



Comparative Analysis of QoS VSAT IP and VSAT Star TelkomSAT

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A B S T R A C T

Technological developments and the increase in internet users, estimated to reach 185 million in early 2024, have driven the need for reliable communication network services, especially for underdeveloped, frontier, and outermost (3T) areas in Indonesia, where internet coverage is still minimal. Based on these problems, telecommunications service providers need to prepare appropriate designs to provide optimal service to customers by providing a quality network. TelkomSAT offers solutions through satellite-based services, especially very small aperture terminals (VSAT). Quality of service (QoS) testing is carried out by measuring throughput, packet loss, delay, and jitter using transmission control protocol (TCP) and user datagram protocol (UDP) data to compare the performance of VSAT IP and VSAT Star. The results show that VSAT Star is superior in throughput and delay, with an average throughput of 8.79 Mbps and an average delay of 12.32 ms. This is better than VSAT IP which only produces 6.43 Mbps and 83.94 ms. Both services have the same average packet loss of 0%. However, VSAT IP is more stable in terms of jitter with an average value of 0.36 ms compared to VSAT Star which produces 1.05 ms. In the ping test to the public domain (Google.com), VSAT Star showed an excellent average value of 38.55 ms compared to 584.05 ms for VSAT IP. Overall, VSAT Star has greater potential because of its advantages such as auto point, larger bandwidth, and lower delay.

INTRODUCTION

Technological developments accompanied by a surge in internet users have become crucial in maintaining the reliability and availability of communication network services. Communication is one of the important things so that individuals or groups can interact with each other [1]. According to Katadata.co.id, internet users have increased from 2014 to 2024. Even in January 2024, the number reached 185 million individuals in Indonesia, representing around 66.5% of the total national population of 278.7 million. This also shows that around 33.5% of people have not had internet services or connections. Some factors can influence this, namely areas that are classified as underdeveloped, frontier, and outermost (3T) categories [2].

The 3T region is a part of the country that requires special attention because many problems occur there. One of the main problems is internet service coverage, which is influenced by geographical, social, and cultural development factors [3]. In addition, limited infrastructure makes it difficult for cable and cellular internet services to reach this area, plus challenging geographic conditions such as mountains and remote islands, as well as political instability, make telecommunications service providers reluctant to operate there [4].

Based on these problems, telecommunications service providers need to prepare appropriate designs to provide optimal service to

customers by providing a quality network [5]. TelkomSAT is here to solve this problem by providing upstream and downstream satellite-based telecommunications services. TelkomSAT currently operates 3 satellites, including the Telkom-3S Satellite, Merah Putih 1, and Merah Putih 2, which can meet telecommunications service needs that cannot be reached by cable or cellular technology [6]. TelkomSAT is also collaborating with SpaceX to support the acceleration of equitable connectivity throughout Indonesia through Starlink products [7]. Starlink is the world's first and largest satellite constellation, using thousands of satellites orbiting at a distance of 500 km (low earth orbit) [8]. TelkomSAT currently relies on very small aperture terminal (VSAT) technology, including VSAT IP and VSAT Star. Even though they are similar, they both have different configurations. These differences can be seen from the type of satellite, orbit location, frequency, and the ground segment device used [9].

Several studies discussing the performance of VSAT services have been published in the last few years [10] [11] [12] and concluded that the service is classified as good according to quality of service (QoS) standards and is suitable for implementation. QoS parameters such as throughput, packet loss, delay, and jitter can be a reference for whether a network's performance is good. The drawback of this research [10] [11] [12] is that the calculation of QoS parameters must be done manually and does not compare the performance of different data protocols. Comparing different data protocols, such as transmission control

protocol (TCP) and user datagram protocol (UDP), is very important because each protocol has its characteristics for transmitting data. TCP has the characteristic of guaranteeing that data packets reach their destination safely, even though it takes longer. UDP has the characteristic of prioritizing the speed of arrival time (latency) of a data packet. However, it does not have retransmission capabilities when the data packet is lost in transit [13]. Network traffic generator tools such as Distributed Internet Traffic Generator (D-ITG) can automate QoS measurements, send TCP and UDP data packets with varying loads, and automatically display throughput, packet loss, delay, and jitter [14].

