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Full Length Research Paper

Fibre Broadband Development In Nigeria: A Catalyst To Economic Growth And Social Development

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The term broadband commonly refer to as high-speed and high capacity Internet access that is faster than the traditional dial-up access. Fibre broadband is being referred to as ultra fast and super speedy broadband which has a speed incomparable with the preceding technologies especially ADSL2+. Fibre broadband is a medium of transmission oriented technology which involve using Fibre optic cables for transmission and distribution instead of copper cables as in ADSL and other earlier technologies hence the advantages of fibre optic network over copper network in data transmission was extensively discussed. For our country Nigeria to adopt the technology, what are needed to put in place vis-à-vis the present level of readiness of the adoption fibre broadband was also reviewed. The facilities available within the country for future developments was highlighted, which include the issue of the numerous submarine fibre cables that are already present at the shore of the country which is a step forward. The advantages of using fibre cable instead of satellite were also explained. The source of information used in this paper is that of the report of the research carried out in U.K by Regeneris company of Britain on the £2.5billion invested by BT Company on fibre broadband. In the conclusion part, based on the report given by Regeneris concerning the great positive impact of fibre broadband on economy and social life of the citizens of Britain, it was stated that adoption of fibre broadband is worth given full support in order for the country (Nigeria) to develop further technologically, socially and economically.

Keywords : ADSL2+, Broadband, Fibre broadband, fibre optic cable, Submarine cables, FTTH/FTTP, FTTC.

INTRODUCTION

The term broadband commonly refers to a type of internet connection with a high-speed and high capacity Internet access that is always on and faster than the traditional dial-up access. In addition, broadband has the ability to transport multiple signals and traffic types simultaneously (Benat et al., 2013). In search of very fast internet connections, there has been many technologies adopted in some vicinities but on the long run and most especially when data hungry equipment are connected, such as those for teleconferencing, such technology tend to produce a very slow and frustrating scenario. (Benat et al., 2013) (Thinkbroadband.Com 2013); that was even before the explosion in web-connected laptops, smart phones, tablets, games consoles and smart TVs. It was

against this backdrop that the quest for broadband became high. (Atkinson et al., 2013) (Thinkbroadband.Com 2013) [10]

Broadband involve several high speed transmission technologies such as: Digital Subscriber Line (DSL), Cable Modem, Fibre, Wireless, Satellite and Broadband over Power Lines (BPL). (Broadband.Gov).

What is Fibre Broadband

Fibre broadband is a medium-of-transmission oriented broadband technology with little emphasis on the type of connection. Fibre broadband is a new type of broadband that is currently being deployed in the UK by BT Virgin media which uses fibre optic cables to help increase the speed of broadband connections. In contrary to ADSL and ADSL+, Fibre broadband replaces copper telephone wires with a network of fibre optic cable. It is often referred to as 'super-fast broadband' or 'next-generation broadband' as it offers faster speeds than have been available to date using older generation networks. It is available to both home and business users. (Vangie, 2013).

As earlier declared, Fibre broadband is a new type of broadband that is currently being deployed in the UK by BT Virgin media which uses fibre optic cables to help increase the speed of broadband connections. There are two main types of fibre broadband and they are FTTC and FTTH. FTTC mean Fibre To The Cabinet while FTTH or FTTP means Fibre To The Home or Fibre To The Premises. The two types produce very fast connections but that of FTTH is of higher performance in the sense that it involves the fibre cable linking your home directly while in FTTC, the fibre cable is supplied to the community cabinet which may be a little far from where you are living. (Dean Evans 2013).

Two Types of fibre broadband explained

Fibre broadband is the future of broadband as it can deliver significantly faster downloads broadband speeds than conventional ADSL or the latest version ADSL2 services.

Currently, two types of fibre broadband are being rolled out in U.K: Fibre to the Cabinet (FTTC) and Fibre to the Premises (FTTP). FTTC services offer download speeds up to 76Mbps while FTTP services offer download speeds up to 330Mbps which seems magical.

Fibre-to-the-Cabinet (FTTC) involves running fibre optic cables from the telephone exchange or distribution point to the street cabinets which then connect to a standard phone line to provide broadband. This is combined with a copper cable from the cabinet to the home or business which uses VDSL or similar technology that can deliver much faster speeds over shorter distances while Prior to the advent of fibre broadband, the most popular technology adopted had been ADSL, ADSL2+. However, the two technologies are giving way to Fibre Broadband due to their shortcomings and the inherent advantages associated with Fibre broadband.

Popular Prior Technologies?

The prior technologies are many but the most popular recent ones would be discussed; they are Dial-Up Internet Access, VDSL, ADSL and ADSL2+

Dial-Up Internet Access:

Dial-up Internet access is a form of Internet access that uses the facilities of the Public Switched Telephone Network (PSTN) to establish a dialed connection to an Internet service provider (ISP) via telephone lines. The user's computer or router uses an attached modem to encode and decode Internet Protocol packets and control information into and from analogue audio frequency signals, respectively. Dial-up internet is rarely used anymore. Broadband internet access is what the vast majority of people use.

Dial-up connections to the Internet require no infrastructure other than the telephone network and the modems and servers needed to make and answer the calls. Where telephone access is widely available, dial-up remains useful and it is often the only choice available for rural or remote areas, where broadband installations are not prevalent due to low population density and high infrastructure cost. Dial-up access may also be an alternative for users on limited budgets, as it is offered free by some ISPs, though broadband is increasingly available at lower prices in many countries due to market competition.

Dial-up requires time to establish a telephone connection (up to several seconds, depending on the location) and perform configuration for protocol synchronization before data transfers can take place. In locales with telephone connection charges, each connection incurs an incremental cost. If calls are time-metered, the duration of the connection incurs costs.

Dial-up access is a transient connection, because either the user, ISP or phone company terminates the connection. Internet service providers will often set a limit on connection durations to allow sharing of resources, and will disconnect the user—requiring reconnection and the costs and delays associated with it. Technically inclined users often find a way to disable the auto-disconnect program such that they can remain connected

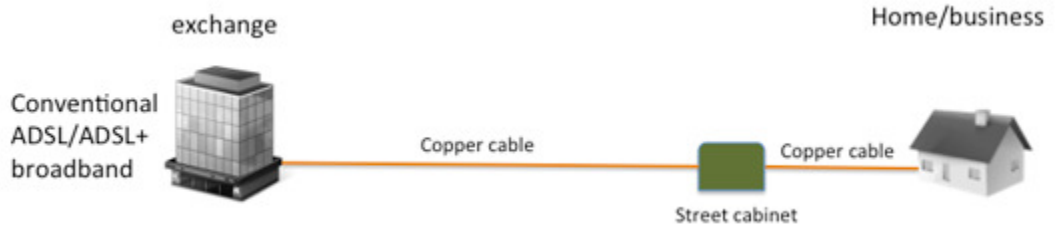


Figure 1.1: ADSL uses copper cable

for days. (Wikipeadia: Dial-up Internet access; 2013)

ADSL (Asymmetrical Digital Subscriber Line

ADSL differs from the less common Symmetric Digital Subscriber Line (SDSL). Bandwidth (and bit rate) is greater toward the customer premises (known as downstream) than the reverse (known as upstream). This is why it is called asymmetric. Providers usually market ADSL as a service for consumers to provide Internet access in a relatively passive mode: able to use the higher speed direction for the download from the Internet but not needing to run servers that would require high speed in the other direction. However, copper is the medium of transmission in ADSL

The acronym DSL stands for Digital Subscriber Line and refers to technology allowing a normal telephone line to carry internet data at the same time as voice calls. ADSL is the most common version of this technology. The A stands for "Asymmetrical" and refers to a set-up which allows a faster speed for downloading data than uploading it. Because most home users download much more data than they upload, ADSL is more efficient and thus more economically viable than dial-up Internet access.

