Enhancing Offshore Oil Operations with Cost-Effective and Innovative Telecommunication Solutions

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ABSTRACT

Crude oil constitutes a large percentage of the Nigerian economy. The activities associated with crude oil production involve exploration, drilling, and transportation. Of these activities drilling is known to be the most arduous and expensive venture. The drilling sites are often remote, harsh, hostile, oppressive areas and lack necessary communication infrastructure.

The terrestrial infrastructure in Nigeria is often insufficient, antiquated, or non-existent. The dearth of efficient telecommunications facilities therefore poses a serious problem to the oil companies. Since drilling, exploration, and production of oil and gas have expanded in Nigeria, oil companies [4] have been seeking innovative, efficient, and cost-effective telecommunication solutions to carryout these activities safely and economically.

Over the years, a majority of oil companies in remote oil locations in the Eastern and Western Delta areas of 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 perplexing design of radio, telephone, and microwave networks. Seamless 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.

This paper has tried to present innovative telecommunication solutions, more than the traditional voice and fax services, to remote and hostile locations in order to enhance oil operations.

(Key words: remote communications systems, Nigerian delta region, wireless, broadband, satellite, radio, telephone).

INTRODUCTION

This paper will attempt to present innovative telecommunication solutions that can be applied within harsh or remote environments. Our suggestions go beyond the traditional voice and fax services presently applied in the Nigerian oil industry in order to enhance oil operations.

Wireless technology [3], quite simply, refers to communications without wire. Wireless transmission systems therefore, do not make use of physical conductors or guides to blend the signal. Therefore, they are also known as unguided or unbounded systems. Rather than relying on electrical energy, such systems generally make use of radio waves; hence the term “radiated” often is applied to wireless transmission.

Such systems employ electromagnetic energy in the form of radio or light waves that are transmitted and received across space. Such systems often are referred to as airwave systems, although space wave is a more accurate term, as the air in the space between transmitters actually serves to weaken the signal. While microwave and satellite communications are without wires (i.e. wireless), those technologies generally are considered to be high-speed, network backbone, or access technologies that are considered point–to-point, point–to-multipoint, or broadcast in nature.

In the context of this paper, most of the applicable wireless technologies are local loop or local in nature, and are transport oriented. The technologies discussed here are also application and service oriented. Wireless networks include those of cellular telephoning, paging, and voice-grade data. The networks are all essentially terrestrial in nature, although paging networks often employ a satellite element.

Wireless Local Loop (WLL) [4] technologies offer an excellent alternative for gaining high-speed access to both voice and data wireless networks. Wireless technology is considered as one element of a convergence scenario. In other words, wireless is just an alternative access technology with service limitations in terms of limited spectrum, which translate to limited bandwidth. Wireless technologies always are distance limited in consideration of frequency re-use and, therefore, involve limitations on power levels. On the positive side, the technologies offer advantages of portability and mobility. Additional advantages include speed and low cost of deployment. Although wireless technologies do not have the potential to serve as a backbone network, they can certainly support voice, data, fax, video entertainment, TV, multimedia, and Internet access.

Broadband [5], by contrast involves a signal where bandwidth is over 10% of the carrier. The carrier [6] is a constant signal on a circuit that is at a certain frequency, or within a certain frequency range. While the primary value of the carrier is in its support of information–bearing signals, it also can support signaling and control information used to coordinate and manage the network operation. Broadband [7] capacity is equal to or greater than 45Mbps (T-3), according to North American standard (equal to or greater than 34Mbps, according to European and international standards). But in simple terms, broadband describes a transmission facility having bandwidth greater than 20 KHz (i.e. a bandwidth sufficient to carry several voice channels).

A satellite communication involves a man-made object designed to orbit the earth, the moon, or other celestial body. Active communications satellites are satellites with a self-contained energy source, designed to transmit radio communication signals back to earth. There are several of these satellites in orbit, for example, the Intel Sat series, the low orbiting satellites, and the geostationary satellites.

This paper, therefore, focuses on the possibility of interfacing wireless networks with satellite communications broadband facilities to provide a variety of telecommunication applications such as transaction-oriented or point-to-point networks, internet protocol (IP) multicasting, backbone connectivity, and basic voice and data communications where terrestrial infrastructure is either insufficient or non-existent.

