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Establishment of Network Topologies using V-SAT Platform to improve Oil Exploration in Nigeria

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Abstract-Over the years, a majority of oil companies in isolated oil locations in Nigeria are getting on with only an analogue phone line and a thermal paper fax machine. Communications to drilling rigs were primarily accomplished through the design of radio, telephone, and microwave networks. Flawless as it may have seemed to the end user, the services are made up of a combination of technologies including radiotelephones tied back to back with analog microwave channels in a four-wire E and M configuration. Very Small Aperture Terminals (VSAT) allows for the provision of Broadband services using Satellite technology. The technology has been deployed for many years and was traditionally reserved for large telecommunication operators.

This paper is aimed at presenting an innovative telecommunication solution that can be applied within isolated environments in Nigeria to enhance oil operations.

During the course of this research, mesh, star, and virtual star networks using V-SAT platform where implemented in remote locations of oil exploration and drilling sites in Nigeria.

Keywords: VSAT, Mesh, Star, Virtual, Broadband, Satellite

I. INTRODUCTION

The drilling sites of Crude oil in Nigerian are often located in remote, harsh, hostile, oppressive areas and lack necessary communication infrastructure.

The terrestrial infrastructure in Nigeria is often inadequate, obsolete, or imaginary. The shortage of competent telecommunications facilities therefore poses a serious problem to the oil companies. Owing to the expansion drilling, exploration, and production of oil and gas in Nigeria, oil companies have been seeking an efficient, telecommunication system that will help them to carry out these activities securely and inexpensively [1]. In these instances, VSAT technology comes in useful, as it creates a significant way to communicate securely in remote, harsh, hostile, and oppressive areas.

VSAT stands for Very Small Aperture Terminals. It allows for the provision of Broadband services using Satellite technology. VSAT networks provide simple and economical solutions for quickly implementing communication infrastructure to link these areas to the rest of the world. Its network consists of three components of a central hub, satellite, virtually unlimited number of VSAT user terminals. VSAT is capable of providing Broadband services [2].

This paper focuses on the prospect of interfacing wireless networks with V-SAT technology platform to provide telecommunication services infrastructure in remote, harsh, hostile, and oppressive oil drilling and exploration areas in Nigeria. A VSAT system also allows the provision of an always-on Internet service. This allows users to use the Internet whenever they want and avoids the needs to establish dial up connections where users are charged on a time basis [3].

VSATs access satellite(s) in geosynchronous orbit to relay data from small remote earth stations (terminals) to other terminals (in mesh topology) or master earth station "hubs" (in star topology). Satellite circuits are also capable of providing bandwidth on demand services, which increases the flexibility for business.

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A satellite communication involves a man-made object designed to orbit the earth, the moon, or other celestial body. It is located in a fixed-point 36,000kms above the surface of the earth. This position is known as the geostationary orbit[4]. Satellites located at this height orbit the earth at the same speed as the earth rotates on its own axis. This allows the VSAT earth station equipment to be positioned at the satellite and avoids the need for the VSAT earth satellite dish to be repositioned once the initial installation has been completed. A star network consists of a central HUB location with many remote supporting outbound and inbound traffic requirements (e.g. from drilling rig platforms, seismic sites or oil production wells). A mesh network is made up of many terminals with one or two assigned terminals assigned to administer the network. No central HUB location (although optional higher traffic gateways are possible). They support any-to-any connectivity. A virtual star network comprises two or more hubs or gateways, provides mesh connectivity between hubs, remote-to-multi-hop connectivity, and asymmetric data rates. Virtual star networks are essentially two-tiered topologies supporting high-traffic gateways with mesh connectivity to each other and small remote location (e.g. house boat or cabin in drilling or production sites) that are connected to the high traffic gateways

II. HISTORICAL BACKGROUND

The idea of the geostationary orbit was originated by Russian thinker Konstantin Tsiolkovsky. He wrote articles in space travel at the turn of the century. In the 1920s, Hermann Oberth and Herman Potocnik described an orbit at an height of 35,900 kilometers. Its orbital period, or the time for it to make one complete orbit about a different object, accurately harmonized the Earth's revolving period, making it become visible to fly a fixed point on the Earth's equator[5]. Arthur C. Clarke contributed to the understanding of satellites through an article published in Wireless World in October 1945 titled "Extra-Terrestrial Relays: Can Rocket Stations Give Worldwide Radio Coverage?"