There are both technical and marketing reasons why ADSL is in many places the most common type offered to home users. On the technical side, there is likely to be more crosstalk from other circuits at the Digital Subscriber Line Access Multiplexer (DSLAM) end (where the wires from many local loops are close to each other) than at the customer premises. Thus the upload signal is weakest at the noisiest part of the local loop, while the download signal is strongest at the noisiest part of the local loop. It therefore makes technical sense to have the DSLAM transmit at a higher bit rate than does the modem on the customer end. Since the typical home user in fact does prefer a higher download speed, the telephone companies chose to make a virtue out of necessity, hence ADSL.

The marketing reasons for an asymmetric connection are that, firstly, most users of internet traffic will require less data to be uploaded than downloaded. For example, in normal web browsing a user will visit a number of web sites and will need to download the data that comprises the web pages from the site, images, text, sound files etc. but they will only upload a small amount of data, as the only uploaded data is that used for the purpose of verifying the receipt of the downloaded data or any data inputted by the user into forms etc. This provides a justification for internet service providers to offer a more expensive service aimed at commercial users who host websites, and who therefore need a service which allows for as much data to be uploaded as downloaded. File sharing applications are an obvious exception to this situation. Secondly internet service providers, seeking to avoid overloading of their backbone connections, have traditionally tried to limit uses such as file sharing which generate a lot of uploads. [22]

ADSL2:

(ITU G.992.3 and G.992.4) adds new features and functionality targeted at improving performance and interoperability and adds support for new applications and services. Among the changes are improvements in ADSL's data rate, an increase in the distance ADSL can reach from the local telephone exchange, dynamic data rate adaptation, better resistance to noise, diagnostics, and a stand-by mode to save power. ADSL2 also reduces the initialisation time from more than 10 seconds (as is required for ADSL) to less than 3 seconds. ADSL2 has the same signal footprint as ADSL.

ADSL2 works on the same principles, but uses an advanced form of the technology to cope with faster speeds. It requires new equipment at both ends of the connection. This means that ADSL2 will only be available in an area once the local telephone exchange has been upgraded. Customers who want to use ADSL2 services will then need a new modem router. There is no need to make any changes to the phone line itself. Whether companies charge more for an ADSL2 service is up to them, though some analysts believe competition between providers will mean there is little room for price rises.

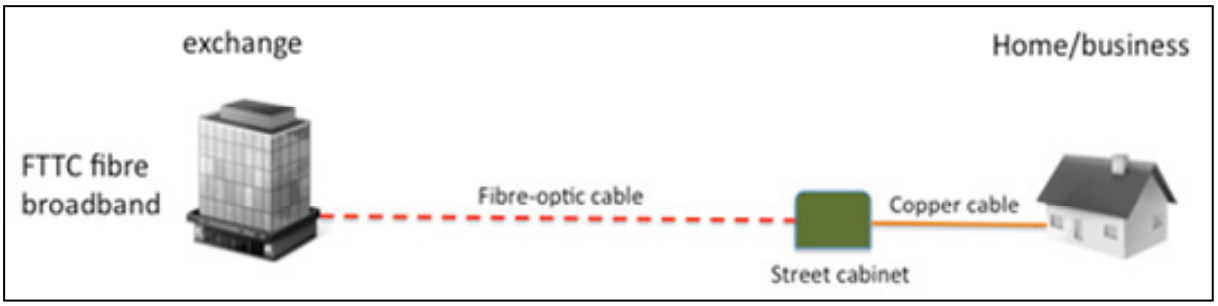


Figure 1.2. FTTC uses optical fibre and copper

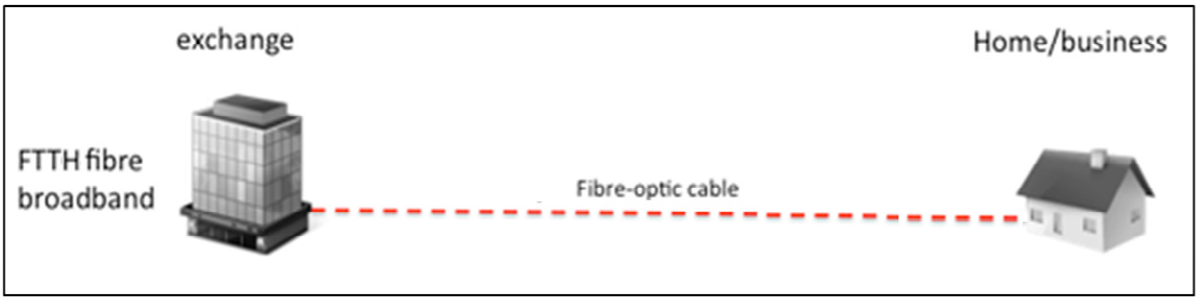


Figure 1.3. FTTH (or FTTP) uses only optical fibre optic

As well as offering faster speeds on a line, ADSL2 also makes it possible to use two phone lines for a single connection. This is known as using "bonded lines." Doing this will increase the speed available, though it won't necessarily double the speed.

ADSL2+:

ADSL2+, like ADSL2 and ADSL, is a standard for delivering internet connectivity through telephone connections. It is designed to work approximately twice as quickly as ADSL. This means speed of up to 24Mb/s for downloads and 3.5Mb/s for uploads are theoretically possible.
ADSL2+ (ITU G.992.5) doubles the bandwidth used for downstream data transmission, effectively doubling the maximum downstream data rates, and achieving rates of 20 Mbps on telephone lines as long as 5,000 feet. ADSL2+ solutions will interoperate with ADSL and ADSL2. ADSL2+ will include all the feature and performance benefits of ADSL2 while maintaining the capability to interoperate with legacy ADSL equipment.
As with standard ADSL, ADSL2+ is still affected by the distance between the customer and the local telephone exchange. This is because the signal degrades more the further it has to travel over copper lines. Customers who live further away from the exchange will usually get slower speeds. This is unlike fibre-optic connections such as that offered by fibre broadband providers, where speed is not affected by the distance.

Structural Difference Between ADSL2+ and Fibre Broadband

The structural difference between ADSL2+ and fibre broadband lies majorly in the medium of transmission employed. ADSL2+ employed copper cables in the final connection into the subscriber's home or place of business while fibre broadband employed fibre optic cable in the final connection into the subscriber's home or place of business. Being the latest technology, fibre broadband replaces copper with fibre optic cables. Fibre broadband, as stated earlier is a medium of transmission based technology rather than the method of network connection. It involves employing optic fibre in its transmission from the exchange centre to the home or to the cabinet/curb.
The structural difference, though seems very simple, has in no small measure, enhances the speed and capacity of transmitting signals over the medium.
It was against this backdrop that we study the basic performance of fibre optic network, advantages of optic fibre over copper and the inherent advantages of Fibre Broadband over ADSL2+ would be discussed in the next section.