MATERIALS AND METHODS

The most dynamic solutions which this paper has explored involve a network supported by a satellite backbone infrastructure, which incorporates broadband V-Sat networks, and a variety of wireless networks, such as ad-hoc network, IP, ATM, frame relay, ISDN and SS7. This innovative telecommunication solutions which extends telecommunications services to remote sites with little or no infrastructure, involves new advances in VSAT technology [8], extending terrestrial infrastructure over large geographical areas seamlessly.

The fifth-generation satellite networking terminal can be adapted to provide native support for important telecommunications standards such as IP, ATM, frame relay, ISDN, and SS7. In addition to efficient time division multiple access (TDMA) and automated bandwidth on demand (BOD), this product eliminates the need for additional third-party networking equipment, resulting in an overall network reliability, lower costs, and simplified integration with terrestrial networks.

This new V-SAT platform contains enhanced features, which provide architecture that supports different topologies such as the mesh, star, and virtual star. This allows individual VSAT locations to be configured as low-cost remote terminals and economical high capacity gateways.

There are today, broadband V-SATs that support multiple antennae and RF transceiver configurations with flexible carrier parameters that include variable bit rates, power levels, and forward error correction (FEC) settings for each carrier. An effective broadband VSAT platform must provide the following capabilities and facilities to address diverse multimedia networking applications.

- Support for broadband range of network topologies
- Native support for widely used packet and circuit switching protocols
- Flexible connectivity and satellite access
- Efficient demand assigned bandwidth.

Bearing all these factors in mind, would lead us to designing the following network topologies. Figure 1 shows star, mesh, and virtual star hybrid network configurations.

1. 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).

2. 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.

3. 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.

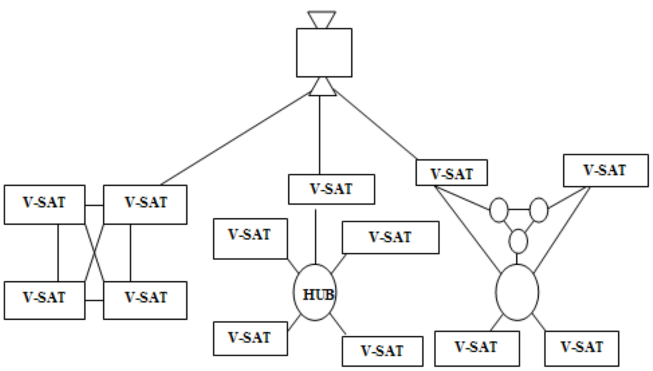

Figure 1: Network topologies showing Star, Mesh, and Virtual Star networks in remote locations.

The V-SATs support all three topologies and standard interfaces for packet switched IP, ATM, frame relay and circuit switched (ISDN, SS7) networking applications, broadband data rates between 312 Kbps and 5 Mbps, and demand assigned allocation of bandwidth.

FEATURES, BENEFITS, AND RESULTS

Some features in the design worth mentioning are:

- Native communications 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. A special indoor unit (IDU) supports IP, ATM and frame relay packet-switching protocols and ISDN and SS7 circuit switching protocols.

- IP service features consist of dynamic routing of IP packets and support of unicast and multicast services and frame relay support over IP. Numerous applications are possible with native IP support including voice over IP and LAN-to-LAN connections.

- Solutions or products can be designed to meet the strident performance requirements of ATM [4], complying with ATM forum uni 3.0 and achieving bit error-rate (BER) performance similar to that encountered with optical fiber. ATM cells can be processed to a maximum throughput of 4 Mbps on a satellite network.

- This product provides frame relay service features. The VSAT terminals provide synchronous serial interfaces (EIA-530/RS-449/V.35) to frame relay routers, access devices, and switches.

- ISDN/SS7 service features are provided in this product. This includes ISDN signaling over T1 (23B +D) or E1 (30B+D) lines, supporting NX64 kbps calls and private and public number plans. Bandwidth is allocated on a call-by-call basis. The SS7 [11] facility provides T1 and E1 traffic interfaces and complies with ITU – T specific message transfer (MTP) and ISDN user part (ISUP) protocols. The ISDN/SS7 interfaces support a variety of commercially available voice and data switching equipment. Voice compression to 8 Kbps (G.729a) is also supported.

- Legacy protocol support such as SDLC [12], X.25 and two/four wire analogue voice requirements are supported by combining the IP or frame relay interfaces with external routers or frame relay access devices.

- Flexible connectivity and satellite access are possible, since broadband and multi media applications require flexible network architecture and a variety of satellite connectivity options.

