VSAT Solution for Education: A Case Study for the Institute of Mathematics and Physics

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Abstract

Nowadays, access to the Internet seems to be ubiquitous. The presence of satellite in the future broadband networks is therefore no longer an option. Satellites systems allow a perfect territorial equity by providing a global coverage of the world. On another side, Internet is no longer yet another technique but is becoming the point of convergence of other information and communication technologies such as the television, the telephone, the videoconference which are being added to the traditional Internet applications. Infrastructure problems are today a barrier to the development of Internet in Africa. The satellite systems are thus presented as the most realistic and effective solution, since they minimize the investments in terms of infrastructure.

The purpose of this article is to present a feasibility study of the installation of a communication system by VSAT which can be adapted to offer the multi-media services (voice, video) for the IMSP (Institute of Mathematics and Physics) on its new site in Dangbo. This study highlights the main steps to consider when planning a VSAT installation in Benin and most of West African countries

1. Introduction

Nowadays, access to the Internet seems to be ubiquitous. The presence of satellite in the future broadband networks is therefore no longer an option. Satellites systems allow a perfect territorial equity by providing a global coverage of the world. On another side, Internet is no longer yet another technique but is becoming the point of convergence of other information and communication technologies such as the television, the telephone, the videoconference which are being added to the traditional Internet applications. Infrastructure problems are today a barrier to the development of Internet in Africa.

The Institute of Mathematics and Physics (IMSP) as a national research centre expressed the needs to have a very effective system of telecommunications, in order not only to make facilitate students research, but also to be a centre of reference in Benin in terms of interconnection to the world.

The objective of this article is to present a feasibility study of the installation of a communication system by VSAT which can be adapted to offer the multi-media services (voice, video) for the IMSP on its new site in Dangbo. This study highlights the main steps to consider when planning a VSAT installation in Benin and most of West African countries and presents some of the proposals made for a better connection of the Institute.

2. Satellite and VSAT Background

In the 1950's the Soviet Union launched Spoutnik-1, the first artificial satellite which was put in orbit round earth. The already existing concept of satellite communication was brought to life. First satellites were passive because they simply reflect signals which came from earth stations. The major weakness was that signals were dispersed in all directions and can be received by anybody in the world. In those times antennas were too large in order to enough power of emission and reception.

Active satellites introduced later have their own signals emission and reception system. Telstar 1 was the first active satellite which was put in orbit in 1962 by USA. They allow evolution in satellite communications, like the use of very small stations at low cost which called Very Small Aperture Terminal (VSAT)

VSAT system is based on geostationary satellites and enables the use of small terminal to send and receive signals in an asymmetric way. The first VSAT system was developed by Schlumberger with Hughes Aerospace collaboration in the USA in the 1980's. It was easy to move and install. The antenna's parabola diameter was around 1m. It was perfectly fit for professional applications, which require scalable, low footprint and available interconnection infrastructures. In addition it was always beneficial to long distance transmission.

2.1. Operation mode

Telecommunication satellite can be seen as a sort of air relay. His principal role was to regenerate signals received from earth or others satellites and to retransmit it, amplified in frequency to receiver. Satellite permit also to diffuse signals received from earth to many others stations. In the same way, it can be gather some information from stations and retransmit it to particular station. Further, it's possible to connect satellites this is permitted to use little earth stations during transmission.

Satellite solutions advantage is the little dependence of earth stations with terrestrial infrastructures existing trough the world. Thus, terrestrial station can be mobile.

Emission power of VSAT is low, and it's not possible for two VSAT stations to interact directly. It's necessary to transit all communications through the main station which called Hub.

Hub station's parabola has a large diameter with high gain. It has two principals role:

- Amplify and relay the signals which are transmitted by VSAT stations.
- Manage access to communication support.

2.2. Frequency band and coverage areas

International Union of Telecommunications (IUT) had defined international Radio regulation about frequency distribution. This regulation includes a definition of the orbital position of satellites, the frequency bands and the satellites communications services.

We have three types of satellite services:

- Fixed Satellite Service (FSS)
- Mobile Satellite Service (MSS)
- Broadcasting Satellite Service (BSS)

IUT has also defined 7 frequency bands and three geographical regions.

- Region 1: Europe, Africa, Middle-East and ex-USSR's old countries.
- Region 2: America.
- Region 3: Asia, ex-USSR and Oceania.

Table 1 summarizes a few frequencies bands in use in Region 1.

Today, Band C is congested because it was the first which was used by commercial satellites for Fixed Satellite Service (FSS). Presently VSAT network providers develop VSAT solutions in Ku and Ka bands for Africa.