Based on this statement, research was conducted entitled "Comparative Analysis of QoS VSAT IP and VSAT Star Telkomstar". The QoS parameters measured are throughput, packet loss, delay, and jitter. The testing scheme is carried out by loading TCP and UDP data packets of 5 MB, 10 MB, 15 MB, 20 MB, and 25 MB for 25 seconds with twenty iterations using the D-ITG tool as a packet generator and Wireshark to see traffic when the data is transmitted. Load delivery testing is peer-to-peer from one virtual machine (VM) to another VM installed on the VMware emulator software by utilizing the network of the two services being tested. Also, delay testing was conducted by conducting a ping test towards the public domain, namely Google.com.

METHODS

Survey

Before collecting data, a survey was conducted first with the person in charge of Telkomstar's VSAT IP and VSAT Star services to find out the specifications. It is known that the VSAT IP service uses the Merah Putih 1 satellite, which is at a distance of 35,786 km and has a visibility time of 24 hours (geostationary earth orbit). Meanwhile, the VSAT Star service uses the Starlink satellite with a distance of 500 km and a visibility time between 10 and 20 minutes [13].

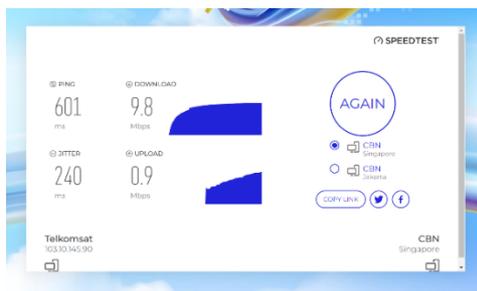


Figure 1. VSAT IP Speed Test Results



Figure 2. VSAT Star Speed Test Results

VSAT IP services use C-Band frequencies, while VSAT Star uses Ku-Band. For bandwidth, VSAT IP has upload speeds of 1 Mbps and downloads of 10 Mbps, while VSAT Star offers uploads of 40 Mbps and downloads of 10 Mbps. Based on the speed test results show that the Ku-Band frequency can produce greater bandwidth than the C-Band frequency [14]. The VSAT IP and VSAT Star service speed test was carried out at the Telkomstar office, which can be seen in Figures 1 and 2.

Very Small Aperture Terminal

A very small aperture terminal (VSAT) is an antenna used on the ground segment as an earth station/terminal to transmit data, both sending and receiving from satellites. VSAT consists of two parts, namely the outdoor unit (ODU), which functions as a transceiver, which is placed outside the room, and the indoor unit (IDU), which transmits to end-user devices such as computers, telephones, etc. [15].

Quality of Service (QoS)

Quality of service (QoS) is used to evaluate service quality. This aims to ensure the reliable performance of a system [15]. One of the standards commonly used in QoS evaluation is Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON), issued by the European Telecommunication Standard Institute (ETSI). QoS parameters are important in assessing the overall effectiveness of network traffic [16]. The QoS parameter index can be seen in Table 1.

Table 1. QoS Parameter Index

Index	Percentage (%)	Category
3.8 - 4	95 - 100	Excellent
3 - 3.79	75 - 94.75	Good
2 - 2.99	50 - 74.75	Fair
1 - 1.99	25 - 49.75	Bad

Throughput is a parameter that assesses the total number of packets successfully sent from the sender to the recipient within a predetermined time interval. This measure indicates the actual amount of data that can be transferred at one time, often considered a true reflection of bandwidth. Table 2 is the throughput parameter index based on the TIPHON standard [16].

