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Original Article

ATM VSAT Switchover Planning Telkom-1 Satellite Case Study to BRIsat Satellite

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Abstract — *The anomaly on the Telkom-1 satellite resulted in many ATMs (automatic teller machines) via offline satellites. Solving the anomaly is necessary to minimize offline time, so switch over migration to other satellites, namely BRIsat. Switch over ATM VSAT (Very Small Aperture Terminal) satellite to BRIsat satellite is planned with 321 BRI (Bank Rakyat Indonesia, one Indonesian bank) ATM links. The plan was carried out to provide an overview after the link is switched over to the BRIsat satellite and information about the link budget. The initial step is to create or provide an IP that was enabled to the new Hub. The EIRP of the earth satellites was obtained for 61.93dBW with the allocated allocation bandwidth of 6311.11 kHz. The ATM here uses a bandwidth of 32 Kbps.*

Keywords — *Automatic Teller Machine, Cross Pole, Link Budget, Routing, Switch Over.*

I. INTRODUCTION

The Telkom-1 satellite lost contact on August 25, 2017, and a large amount of debris was ejected [1]. Telkom 1 managed to pass its age to more than 3 years and several days until it disappeared from its geostationary orbit. The most significant impact from the Telkom-1 impact is ATM (Automatic Teller Machine). ATMs that were affected include major bank companies such as BCA (Bank Central Asia), BNI (Bank Nasional Indonesia), BRI (Bank Rakyat Indonesia), and Bank Mandiri, which experienced the most downtime. There are around 11574 VSAT (Very Small Aperture Terminal) satellite sites from banking ATMs. The affected BRI links are around 321 sites. It is necessary to migrate to another satellite to solve anomaly problems to prevent any economic loss immediately.

One of them is the BRIsat satellite. BRIsat is the name for the satellite belonging to Bank Rakyat Indonesia (BRI), a banking company in Indonesia. The BRIsat satellite was created by Space System Loral (SSL) and launched at the Arianespace launch center.

The purpose of this final project is to accelerate the switchover process of ATM migration by planning a new Hub system via the BRIsat satellite and providing information on the planning process for Hub migration, repointing, and routing to the BRIsat satellite.

II. LITERATURE REVIEW

A. VSAT Communication System

Satellite communication or VSAT as an alternative to communication via cable, optics, microwave in various developments continues to be made to get a device accepted by the wider community [2], [3]. The satellite communication antenna was initially tens of meters wide, making it very difficult to install in a narrow location. VSAT now generally utilizes an antenna for a minor diameter of between 1.8m to 3.8m. While at the Hub station, an antenna with a larger diameter of 4.5m to 9.0m is applied [4]. VSAT at the Hub station was equipped with a master control center as a network regulator, which is necessary for communication between remotes.

B. VSAT Communication System Configuration

VSAT communication is a concept in the Indonesian telecommunications system using satellite as the primary medium. VSAT is widely applied in various applications because this technology can provide integrated services to users. Generally, VSAT consists of two parts, namely outdoor and indoor [5]. Ordinary outdoor called ODU (Outdoor Unit) consists of a transceiver placed in an open place to receive signals from the satellite directly, and the indoor part is usually called the IDU (Indoor Unit), which functions to connect receivers and end-user communication devices.

The multiple access technique of VSAT was divided into three methods, Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), and Frequency Time Division Multiple Access (FTMDA) [6], [7].

a. FDMA was applied of different frequencies at the same time by several VSATs in communicating with the Hub.
b. TDMA was applied of the same frequency at different times by several VSAT.
c. FTDMA combines FDMA and TDMA techniques. Almost all VSAT technologies apply this technique. Meanwhile, FDMA and TDMA are starting to be abandoned.

C. Types of Antennas

The antenna is an outdoor device that transmits and receives RF (Radio Frequency) radio waves [8]. The antenna applied in satellite/VSAT communications is a parabolic antenna. The function of the parabolic antenna in VSAT communication is as follows:

a. Transmit RF radio waves from earth station to satellite.
b. Receive RF radio waves from satellite to earth station.