Review of The Performance of Fibre Optic Network

In this section, the review of the performance of Fibre broadband is carried out. However, to start with, we look at the basic principle of communication in fibre optics to

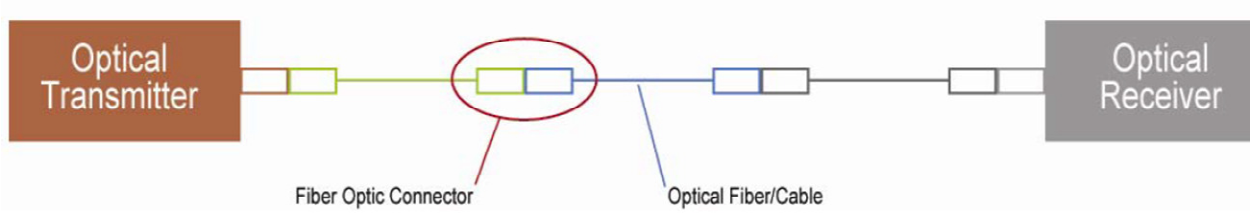


Figure 2.1: Simple Fibre Optic Link

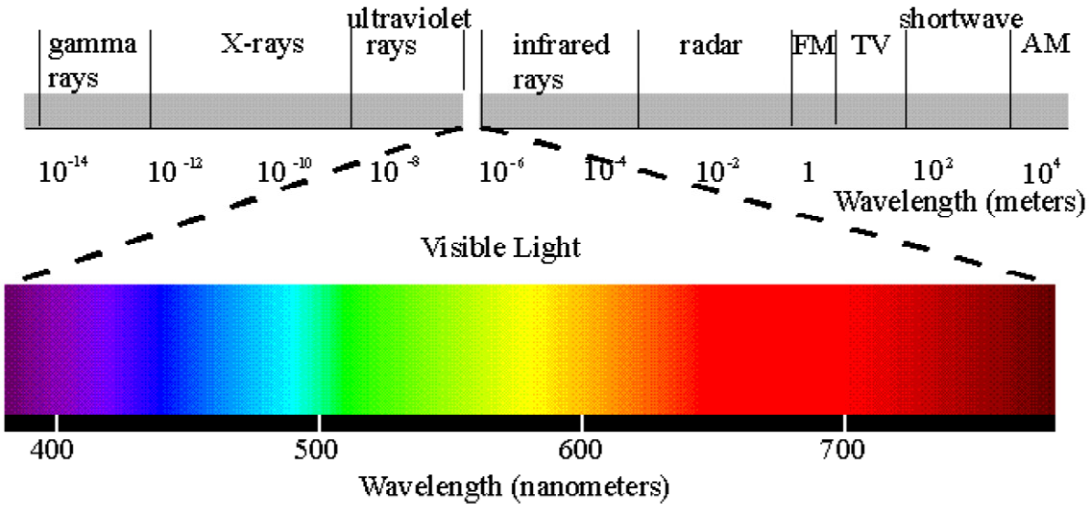


Figure 2.2: Wavelength of Electromagnetic Waves

understudy the nitty-gritty of how the medium perform since Fibre broadband is a medium of transmission oriented technology and the medium in question is optical fibre.

Basics of Fibre Optics

Fibre Optic technology is simply the use of light to transmit data. The general use of fibre optics did not begin until the 1970s. Robert Maurer of Corning Glass Works developed a fibre with a loss of 20 dB/km, promoting the commercial use of fibre. Since that time the use of fibre optics has increased dramatically. Advances in fibre technology, lower production costs, and installation have all contributed to the wide use of fibre.
In order to comprehend how fibre optic applications work, it is important to understand the components of a fibre optic link. Simplistically, there are four main components in a fibre optic link (Mark Curran/Brian Shirk, 2014).

i. Optical Transmitter
ii. Optical Fibre/Cable
iii. Connectors
iv. Optical Receiver

Optical Transmitter

The transmitter converts the electrical signals to optical. A transmitter contains a light source such as a Light Emitting Diode (LED) or a Laser (Light Amplification by Stimulated Emission of Radiation) diode, or a Vertical Cavity Surface Emitting Laser (VCSEL).
LED: Is used in multimode applications and has the largest spectral width that carries the least amount of bandwidth.
VCSEL: Is also used in multimode applications with a narrower spectral width that can carry more bandwidth than the LED.
LASER: Has the smallest spectral width, carries the most bandwidth, and is used in singlemode applications.
These sources produce light at certain wavelengths depending upon the materials from which they are made. Most fibre optic sources use wavelengths in the infrared band, specifically 850nm (1nm=10-9m), 1300nm

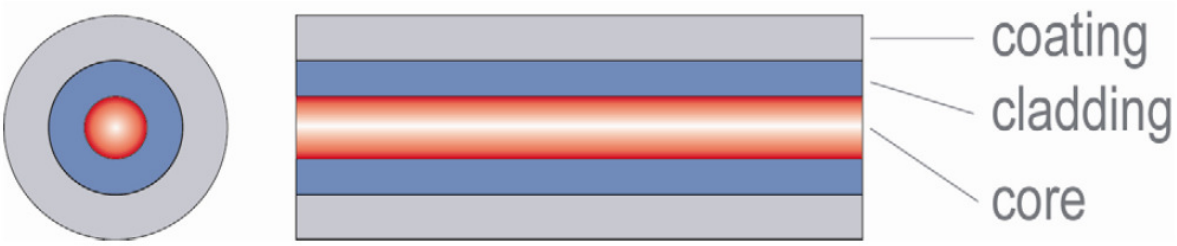


Figure 2.3: Optical Fibre Construction

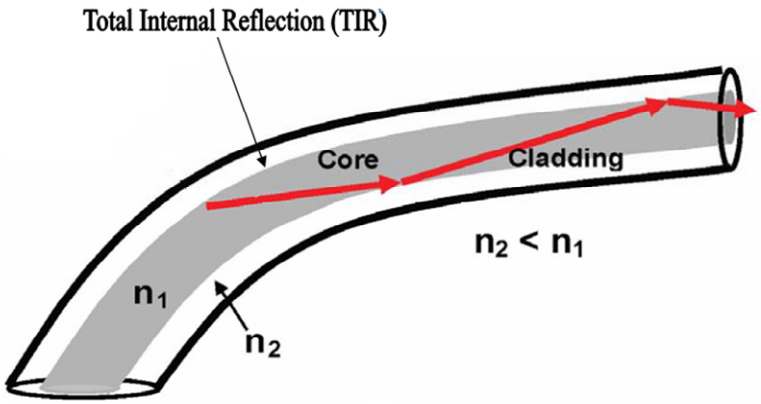


Figure 2.4: Diagram showing Total Internal Reflection

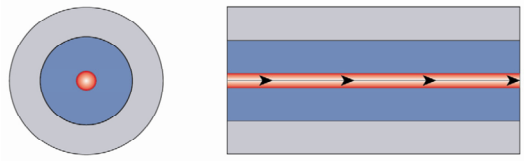


Figure 2.5: Single Mode Fibre Light Propagation

and1550nm. For reference, visible light operates in the 400-700nm range (see Figure 2.1).

Optical Fibre/Cable

An optical fibre is a flexible, transparent fibre made of high quality extruded glass or plastic, slightly thicker than a human hair. It can function as a waveguide, or light pipe to transmit light between the two ends of the fibre. (Wikipeadia).
An optical fibre is made of 3 concentric layers (see Figure 2.1):
Core: This central section, made of silica or doped silica, is the light transmitting region of the fibre.

Cladding: This is the first layer around the core. It is also made of silica, but not the same composition as the core. This creates an optical waveguide which confines the light in the core by total internal reflection at the core-cladding interface.
Coating: The coating is the first non-optical layer around the cladding. The coating typically consists of one or more layers of polymer that protect the silica structure against physical or environmental damage. The coating is stripped off when the fibre is connectorized or fusion spliced.
Buffer (not pictured): The buffer is an important feature of the fibre. It is 900 microns and helps protect the fibre from breaking during installation and termination and is located outside of the coating. (Mark Curran/Brian

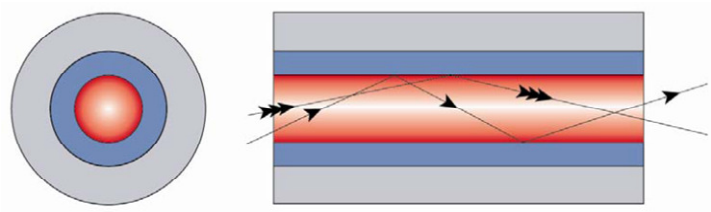


Figure 2.6: Multimode Fibre Light Propagation

Shirk, 2014)
The light is "guided" down (see Figure2.4) the core of the fibre by the optical "cladding" which has a lower refractive index (the ratio of the velocity of light in a vacuum to its velocity in a specified medium) that traps light in the core through "total internal reflection."
Index of refraction is the ratio of the velocity of light in a vacuum to the velocity of light in a material. The speed of light in a vacuum is equal to 300,000,000 meters per second.The higher the index of refraction, the slower the speed of light through the material.

