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A Survey of Broadband Situations in Rural and Remote Areas: A Case Study of Sambisa Forest in Northeast Nigeria

Ifeanyi B. Ezugwu*, Brice Noumsi Damien**Oladejo M. Comfort***
*(Electrical/electronic Department, Dorben Polytechnic, Bwari-Garam road, FCT-Abuja, Nigeria)
** (Electrical/electronic Department, University of Agriculture,Makurdi, Nigeria)
*** (Computer Engineering Department, Dorben Polytechnic, Bwari-Garam road, FCT-Abuja, Nigeria)

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Abstract:

There has been a growing raise in the use of mobile smart devices for accessing of the internet in present times. Therefore, provision of affordable and reliable internet access to rural areas will go a long way to boost socio economic development of such areas. It is important to note that insurgency and violence is one of the factors prevailing against infrastructural development in many rural and remote communities in developing countries. Sambisa forest in the north-eastern Nigeria is one of such remote arears that has been very negatively affected by insecurity, insurgence and violence. This paper presents broadband communications as a low cost alternative to the challenges inherent with providing fibre-optics based terrestrial internet links to areas that are highly prone to insurgency and violence.It also presents satellite and worldwide interoperability for microwave access (WiMAX) technologies as a suitable solution to the problem of reliable and affordable high speed internet access in the Sambisa area. These two technologies proposed in this study will provide a wider coverage area and eliminate the seemingly communication and social development problems in Sambisa forest.

Keywords **—**Sambisa, VSAT, DSL, WiMAX.

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I. INTRODUCTION

The rate at which internet and mobile communication is increasing in Nigeria has become interestingly overwhelming. Present statistics shows that there are currently about 103million Nigerians use the internet for various purposes ranging from relationships, commerce, education and learning, information gathering and sharing, banking transactions and so on [11]. This raise in mobile internet appetite comes as a result of factors including poor infrastructure and insecurity which has made fixed internet such as digital subscriber line (DSL), cable and fibre unreachable for consumers. A more extensive broadband incursion in Nigeria will bring the internet nearer and accessible to rural communities such as the Sambisa forest in northeast Nigeria. Broadband wireless access has become the most effective techniques for achieving fast internet connection and related services in remote and rural areas because it can extend fibre optic networks and increase capacity as compared to cable networks or DSL[5]. It is no longer news that the role of internet in this contemporary technology driven globe cannot be overemphasized. However, apart from being an insurgent invaded area, the Sambisa forest is also known for not having appropriate infrastructures to support technological and social development. It is obvious therefore that providing fiber-optic based terrestrial internet links will be very challenging considering the many threats accompanying insurgency and violence. Notwithstanding the underlying obstacles in providing fiber-optic based terrestrial internet links to rural or remote areas, which among others are the high cost structure for industries, cost of laying cable networks and disproportionately low rate of return on investments as a result of low density of paid users, there is still the issue of threats of vandalisation and theft of the installations and general insecurity of materials and men on site.Furthermore, knowing convincingly well that provision of affordable Internet access to Sambisa forest will boost both economic and social development of the area, this paper therefore presents broadband internet viasatelliteand worldwide interoperability for microwave access (WiMAX) technologies for reliable and affordable high speed internet access in the Sambisa area.