Based on the design type, the antenna is divided into 3 types, as explained below.

a) Prime Focus Antenna

Prime focus antennas are easy to set up and aim at the desired satellite. This type of antenna is a single reflector, and the horn was positioned at the focal point. The prime spoiler points downward. The weakness of this antenna is that the feedhorn can block and reflect part of the RF signal. Prime focus antenna as shown in Figure. 1.

b) Cassegrain antenna

The Cassegrain antenna has the characteristic of the feeder funnel located on or behind the antenna dish. This antenna utilizes a dual reflector in the form of a paraboloid. The sub-reflector is in the form of a hyperboloid. This antenna also has a low level of sidelobe—Cassegrain Antenna, as shown in Figure. 2.

c) Gregorian antenna

The Gregorian antenna is the same as the Cassegrain antenna, distinguishing it from a concave ellipsoidal secondary reflector. This Gregorian antenna is slightly larger than the Cassegrain antenna in terms of design, but with a smaller secondary reflector, it gives the advantage of only slightly blocking the beam so that the Gregorian antenna is more efficient than other designs. Gregorian Antenna s shown in Figure. 3.

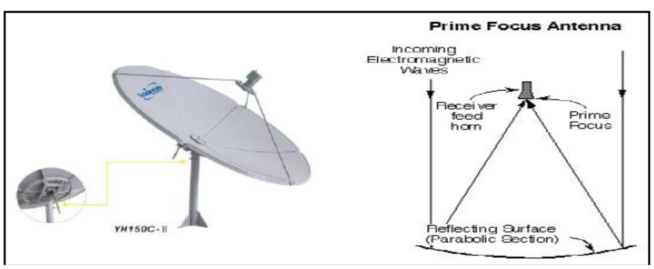

Fig. 1 Prime focus antenna [9].

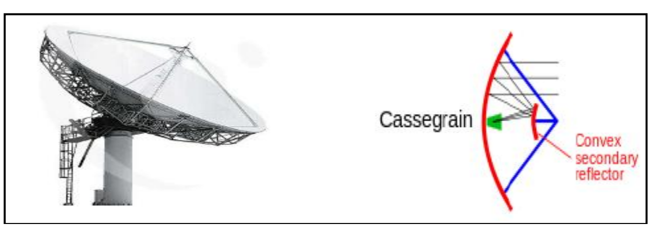

Fig. 2 Cassegrain antenna [9].

Fig. 3Gregorian antenna [9].

D. Routing Concept

Routing is a protocol applied to get routes from one network to another. Information from the route can be dynamically assigned to another router or given statically to another router. Routing also functions to forward packets from a router to the destination network. A router was made decisions based on the IP (Internet Protocol) address the packet points. All routers use the destination IP address to send packets [10]–[12].

For these routing decisions to be correct, routers must learn how to achieve their goals. When a router utilizes dynamic routing, this information is learned from other routers. When using static routing, a network administrator manually configures the information about the network to go. If the routing applied is static, then the configuration must be done manually. The network administrator must enter or delete the static route if there is a topology change.

E. Routing Concept

To get the best satellite communication system, it takes several values that need to be calculated from several parameters of the satellite link[13]. Budget link size is very influential on the performance of the satellite link. The purpose of calculating the link budget is to determine the transponder power consumption, know the High-Power Amplifier (HPA) requirements, and the transponder capacity. The satellite communication link budget calculation can be found using three components, namely the satellite payload, the earth satellite component, and the propagation path component [14], [15].

a) Satellite payload components

The satellite payload component is a component contained in the satellite which functions for the communication process. The satellite payload parameters are divided into 2 parts.

a. The satellite transmits side parameters consisting of satellite effective, or Equivalent, Isotropic Radiated Power (EIRP) which determines the transmit power level of the satellite.
b. The satellite receives side parameters consist of Gain-to-Noise-Temperature (G/T), which determines the quality, and Saturation Flux Density (SFD), which determines the signal reception sensitivity on the satellite.