For example:
Air = 300,000,000 meters/second
IR = 1
Glass = 200,000,000 meters/second
IR = 1.5

Splicers and Connectors

As optical fibre cables have higher fibre counts, the need for joining fibres becomes greater.
Splicing and connectorizing play a critical role both in the cost of installation and in system performance.
The object of splicing and connectorizing is to precisely match the core of one optical fibre with that of another in order to produce a smooth junction through which light signals can continue without alteration or interruption. There are two ways that fibres are joined: splices and connectors.

splices, which form permanent connections between fibres in the system and connectors, which provide remateable connections, typically at termination points. Connectors are used in applications where flexibility is required in routing optical signal from lasers to receivers, wherever reconfiguration is necessary, and in terminating cables. These remateable connections simplify system reconfigurations to meet changing customer requirements.

Optical Receiver

The last component of the fibre optic link is the optical receiver, which uses a photodiode to convert the optical signals into electrical. The two types of photodiodes used are: Positive Intrinsic Negative (PIN) and the Avalanche Photo Diode (APD)
In a similar fashion as that of the laser transmitter, the photodiode will receive wavelengths depending on material composition.

Operation of Optical Fibre

The operation of an optical fibre is based on the principle of total internal reflection. Light reflects (bounces back) or refracts (alters its direction while penetrating a different medium), depending on the angle at which it strikes a surface. Controlling the angle at which the light waves are transmitted makes it possible to control how efficiently they reach their destination. Lightwaves are guided through the core of the optical fibre in much the same way that radio frequency (RF) signals are guided through coaxial cable. The lightwaves are guided to the other end of the fibre by being reflected within the core.
The composition of the cladding glass relative to the core glass determines the fibre's ability to reflect light. That reflection is usually caused by creating a higher refractive index in the core of the glass than in the rounding cladding glass, creating a "waveguide." The refractive index of the core is increased by slightly modifying the composition of the core glass, generally by adding small amounts of a dopant. Alternatively, the waveguide can be created by reducing the refractive index of the cladding using different dopants.
There are generally two modes of optical fibre: single-mode and multimode fibres.

Single Mode Fibre

Single mode fibre has a very small core causing light to travel in a straight line and typically has a core size of 8

Table 2.1: Single Mode and Multimode Characteristics

	Single Mode Fiber	Multimode Fiber
Bandwidth	High	Lower
Signal Quality	High	Lower
Main Source of Attenuation	Chromatic dispersion	Modal dispersion
Fiber Designs	Step index, & Dispersion shifted	Step index & Graded index
Application	Long transmission, higher bandwidth	Short transmission, lower bandwidth

or 10 microns. It has unlimited bandwidth that can go unrepeated for over 80 km, depending on the type of transmitting equipment. Single mode fibre has enormous information capacity, more than multimode fibre.
Single-mode fibre, on the other hand, has a much smaller core that allows only one mode of light at a time to propagate through the core. While it might appear that multimode fibres have higher capacity, in fact the opposite is true. Single mode fibres are designed to maintain spatial and spectral integrity of each optical signal over longer distances, allowing more information to be transmitted. Its tremendous information-carrying capacity and low intrinsic loss have made single-mode fibre the ideal transmission medium for a multitude of applications. Single-mode fibre is typically used for longer-distance and higher-bandwidth applications. Multimode fibre is used primarily in systems with short transmission distances (under 2 km), such as premises communications, private data networks, and parallel optic applications.

Multi Mode Fibre

Multimode fibre was the first type of fibre to be commercialized. It has a much larger core than single-mode fibre, allowing hundreds of modes of light to propagate through the fibre simultaneously. Additionally, the larger core diameter of multimode fibre facilitates the use of lower-cost optical transmitters (such as light emitting diodes [LEDs] or Vertical Cavity Surface Emitting Lasers [VCSELs]) and connectors.
Multimode fibre supports multiple paths of light and has a much larger core and has a core size of 50 or 62.5 microns. The light travels down a much larger path in multimode fibre, allowing the light to go down several paths or modes.
Multimode fibre can be manufactured in two ways: step-index or graded index. Step-index fibre has an abrupt change or step between the index of refraction of the core and the index of refraction of the cladding.
Multimode step-index fibres have lower bandwidth than other fibre designs.
Graded index fibre was designed to reduce modal dispersion inherent in step index fibre. Modal dispersion occurs as light pulses travel through the core along higher and lower order modes. Graded index fibre is made up of multiple layers with the highest index of refraction at the core. Each succeeding layer has a gradually decreasing index of refraction as the layers move away from the centre. High order modes enter the outer layers of the cladding and are reflected back towards the core. Multimode graded index fibres have less attenuation (loss) of the output pulse and have higher bandwidth than multimode step-index fibres. (Jarao and Janyani, 2011).

Comparing the Performance of Optical Fibre and Copper as Data Communication Media

Copper over long period of years has been known as very good medium of transmission. It may be in form of twisted pair cable, co-axial cable or just ordinary copper cable with a single core. However, advances in technology and the quest for better performing medium had prompted the technologist to search for alternatives of which a good competitor is fibre optic cable. Fiber optical cables, as explain earlier, are usually made of glass or plastic. The factor that matter is the refractive

index as it differs to copper in the type of signal being transmitted. Optical fibres transmit light waves instead of copper that transmit electrical waves.

To further understand why optical fiber are preferred to copper, the advantages and disadvantages of fiber optics are highlighted below.

Advantages of using Optical Fibre over Copper in Communication Networks

More Versatile: For over a century, copper wire has been used to conduct power, transfer data, and network machinery. However, copper has many limitations that have become more apparent and more troublesome as industries have found new data to gather, new conditions to sense, new environments in which to operate, new robotics to control, and so on. However, fibre cables are found to be more versatile.

Faster with more capacity: Optical fibre in its many forms, cable configurations, and connectorizations meets all the new industrial needs with plenty of room for future growth and expansions. Glass optical fibre has greater bandwidth and faster data rates. Ounce for ounce, meter for meter, dollar for dollar, millisecond for millisecond, fibre carries more data and faster than copper. Compared to copper-based systems, fibre-based system has many advantages, and some applications would actually be impossible without it. Fibre optic cables are easier to install, require less duct space, and weigh approximately 13 times less than metal cables. A single fibre optic cable can carry significantly more data than a single electrical cable, which saves space within a building or other small space.

Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) immunity: Glass optical fibres do not emit any radio or electromagnetic waves or radiation to interfere with other non-optical components in the vicinity. Fibre is immune to Electromagnetic and Radio Frequency Interference (EMI/RFI) as well as voltage fluctuations and requires no ground-loop insulation. As a basic example, EMI results in the static you would see on your television set if you were to run a vacuum cleaner in proximity to it. Power surges or brownouts also have no effect on the optical transmission of data over optical fibres or cables (although electronic components on either end of the transmission fibre may still be affected.)

Reduced Attenuation: Optic cables use 'Total Internal Reflection'; they have a much lower signal degradation / loss in comparison with Copper. In the case of data transmission, this loss is usually referred to as "attenuation." Fibre optics experience very little data loss, even over long distances, because light travels through the fibre without experiencing attenuation or a loss of intensity over time.