- Demand assigned bandwidth management is possible by the VSAT network which runs a central bandwidth management program for efficient use of space segment. The bandwidth management function performs both fixed bandwidth allocation and dynamic bandwidth allocation or bandwidth on demand. Dynamic bandwidth allocation is made possible by a "Bandwidth Reporter" program that continuously monitors incoming user traffic and collects reports form all VSATs and periodically runs and algorithm that distributes available bandwidth resources in a fair and efficient manner.

For different configurations and interconnection possibilities stated above, see Figures 2, 3, 4, 5 and 6. Figure 2 shows how a VPN service provider can establish virtual ATM, IP, or Frame relay circuits over satellites using broadband V-SATs as entry points for client locations.

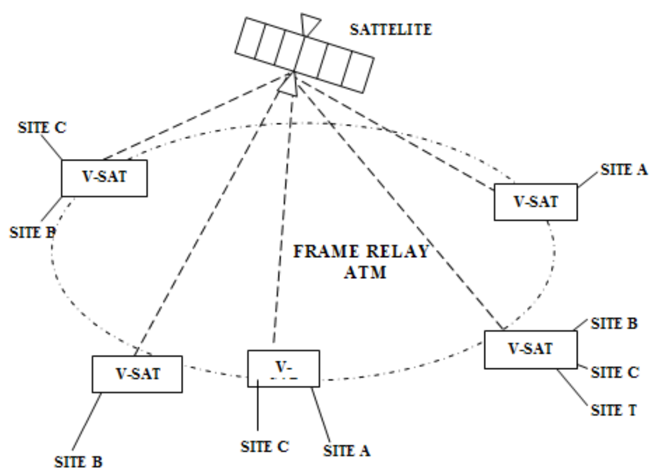

Figure 2: VPN establishment of ATM, IP, or frame relay over satellite.

Figure 3 shows how V-SATs are configurable for any network topology. Oil companies can provide broadband content to and from multiple locations affordably. Figure 4 shows an ISP application supported by a V-SAT network.

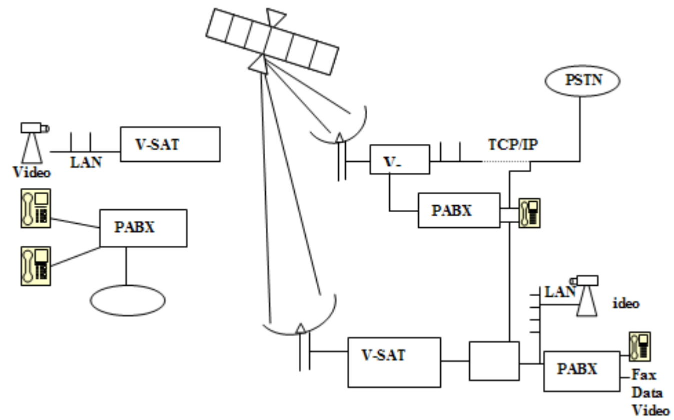

Figure 3: V-SAT configurations for any network topology.

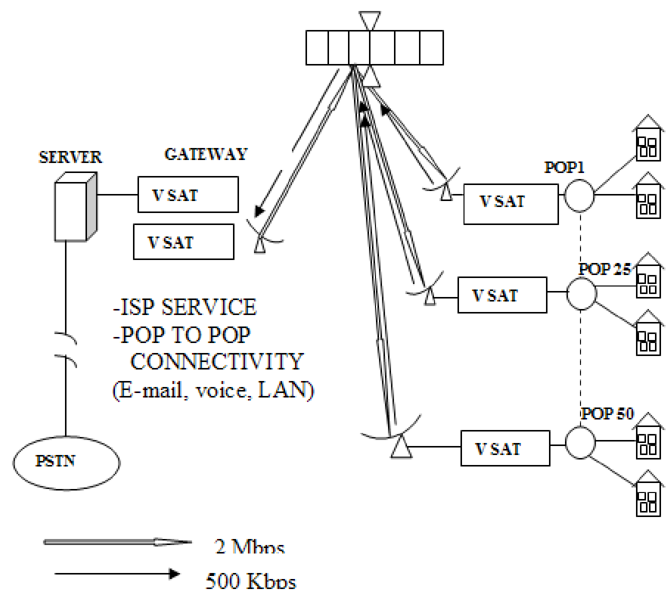

Figure 4: V-SAT supporting ISP applications.