The coverage of a satellite payload is determined by the radiation pattern of its antennas. The receiving antenna and the transmitting antenna may have different patterns and hence there may be a different coverage for the uplink and downlink. The coverage is usually defined by a specified minimum value of the antenna gain. The more the satellite is far from earth, the larger its coverage area. The coverage criteria are key in satellite solution elaboration and choice as the chosen satellite should cover the targeted zone. However, most of the commercial satellite networks have a global coverage even if each network usually has its own characteristics and applications field.

Table 1: Frequency bands in Region 1

Bands	Uplink/Downlink	Bandwidth
FSS		
Band C	6/4 GHz	1100 MHz
Band X	8/7 GHz	500 MHz
Band Ku	14/11 GHz	1000 MHz
Band Ku	14/12 GHz	250 MHz
Band Ka	30/20 GHz	2500 MHz
MSS		
Band L	1.6/1.5 GHz	29 MHz
BSS		
Band K	17/12 GHz	800 MHz

2.3. VSAT architecture

The basic architecture of a VSAT network is usually a point to multipoint or star topology. The network is composed of a central hub, remote VSAT stations and space segment on satellite transponder. Additional architecture options include meshed and mixed topologies.

VSAT station equipment is composed of two elements:

- OutDoor Unit (ODU) which is a parabolic antenna equipped with radio frequency receiver and transmitter.
- InDoor Links (IDU) is connected to ODU by a simple cable (maximum 60 m). The role of IDU is to transform the signal received from the antenna so that it is usable by a computer. In the same way, it translates signals coming from the computer so that it can be relayed by the antenna to the satellite.

3. Feasibility study

In order to deal with the growth of its activities, the IMSP is moving to a new location located in the tiny town of Dangbo. With this move the Institute wanted to keep and even improve the capabilities of its communication system in order to offer multimedia services but on the other side, due to its location, the town of Dangbo has very little established communication infrastructure. The

VSAT has then emerged as a potential solution allowing to combine the two conflicting requirements, thus the need of a feasibility study.

3.1. General process

The general methodology used in this study starts in a first phase with an analysis of the needs of the Institute which are then translated into functional specifications. Those specifications will allow a calculation of the appropriate bandwidth, the development of the technical specifications and an architecture proposal for the local network. Based on those technical elements and on the user experience of VSAT in two local companies, we can request quotations and compare some suppliers present in Ku and C bands in Africa. We complete the study by the presentation of the juridical and statutory aspect.

3.2. IMSP requirements and functional specifications

3.2.1 IMSP requirements

Today, the IMSP has fifty students and professors. There are twenty computers connected to internet with eight permanently in use. Presently, IMSP uses ADSL technology to have internet access with a theoretical 256 Kbps uplink and 512 Kbps downlink. Network users use the computers for web browsing, mail, audio and video conference with MSN Messenger, Yahoo Messenger and Skype.

On the new campus, it is projected to have 150 students and 60 computers connected with 30 in use continuously. They will also be some new needs like VoIP, ToIP (Telephony over IP), mail, web server hosting and DNS servers which require more bandwidth. All those applications will enable distance learning, sharing of internal resources, access to external resources available on internet and online collaboration making handy for the institute many more human and material resources than before.

3.2.2 Functional specifications

The need of the institute includes data, voice and video. Our work will focus essentially on email, web browsing, VoIP and videoconference applications.

One of the main constraints is a high availability of the system as most of the resources will be in continuous use. We may also have to manage users and user groups in order to optimize resource utilization. The envisioned solution can be either on share or dedicate bandwidth depending on the forecast and on the resource available. The VSAT provider should offer coverage for West Africa in C, Ku or Ka band and the pros and cons of each solution will be taken into account in the final choice.

3.3. Determination of the appropriate bandwidth

The amount of bandwidth required is a key factor to consider when purchasing VSAT solutions. Some applications such as voice and videoconferencing require a minimum dedicated bandwidth, while others like email or simple web browsing do not have hard minimum limits.

Email is asynchronous and in most cases read offline and does not require a constant connection. We can thus envisage 4 Kbps in Downlink (DL) and 2 Kbps in Uplink (UL). For our thirty (30) computers, which are continuously in use, we will need 120 Kbps in DL and 60 Kbps in UL.

For web surfing we need a minimum capacity and we suggest to allow 8 Kbps in DL and 2 Kbps in UL. For thirty computers that amounts to 240 Kbps in DL and 60 Kbps in UL.

For audio and video conferencing using MSN Messenger, skype, etc., we need symmetrical capacity, and suggest 128 Kbps for Downlink and Uplink. This capacity will be shared by our users.