More durable: Fibre — with the addition of specialty coatings — can be made far more durable than traditional, outdated copper cabling . Certain coatings can be used to make fibre withstand temperatures up to 400°C for short durations.

More flexible: Fibre can be designed to squeeze around tight corners and withstand outerspace and oceanic environments while continuing to transmit data flawlessly where other transmission media would be unreliable or fail.

Less Maintenance: Copper can corrode or expand and contract with temperature changes, but glass cannot. Therefore copper-core cables need periodic maintenance programs to prevent corrosion and loosened connectors. Because glass never corrodes, such maintenance is not necessary.

Cheaper: Fibre optic cables cost less than copper wire, making optical cables a more economical choice when transmitting data over large distances.

Space Saver: A single fibre optic cable can carry significantly more data than a single electrical cable, which saves space within a building or other small space.

Disadvantages of Optical Fibre when compared with Copper

Some disadvantages of using fibre optic cables are as described below:

Cost More to Install: Fibre cables are more expensive to install compared to conventional cables having conventional metal wire conductors. There is always high cost of civil engineering work to construct duct. [Broadband and economy]

More Fragile : Fibre-optic cables are more fragile than metal wire conductors, so they must have adequate and strong protective sheathing to suit the environment in which they are to be installed

Higher Costs for the Electronic End-Terminals: Fibre-optic cables have higher costs for their electronic end-terminals compared to the end-terminals needed for conventional cables having metal wire conductors

More Difficult to Split: Fibre-optic cables are more difficult to split. More electronic End-Terminal units must be used than for cables using conventional metal wire conductors. It is also difficult to make connections to fibre optic cable

Non Availability: Fibre optic connections are not available in many areas. Currently, this is one of their biggest disadvantages.

However, the advantages of fibre-optics far outweigh its disadvantages. One grey area of using fibre is the cost of cabling. Apart from that, one single mode fibre can replace a metal cable that is thousands of times larger and heavier. Multi-mode optical cable has a larger diameter and can be used to carry signal over short distances.

Table2.2: ADSL2 Cabinet to premises speed estimate (Source: [3])

Distance to cabinet (metres)	Estimated downstream connection speed	Estimated upstream connection speed	Cumulative %'age of premises at this distance
100m	100 Mbps	25 Mbps	5%
150m	80 Mbps	20 Mbps	10%
200m	65 Mbps	18 Mbps	20%
300m	45 Mbps	17 Mbps	30%
400m	42 Mbps	16 Mbps	45%
500m	38 Mbps	15 Mbps	60%
600m	35 Mbps	14 Mbps	70%
700m	32 Mbps	11 Mbps	75%
800m	28 Mbps	10 Mbps	80%
900m	25 Mbps	9 Mbps	85%
1000m	24 Mbps	8 Mbps	90%
1250m	17 Mbps	5 Mbps	95%
1500m	15 Mbps	4 Mbps	98%

Attenuation in ADSL2.

ADSL, ADSL2 or ADSL2+ technologies use copper as the medium of transmission and as a result the performance of any of these technologies is being affected by attenuation. The extent to which the attenuation affect the performance of ADSL2 was investigated and the result has been highlighted here using graph.

The result of the investigation as it affect the downstream and upstream section of data transmission by ADSL2 is highlighted in Table 2.2, Figure 2.3 and Figure 2.4

Transmission of data by means of light waves rather than by electricity over copper or other metallic media drastically reduces attenuation; and this property allows for longer cable runs and fewer repeaters (or re-transmitters) along the route. Fibre optics experience very little data loss, even over long distances, because light travels through the fibre without experiencing attenuation or a loss of intensity over time

In Table 2.2, as the distance of the cabinet to the exchange increases, the downstream connection speed reduces. This signal degradation is attenuation and is high in any network using copper as its medium. The attenuation is caused by resistance of copper to the flow of electrical signals. However, transmission of data through optical fibre involves transmission of light waves rather than electrical signals and this make attenuation issue to be reduced in fibre optic networks.

Fibre Optic as a Medium of International or Regional Connectivity and National Backbone.

By the present day technology, the best medium to connect a region or country to the rest of the world is fibre cables. There are two classes of fibre cables commonly employed for this purpose when the issue of geographical area of passage is considered as a factor and this involve: submarine fibre cable and terrestrial cables. Submarine communication cables are used to connect countries and continents to the Internet while terrestrial fibre optic cables are used to extend this connectivity to landlocked countries or urban centers within a country with submarine cable access. Submarine cables usually pass through water (oceans) to the expected points.

The construction of both submarine cables and their terrestrial extensions is thus considered an important and first step to develop a fibre broadband.

In case of Nigeria, there are many submarine cables available at the shore of the country and they are having the capability of supplying more than enough data needed by the country. However, the connectivity to the major towns and eventually to the various sub urban and rural areas within each of the states is the major challenge facing the country. The various elements of