Figure 5 shows the configuration of real time digital video internetworking. Video conferencing and video surveillance comprising of several distinct user groups are combined to form one network consisting of many remote surveillance instances, each monitoring distinct traffic locations. Figure 6 shows the connectivity of V-SATs to accommodate cellular or PCs base stations over satellite by using ISDN call routing, SS7 support, and TDMA carriers. Typical base stations require T_1/E_1 connections to the central office on demand

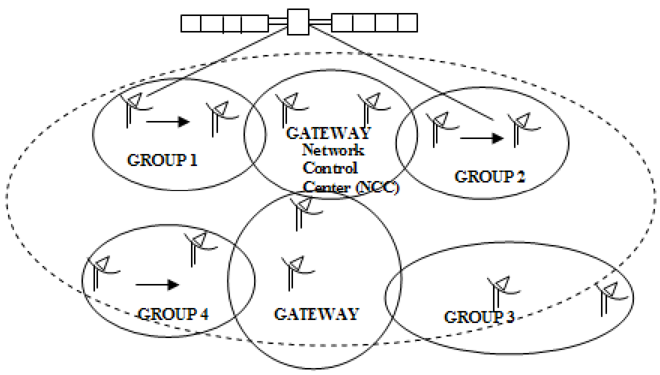

Figure 5: Real time digital video internetworking.

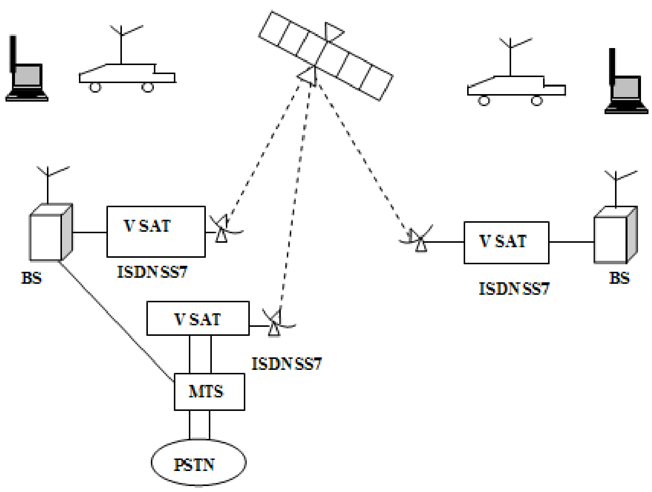

Figure 6: A wireless interconnection application.

ANALYSIS OF RESULTS, DISCUSSIONS, AND APPLICATIONS

The star network applications include broadcast services, specific interactive systems, public switched network extensions, and internal network extensions. Mesh network applications include corporate wide-area voice and data communications, LAN extensions, and video conferencing. Some virtual star network applications include multinational corporate wide area networks (WANs), intranets, and service provider-operated virtual private networks (VPNS).

This innovative telecommunication solution is particularly well suited to the diverse network topologies needed for today's broadband network service providers and multinational corporations and can establish economical mesh, star, or virtual star networks using a VSAT platform. This is important for a service provider offering VPNS to multinational organizations (e.g. oil companies), since mesh networks support teleconferencing requirements, star networks support internet access, and virtual star networks support corporate data intranets connecting remote offices to headquarters (e.g. oil drilling rigs, oil exploration sites and oil production sites) to oil company local headquarters and overseas head offices.

Popular broadband VSAT network examples include VPNS, private corporate networks, internet service provider (ISP) connections, real time digital video internetworking, and wireless base station connections.

SUMMARY AND CONCLUSIONS

Broadband multimedia networks can now be made possible using a powerful VSAT platform. The new platform combines inherent flexibility and immediate infrastructure by using existing satellite systems operating at C and KU frequency bands with native support for widely used packet and circuit switching protocols, flexible network connectivity options, and automated 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 solution is better applied in remote locations such as deep sea oil drilling and remote oil prospecting areas of Nigeria, where there is no communication infrastructure.

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GLOSSARY

ATM	- Asynchronous Transfer Mode
BOD	-Bandwidth on demand
IP	-Internet Protocol
ISDN	-Integrated Services Digital Network
ISP	-Internet Services Provider
ISUP	-Integrated Services Unit Protocol
ITU-T	-International Telecommunication Union Telecommunications Standardization Sector
MTP	-Mail Transfer Protocol
SDLC	-Synchronous Data Link Control
SS7	-Signaling System 7
TDM	-Time Division Multiplex
VPN	-Virtual Private Network
V-SAT	-Very Small Aperture Terminal

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