II. AN OVERVIEW OF SAMBISA FOREST

Sambisa Forest is vast location in Borno state in northeast Nigeria, covering about 518 km² of landscape on a plain, having the Ngadda and Yedseram rivers flowing off gradually through it [8]. This forest was a games reserve situated about 14 kilometers off Kawuri village, along Maiduguri-Bama road. In March 2014, the forest was invaded by a very notorious terrorist sect identified as Boko-Haram, killing about 85 people (including infants and children) with properties worth millions of Naira destroyed. When members of Boko - Haram sect were dislodged by the Nigeria army and vigilante youths from Maiduguri, most of them moved to the Sambisa forest, destroyed the games reserve, killed some of the workers and turned it into a base from where they launched their inhumane and cannibalic attacks [1]. Sambisa forest was an abode to various species of games such as leopards, bush elephants, hyenas, baboons, lions, monkeys of different kinds, as well as numerous different kinds of birds. It also had abundant vegetation such as baobab, acacia, tamarind, rubber, etc [7]. It is very unfortunate to note that the effect of insurgency on this vast green landscape has led to the demise of various games and vegetation that were found in abundant in Sambisa leaving the land with a battalion of Nigerian troops combating a mix of barbarous radicals that specialize in all kinds of destruction including bombings, beheadings, killings, and forcefully carrying away of women and girls for sex slavery. It has gradually metamorphosed from a game reserve for the delight of animal and human into a human abattoir of unthinkable and unbelievable dimensions. The terrorists later turned the forest to their headquarters and also set up camps from where they unleashed various plans of attacks ranging from launching of terrible raids on villages and towns for suicide bombing, killings, etc [8].

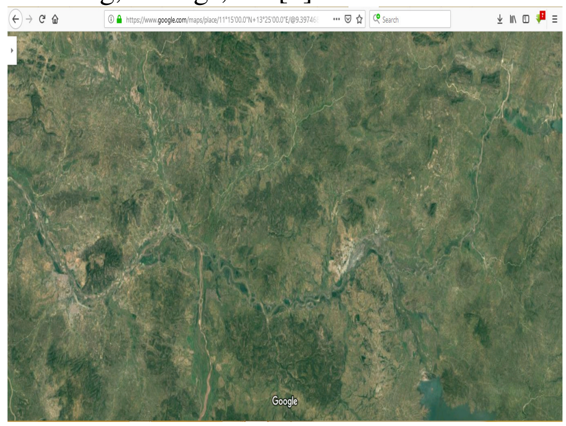

Figure 1: An aerial view of Sambisa forest from google map (Latitude: 11° 15' 00" N and Longitude: 13° 25' 00" E) [10]

III. AN OVERVIEW INTERNET ACCESS VIA SATELLITE TECHNOLOGY

A satellite is any object that changes direction abruptly in a curved route around a planet [3]. The provision of internet access using satellites has been long in existence. In 1973, a satellite link was used to connect two computers at a European research facility to an American network. The world's first consumer satellite Internet service was started in USA in 1996 by DirecPC, which later became the HughesNet. Satellite Internet was earlier promoted commercially to Internet users in rural areas or users who had no access to local points-of-presence (POP). This approach exists even presently and satellite Internet offers near-broadband speeds to customers who would otherwise have no data connectivity [3].The rate at which satellite communications is preferred to land options depends on many interconnected elements. Over a long period of observation, it has been seen that satellite communication has the following merits over variety of terrestrial systems.

- Wide area coverage of a country, region, or continent with wide bandwidth available throughout;

• Autonomous of terrestrial infrastructure;
• Easy and speedy setup of ground network and low cost per added site;
• Unvarying service features;
• Mobile or wireless communication, location notwithstanding and total service from a single provider.

For the network system proposed in this paper, one central hub will be sited in any nearby town to Sambisa forest or in any other convenient urban location in Borno state, acting as the ISP backend and networks operation center (NOC) connecting the network system to the Internet backbone. The central hub will be connected through multiple data channels to the satellite in inclined geostationary orbit to provide satellite Internet links to Sambisa hubs. These hubs will act as a Wi-Fi hotspot to provide last mile connections wirelessly. Hence, star topology is chosen, which comprises the central NOC, the Sambisa forest hubs and workstations within the Sambisa forest as shown in figure 2.