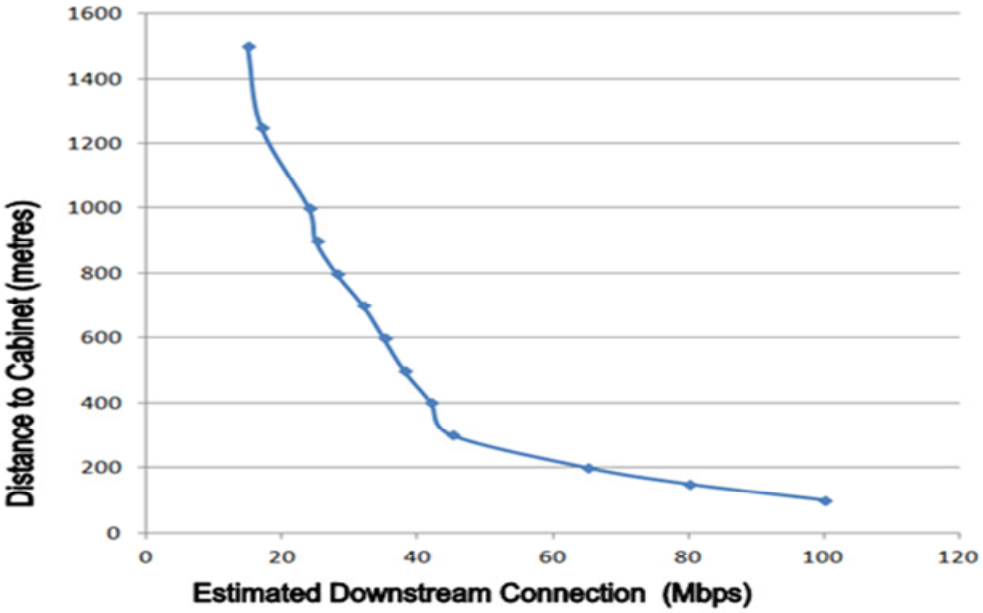


Figure 2.3: ADSL2 Cabinet to Premises Downstream speed

Figure 2.3: ADSL2 Cabinet to Premises Downstream speed

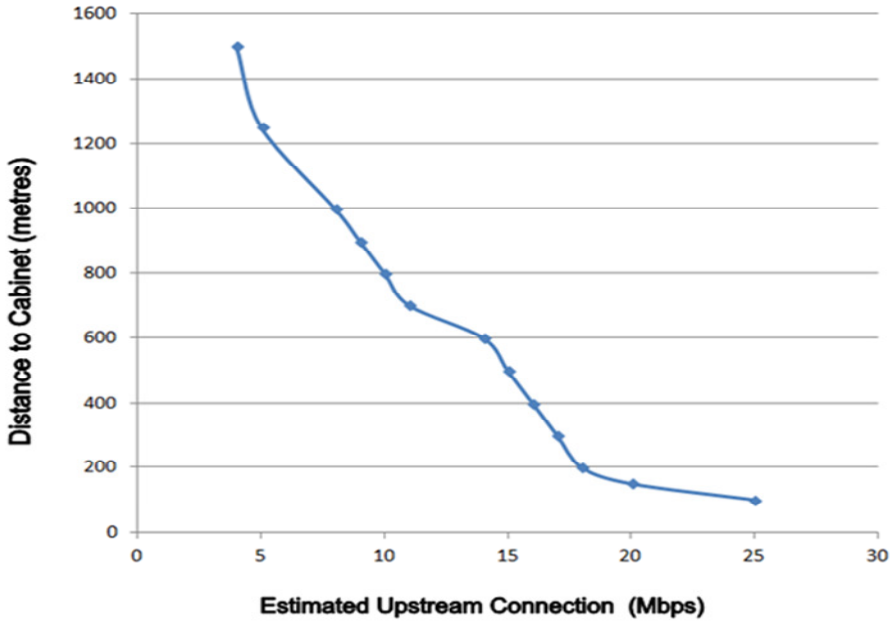


Figure 2.4: ADSL2 Cabinet to Premises Upstream speed

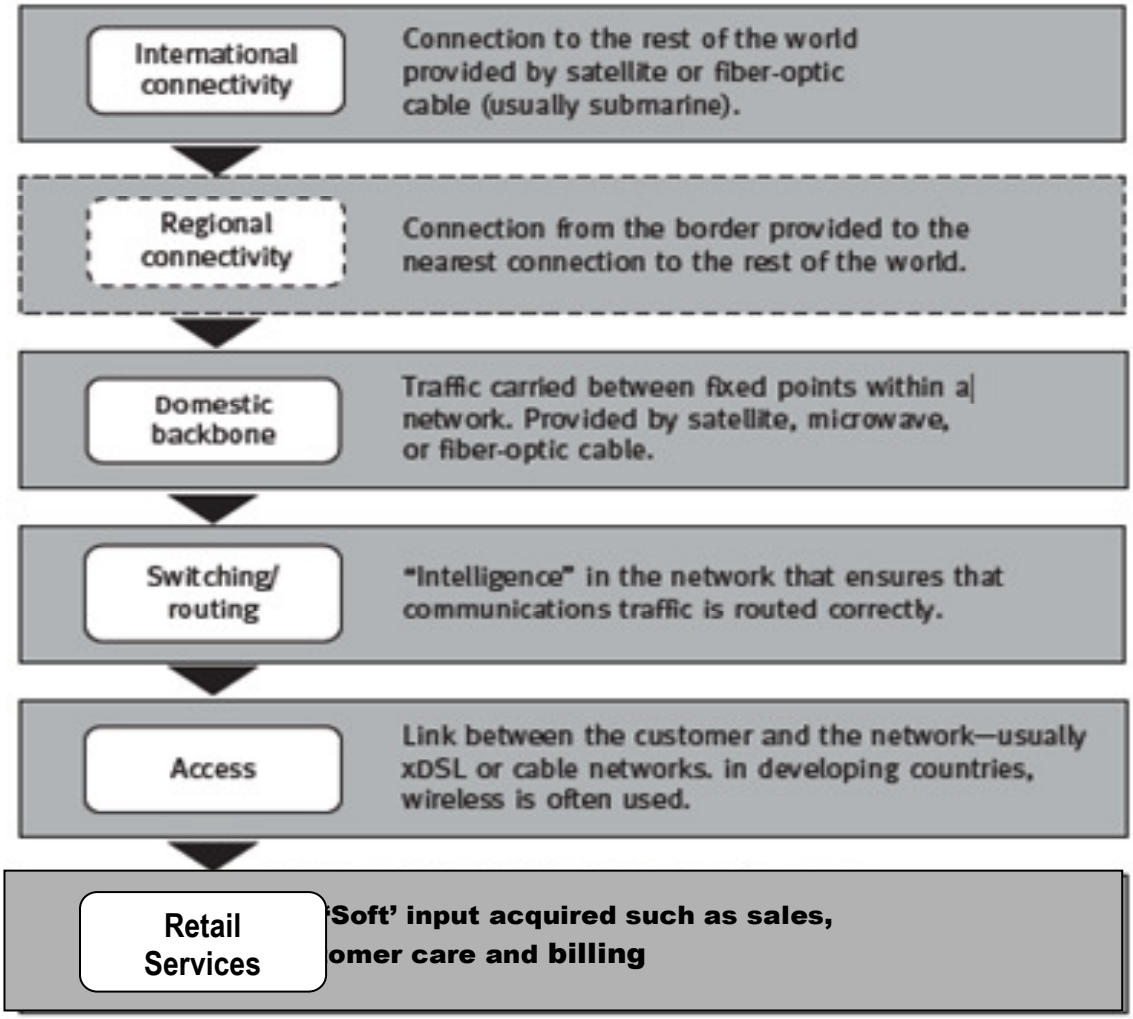
Fibre Broadband connectivity for a country are described below:

Various Elements of Fibre Broadband Connectivity

The provision of Fibre broadband connectivity to end users involves several elements. A problem in any of these elements will constrain the delivery of affordable broadband services. In Nigeria, the inadequacy of one element, domestic backbone networks, is one of the factors underlying the limited growth of broadband in Nigeria. (Benat et al., 2013) (Mark Williams, 2010).

Supplying communications services involves a combination of network elements, processing, and business services. These can be thought of as the "supply chain." At the top of the chain is the international connectivity that provides the link to the rest of the world.

Table *2.5:* Broadband Communication supply Chain



The second level is the domestic and regional backbone networks that carry traffic from the landing point of the international communications infrastructure to other points within the country (in some African countries, regional connectivity is missing). The third level is the "intelligence" contained in the networks. Below this is the access network that links the core network to the customer. Finally, there is a suite of retail services such as customer acquisition, billing, and customer care that allow the business to function. This supply chain is illustrated in Table 2

In practice, there are many variations on the structure of this supply chain. For example, voice services do not rely as heavily on international connectivity as Internet services, and landlocked countries require regional connectivity if they are to access high bandwidth submarine fibre-optic cable networks.

Domestic backbone networks lie at the heart of any communications services supply chain and are an integral component in the provision of broadband connectivity.

One of the first decisions to be made is what kind of connection you want. There are several options for setting up high-speed services, which all come under the broadband umbrella. However, the type of broadband service you need and have access to will be determined by the speed requirements, budget, and the location (city or regional) of your home or office.

Comparative Advantage of Fibre Optic Networks Over Satellite in Building Broadband Backbones for a Country

The two commonly used media for connecting a country to the rest of the world and domestic backbone include satellite and fibre optic networks. However, in spite of the popularity of satellite in building national backbone, there

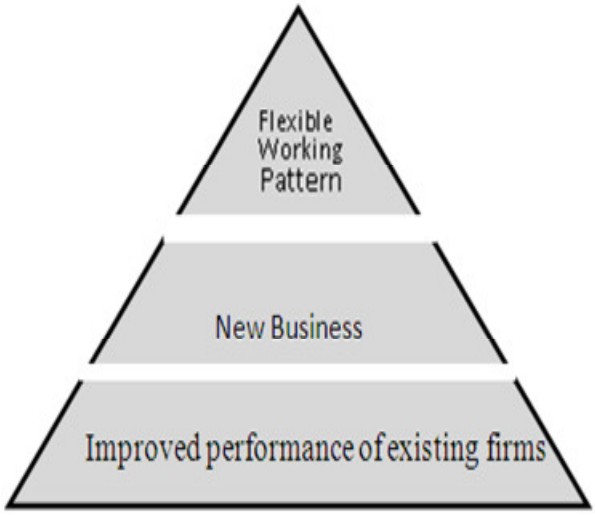


Figure 4.1: Impact of Fibre broadband on economy [Regeneris Consulting, 2012]

are some shortcomings associated with satellite which are reduced or absent in network with fibre optic.