For Video and Voice over IP in order to do distance learning, we need large capacity of the connection to ensure best quality during transmission. In this case we add 128 Kbps to precedent capacity and we have 256 Kbps in UL and DL. Voice and Video will shared the same channels. We also use this capacity for ToIP.

For our three server's setup, we envision to allocate for mail and FTP servers, 30 Kbps in UL. For web server, we suggest 128 Kbps in UL to cope with high load periods.

By adding all the needs, the amount of bandwidth required is 616 Kbps in Downlink and 564 Kbps in Uplink.

To consolidate our assumptions, we use the DU Meter software to measure real throughput consumed by real application currently used on the network. The results are presented in Table 2.

Table 2: Real throughput consumed by some applications on the network

Applications	DL (Kbps)	UL (Kbps)
Skype (text)	1.6	3.2
Skype (audio)	59.2	56.8
Yahoo Messenger (audio)	25.6	27.2
Yahoo Messenger (text)	0.8	2.4
Yahoo Messenger (video)	8.8	40
MSN Messenger (audio)	24	28
MSN Messenger (text)	0.8	1.6
MSN Messenger (video)	4	72
Surfing	64	8.8
Mail	32	8

The figures in that table are in line with our assumptions. Our proposed theoretical capacity was practically the same with the real time capacity in our network. In addition, the amount of bandwidth we proposed is also in line with Bandwidth Task Force [4] formula for Higher Education bandwidth calculation which is:

$$\frac{\text{10 MB/day x 8 bits x 10 people x number of computers}}{\text{Seconds/10 hours}} = \text{number of Mbps}$$

When we use this formula to calculate bandwidth required for our thirty computers we have 0.66 Mbps = 660 Kbps. This bandwidth is in conformity with our calculation in which we are proposing 640 Kbps.

In summary, the needs for the Institute VSAT connection can be summarized as:

- Provider in Band C, Ku or Ka
- Symmetrical bandwidth 640/640 Kbps
- Contention Rate 1:5
- 40 Public IP addresses to add more servers.

3.4. Technical specifications

In this section, we will define the characteristics of the space segment, the size of our antenna and finally the network architecture.

The targeted solution could offer coverage in the C or Ku band space segment. The antenna should be big enough to allow upgrades and easy bandwidth increase. The size of our antenna must vary between 1.2 m and 2.4 m.

On the local network, we propose a PABX which will enable us to manage the internal and external calls by using IP telephony. We also propose a router to which the computer of our LAN will be connected. The PABX will be connected to the router which will allow it to connect to both the local network and the public switched telephony network. The PABX will manage the traditional analog telephones, the IP phones and the soft phones installed on computers. The servers will be installed in a demilitarized zone in order to make them accessible from outside, and at the same time isolate them from the rest of the network in order to avoid attacks.

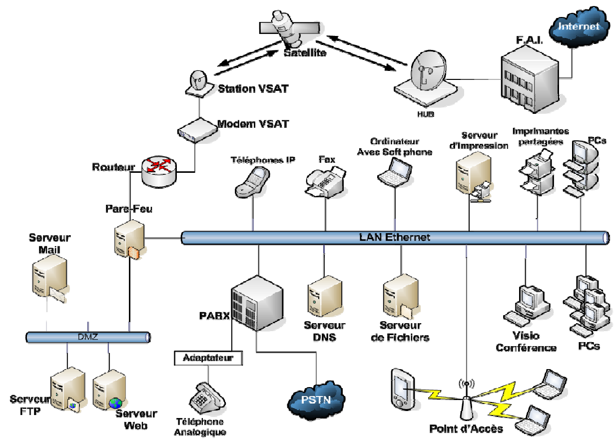

Figure 1: Proposed architecture for the local network

3.5. Case study on two local companies

The objective of this section is to determine the use which is currently made by some selected local companies of their VSAT system, in order to determine the difficulties, to know the procedures of acquisition of the material, frequency bands available and accessible in Benin.

We contacted several companies like: Kerr-McGee, BCEAO, Benin Telecoms SA but were able to get enough feedback only from the two first.

In the light of the data collected in the companies we have made the following analysis.

In general, the VSAT is used to make:

- Phone calls
- Data transmission in real time
- Distant accesses to databases
- Videoconference, teleconference
- Email and web browsing

The above application helps improve the company's productivity and rentability by reducing travel time and costs.

In addition, the use of the VSAT also allows the companies to secure their data transmission by having dedicated encrypted virtual link.

