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ANALYSIS OF THE IMPACT OF VSAT AND FIBER OPTIC ACCESS MEDIA USAGE ON THE NETWORK PERFORMANCE OF BANK SYARIAH INDONESIA (BSI) ATMS IN LINTASARTA, KALIMANTAN AREA

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Abstract (English)

The ATM communication network in the Kalimantan region utilizes two main access media: VSAT and Fiber Optic. VSAT is used in remote areas with limited infrastructure, while Fiber Optic is implemented in urban areas with better connectivity. This study aims to analyze the performance of both access media based on bandwidth, delay, and packet loss parameters across 20 ATM samples of Bank Syariah Indonesia (BSI) in Kalimantan. The results indicate that VSAT has higher latency and is more susceptible to weather conditions, although it still provides an average SLA above 99%. Meanwhile, Fiber Optic demonstrates more stable performance with low latency and high speed but is vulnerable to physical disruptions such as cable cuts. To enhance network quality, bandwidth optimization for VSAT and Fiber Optic infrastructure expansion into semi-urban areas are necessary.

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Key Words

VSAT, Fiber Optic, ATM, network performance, SLA.

I. PENDAHULUAN

The advancement of communication technology has driven the increasing demand for reliable network services, including in the banking sector. Bank Syariah Indonesia (BSI), as one of the largest financial institutions in the country, faces significant challenges in ensuring the availability of Automated Teller Machine (ATM) services in Kalimantan, a region characterized by diverse geographical conditions. In urban areas, telecommunication infrastructure has developed well, making Fiber Optic (FO) the primary choice. Fiber Optic, commonly known as optical cable, is a data transmission medium made of thin and flexible glass fibers with a diameter of less than 200 micrometers. This technology utilizes light as the transmission medium, offering high-speed data transfer and remarkable reliability compared to traditional copper cables (Arya Dwi Purnama & Lammada, 2024).

Meanwhile, in remote areas that are not yet covered by fiber optic networks, BSI employs Very Small Aperture Terminal (VSAT) technology as a connectivity solution. VSAT is a satellite-based communication system equipped with a small dish antenna, typically less than three meters in diameter (Hendrian et al., 2023). In rural and underdeveloped areas with limited infrastructure, BSI adopts VSAT access media to ensure continuous ATM operations even in locations with minimal telecommunication access. This is also supported by the Regulation of the Minister of Defense of the Republic of Indonesia Number 19 of 2023 concerning the Procedures for the Use of Telecommunication Services within the Ministry of Defense and the Indonesian National Armed Forces. Chapter II, Part Two, Article 11, Paragraph 1, stipulates that VSAT, as referred to in Paragraph (2), is prioritized for outermost, underdeveloped, and frontier regions, as well as areas not yet served by fiber optic or terrestrial networks. Furthermore, Article 12, Paragraph 1 specifies that VSAT IP, as mentioned in Article 4, Point (g), is used as a communication service with satellite transmission media where data packets are transmitted and received in the form of Internet Protocol (Permenhan RI, 2014).

VSAT enables ATMs to connect directly to BSI's central servers via satellite, ensuring real-time transaction processing. This capability is crucial for maintaining reliable and efficient banking services for customers in remote regions (Team, 2024). Both FO and VSAT offer

distinct advantages and limitations, thus requiring a comprehensive performance analysis to determine their effectiveness in supporting BSI's ATM services.

The main issue identified in this study is the significant performance gap between VSAT and Fiber Optic access media. While VSAT is capable of reaching remote areas, it suffers from several limitations, including high latency, limited bandwidth, and susceptibility to weather conditions. In contrast, Fiber Optic provides stable performance with high bandwidth capacity and low latency, but its implementation is restricted to regions with adequate infrastructure. This imbalance raises questions about the effectiveness of each technology in supporting BSI's ATM operations.