Live satellite communications was developed in the sixties by the National Aeronautics and Space Administration (NASA), named Syncom 1-3 [6]. It is transmitted live coverage of the 1964 Olympics in Japan to viewers in the United States and Europe. Soon after, on April 6, 1965, the first viable satellite was launched into space, Intelsat I, nicknamed Early Bird [7].

The first commercial VSATs were C band (6 GHz) receive-only systems by Equatorial Communications using spread spectrum technology. More than 30,000 60 cm antenna systems were sold in the early 1980s. Equatorial later developed a C band (4/6 GHz) two-way system using 1 m x 0.5 m antennas and sold about 10,000 units in 1984-85.

In 1985, Schlumberger Oilfield Research co-developed the world's first Ku band (12-14 GHz) VSATs with Hughes Aerospace to provide portable network connectivity for the oil field drilling and exploration units. Ku Band VSATs make up the vast majority of sites in use today for data or telephony applications. The largest VSAT network (more than 12,000 sites) was developed by Spacenet and MCI for the US Postal Service.

III. METHODOLOGY

There are three main components in communication architecture with VSATs are: a high performance hub earth station, a satellite and a VSAT stations.

The most common access technology used in VSAT is known as TDM/TDMA. The outbound or outgoing channel (from the hub to the satellite) uses Time Division Multiplexing (TDM). In TDM, numerous signals are combined for transmission on a single communications line or channel. TDM works in a satellite in the same way that a T1 or E1 dedicated phone connection. The line (carrier) consists of 24 or 32 (T1/E1) individual channels, each of which supports 64 Kbps. Each 64 Kbps channel can be configured to carry voice or data traffic.

In the client side, (Time Division Multiplexing Access) TDMA is used by the dispersed VSATs to share the incoming or return channel (from stations to satellite). Each station access the shared channel in a certain number of time slots.

Figure1 below shows the V-SAT configurations for any network topology, while figure2 shows the Network topologies showing Star, Mesh, and Virtual Star networks in remote locations.

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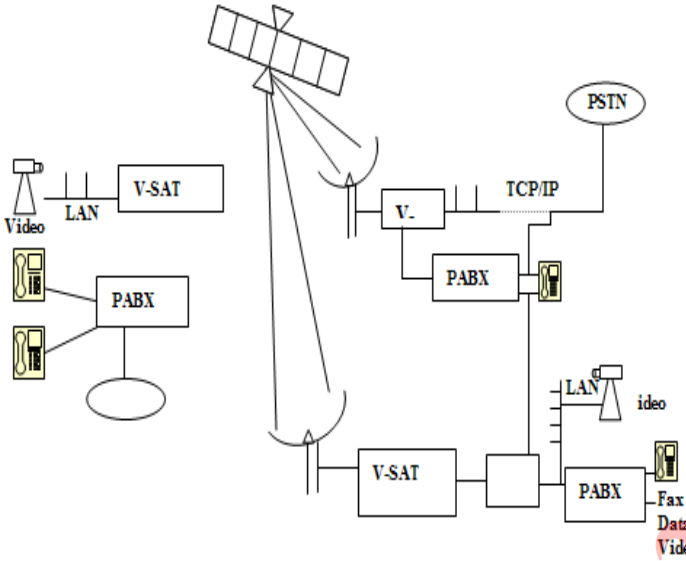