Table 2. Throughput Parameter Index

Index	Throughput	Category
4	> 2.1 Mbps	Excellent
3	1200 Kbps - 2.1 Mbps	Good
2	700 - 1200 Kbps	Fair
1	338 - 700 Kbps	Bad
0	0 - 338 Kbps	Very Bad

Packet loss is a parameter that measures the number of data packets lost during the transmission process. Packet loss can be caused by various factors, ranging from collisions to network traffic congestion. This condition can affect the overall performance of connected applications, reducing network efficiency even though the available bandwidth is sufficient. Table 3 is the packet loss parameter index based on the TIPHON standard [16].

Table 3. Packet Loss Parameter Index

Index	Packet Loss	Category
4	0 %	Excellent
3	3 %	Good
2	15 %	Fair
1	25 %	Bad

Delay or latency is a parameter that measures the total time required to transmit data from the sender to the receiver. Factors such as distance, hardware used, and traffic levels can affect the resulting delay. Table 4 is the delay parameter index based on the TIPHON standard [16].

Table 4. Delay Parameter Index

Index	Delay	Category
4	< 150 ms	Excellent
3	150 – 300 ms	Good
2	300 – 450 ms	Fair
1	> 450 ms	Bad

Jitter or arrival fluctuation is a parameter that measures variations in the arrival of data packets in a network. These variations can occur due to various factors such as long queues, packet processing, and retransmissions on network devices. Table 5 is the jitter parameter index based on the TIPHON standard [16].

Table 5. Jitter Parameter Index

Index	Jitter	Category
4	0 ms	Excellent
3	0 - 75 ms	Good
2	75 - 125 ms	Fair
1	125 - 225 ms	Bad

Network Protocol

Network protocols are rules that govern all data transmission in a network. With this protocol, data can be sent, received, and managed properly, allowing interaction between network devices. Some of the most commonly used network protocols are TCP and UDP. TCP is a connection-based protocol that builds a connection first between the sender and receiver before transmitting data, thus allowing the data to be sent to be more structured and allowing for retransmission if a failure occurs. On the other hand, UDP is a more straightforward protocol and does not require establishing a relationship before sending. Even though its security is not guaranteed and does not have data retransmission capabilities like TCP, UDP has the advantage of faster delivery times [17]. Testing using TCP and UDP protocols is to compare the resulting QoS. Considering that the two data protocols have different characteristics.

Emulator

An emulator is a software that is used so that an operating system can run on top of another operating system. One of the most popular emulator software applications is VMware. VMware is often used for testing and development, as it allows the creation of secure systems without damaging the main system [18]. VMware functions to run the VM used for testing media.

Network Traffic Generator

Network traffic generators create artificial traffic to measure network performance and reliability. D-ITG is a tool that plays a role in making network traffic in the form of TCP and UDP data

protocols, and it functions as a tool for measuring QoS. D-ITG operates through two nodes that play different roles: server and client. On the client side (ITGSend), the task is to generate and send a data stream to the server, which is then recorded in the server log (ITGLog). On the server side (ITGRecv) the device acts as a recipient of the data flow from the client and can store the data in the server log (ITGLog) [18]. The function of D-ITG in this research is to generate data packets in the form of TCP and UDP, as well as automatically measure QoS parameters of the resulting VSAT IP and VSAT Star services.

Network Packet Analyzer

Network traffic analyzers monitor, record, and analyze traffic passing on a network. This can help network administrators understand the network activity being investigated. Wireshark is a commonly used network traffic analyzer tool. The Wireshark analysis process starts by capturing packets from a network connection directly, then filtering by cutting out several unnecessary parameters, and finally, visualization to display the analysis results so that they are easy to understand [19]. The Wireshark function checks the type of data protocols that pass when testing.

Research Flow

The research was conducted to know the differences in the performance of VSAT IP and VSAT Star services. Apart from comparison, this research aims to provide education for potential consumers so that they know the advantages and disadvantages of the services being tested. This can provide a reference for potential consumers to see various existing aspects. The research flow can be seen in Figure 3.