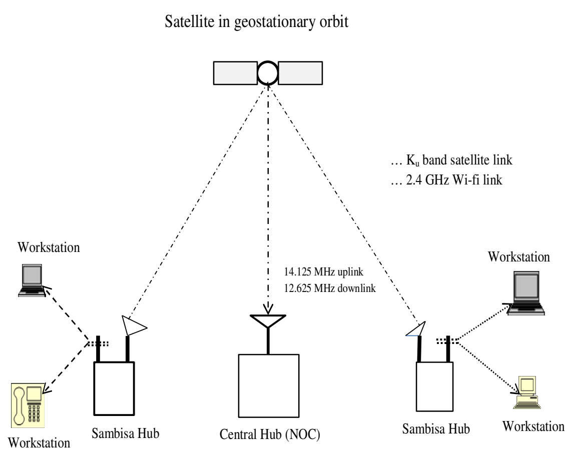

Figure 2: Proposed Satellite Systems Block diagram.

Connection to the Internet can be achieved in this system by the following procedure: a connection request in the form of a data packet is sent to the Sambisa forest hub through a Wi-Fi link. The Sambisa forest hub forwards this request to the central hub via the satellite. The packet contains a station ID describing its location. The central hub station decodes the request and notes the location of the requesting station. The connection between the Internet and the Sambisa forest hub is established through an Internet Service Provider (ISP). A response from the ISP is sent back to a requesting station using the satellite and the local Wi-Fi link. The links between the ISP and the stations in this system are highly spatial. The connecting stations can send only short requests at a low data rate. The ISP then dumps data to the workstation at a high data rate. This mode of operation suits applications where the workstation is used generally to surf the internet for information, or is requesting bulky files or video frames from the Internet.

IV. System components description

A. The central Hub

The central hub requires a high power and a large antenna to be installed at the chosen location, which will enable transmission and reception of various channels of data traffic. The central hub will serve as a network operations center (NOC), transporting data back and forth from the hubs within the Sambisa forest in a star topology.

B. The Sambisa forest Hub terminal

The proposed system is designed such that the Sambisa forest will have two hub terminals to provide for a wider and robust coverage. The Sambisa hub terminals design is a Very Small Aperture Terminal (VSAT). A VSAT is a two-way satellite ground station with a dish antenna that is smaller than 3 meters. The majority of VSAT antennas range from 75 cm to 2.5 m. VSATs access satellites in geosynchronous orbit to relay data from small remote terrestrial stations called terminals to a master terrestrial station called the network operations center (NOC) in star configurations [2]. To ensure a low installation costs, the forest hubs will use VSAT parabolic dish antennas with diameter 2.0 meters.

The Sambisa forest hub receives a data stream from the NOC at the central hub via the satellite. Moreover, the hub itself also acts as a local NOC, distributing the data stream among workstations or subscribers within the area wirelessly using IEEE 802.11n Wi-Fi protocol. For this reason, the Sambisa hub must contain a Wi-Fi router and an antenna to transfer Internet data stream using the 2.4 GHz band.

As much as it's important to keep the cost of equipment's and installations as low as possible, the components used in the Sambisa system must provide reliable data communication link that meets the intended and specified quality of service. Solid-state high-power amplifiers are to be used on the transmitting channel because they do not require very high voltages. The amplifier on the receiver side is required to have a very low noise temperature [3].

The Sambisa forest is a remote rural area without a reliable electricity supply, hence it is imperative to keep power requirement of the hubs as low as possible during design. Borno state of Nigeria where the Sambisa forest is located in the tropical climate zone and receive abundant sunlight for most of the year. In order to take advantage of this, solar panels with photovoltaic cells are to be set up at Sambisa hub to provide most of the energy requirement of the hub. A standby generator can be included for emergency power backup.

C. Satellite Transponders

The satellite proposed for this study is the NigComSat-1R, a hybrid geostationary satellite with 28 transponders for providing cutting-edge telecommunications solutions that are both reliable and cost-effective. The transponders of NigComSat-1R satellite include; 4 C band, 14 K_u band, 8 $K_a$band, 2 L band. This satellite was designed to provide internet coverage to many parts of Africa. It is equipped with the following features:

- Strong footprints and center beams over the African, European and Asia Continent
- Better look angle and shorter latency for intra Africa communication traffic
- Powerful signal strength
- Increased reliability and availability of Ku-band due to adequate fade margin compensation for attenuation losses by rain
- Reduced cost of deployment for VSAT installations via acquisition of smaller equipment
- Availability of Ku-band for broadband services at lower cost arising from the frequency re-use techniques, competitively priced transmission capacity, small antennas and reduced terminal prices.