Fig1 V-SAT configurations for any network topology

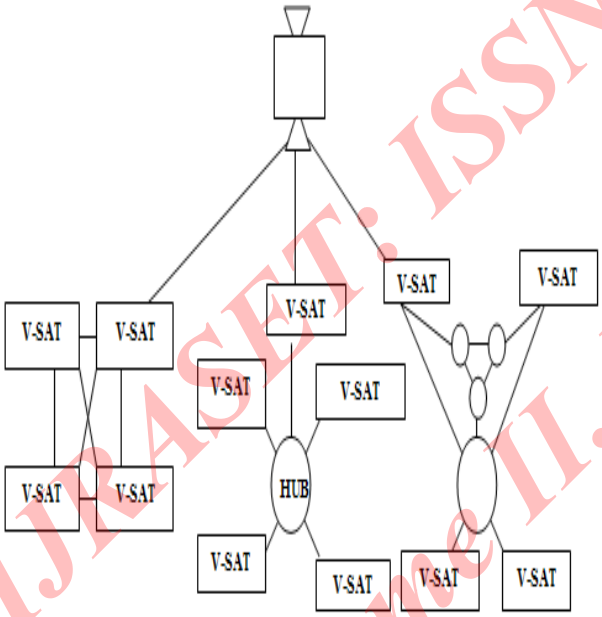

Figure 2: Network topologies showing Star, Mesh, and Virtual Star networks in remote locations.

IV. RESULT

Table 1 below shows the technical specifications of VSAT based rural telephony solutions

Table 1: Technical Feature of Rural Telephony solutions

Variables	**VSAT Alone**	**VSAT & Wired Loop**	**VSAT & Wireless Loop / Cordless Access Solution**	**VSAT & Wireless Macrocellular Solution**
Population Distribution	Scattered	Concentrated & clustered	Clustered	Uniform
Subscriber Density	Very low (<0.1/sq. km)	Low to medium	Low to medium	Low to medium
Applications	Voice, data, fax	Voice, data, fax	Voice, data, fax	Voice, data, fax
Data Rate	Broadband	Broadband	Up to 64 kbps	Narrowband, up to 14.4 kbps
Mobility	None	None	Limited	Yes
Area of Coverage	< 300 m	< 5 km	< 5 km	< 30 km
Power Supply – Equipment	Low (< 250 Watts)	Medium (< 600 Watts)	Medium (< 700 Watts)	High (~2000 watts)
Power Supply – User Terminal	None	None	Low (< 5 Watts)	Medium (< 30 Watts)
Voice Compression	Selectable (4.8 to 32 kbps)	Selectable	32 kbps	8 to 13 kbps
Access to Switching	Required	Not required	Optional	Not required

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Facilities				
Terrain	Insensitive	Sensitive	Insensitive (No tower required	Insensitive except tower installation
Installation	Rapid (2-3 days)	Lengthy (wired network)	Rapid (2-3 days per site)	Rapid, except tower installation
Maintenance	Very Low	Medium	Low	Low
Security issues	Antennas and shelter	Wire theft and shelter	Antennas and shelter	Antennas, tower and shelter
Regulatory Issues	VSAT license (C or Ku band)	VSAT license	Cordless and VSAT licenses	Cellular and VSAT licenses

V. SUMMARY AND CONCLUSIONS

This paper has shown how a Broadband multimedia networks can be made possible using VSAT platform. The protocols and interfaces (the support of which is provided by the VSAT especially for packet switching and circuit switching protocols) allows seamless transitions between terrestrial networks and the satellite network. The technology was capable of providing uninterrupted continuous broadband coverage to the remote locations in which it was placed. The innovative proposal combines intrinsic litheness and direct infrastructure by using on hand satellite systems working at C and KU frequency bands with local support for broadly used packet and circuit switching protocols, flexible network connectivity options, and programmed bandwidth on demand. Mesh, star, and virtual star topologies can be implemented with one VSAT platform that is configurable as a low cost remote terminal or an economical high capacity gateway.