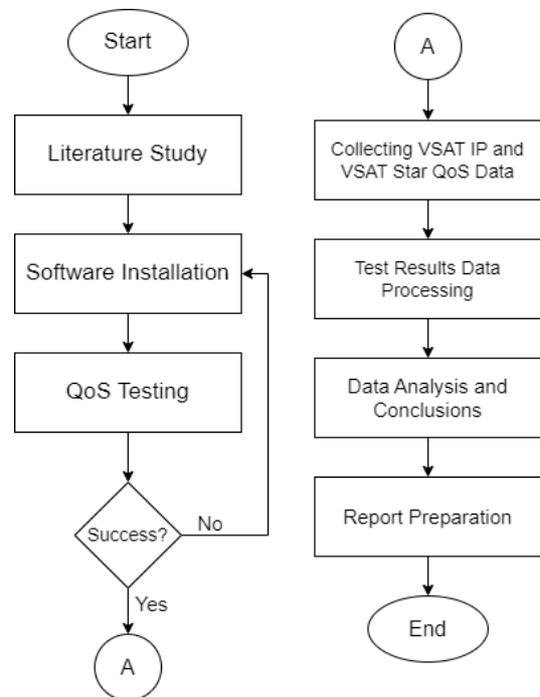


Figure 3. Research Flow

The method used to analyze the performance of VSAT IP and VSAT Star services uses TIPHON standardized QoS parameters. Whether the service performance is good or not can be seen from the resulting index. The scenario used is sending TCP-UDP data packets peer-to-peer from one VM to another with load variations

ranging from 5 MB, 10 MB, 15 MB, 20 MB, and 25 MB. Testing was conducted for 25 seconds with twenty iterations to ensure data accuracy. He also carried out a ping test towards the google.com domain to determine how long it took for the data to arrive.

RESULTS AND DISCUSSION

The research process was carried out by testing the performance and analyzing the QoS of the VSAT IP and VSAT Star services. Data retrieval is carried out by sending loads of TCP and UDP data packets from one VM to another and observing the resulting QoS values. The D-ITG tool will display the resulting QoS parameters, assisted by Wireshark, to ensure the data packets transmitted are correct. A ping test was conducted in the public domain to determine how long the data took to return.

Throughput Parameter Analysis

Based on the data in Figure 4 shows that the average service quality of both VSAT IP and VSAT Star is equally good, even though the VSAT Star service is still superior. This difference is largely due to the bandwidth allocation used by the two services. VSAT Star has a bandwidth of 10 Mbps for downloads and 40 Mbps for uploads, while VSAT IP uses 10 Mbps for downloads and 1 Mbps for uploads. These differences directly affect the throughput generated by each service. Throughput is a real representation of the bandwidth that can be used in a network, and throughput tends to increase as the available bandwidth increases. In testing the VSAT Star service, average throughput reached its highest point at 8.79 Mbps when testing 25 MB TCP data delivery. This result is higher than when testing the VSAT IP service, which only reached 6.43 Mbps when performing the same test. This shows that a network with greater bandwidth can quickly transmit data, improving service performance.

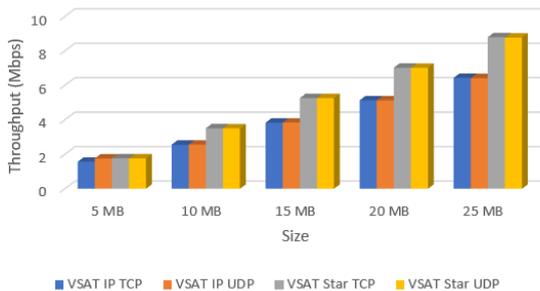


Figure 4. Throughput Testing Results

Testing was conducted with various data sizes, ranging from 5 MB to 25 MB. The results show that the quality of service at a data size of 5 MB only produces an index of "3" or "Good" based on the TIPHON standard, while for larger data sizes such as 10 MB, 15 MB, 20 MB, and 25 MB the quality increases to "4" or "Very Good". This shows that the VSAT Star service can handle larger data loads with better performance. In other words, the larger the data size sent, the greater the throughput that can be achieved. Although both VSAT services are of good quality, the difference in bandwidth allocation makes VSAT Star superior in situations that require higher network performance. Users requiring fast and reliable data transmission and huge data loads will benefit more from VSAT Star services. The throughput testing results can be seen in Table 6.