The quad band satellite is located at 42.5 degrees East with a lifespan of at least 15years and footprints in West, East and Southern Africa, Europe and Asia. NigComSat-1R inherits many flight proven technologies used by NigComSat-1, VENESAT-1 and DHF-3 series spacecrafts.

The NigComSat-1R communications subsystem consists of C-band, Ku-band, Ka-band and L-band. The Ku-Band payload has fourteen (14) channels with a bandwidth of 31.5MHz each. It consists of channel filters to provide input multiplexers for transmission path separation and output multiplexers for establishing a means of combining RF signals at the appropriate transmit antenna. The input section has three (3) fixed receive beams covering Ecowas1, Ecowas2 and Kashi (NIGCOMSAT – 1R TECHNICAL MANUAL).

The high power amplifier (HPA) configuration has fourteen (14) active amplifiers where each amplifier is equipped with linearized channel amplifiers (CAMP), a dedicated electronic power condition (EPC) and a traveling wave tube antenna (TWTA). It has a single redundancy ring of 16:14 with radio frequency (RF) switches provided at the output of the TWTA and the input to the CAMPS such that any two amplifiers in the ring can fail without loss of operation at any channel.

V.INTERNET ACCESS VIA WIMAX

WiMAX is an acronym for Worldwide Interoperability for Microwave Access [5] and it belongs to the IEEE 802.16 group of standards. It is an innovation that allows for reliable, secured and affordable broadband wireless internet connectivity for communication among mobile and stationary devices. The 802.16 group will be an affordable and considerable option for rural areas like the Sambisa forest. The modulation technique used in WiMAX is Orthogonal Frequency Division Multiplexing (OFDM) [4]. Practically, WiMAX operates similar to WiFi but at higher speeds, over wider range of distances and for a greater number of users. WiMAX can potentially serve as a solution to areas like the Sambisa forest that currently have no broadband Internet access because phone and cable companies have not yet run the necessary wires to that location as a result of threats of insurgence and insecurity that has bedeviled the area over time.

Since WiMAX is fashioned to provide Wi-Fi type connectivity over a very broad distance, hence it is suitable for use as a point-to-multipoint last mile broadband wireless access technique. The IEEE 802.16 standard was introduced to deliver non line – of – sight (NLOS) connectivity between a subscriber station and base station [9]

A typical WiMAX system is made up of two parts:

- A tower, same in construct to a cell-phone tower - A single WiMAX tower can provide coverage to a very broad area -- as big as 3,000 square miles (~8,000 square km).
- A receiver - The receiver and antenna can be a small box or PCMCIA card, or they can be integrated into a PC, Laptops, PDA's etc; the same way WiFi is access on similar devices today[6]

A WiMAX tower station can connect directly to the Internet using a high-bandwidth, wired connection and also it can connect to another WiMAX tower using a line-of-sight, microwave link. This connection to a second tower is often referred to as a backhaul. The ability of a single tower to cover up to 3,000 square miles is what allows WiMAX to provide coverage to remote areas.

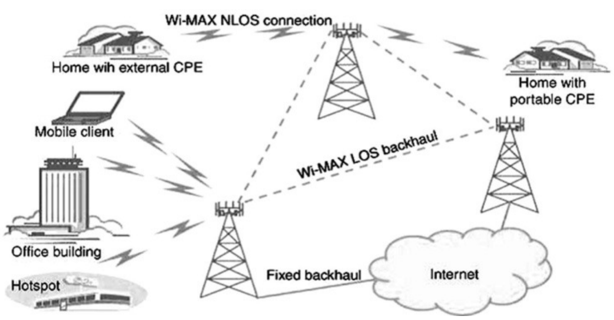

Figure 3: WiMAX system diagram[5]