Based on this problem, the research was conducted to analyze the impact of using VSAT and Fiber Optic access media on the network performance of BSI's ATMs in the Kalimantan region. The study employs technical parameters such as bandwidth, delay, and packet loss, while also referring to the Service Level Agreement (SLA) data provided by Lintasarta as the network provider. By focusing on 20 ATM locations, this research aims to provide a comprehensive overview of the reliability of both access media under different geographical conditions.

The primary objective of this study is to provide a deeper understanding of the strengths and weaknesses of each access medium and to compare their resulting network performance. Furthermore, the research seeks to offer strategic recommendations for BSI and network service providers in selecting the most appropriate technology based on operational needs and geographical constraints. In this way, the study is expected to make a tangible contribution to the development of more equitable banking services in Indonesia.

The results of this research are not only academically valuable in enriching the literature on the performance of VSAT and Fiber Optic networks, but also practically beneficial for the industry. For BSI, the findings may serve as a foundation for decision-making regarding network implementation strategies, while for service providers such as Lintasarta, this study may provide insights into developing services that are better aligned with customer needs. Through a combination of technical analysis and strategic considerations, this research is expected to support the improvement of banking service quality in Kalimantan, both in urban areas and in remote regions.

II. THEORETICAL

2.1 Sistem Komunikasi Satelit

A Satellite Communication System is a communication system that utilizes satellites as its transmission medium. In general, a satellite communication system consists of a satellite functioning as a repeater station in outer space, which is interconnected with several earth stations. Signals transmitted from the originating earth station are received and amplified by the equipment on the satellite, and then retransmitted to the designated earth station (Sadikin, Nanang, 2020).

This satellite communication system is commonly used in areas that are difficult to reach by terrestrial networks. This serves as one of the key advantages of satellite communication systems compared to other communication systems. Due to its wide coverage, satellite communication is capable of reaching remote areas, making it highly suitable for Indonesia's

2.2 VSAT (Very Small Aperture Terminal)

VSAT, which stands for Very Small Aperture Terminal, is a satellite signal receiving station equipped with a dish antenna with a diameter of less than three meters. The main function of VSAT is to transmit and receive data from satellites. Satellites serve as repeaters, forwarding the transmitted signals to other points on the earth's surface. The VSAT dish is directed toward a Geostationary Satellite. A Geostationary Satellite is one that remains in the same position relative to the earth's surface, synchronized with the earth's rotation on its axis,

made possible by orbiting at a specific point above the earth's surface and continuously following the earth's rotational movement (Hendrian et al., 2023).

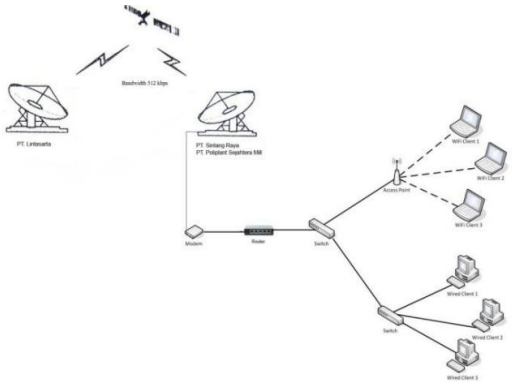

Figure 2.1. VSAT Network Architecture

2.3 Parameter QoS pada jaringan VSAT

Quality of Service (QoS) refers to the ability of a network to provide optimal service in accordance with established standards related to network capacity, filtering, and delay management. QoS is used to measure a set of performance attributes that are specified and associated with a particular service (Yusuf, Abdilah et al., 2024). To evaluate the performance of VSAT, several parameters are required, including:

2.3.1 Bandwidth

The bandwidth of a network is determined by the number of bits that can be transmitted through the network within a specific time interval. Bandwidth is usually measured in bps (bits per second) or Kbps (kilobits per second) (Sugiyanta, Lipur et al., 2024).