b) Earth station components

The earth station component is a component that belongs to the earth station. This component has several parameters, including:

a. Uplink and downlink frequency.
b. Location of earth station coordinates (longitude and latitude) affect the azimuth and elevation of the antenna position at the earth station.
c. Earth station antenna gain on the Transmit side (Tx) and the Receive side (Rx) was influenced by the antenna diameter and antenna efficiency.

c) Propagation path components

The satellite communication propagation path calculates free air with about 36000km through the atmosphere and vacuum. These lines have various damping effects that affect the transmitted or received signal [16]–[19]. The types of propagation path attenuation are:

a. Free Space Loss (FSL)
b. Rain attenuation
c. Atmospheric Losses
d. Pointing loss
e. Other signal degradation (effect of solar fade, ice, clouds, fog, smoke.)

III. RESEARCH DESIGN

A. Hub Station System Planning

In the planning of this Hub, the current new satellite, BRIsat, was applied. In the planning of this hub station, an antenna with a diameter of 9 meters was applied as a hub station, and a modem system output from Hughes HX Systems was applied. HX System is Hughes broadband VSAT IP output. This system was specially designed for VSAT networks that require high Quality of Service (QoS). The Block diagram of hub station system planning is shown in Figure. 4.

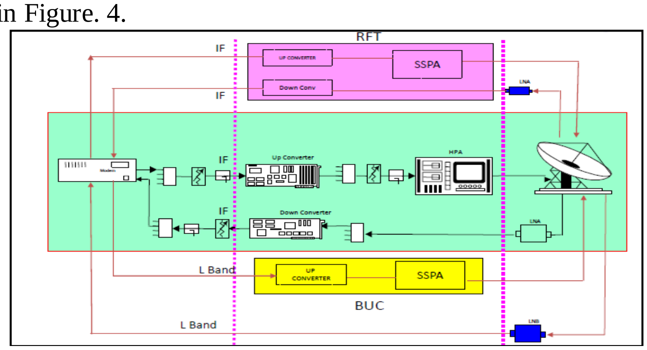

Fig. 4 Block Diagram of Hub Station and remote communication lines

The earth station component consists of Radio Frequency Transceivers (RFT) in the form of Antenna and Antenna Sub-system, High Power Amplifier (HPA) Solid State Power Amplifier (SSPA), Low Noise Amplifier (LNA), Up Converter (U/C), Down Converter (D/C), Modulator and Demodulator, Tail link, Adaptive Differential Pulse-Code Modulation (ADPCM), Echo Canceller.

The satellite was sent an RF signal from the ground station, which was forwarded through the BPF (Band Pass Filter) to the antenna's LNA (Low Noise Amplifier) . First, enter the modem. In this modem, the data was modulated. The modulation process uses the PSK technique. The purpose of this modulation aims to transmit information frequency waves into other waves at a higher frequency to be carried to the transmission medium. After that, it was the RFT (RF Transmission) device. In this RFT, there is an up and down converter. For the transmit process, an up-converter is used, which functions to translate the signal from an IF (Intermediate Frequency) medium frequency into an RF (Radio Frequency) signal. The output signal is 5.925 – 6.425 MHz. The following process enters the HPA. The HPA on this Hub uses the HPA SSPA (Solid State Power Amplifier) type to amplify the RF signal to be received by satellite. The signal that enters the feedhorn was reflected by the satellite with an antenna.