In general the C Band is recommended for countries like Benin, which are below the tropics. Table 3 presents the pros and cons of each of the Ku, C and Ka bands

Table 3: Comparison of the Ku, C and Ka band

Band	Band-width	Advantages	Disadvantages
C	500 MHz	▪ Little affected by the rain ▪ Reliability	▪ Terrestrial interference ▪ Heavily used
Ku	500 MHz	▪ Available ▪ Small Antenna	▪ Absorption by the rain
Ka	3500 MHz	▪ Broad Band-width ▪ Small Antenna	▪ Absorption by the rain ▪ Cost of the equipment

3.6. Comparison of some KU and C band providers

We contacted some suppliers of connection by satellite in order to have some proposal. In order to achieve that, we sent them a letter of invitation to tender. The main requirements listed in the letter of invitation can be summarized as:

- Coverage of the West Africa region in C or Ku Bands.
- Symmetrical flow of 640 Kbps, which can evolve/move to 1.2 Mbps, with a maximal contention rate of 1:5 and 40 public IP addresses.

Table 4 summarizes the proposal received.

3.7. Legal aspects

In the general context of regulation of the VSAT, two aspects are to be considered:

- Attribution of the frequency bands specific to the various services
- Definition of the qualitative goals and the standards Worldwide, the regulation is made by the International Telecommunication Union (ITU)

Since 1994, the ITU has been reorganized in three sectors:

- Sector of the Radio communications
- Sector of standardization of telecommunications
- Sector of Development

For the satellite systems, the attribution of the frequencies is decided on three cascading levels:

1. Worldwide, the ITU allocates frequency bands to services in each geographical region.
2. At the African level, the African Union of Telecommunications (UAT) takes care of the harmonization of the frequencies.
3. At the national level in Benin, there is no formal regulation authority. Due to the earlier state monopoly on telecommunication, the frequency usage is directly coordinated by the Ministry of Communication and new Technologies. An authority of regulation of the frequencies will be put in place very soon. It will be given the responsibility to make a rational management of the frequency spectrum.

4. Implementation plan study

After analysis of the requirements and needs of the institute, the derivation of the functional specifications, the local examples, the proposal received by providers, we have made the following proposal for implementation.

We keep the architecture of Figure 1. This architecture includes:

- A VSAT station with modem.
- A router which ensure packets routing.

Behind the router, we have a firewall to which the local network and the DMZ (demilitarized zone) will be connected.

In the LAN, we have Visio conference room, computers with soft phones, IP telephones, shared printers, file server, printing server, DNS/DHCP server, many WIFI access point and a PABX which allows internal calls and external calls from LAN to PSTN.

The Demilitarized zone contains for moment three servers: a web server, a FTP server and a mail server. We can add others servers if necessary. The architecture should also include at least one backup server.

5. Conclusion

The purpose of this article was to present a feasibility study of the installation of a communication system by VSAT which can be adapted to offer the multi-media services (voice, video) for the IMSP (Institute of Mathematics and Physics) on its new site in Dangbo. This study highlights the main steps to consider when planning a VSAT installation in Benin, starting form the requirement to the implementation via the legal aspects.

The methodology is applicable also to most of the West African countries. For the Institute, the project is feasible and we made an implementation proposal. From the practical side, this article has not presented the cost aspects which are key in the selection of a solution fitting the available budget.

Finally, we recommend that real tests are carried out whenever possible before the acquisition of a VSAT system and in order to better evaluate the impact of the climate, the real throughput achieved and the system fine tuning.

Table 4: Summary of proposal received from providers

Suppliers	Flow DL/UL (Kbps)	Guaranteed flow (Kbps)	Availability	Band	Rate of Application	Provided materials	Cost of acquisition	Freight	Monthly subscription	Installation and start-up	Expenses of activation
WP & T	2048/ 128	Best Effort	-	Ku	1: 5	▪ Antenna offset doubles optical of 1,2 m ▪ 2 * 50 m of coaxial cable ▪ 5 connectors F ▪ O.D.U. 1 Watt (Ku) ▪ L.N.B and I.D.U. (modem router) ▪ installation and Instruction manuals	2950 €	580 €	1800 €	-	-
Gilat Satcom	640/ 640	320	-	C	1: 2	▪ Antenna 2.4m ▪ BUC 8W ▪ Radyne DMD20LBST 5MB, 8PSK, Turbo ▪ LNB and Vbox ▪ Cisco 1721 Router	$ 15568	$ 3500	$4080	-	$ 950
Africa Telecom	640/ 640	320	99.2%	Ku	1: 2	▪ Antenna 1.2m ▪ Modem i-4000 ▪ Amplifier 3W + Emission/Reception head	3190 €	800 €	5250 €	2000 €	-
Africa Telecom	640/ 640	128	99.2%	Ku	1: 5	▪ Antenna 1.2m ▪ Modem i-4000 ▪ Amplifier 3W + Emission/Reception head	3190 €	800 €	2100 €	2000 €	-

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