2.3.2 Delay

Delay is the time interval required from the moment data is transmitted until it is received at the destination point. The quality of a network is highly influenced by the magnitude of delay. Table below presents the standardization of delay according to TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) (Sugiyanta, Lipur et al., 2024).

Table 2.1. Delay Standardization According to TIPHON

Category	Delay Range
Excellent	< 150 ms
Good	150 s/d 300 ms
Fair	300 s/d 450 ms
Poor	> 450 ms

2.3.3 Packet Loss

Packet Loss refers to the condition where a certain number of data packets fail to reach their intended destination. This may occur due to collisions, network congestion, or physical damage in the transmission medium. The following table presents the standardization of Packet Loss according to TIPHON (Telecommunications and Internet Protocol Harmonization Over Networks) (Sugiyanta, Lipur et al., 2024).

Table 2.2. Packet Loss Standardization According to TIPHON

Category	Packet Loss Rate
Excellent	0%
Good	3%
Fair	15%
Poor	25%

2.4 Fiber Optic (FO)

Fiber Optic is a type of network that enables the transmission of light as a substitute for electrical signals, which are commonly used in copper-based networks. Although relatively expensive, Fiber Optic offers a much longer transmission range, from more than 550 meters to hundreds of kilometers, and is capable of delivering data at higher speeds compared to other types of networks. In addition, Fiber Optic is resistant to electromagnetic interference. To transmit information, bit signals are converted into light signals before being transmitted through the optical fiber (Muhammad Ridhwan & Lela Nurpulaela, 2023).

The Fiber Optic telecommunication system involves the transmission of light energy through the optical fiber. How light travels within Fiber Optic depends on the properties of light and the structure of the optical fiber being used. In the context of telecommunications, light is regarded as a form of energy that propagates in the form of waves. Therefore, Fiber Optic is also referred to as an optical waveguide, since it serves as a light guide for optical waves. Light can propagate in two different media and do so in three ways: traveling straight, refracting, or reflecting. When light passes through two different media, part of the light is reflected back into the first medium while the other part is refracted. The structure of Fiber Optic can be seen in Figure 2.2.

Figure 2.2 Fiber Optic Structure

2.5 How Fiber Optic Works

While conventional cables use electric current to transmit data, Fiber Optic utilizes light signals. The light flow used is the result of converting electrical signals into optical form, making it completely immune to electromagnetic interference. Furthermore, Fiber Optic employs glass fibers to achieve high levels of light reflection, ensuring that all data can be distributed and transmitted at optimal speed. This reflection occurs when light propagates through glass fibers at low angles. In practice, the efficiency of Fiber Optic transmission is influenced by the purity of the material: the purer the glass, the lower the light absorption. This results in higher reflection and, consequently, high-speed data transmission (Fahmi, 2022).

2.6 QoS Parameters in Fiber Optic Networks

2.5.1 Bandwidth

Bandwidth is the range of frequencies used by a signal within the transmission medium to send or receive data in computer networks. Bandwidth is usually measured in bps (bits per second) or Kbps (kilobits per second) (Arditya et al., 2024).

2.5.2 Delay

Delay, or latency, is the amount of time required for data to travel from the source point to the destination point. Factors such as distance, physical medium, congestion, or processing time may affect the level of delay (Arditya et al., 2024).

$$Delay = \frac{Total\ Delay}{Jumlah\ Total\ Paket} \quad \text{.....(1)}$$

Table 2.3 Categories of Delay in Fiber Optic

Category	Delay Value
Excellent	< 150 ms
Good	150 s/d 300 ms
Fair	300 s/d 450 ms
Poor	> 450 ms

2.5.3 Packet Loss

Packet Loss is a parameter that indicates the number of lost packets, which can occur due to collisions and obstructions within the network.