One of the most likely reactions one gets when discussing fibre-optic networks in Nigeria is "why not satellite technology?" Satellite communications has been around for a while and has provided telecommunications links between Nigeria and the rest of the world. However, a comparison between fibre optic and satellite technologies reveals that although satellite systems are the most efficient solutions for TV broadcast, for access to remote locations, areas with hilly terrains and rural areas, and essentially, for wireless access to the local loop and the network backbone, fibre optic networks are more suited for high bandwidth transmission between countries and continents though core networks (or backbones) and submarine links respectively. Fibre optic networks offer very high bandwidth necessary for a country (Nigeria) or African nations to catch up with the new global information technology. For example, fibre cables today can have capacity up to 2 Tbps - an equivalent of millions of simultaneous voice channels per cable. This is far from the reach of any anticipated satellite system, which is less than 1Gbps - lower than our own SAT-3/WASC/SAFE undersea cable system.

Real time transmission and very low bit error rate offered by fibre optic networks are among the advantages of fibre over satellite. Satellite communications add a delay to communications making interactive data transmission difficult and subject the quality of transmission to external factors. A geostationary satellite link has a transmission delay of up to 600 milliseconds compared to 100ms for a combination of fibre and coaxial cable networks.

The open space nature of satellite (and any other wireless) communications makes satellite communication vulnerable to interception and corruption. Although several schemes are available for data encryption for IP over satellite, the high bit error rate may cause failures in the encryption systems. Fibre optic transmission offers undoubtedly the best confidentiality and security of transmission than any other means by its mere nature.

In order to address increasing traffic demand, it is relatively easy to increase the capacity of fibre optic networks during their lifetime by means of wavelength division multiplexing technology. For example, the SAT-3/WASC/SAFE system can be upgraded 12 fold from 10Gbps to 120Gbps. It is impossible to do a similar upgrade on satellite systems.

Perhaps the main disadvantage of satellite communication is their high cost relative to fibre optics communication. In the US, for example, the monthly rate for broadband connectivity through cable is about $35 for 3Mbps data rate compared to $200 for 200Kbps by Satellite. While the initial cost of a continental fibre optic network for Africa may appear too high, the long term cost savings over satellite transmission are overwhelming.

Thus due to their high bandwidth, high reliability, high signal quality, long lifetime, better security and low service cost, fibre optic networks are suited for inter and intra continental backbone network infrastructure. On the other hand, satellite systems are more dedicated to video broadcasting and personal communication services such as mobile telephony satellite or to access remote areas.

Steps To Developing Fibre Broadband In Nigeria

The best option for this country is to invest in fibre broadband which is tagged as the next generation network instead of involving our resources in some

technology that would in no time considered outdated and unable to make great impact on the socio-economic situation of the country.

Adoption of Fibre Broadband will in no small measure change the country but it require a high amount of money and commitment. If achieved, then the country will be at par with the developed country like U.K and we will stand to reap its benefit.

Present State of Broadband Infrastructure Within Nigeria

According to experts, any country seeking growth, job and wealth creation must address how it can increase its access to broadband and if governments can improve broadband penetration in the continent most Africans would have increased access to the internet.

Today, people are realising their life goals due to broadband services with greater access to researches and findings about education, culture and entertainment.

The major Broadband backbone infrastructure in Nigeria includes NigcomSat-1R, WACS, Main-one and Glo 1 fibre optic Cables. SAT-3/WASC (South Africa Trans-Atlantic - West Africa Submarine Cable) which continues from South Africa to Portugal and Spain in Europe with landings at a number of west and southern African countries; NITEL's cable, international submarine fibre-optic cable (Glo-1),

Part of the former NITEL properties could still be converted to support the new technologies, such as fixed line broadband technology, instead of being allowed to waste.

In Nigeria, the inadequacy of one element, domestic backbone networks, is one of the factors underlying the limited growth of broadband in Nigeria. For fibre broadband, the domestic backbone medium must be of fibre optic cable

Fibre-Optic backbone infrastructure in the Nigeria states and the federal capital territory are not interconnected and are concentrated in the state capitals and a few urban areas. It is recorded that Broadband penetration is low and of about 6% (The Conversion Technology Experts, 2014) while that of Internet penetration is equally low and of about 28% and 33%.

Few states such as Ondo State are having special schemes (Ondonet) inaugurated mainly to supervise the connectivity of broadband infrastructure to the interior towns apart from the state capital having interconnection of broadband infrastructure with other parts of the state (Ondonet 2009). The situation is different in most states of the country.

There is no long distance national backbone to carry and distribute the capacities provided by submarine cables to the users in offices, schools, and homes in the hinterland.

Socio-Economic Benefits Derivable From Fibre Broadband Technology

The benefit derivable from Fibre was assessed from two perspective: the Economic aspect and the Social aspect.

The Economic Benefits Derivable From Fibre Broadband by a Country.

BT recently commissioned Regeneris Consulting to assess the potential economic benefits of BT's £2.5 billion investment in fibre broadband in the UK market,9 focusing on four areas: • Norfolk and Suffolk, a rural area; • Caerphilly, a town in Wales; • Sunderland, a city in the northeast of England; and • London, the United Kingdom's capital city. Where fibre broadband is prevalent, businesses can be encouraged to remain in or relocate to regions previously excluded from traditional regeneration, creating jobs and bringing economic growth to those areas. Supplying commercial premises with fibre broadband will help businesses grow and benefit the local economy by facilitating flexible working patterns, enabling new startup businesses, and helping to improve the performance of existing businesses (Enrique De Argaez 2013) (Regeneries consulting, 2012) (see Figure 3).

Improved performance of existing firms Fibre broadband will allow businesses to operate more efficiently and to develop new products and services: • Small and medium-sized firms will be able to take advantage of the latest generation of online collaboration tools—such as file and document sharing, shared workspaces, and high-definition video conferencing—that, before the advent of fibre broadband, only large enterprises could afford to exploit. • Real-time online collaboration among colleagues and business partners can accelerate decision making and time to market, and reduce delays and the need for business travel. By reducing or even eliminating the requirement to travel, it can reduce a firm's carbon footprint and improve employees' work-life balance. • Several people can share the same connection and not notice any degradation in performance, even if they are using bandwidth-hungry applications such as video conferencing or uploading large files. • In all types of business, interaction with customers and suppliers can also be enhanced—for example, by enabling slicker, more interactive e-commerce sites, and by reducing the time needed to upload product demonstrations and how-to videos to both the business's own site and social media sites such as YouTube. Regeneris expects knowledge-based industries, and the places where they are most concentrated, to exploit faster broadband most effectively and generate the greatest impacts. For example, the time required for transferring large files such as videos,

graphic designs, or software applications can be cut from hours to minutes. (Regeneries consulting, 2012) New businesses Fibre broadband is expected to help greater numbers of new businesses emerge by reducing barriers to entry in certain sectors. Although there are many ways in which this can occur, cloud computing is perhaps the most significant because it dramatically reduces the required upfront capital and ongoing support costs of setting up in business and allows steady, flexible growth. Superfast connectivity will also help firms of all sizes exploit cloud computing so they can scale their information technology (IT) systems dynamically to fit their business needs, obviating the requirement for firms to invest in server hardware and software licenses. This can further help relieve the IT burden by making remote data storage and backup easy to operate in the background. The burden of security and upgrade falls to the service provider and not to the business. The carrot of abundant fibre broadband can also encourage firms with purely digital business models to relocate to previously underdeveloped areas.