WiMAX can provide two forms of wireless services namely line – of – sight (LOS) and none line –of – sight (NLOS). The line-of-sight service is a type of configuration where a fixed dish antenna points straight at the WiMAX tower from a pole or rooftop. The WiMAX Line-of-sight transmissions employ higher frequencies, which ranges up to 66 GHz with less interference and more bandwidth at higher frequencies. The line-of-sight configuration is more robust and stable, so it can transmit a lot of data with fewer errors at a range up to 50 km (30 miles). However the non-line-of-sight configuration is a WiFi sort of service with a lower frequency range from 2 GHz to 11 GHz, typically up to 6 - 10 km (4 - 6 miles) for fixed Customer Premises Equipment, where a small antenna on a PC connects to the tower. Lower-wavelength transmissions are not easily disrupted by physical obstructions and they have the ability to bend around obstacles. Also it can provide radio coverage distance of about 50 and data throughput up to 75 Mbps. The data rates for the fixed standard will support a maximum of 75 Mbps per subscriber or workstation in 20 MHz of spectrum, but normal data rates will be between 20Mbps and 30Mbps. Mobile devices will support 30 Mbps per subscriber, in 10MHz of spectrum, although normal data rates will be 3 - 5 Mbps [4].

The WiMAX media access control (MAC) layer employs a smart planned sequence of steps that enables workstations to vie only once for first entry into the network. This also ensures symmetry in overloaded conditions which yields improved bandwidth efficiency. Multiple antennas help to achieve improved speed and distance to enable WiMAX transport more data traffic.

A. WiMAX connectivity within the Sambisa forest

The Sambisa forest WiMAX system configuration will be designed such that an Internet service provider sets up a WiMAX base station at about 10 miles from the Sambisa forest. Intending users or subscribers must buy a WiMAX – enabled PC or upgrade their old computers to include WiMAX capability. Each subscriber or workstation will access the base station through a special encryption code and the base station will then transmit data from the Internet to the subscriber's computer or workstation at a very high speed. The cost for this service is expected to be considerably low since the installations does not require running of cables.

In the case of a local area network (LAN) or a home network within the Sambisa forest, the WiMAX base station will send data to a WiMAX-enabled router, which will then send the data to the different subscribers or workstations on the network. For this network WiFi and WiMAX can be combined by having the router send data to workstations via WiFi.

The WiMAX protocol is planned to accommodate many dissimilar methods of data transmission, one of which is Voice over Internet Protocol (VoIP), which allows subscribers to make local and long-distance calls through a broadband Internet connection, bypassing phone companies completely. The increase of WiMAX-compatible workstations within the Sambisa forest will lead to a significant increase in the use of VoIP. Almost every laptop has the capability of making VoIP calls in present modern days.

VI CONCLUSIONS

This Paper proposes alternative methods of providing internet access to rural remote areas where terrestrial cable internet connectivity might be near impossible due to factors such as lack of infrastructure, insecurity and insurgency using Sambisa forest in Borno state of Nigeria as a case study. This study therefore recommends that implementing a fast, reliable and affordable wireless broadband internet within the remote area of Sambisa forest is achievable through satellite or WiMAX technologies. The above mentioned broadband technologies were chosen because of their various merits over Digital Subscriber Line (DSL) and other cable technologies.

Satellite and WiMAX solves the problem of high installation cost, as they are suitable for last-mile delivery of wireless broadband access. The benefit of satellite and WiMAX is in their ability to address the network requirements presently, having a wider coverage area compared to other technologies.

Wi-Fi in this study is implemented for indoor and outdoor broadband coverage since majority of devices presently are Wi-Fi ready.

Finally, wireless networking will offer the intended alternative means to the challenges of information access and social civilization in a rural area like the Sambisa forest. Satellite or WiMAX technologies will definitely change the way people communicate and share information by eliminating the bottlenecks associated with distance and location.

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