Table 2.4. Packet Loss Categories in Fiber Optic

Category	Packet Loss Rate
Excellent	≤ 3%
Good	> 3 s/d 15%
Fair	> 15 s/d 25%
Poor	> 25%

III. RESEARCH METHODOLOGY

3.1 Research Method

The method used in this study is the quantitative research method. Quantitative research is employed to analyze structured data collected in accordance with existing theories, enabling the data to be analyzed systematically. The stages conducted in this research include literature review, data collection, and data analysis.

3.2 Types of Data

The data used in this research consist of both primary and secondary data. Primary data refers to data obtained from the Lintasarta network monitoring system, with performance parameters such as bandwidth, latency, and packet loss. Secondary data refers to Service Level Agreement (SLA) data, which include complaint reports from BSI and are calculated based on opened complaint tickets. SLA data are derived from official agreement documents between BSI and Lintasarta, containing information related to the performance of VSAT and Fiber Optic networks.

3.3 Data Collection Method

The required data were collected through several documents containing allocated bandwidth for each ATM, network topology for both VSAT and Fiber Optic, as well as performance and SLA records for both access media using parameters such as bandwidth, delay, and packet loss during the period of April–September 2024. This data collection was conducted to allow a direct comparison of the performance between VSAT and Fiber Optic networks operating in Kalimantan, particularly in West Kalimantan and South Kalimantan.

Network performance data were obtained from Lintasarta. These data include the operational performance of VSAT and Fiber Optic networks for BSI in Kalimantan based on both parameters and SLA. The collected data were then compared with real measurement results to verify whether the network performance met the agreed standards. Network performance data contain service quality indicators based on parameters that measure the performance of ATM networks.

3.4 Data Analysis Technique

Once the research data were collected, the analysis method used was SLA compliance analysis. This analysis was conducted by comparing actual performance data with the performance standards defined in the SLA. If there were significant discrepancies between actual results and SLA agreements, further analysis was carried out to identify the causes, such as weather disturbances or technical issues.

IV. RESULTS AND DISCUSSION

This research was conducted based on network performance data collected over six months, from April to September 2024, in the Kalimantan area, specifically in West Kalimantan and South Kalimantan provinces. The study focused on parameters such as bandwidth, delay (downtime), and packet loss at 20 BSI ATM locations. VSAT and Fiber Optic access media have different characteristics, making this analysis essential to compare their performance. In addition, this discussion also covers factors influencing network performance based on data analysis results.

The findings show that both access media generally demonstrated good performance, although certain technical challenges affected service quality at several locations. These challenges included physical disturbances in Fiber Optic infrastructure and technical issues in VSAT systems. Performance analysis was carried out by examining the levels of delay (downtime) and packet loss.

Fiber Optic was used at 10 ATM locations, most of which were located in urban areas of West and South Kalimantan provinces, where network infrastructure is more developed. This access medium generally provides greater connection stability because it relies on physical cable pathways. VSAT, on the other hand, was deployed at 10 ATM locations in West Kalimantan province, mostly situated in remote areas or locations that are difficult to reach by Fiber Optic networks. This access medium leverages satellite technology, which offers greater flexibility but tends to be affected by weather conditions and other external disturbances.

Table 4.1 Bandwidth, Delay, and Packet Loss

No	Service ID	Remote Name	Bandwidth	*Delay (Latency)*	*Packet Loss*
1	2023356757	ATM RS PELITA INSANI	64 K	128 ms	<1 %
2	2014000537	ATM KEMENAG PALANGKARAYA	64 K	128 ms	<1 %
3	2017007730	ATM SWALAYAN CITRA JERUJU PONTIANAK	64 K	128 ms	<1 %
4	2017011303	ATM TOKO ATK MARKET PANCASILA	64 K	128 ms	<1 %
5	2017004714	ATM OBELIX PALANGKARAYA	64 K	128 ms	<1 %
6	2014001972	ATM STAR MART PONTIANAK	64 K	128 ms	<1 %
7	2021287454	ATM AHMAD YANI MEGAMALL	64 K	128 ms	<1 %
8	2021287502	ATM UNIVERSITAS MUHAMMADIYAH PALANGKARAYA	64 K	128 ms	<1 %
9	2021287549	ATM IAIN PONTIANAK	64 K	128 ms	<1 %
10	2022337319	ATM PDAM TIRTA MELAWI	64 K	128 ms	<1 %
11	2021287555	ATM PT ASM	64 K	697 msec	<1 %
12	2021287457	ATM PT ANDES AGRO KETAPANG	64 K	656 msec	<1 %
13	2021287460	ATM INDO SAWIT KEKAL	64 K	717 msec	<1 %