The receive process starts from the antenna receiving a signal from the satellite, the signal received by the antenna is then reflected the feedhorn, then from the feedhorn, the signal is forwarded to the LNA (Low Noise Amplifier) , which functions to suppress noise and amplify the received signal. Then the signal was forwarded to the down converter, whose function is to translate the RF signal into IF. After entering the down converter, the IF signal enters the modem device to carry out the demodulation process. This process is intended to separate the carrier signal from the information contained in it. Information that has been separated from the carrier signal was forwarded to user devices such as routers, multiplexers, or others

Hub station was applied by the BRIsat satellite. Following are the technical specifications for the BRIsat satellite:

a. Position: 150.5 °N
b. Mission Duration: 15 Years
c. Launch Date: June 16, 2016
d. Capacity: 45 Transponders
e. EIRP: 43dBW
f. G/T: 1dBK
g. Reliability: 0.85
h. Launcher: Space System /Loral (SS/L)
i. Altitude: 35782.04km

Figure. 5 is a flow chart of the switchover planning process from the Telkom-1 satellite to the BRIsat satellite.

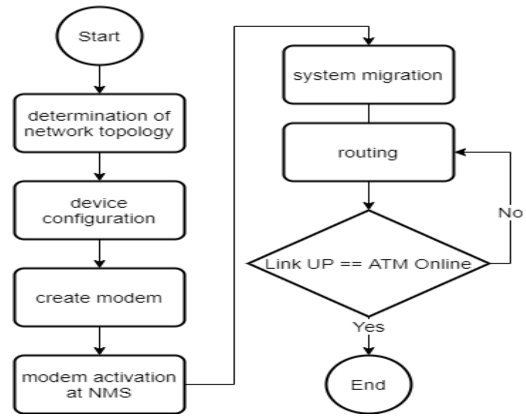

Figure. 5 Research Planning Flowchart

B. HX System Architecture

The core component of the HX System is the HX Gateway which functions as the system master and includes network management and bandwidth management. HX Gateway utilizes a DVB-S2 system with Adaptive Coding and Modulation (ACM) technique as the outbound channel received from all remote HX Systems. The Remote HX System utilizes FDMA/TDMA channels to communicate with the star or mesh network topology.

The highly efficient FDMA/TDMA of the HX System is based on current industry standards. The HX System FDMA/TDMA supports speeds of up to 9.8 Mbps. Efficiency and flexibility in utilizing terminal bandwidth are the advantages of the HX System. The following is a picture of the HX System on BRIsat.

C. RF Device and Antennas

The antenna applied in the BRIsat Hub system utilizes a Cassegrain antenna type [20], [21]. An example of a BRIsat Hub system satellite is shown in Figure. 6.

The antenna sub-system consists of a feedhorn, duplexer, polarizer, and manual jack. The feedhorn on the BRIsat Hub antenna utilizes a single polarization type.

HPA (high power amplifier)

The high-power amplifier can amplify the RF signal, which was transmitted to the satellite via the antenna. The HPA output power must be sufficient to transmit the RF carrier signal to the satellite and anticipate a sufficiently large propagation attenuation. The HPA applied at BRIsat is the HPA Solid State Power Amplifier (SSPA). HPA SSPA is an amplifier that provides RF signal amplification where both amplifier drivers apply transistor amplifiers. This SSPA bandwidth is 800MHz.

LNA (low noise amplifier)

LNA reinforces the signal coming from the satellite through an antenna with low noise and wide bandwidth (500 MHz).

Upconverter

Serves to convert Intermediate Frequency (IF) signals into Radio Frequency (RF) signals.

Downconverter

Serves to convert Radio Frequency (RF) signals into Intermediate Frequency (IF) signals.

Figure. 6. BRIsat Hub antenna.

D. Switchover Process

Switchover process or stages. At this switchover stage, the existing ATM Hub was moved to the new Hub. There are around 321 BRI ATM links via Telkom [22] that was switched over, and there are several steps, including:

Setting up data provisioning

This provisioning data is a new IP LAN and IP MAN to be created on the new system. After this data was created, the creation process was carried out faster.

Repointing and cross pole

Repointing and cross pole is one of the most critical things in the switchover process. Repointing and cross pole was done to change the direction of the antenna from the existing Hub to the new Hub. To do repointing, first determine the reflector azimuth angle roughly with a compass. BRIsat earth station is in the Ragunan area, South Jakarta. The azimuth and elevation positions are 83.5º and 38°.