This result is better applied in distant locations such as subterranean sea oil drilling and isolated oil prospecting areas of Nigeria, where there is no communication network

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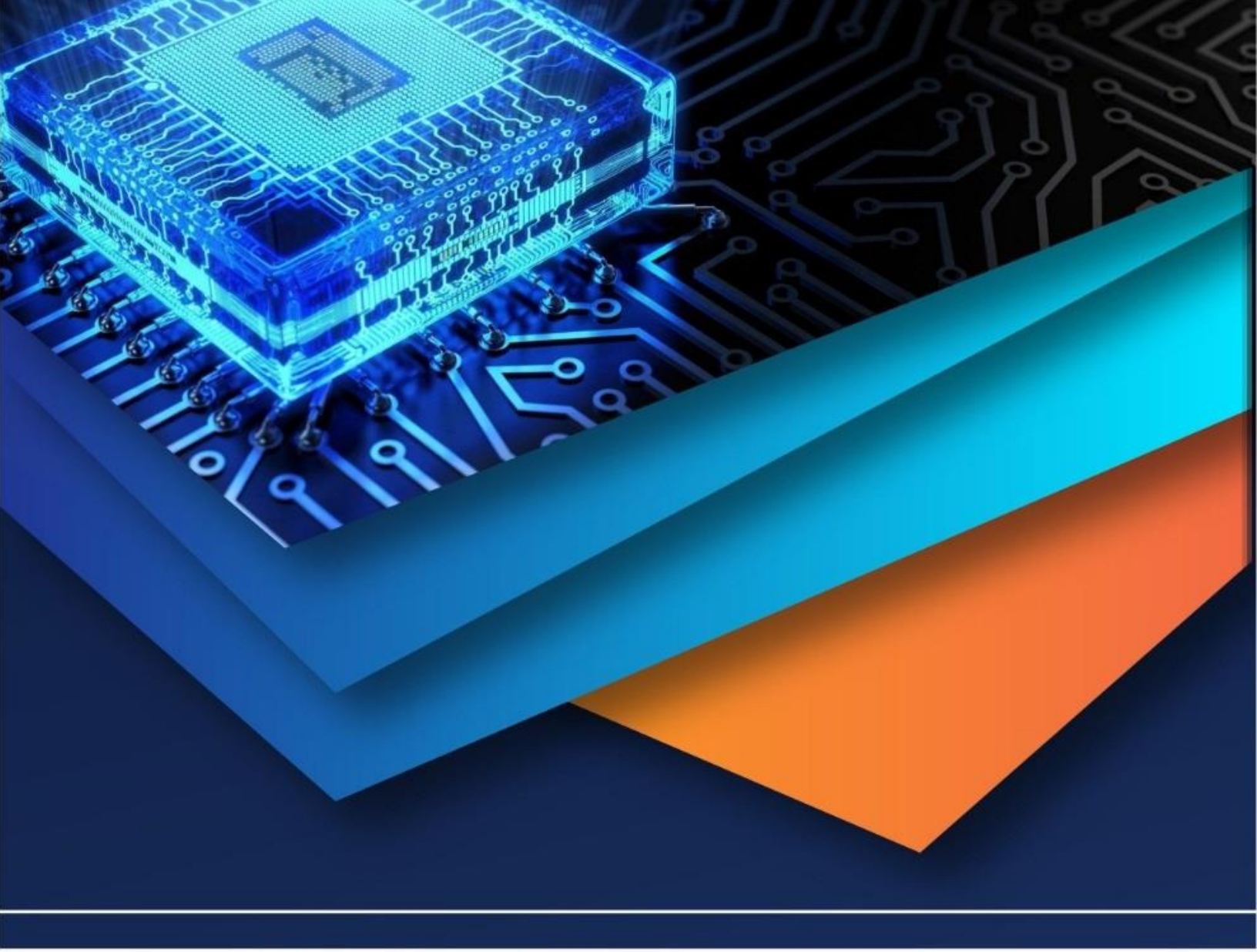

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