14	2021287464	ATM HARAPAN SAWIT LESTARI	64 K	664 msec	<1 %
15	2021287465	ATM ANDES AGRO INVESTAMA	64 K	658 msec	<1 %
16	2021287540	ATM AIR UPAS	64 K	797 msec	1%
17	2021287543	ATM ARGO INVESTAMA	64 K	802 msec	1%
18	2021291228	ATM PT USAHA AGRO INA SAMPOERNA	64 K	642 msec	3%
19	2021287824	ATM PT POLIPANT SEJAHTERA	64 K	632 msec	<1 %
20	2021287468	ATM RUMAH MAKAN KURAYU SAMBAS	64 K	632 msec	<1 %

Table 4.1 presents the allocation of two types of access media, namely Fiber Optic and VSAT, in ATM networks across various locations. A total of 10 ATMs utilize Fiber Optic, which are generally located in urban areas. The selection of Fiber Optic in these regions is due to the more advanced infrastructure, enabling networks with low latency and minimal packet loss. This is crucial to ensure that banking transactions are executed quickly and efficiently, particularly in areas with high transaction volumes.

In contrast, 10 ATMs employ VSAT as their access medium, mostly situated in remote areas or locations with limited telecommunication infrastructure. VSAT is chosen for its ability to provide connectivity in regions that are difficult to reach via terrestrial networks. However, VSAT networks tend to have higher latency compared to Fiber Optic, especially under adverse weather conditions. This can affect the processing speed of ATM transactions, although operations remain possible in areas without alternative network options.

The allocated bandwidth of 64 Kbps reflects the standard bandwidth provisioned for ATM operations. Nevertheless, the effectiveness of this bandwidth still depends on the connection quality provided by each access medium. To enhance ATM network performance, it is necessary to optimize infrastructure—either by increasing Fiber Optic capacity in urban areas or by developing VSAT technology with lower latency in remote regions.

SLA analysis was conducted to identify and evaluate the level of downtime experienced at several locations during the period of April–September 2024, as presented in Table 4.2.

Table 4.2 Network Performance Based on SLA

No	**Service ID**	**Remote Name**	**Media Akses**	**Freq**	**Downtime Pelanggan**	**Downtime LA**	**Perf. LA (%)**
1	2023356757	ATM RS PELITA INSANI	FO	1	0Mins	9Hrs, 1Mins, 16Secs	98.74
2	2014000537	ATM KEMENAG PALANGKARAYA	FO	0	0Mins	0Mins	100
3	2017007730	ATM SWALAYAN CITRA JERUJU PONTIANAK	FO	0	0Mins	0Mins	100
4	2017011303	ATM TOKO ATK MARKET PANCASILA	FO	0	0Mins	0Mins	100
5	2017004714	ATM OBELIX PALANGKARAYA	FO	0	0Mins	0Mins	100
6	2014001972	ATM STAR MART PONTIANAK	FO	0	0Mins	0Mins	100
7	2021287454	ATM AHMAD YANI	FO	0	0Mins	0Mins	100