Table 6. Throughput Testing Results

Service	Data Protocol	Size	Throughput (Mbps)
VSAT IP	TCP	5 MB	1.56
		10 MB	2.56
		15 MB	3.80
		20 MB	5.13
		25 MB	6.43
	UDP	5 MB	1.75
		10 MB	2.56
		15 MB	3.84
		20 MB	5.13
		25 MB	6.42
VSAT Star	TCP	5 MB	1.76
		10 MB	3.51
		15 MB	5.26
		20 MB	7.02
		25 MB	8.79
	UDP	5 MB	1.76
		10 MB	3.50
		15 MB	5.26
		20 MB	7.01
		25 MB	8.77

Packet Loss Parameter Analysis

Figure 5 shows that the average quality produced is the same for both VSAT IP and VSAT Star services when transmitting packets. The same good quality is reflected in all test scenarios' average packet loss test results of 0%.

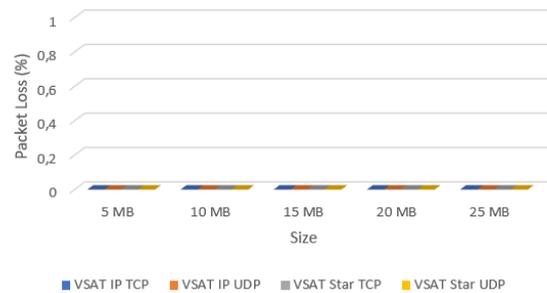


Figure 5. Packet Loss Testing Results

In the context of a communications network, having no data packets lost during transmission is a very positive indicator so that network performance can be categorized with an index of "4" or "Excellent" according to the TIPHON standard. Testing was conducted with varying data sizes, ranging from 5 to 25 MB. Interestingly, there is no difference in service quality even though the size of transmitted data increases. This shows that the VSAT network tested has adequate capacity and is stable in handling various load sizes. The network's ability to maintain the same quality across a wide range of data sizes is critical to maintaining user satisfaction. It can be concluded that VSAT IP and VSAT Star services are reliable solutions for data communication needs, both on a small and large scale. Stable service quality supports using VSAT in broader scenarios, including industries requiring constant and uninterrupted data transmission, especially in the 3T area. The packet loss testing results can be seen in Table 7.

Table 7. Packet Loss Testing Results

Service	Data Protocol	Size	Packet Loss (%)
VSAT IP	TCP	5 MB	0
		10 MB	0
		15 MB	0
		20 MB	0
		25 MB	0
	UDP	5 MB	0
		10 MB	0
		15 MB	0
		20 MB	0
		25 MB	0
VSAT Star	TCP	5 MB	0
		10 MB	0
		15 MB	0
		20 MB	0
		25 MB	0
	UDP	5 MB	0
		10 MB	0
		15 MB	0
		20 MB	0
		25 MB	0

Delay Parameter Analysis

Figure 6 shows that the average delay quality from peer-to-peer load delivery testing produces excellent quality for the two services tested.