Furthermore, to do pointing receive by directing the antenna to the satellite, rotate the azimuth and elevation slowly until a signal is obtained from the satellite. To rotate the elevation angle after getting the signal to a maximum, tighten the azimuth bolt, then rotate the feedhorn polarization to get the CPI and maximum C/N. The minimum CPI required at BRIsat is 30 dB according to the specifications. This step was repeated until the maximum receive signal was obtained. After the minimum square feet required at BRIsat was obtained, around 65 to 70, a modem is immediately created into the system. This process can be done quickly because the LAN IP and MAN IP have been obtained. Parameters can be entered into the modem and the BRIsat Hub system.

Routing Process and Hub topology to the BRIsat network

The routing process to the BRIsat Hub here uses the type of static route and OSPF. The static route is used towards the network hub and the BRI network using OSPF.

There are 4 routers, 1 switch, and a BRI cloud. To be able to route to BRI, prepare the IP to be moved. There are approximately 321 BRI ATM remotes that were moved, firstly. To faster the routing process, a static route is used to the Hub. This static route reduces the performance of the router processor and does not use the bandwidth used when exchanging information from the routing table when sending packets. Static routing is also safer to use from hackers to spoof with the aim of hijacking traffic. But the drawback of this type of routing is that the network administrator must know all the information from each user. The routing process is complicated due to manual router settings and is prone to errors when static routing data entry is done manually. To go to the BRI network, OSPF was used. This is where the remote ATMs that are migrated were routed. This feature is widely used in enormous network scales. OSPF (Open Shortest Path First) is a dynamic protocol that can maintain, manage, and distribute routing information between networks following any dynamic network changes. When routing is a routing loop, constraints occur because of the wrong route configuration, and the route is not configured.

IV. RESULT AND DISCUSSION

This section shows the results of the link budget calculation, aiming to determine the quality and performance of the link and satellite. The things that affect the performance of this link are the data carrier and the type of modulation applied.

A. Bandwidth Calculation

Specification data on the ATM VSAT IP BRIsat is shown in Table I below.

Table 1. Weapon Dome Rotation Speed Test Results

Data rate	30Mbps
Modulation type	8-PSK
FEC	3/4
Bandwidth ATM	32bps

For the required bandwidth, 321 ATM locations are needed.

$$Total\ Traffic = number\ of\ links \times ATM\ bandwidth$$
$$= 321 \times 32kbps = 10272kbps$$

Accepted net rate with 40% assuming throughput

$$=10272\text{kbps} \times 40\% = 4108.8\text{kbps}$$

Required bandwidth

$$= \frac{Rate(1+\propto)}{N \times FEC}$$

$$= \frac{4108.8(1+2)}{3 \times 0.75}$$
$$= 2929.63\ kHz$$

Bandwidth (Inbound and Outbound) with a guard band

$$= 2191.36kHz \times 1.2 = 2629.63kHz$$

Bandwidth occupied

$$= BW\ Inbound + BW\ Outbound$$
$$= 2629.63kHz + 2629.63kHz$$
$$= 5259.26kHz$$

Bandwidth allocation

B. EIRP Calculation

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The Effective Isotropic Radiated Power (EIRP) to find out the amount of power transmitted from the satellite or the antenna on the earth station can be calculated using the equation below by considering the factors in the table above, including the High-Power Amplifier (HPA) in the system is 10 watts and loss 1 dB feeder. In the calculation of this link, f_{Tx} = 6.070 GHz is used, f_{Rx} = 3.911 GHz, the diameter of the transmitter antenna is 9 meters, the diameter of the antenna is 1.8 meters.

Antenna gain states the magnitude of the gain of the receiving and transmitting antennas at an earth station which is influenced by 3 main components, namely the uplink frequency for the transmit antenna or the downlink frequency for the receive antenna (f), the antenna diameter (D), and the antenna efficiency (y). Based on these 3 components, the antenna gain value (G) can be calculated using the following equation.