		MEGAMALL					
8	2021287502	ATM UNIVERSITAS MUHAMMADIYAH PALANGKARAYA	FO	0	0Mins	0Mins	100
9	2021287549	ATM IAIN PONTIANAK	FO	0	0Mins	0Mins	100
10	2022337319	ATM PDAM TIRTA MELAWI	FO	0	0Mins	0Mins	100
11	2021287555	ATM PT ASM	VSAT	0	0Mins	0Mins	100
12	2021287457	ATM PT ANDES AGRO KETAPANG	VSAT	0	0Mins	0Mins	100
13	2021287460	ATM INDO SAWIT KEKAL	VSAT	2	0Mins	3Hrs, 53Mins, 4Secs	99.47
14	2021287464	ATM HARAPAN SAWIT LESTARI	VSAT	0	0Mins	0Mins	100
15	2021287465	ATM ANDES AGRO INVESTAMA	VSAT	0	0Mins	0Mins	100
16	2021287540	ATM AIR UPAS	VSAT	0	0Mins	0Mins	100
17	2021287543	ATM ARGO INVESTAMA	VSAT	0	0Mins	0Mins	100
18	2021291228	ATM PT USAHA AGRO INA SAMPOERNA	VSAT	6	5Hrs, 3Mins, 41Secs	4Hrs, 1Mins, 55Secs	99.45
19	2021287824	ATM PT POLIPANT SEJAHTERA	VSAT	0	0Mins	0Mins	0Mins
20	2021287468	ATM RUMAH MAKAN KURAYU SAMBAS	VSAT	0	0Mins	0Mins	0Mins

Table 4.3 Details of Network Disturbances Based on SLA

No	Service ID	Ticket Number	Remote Name	Start Time	End Time	RFO	Action	MTTR (Jam)	SLA (%)	Access Media	Month
1	2021287460	2024-000646842	ATM INDO SAWIT KEKAL	27-JUL-2024 06:48:34	27-JUL-2024 07:58:16	Link Down - Kualitas di bawah standar	Push by NMS	1Hrs,9Mins,12Secs	99.47	VSAT	Juli
2	2021287460	2024-000647147	ATM INDO SAWIT KEKAL	28-JUL-2024 11:05:55	28-JUL-2024 13:50:43	Device Hang	No Action dari sisi Lintasarta	2Hrs,43Mins,52Secs	99.47	VSAT	Juli
3	2021291228	2024-000649520	ATM PT USAHAAGRO INA SAMPOERNA	02-AUG-2024 01:27:04	02-AUG-2024 06:18:12	MODEM TIDAK DAPAT LISTRIK	MENUNGGU LISTRIK UP	1Hrs,17Mins,36Secs	99.45	VSAT	Agustus
4	2021291228	2024-000650692	ATM PT USAHA AGRO INA SAMPOERNA	06-AUG-2024 01:44:01	06-AUG-2024 05:09:13	MODEM TIDAK DAPAT LISTRIK	MENUNGGU LISTRIK UP	1Hrs,36Mins,37Secs	99.45	VSAT	Agustus

5	2021291228	2024-000652859	ATM PT USAHA AGRO INA SAMPOERNA	10-AUG-2024 06:21:01	10-AUG-2024 07:49:51	MODEM TIDAK DAPAT LISTRIK	MENUNGGU LISTRIK UP	1Hrs,7Mins, 42Secs	99.45	VSAT	Agustus
6	2023356757	2024-000663547	[GAMAS] ATM RS PELITA INSANI	01-SEP-2024 18:47:12	02-SEP-2024 04:02:37	GAMAS – FO CUT	REJOINTING *FIBER OPTIC*	9Hrs,1Mins, 16Secs	98.74	FO LA	September

Table 4.3 presents data on network disruptions that occurred during the research period across various ATM locations. The information listed in the table includes the Service ID or network number, Ticket Number as the complaint identification for disruption reports, Remote Name indicating the affected ATM location, as well as the start and end times of the disruption. In addition, the table records the RFO (Root Cause of Failure), the Action taken to resolve the issue, the MTTR (Mean Time to Repair) as the average repair duration, and the SLA (Service Level Agreement) indicating the service availability level.