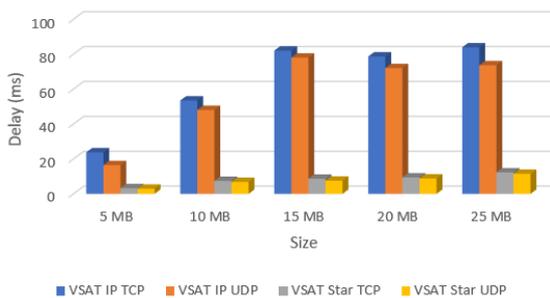


Figure 6. Delay Testing Results

The longest average delay produced by the VSAT Star service reached 12.32 ms when testing 25 MB TCP data delivery, in contrast to the VSAT IP service, which reached 83.94 ms when performing the same test. This is because the satellite used for VSAT IP services is the Merah Putih Satellite. The satellite is located in geostationary earth orbit (GEO), 35,786 km above the earth's surface. This very long distance will undoubtedly cause a delay. This differs from the VSAT Star service, which uses Starlink's satellite located in low earth orbit (LEO), which is only 500 – 2,000 km above the earth's surface. If we look at the test pattern, the more significant the data packet sent, the higher the delay. However, the resulting index is "4" or in the "Excellent" category by TIPHON standards. It can be concluded that the distance between the satellite (orbit location) and the earth (earth station) and the amount of data transmitted can influence the resulting delay. The farther the satellite's orbit is from the Earth, the higher the delay, and vice versa. The resulting delay will be lower if the satellite's orbit is closer to the Earth. The delayed testing results can be seen in Table 8.

Table 8. Delay Testing Results

Service	Data Protocol	Size	Delay (ms)
VSAT IP	TCP	5 MB	23.79
		10 MB	53.48
		15 MB	82.05
		20 MB	78.68
		25 MB	83.94
	UDP	5 MB	16.48
		10 MB	48.04
		15 MB	78.03
		20 MB	72.03
		25 MB	73.63
VSAT Star	TCP	5 MB	3.25
		10 MB	7.43
		15 MB	8.64
		20 MB	9.39
		25 MB	12.32
	UDP	5 MB	2.97
		10 MB	6.79
		15 MB	7.53
		20 MB	8.79
		25 MB	11.47

Jitter Parameter Analysis

Based on the data in Figure 7, shows that the average quality of jitter from peer-to-peer load delivery testing produces good quality.

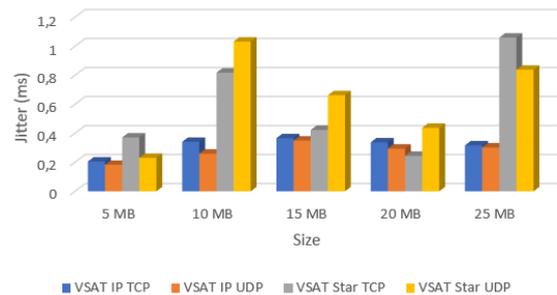


Figure 7. Jitter Testing Results

However, when compared, the VSAT IP service produces better jitter than the VSAT Star service. The highest average jitter produced by the VSAT IP service reached 0.36 ms when testing 15 MB TCP data delivery, in contrast to the Star VSAT service, which reached 1.05 ms when testing 25 MB TCP data delivery. Several factors, such as the type of frequency used, can cause this. The frequency used by the IP VSAT service is C-Band, which is quite stable in all weather conditions compared to the VSAT Star service, which uses the Ku-Band frequency. Even though this frequency has a higher data rate than C-Band, Ku-Band frequencies are known to be vulnerable to climate change. In addition, the orbits used by satellites for VSAT IP are located in GEO. Satellites placed in orbit will always be in the same position or point following the Earth's rotation speed with a visibility time of 24 hours. This is different from the VSAT Star service, which uses LEO satellites. Even though the resulting delay is quite slight because it is closer to the earth, the visibility time is only 10 – 20 minutes, which means it is not always in the same position. The difference in frequency and visibility time can factor in the difference in jitter produced. It can be concluded that the more constant the position of a satellite, the smaller the resulting jitter

or delay variation. However, the resulting index is "3" or in the "Good" category by TIPHON standards. The jitter testing results can be seen in Table 9.

Table 9. Jitter Testing Results

Service	Data Protocol	Size	Jitter (ms)
VSAT IP	TCP	5 MB	0.20
		10 MB	0.34
		15 MB	0.36
		20 MB	0.33
		25 MB	0.31
	UDP	5 MB	0.18
		10 MB	0.25
		15 MB	0.34
		20 MB	0.29
		25 MB	0.30
VSAT Star	TCP	5 MB	0.37
		10 MB	0.81
		15 MB	0.42
		20 MB	0.24
		25 MB	1.05
	UDP	5 MB	0.23
		10 MB	1.03
		15 MB	0.66
		20 MB	0.43
		25 MB	0.83

Delay of Ping Test Parameter Analysis

Based on the data in Figure 8, testing shows that the VSAT Star service has a much lower delay, with an average of 38.55 ms, compared to 584.05 ms for the VSAT IP service.