Flexible working patterns Widespread availability of fibre broadband will allow more flexible working patterns, opening up new employment opportunities and enhancing the productivity of existing staff. With fibre broadband, employees will be able to access data and applications from home, on the move, or at the premises of customers or suppliers with the same alacrity as they can in the office. Regeneris estimated the cumulative impact on jobs and gross value-added (GVA) among new and existing firms exploiting faster, next-generation broadband services over 15 years. In conducting the analysis, it was assumed that the uptake and exploitation of faster services will, in time, approach those currently found for ADSL services. Regeneris drew on research from across Europe to inform these assumptions.

The Social Benefits Derivable From Fibre Broadband.

Though the social impact of fibre broadband cannot be easily quantified as done to economic impact, however the result of research carried out by Regeneris shows that the social life of the society would be affected positively due to the innovations and developments that are directly connected with the adoption of fibre broadband. The innovations such as e-governance, e-health, e-learning, e-library, e-banking, e-business and e-transact which would be the predominant ways of life and would, in no small measure, affect the social life of people.

E-governance would allow citizens to receive-one-on-one advice from Government officials at a much lower cost. In addition, e-health will also improve the attitude of people to health care and thereby reduce the rate of mortality. As a result of E-learning, academic establishment can offer remote access to live lectures and self paced tuition as part of lifelong learning, bringing access to education to those who-because of a disability or social reasons, are unable to regularly attend an academic institution.

CONCLUSION AND RECOMMENDATION

CONCLUSION

In conclusion, it was obtained through the research carried out and discussed in this paper on the advent of fibre broadband, that the new technology is able to solve the problem of slow speed in internets downloads, unaffordable cost of teleconferencing, allow a lot of internet hungry gadgets simultaneously without affecting the speed. In addition, the technology has the capability of facing the challenges of the future times.

Technologically fibre broadband perform better than the previously existing technologies such as ADSL, ADSL2+ which involve using copper as the medium of transmission. Fibre broadband involve using optic fibre as the medium of transmission and optic fibre is less affected by attenution. Not that alone, the results of measurements showed that speed of ADSL reduces with increase in distance of the premise or cabinet from the telephone exchange.

In addition, fibre optic cables have some benefits that are paramount to communication better than satellite except on the issue of remote communication with people in remote areas.

Economically, the fibre broadband would affect the economy of this country positively in that it allows the creation of Small and Medium Enterprises (SME). It was also discussed that there would be improvement on the performance of existing firms. Socially, fibre broadband would affect the life of citizens due to the foreseeable predominant technologies such as e-governance, e-banking, e-health, e-learning and others.

RECOMMENDATIONS

As a result of the investigations carried out in this paper, I wish to recommend the immediate adoption of fibre broadband technology in the country because of its inherent benefits that are paramount to national growth and development. In the preparation of the country to adopt the technology, government, like in U.K. should invest heavily in the fibre broadband technology which would in turn placed the country in a better position to solve the myriads of problems facing the country.

Not that alone, Government of all categories and stakeholders in telecommunication should adopt this technology that promises better future than any other previously adopted technologies. State governments should strive to have their states

connected with the national fibre optic cables Government to encourage the usage of ICT based devices in our schools and stop encouraging old fashion way of education. The reason being that the uture employment would be knowledge based and the best way to get more knowledge these days is to have unrestricted access to Internet facilities.

The prayer now is that Government of all categories should strive to encourage E-governance, E-health, e-commerce, e-banking, e-learning e.t.c by developing fibre broadband technology.

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A. ***Longer Distance***: Because of the higher loss in copper cables, electronic signals need to be amplified at periodic intervals. But fiber optic cable has less resistance to the light waves and allows the signals to travel much farther before amplification is needed.
B. ***Cleaner Signal***: Although the shield of a copper-core cable reduces interference from unwanted signals, it cannot eliminate them completely. However, fiber-optic cables act like an infinite number of tiny mirrors in a tubular pattern that allows no other light to enter and cause interference or distortion.
C. **Less Maintenance:** Copper can corrode or expand and contract with temperature changes, but glass cannot. Therefore copper-core cables need periodic maintenance programs to prevent corrosion and loosened connectors. Because glass never corrodes, such maintenance is not necessary.
D. **Low Attenuation**: Fiber optics experience very little data loss, even over long distances, because light travels through the fiber without experiencing attenuation or a loss of intensity over time.
Cheap: Fiber optic cables cost less than copper wire, making optical cables a more economical choice when transmitting data over large distances.
E. **Costs:** Fiber optic cabling can cost more than double what a typical broadband connection costs.
Availability: Fiber optic connections are not available in many areas. Currently, this is one of their biggest disadvantages.
Secure: Fiber optic cables offer more secure communications because they are highly resistant to tapping, radio frequency interference and jamming. The United States Department of Defense has been using fiber optics for secure communications for more than 25 years.
F. **Space Saver:** A single fiber optic cable can carry significantly more data than a single electrical cable, which saves space within a building or other small space.
Speed*:* Fiber optic data transmission is incredibly fast.

(a) Disadvantages Of Optical Fiber Versus Copper Cables

Some disadvantages of using fiber optic cables include the following:
Fiber cables are **more expensive to install** compared to conventional cables having conventional metal wire conductors. There is always high cost of civil engineering work to construct duct. [broadband and economy]
Fiber-optic cables are **more fragile** than metal wire conductors, so they must have adequate and strong protective sheathing to suit the environment in which they are to be installed
Fiber-optic cables have **higher costs for their electronic end-terminals** compared to the end-terminals needed for conventional cables having metal wire conductors
Fiber-optic cables are **more difficult to split**: more electronic end-terminal units must be used than for cables using conventional metal wire conductors. It is also difficult to make connections to fiber optic cable
However, the advantages of fiber-optics far outweigh its demerits. One grey area of using fiber is the cost of cabling. Apart from that, one single mode fiber can replace a metal cable that is thousands of times larger and heavier. Multi-mode optical cable has a larger diameter and can be used to carry signal over short distances.

(b) Medium of Interconnectivity between countries or Regions

The best medium to connect a region or country to the rest of the world is by using fiber cables. The type adopted by Nigeria fiber optic network model is the optic fibre media. [Broadband and Economy). There are two classes of fiber cables commonly employed. They are submarine fiber cables and terrestrial cables. Submarine communications cables are used to connect countries and continents to the Internet while terrestrial fiber optic cables are used to extend this connectivity to landlocked countries or urban centers within a country with submarine cable access. Submarine cables usually pass through water (oceans) to the expected points. The construction of both submarine cables and their terrestrial extensions is thus considered an important and first step to develop a fiber broadband.
In case of Nigeria, there are many submarine cables available at the shore of the country and they are having the capability of supplying more than enough data needed by the country. However, the connectivity to the major towns and eventually to the various towns and rural areas within the states is the major challenge facing the country.

(a). Various Elements of Fiber Broadband Connectivity

The provision of Fiber broadband connectivity to end users involves several elements. A problem in any of these elements will constrain the delivery of affordable broadband services. In Nigeria, the inadequacy of one element, *domestic backbone networks,* is one of the factors underlying the limited growth of broadband in Nigeria.[8][9]
Supplying communications services involves a combination of network elements, processing, and business services. These can be thought of as the “supply chain.” At the top of the chain is the international connectivity that provides the link to the rest of the world. The second level is the domestic and regional backbone networks that carry traffic from the landing point of the international communications infrastructure to other points within the country (in some African countries, regional connectivity is missing). The third level is the “intelligence” contained in the networks. Below this is the access network that links the core network to the customer. Finally, there is a suite of retail services such as customer acquisition, billing, and customer care that allow the business to function. This supply chain is illustrated in Table 2
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