The findings of this study confirm that Fiber Optic (FO) is the best-performing access medium for BSI ATM services. The characteristics of FO, which utilizes optical fiber as the transmission medium, make it resistant to electromagnetic interference and capable of providing low latency and high throughput. Therefore, FO is highly suitable for use in urban areas or regions where cable infrastructure is already available. The disruptions that occurred, such as those at RS Pelita Insani, were primarily caused by external factors such as cable cuts due to fieldwork, rather than limitations of the FO technology itself.

Conversely, VSAT remains the primary solution for remote areas not covered by FO, despite its relatively lower performance. Its limitations are particularly evident in the high latency caused by the signal transmission distance to geostationary satellites, which is approximately 36,000 km, resulting in longer propagation times. Other disruptions found in the SLA data include device hang, modem power failures, and link down due to degraded signal quality. Under these conditions, VSAT SLA still meets service standards, but its quality is highly affected by uncontrollable external factors.

The performance differences have a direct impacton customer experience. FO enables fast transactions, minimal queues, and rare failures, supporting customer satisfaction and trust in BSI services in urban areas. In contrast, VSAT often causes slower transactions, particularly during traffic surges or adverse weather conditions. In fact, a packet loss of 3%, as observed at the ATM of PT Usaha Agro Ina Sampoerna, can lead to transaction failures, potentially reducing customer satisfaction.

This analysis is important to provide a clearer understanding of the speed and stability of the network experienced by end-users in the field. Fiber Optic has significant advantages over VSAT in terms of bandwidth. With its high capacity, Fiber Optic is able to provide faster communication channels, enabling a greater volume of data transactions to be processed more efficiently. In contrast, VSAT faces greater challenges due to its reliance on satellite signals, which have inherent limitations in both capacity and speed. Several ATM locations utilizing VSAT recorded lower bandwidth, which can affect transaction speed and application response times. Nevertheless, VSAT remains the primary option in remote areas without access to Fiber Optic, despite its more limited performance compared to Fiber Optic.

In terms of delay, Fiber Optic generally offers lower latency due to its more direct and efficient communication path. Its higher data transmission speed reduces the time required for data packets to be delivered, which is crucial to ensuring smooth ATM transactions without significant delays. Conversely, VSAT is characterized by higher latency since it involves longer signal travel distances to and from the satellite, which affects

the overall response time.

In addition to delay and bandwidth, packet loss is also a critical parameter in evaluating network performance. Fiber Optic demonstrates lower levels of packet loss, meaning fewer data packets are lost during transmission. VSAT, on the other hand, tends to experience higher packet loss, particularly during adverse weather conditions or technical issues that affect signal quality. This results in a greater amount of data loss, ultimately having a negative impact on the user experience.

The practical implications of this study highlight the need for different infrastructure management strategies for FO and VSAT. For FO, the main focus should be on physical cable maintenance and rapid response to cable cut incidents. For VSAT, additional mitigation is required, such as backup power supply, more proactive device monitoring, and system configuration optimization to minimize the impact of delay.

Thus, this study reaffirms that FO is the ideal solution to ensure the performance of BSI ATM services, while VSAT remains essential to support service equity in regions without cable infrastructure. However, to maintain reliable services, improvements are required in terms of maintenance, monitoring, and disruption mitigation strategies, particularly for locations that still rely on VSAT.

V. CONCLUSION

The use of VSAT as an access medium enables connectivity in remote areas with relatively high stability, although it is characterized by significant latency, largely influenced by weather conditions at the site. Despite this, VSAT provides an average SLA above 99%. On the other hand, Fiber Optic delivers a more stable SLA (100%), lower latency, and higher transmission speed, although it is vulnerable to physical disruptions such as cable cuts. Overall, Fiber Optic demonstrates superior performance with low latency and high throughput, making it ideal for urban deployments. Meanwhile, VSAT, although less efficient in speed and latency, remains more flexible and indispensable for providing connectivity in remote regions.

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