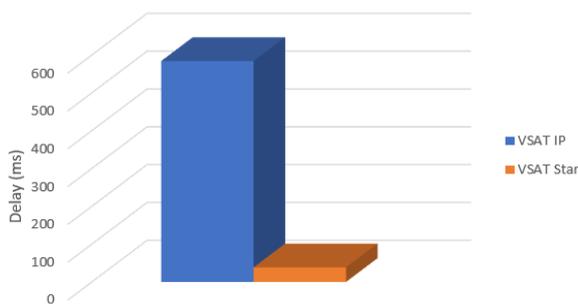


Figure 8. Delay of Ping Test Results

Following TIPHON standardization, the VSAT Star service produces an index of "4" or "Excellent" compared to the VSAT IP service, which produces an index of "1" or "Bad." This significant difference reflects VSAT Star's superiority in network response speed. Delay or latency is the time it takes for a data packet to reach its destination and return. This parameter is key in determining network quality, especially for time-sensitive applications such as video conferencing, online gaming, and other real-time applications. The main difference that influences this delay is the orbital position of the satellites used by each service, as explained in the previous test. The difference is that this time, the test was carried out by sending data packets to the public domain outside the Telkomsat network environment (Google.com), which is different from the previous test, which was carried out on the local network. This test strengthens the statement that the distance between the satellite and the Earth is a

key factor in determining the resulting delay. The closer a satellite is to the Earth, the faster signals can be sent and received. It is proven that the VSAT Star service offers significant advantages in terms of latency compared to VSAT IP. For organizations or individuals needing a low-latency satellite internet connection, especially for applications requiring fast and efficient communication, VSAT Star services are a more appropriate choice. However, it is also important to consider other factors, such as cost, bandwidth requirements, and geographic coverage, when selecting the most appropriate service. The testing emphasizes the importance of selecting the right satellite service according to needs, especially regarding latency and network performance in different conditions in the local and global environment. The delay in ping test results can be seen in Table 10.

Table 10. Delay of Ping Test Results

Ping Test to Public Domain (Google.com)	
Service	Delay (ms)
VSAT IP	584.05
VSAT Star	38.55

QoS testing using TCP and UDP data protocols, especially in satellite communications, has an important role in determining the quality of service and network performance. This is supported by previous research [20] [21] [22] [23] [24], which shows that each data protocol has its characteristics in producing service quality. If a failure occurs, TCP has the advantage of retransmission because it prioritizes data safety over transmission speed. UDP does not have this capability but has better transmission speeds than TCP. Therefore, comparing different data protocols, such as TCP and UDP, is very important because each protocol has different characteristics and test quality.

CONCLUSIONS

This research compares the quality of VSAT IP and VSAT Star services with tests carried out by sending TCP and UDP data packets of various sizes. The results show that VSAT Star is superior in throughput and delay, with an average throughput of 8.79 Mbps and an average delay of 12.32 ms. This is better than VSAT IP which only produces 6.43 Mbps and 83.94 ms. Both services have the same average packet loss of 0%. However, VSAT IP is more stable in terms of jitter with an average value of 0.36 ms compared to VSAT Star which produces 1.05 ms. In the ping test to the public domain (Google.com), VSAT Star showed an excellent average value of 38.55 ms compared to 584.05 ms for VSAT IP. VSAT IP is more stable because it uses a C-Band frequency which is reliable in all weather conditions, while VSAT Star offers advantages in throughput and better delay thanks to the Ku-Band frequency and LEO orbit. Overall, VSAT Star has greater potential because of its advantages such as auto point, larger bandwidth, and lower delay. The testing carried out in this research was located in the city center, especially the Telkomsat office. It is hoped that further research can be carried out in open locations so that the resulting performance can be maximized.

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