G_{ant} = 20.4 + 20 log f(GHz)+ 20 log D(m) + 10 log y

with:

Gain = gain of transmitting or receiving antenna (dB)

F = Uplink or downlink frequency (GHz)

D = diameter of transmitting or receiving antenna (m)

y = Efficiency of transmitting or receiving antenna (%)

Inbound calculation

$G_{ant\ Tx}$ = 20.4 + 20log$f$(GHz) + 20log$D$(m) + 10logη
= 20.4 + 20 log(6.070) + 20 log(1.8) + 10log(0.6)
= 18.86dB

$G_{ant\ Rx}$ = 20.4 + 20log$f$(GHz) + 20log$D$(m) + 10logη
= 20.4 + 20 log(3.911) + 20log(9) + 10log(0.6)
= 28.95dB

Outbound calculation

$G_{ant\ Tx}$ = 20.4 + 20log$f$(GHz) + 20log D(m) + 10log η
= 20.4 + 20log(6.070) + 20log(9) + 10log(0.6)
= 52.930dB

$G_{ant\ Rx}$ = 20.4 + 20log$f$(GHz) + 20log$D$(m) + 10logη
= 20.4 + 20 log(3.911) + 20 log(1.8) + 10 log(0. 6)
= 35.132dB

The EIRP calculation is as follows.

$EIRP_{SB}$ (Hub) = 10log(HPA) + GainTX + Loss feeder
= 10log(10Watt) + 52.930dB – 1
= 61.93dBW

$EIRPVSAT_{Remote}$ = 10log(HPA) + GainTX + Loss feeder
= 10log(10Watt) + 18.86dB – 1
= 27.86dBW

C. Determining Carrier-to-Noise Ratio

The Carrier-to-noise ratio or C/Nis the ratio between the signal power of the carrier and the noise power received. C/N was widely applied in satellite communication systems where it indicates the quality of the satellite link. From the known parameters, the uplink and downlink C/N can be calculated as follows:

1. $EIRP_{SB}$ = 55.354dBW
2. $EIRP_{SAT}$ = 11.44dBW
3. G/T_{SB} = 14.18 dB/ºK
4. G/T_{SAT} = 1dB/ºK
5. Uplink propagation loss = 143.73dB
6. Downlink propagation loss= 138.62dB

$C/N_{uplink} = EIRP_{SB} – L_{propagationTx} + G/T_{SAT} – k – B$
= 61.93 – 143.73 + 1 – (–228.6) –
(10log (6311.11 × 1000))
= 79.80dB

$C/N_{downlink} = EIRP_{SAT} – L_{propagationRx} + G/T_{SB} – k – B$
= 11.34 – 138.62 + 14.18 – (–228.6) –

$$(10 \log (6311.11 \times 1000)$$
$$= 47.498\text{dB}$$

Based on the evaluation done in this previous section the hub station planning in this study, it is obtained the optimal calculation results from the satellite link budget with 6311.11KHz, with the optimal use of HPA, and the results from the appropriate EIRP calculations to obtain the optimum carrier-to-noise ratio at 79.80dB at Uplink and 47.498db at the downlink. This cam helps the application of satellites to save more bandwidth and have optimized performance than before.

V. CONCLUSIONS

Based on the analysis results obtained from the data and analysis, the migration process must perform cross pole to find the minimum copy value that occurs between the primary carrier and the cross-pole carrier. The routing method applied is static routing for networks to the Hub and OSPF towards the BRI network, then the static route is redistributed to the OSPF BRI peer network. The calculation data obtained that the bandwidth allocation is 6311.11kHz from a total of 321 ATM links with an ATM bandwidth of 32Kbps. For bandwidth allocation (70MHz), EIRPSB 61.93dBW is required. Suggestion for further research is to do calculations with other interference to get more measurable results in satellite applications

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