical fiber communication, it is necessary that Nigerians famous NITEL's forgotten fibre cables should be revisited, maintained and utilized to save cost. Multiple splicing is a major challenge in the use of optical fiber communication system. Having cables spliced at intermediate points is not advisable. This is because each splice point is associated with a specific loss. However, cost of deploying optical communication system can be reduced by sharing the exiting optical route. On situations where over head cables are to be used, it is necessary to determine the

state of the electric poles deployed for this purpose. With proper and adequate planning effective communication can be guaranteed with optical fiber communication.

Mitigation against unintended fibre cuts and disturbances

It is important to understudy areas in an urban or rural setting where optical fibers can be laid. These areas should not include drainage paths, unconstructed roads, roads with further need for expansion and maintenance etc. However, field workers should be made to monitor areas where construction work is in progress to avoid destroying under laid cables. Site survey needs to be performed to ensure new sites are officially registered with the required agency or government body.

Greater Government Participation

The government on all levels should not just overlook the importance of the fibre optics networks. This is because if they show their interests and monitor the system even as it deregularized, the parties involved will carry out their duties with some level of sanity. All sectors of economic processes that may be concerned with or may affect the fiber optic network will be monitored and governed accordingly.

6. FUTURE TRENDS

There is prospect in the future of optical fibres in its growing application. One of such trend which has immense potentialities is the Radio over Fiber (ROF) application. This is a combination of optical fibres and radio frequency such that; RF signals modulate the light in one fibre. This can be implemented with a central electro/optical element that modulates the light intensity through RF signals. At the receiving end, an optical/electric modulator recovers the RF frame, producing current signals that are proportional to the intensity of the received light. It is worth mentioning that avionics helps in the elimination of interferences and the lightness of cables however, the big traffic capacity of fibres eliminates congestion problems. One experimentation that is been considered for implementation in the use of ROF is in self driving cars [7].

A prospective trend for the future would involve activities of fiber optic communication totally in the optical space. In such systems, all signs will be prepared in the optical domain, with no form of electrical control as the present optical electric systems introduces delays in the communication [8].

Wider Bandwidth Networks which some authors refer to as a multi-terabit network are proposed. They use the DWDM which allows for greater bandwidth systems since it has low collision and disturbance rate. Furthermore, there has been proposed improvement in the glass fiber used for optical communication. This could be achieved with the addition/removal of impurities in the glass fiber. This has the tendency to increase the rate at which light propagates through the fiber. Another development requires the miniaturization of the optical fiber devices to give room for standard and concise communication equipment.

The polymer optic fibres are envisioned to enter the market because of their low cost and increased flexibility as compared to glass fibre optics communications systems with greater improved and smarts amplification as well as miniaturized cables [9].

Another future trend will involve Improvement with advanced laser technology which can be achieved with a wider variety of lasing wavelength [10]. This can be achieved by deploying short wavelength lasers with very high output power in high density optical application.

Another trend is the application of an intelligent optical transmission network. This trend establishes a fibre optics communication system which is scalable. This implies that the system has the ability to adapt to changes and growth in the network and tackle challenges posed by the traditional optical services [11].

Optical communication to and fro high altitude is gaining tremendous application. This can be found in airship situated above the clouds. Optical links that exist between platforms of high altitude, satellite and ground stations are required to serve broadband backhaul communication channels. This is because they use laser beams where unfavourable atmospheric impact on the laser beam is less [12].

7. CONCLUSION

Fiber optic transmission is still prone to dynamic development due to increase in bandwidth requirement and high data rate. Nigeria needs to wake up to the call of fibre optic technology. The technology is not stagnant. It keeps evolving and the future for it is very bright. As the nation works hard to surmount the challenges it faces in deploying a fibre optic system, every other thing is possible.

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