Implementation of Port Forwarding on Local Servers Using Mikrotik in GPON Technology Network

Hendico Ade Rey[1], Yoyok Heru Prasetyo Isnomo[2*], Mochammad Taufik[3], Nugroho Suharto[4]

[1,2] Digital Telecommunication Network Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[3,4] Telecommunication Engineering Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[1] hendicoader@gmail.com, [2] yoyok.heru@polinema.ac.id, [3]m.taufik@polinema.ac.id, [4]nugroho.suharto@polinema.ac.id

***abstract* — This study aims to implement port forwarding on MikroTik routers to enable access to local servers through internet networks within an environment that utilizes GPON (Gigabit Passive Optical Network) technology at the Fiber Optic Laboratory of Malang State Polytechnic. GPON technology is widely recognized for its ability to deliver high-speed data transmission and improved service quality compared to conventional copper-based or traditional cable networks. By leveraging fiber optic infrastructure, GPON provides higher bandwidth capacity, lower signal attenuation, and greater efficiency in supporting modern network services. The research adopts an implementation-based method that focuses on configuring port forwarding on MikroTik routers and integrating VPN (Virtual Private Network) services provided by tunnel.my.id. This approach is used to address the limitations commonly encountered in networks that rely on dynamic public IP addresses. The results of this study indicate that the implementation of port forwarding combined with VPN services successfully allows local servers, which were previously accessible only through the intranet, to be accessed via the internet network without relying on static public IP addresses. Performance testing shows that the quality of network services meets the standards established by TIPHON and ITU-T. The average data transfer speed on the internet network reaches 20.2 Mbps with a delay of 8.11 ms, while the intranet network achieves a data transfer speed of 978.9 Mbps with a delay of 47.34 ms, demonstrating reliable and efficient network performance.**

Keywords — GPON, MikroTik, Port forwarding, TIPHON, VPN.

I. INTRODUCTION

The development of computers and advances in information technology in the current era of globalization continue to develop in line with human needs that all require ease and speed in accessing information [1]. Information technology has penetrated into various sectors of life, including the education sector [2]. The current era of strong globalization encourages the education sector to adapt to technological developments to achieve better student skill improvement [3]. One way to utilize information technology advances is through the establishment of a fiber optic laboratory located in the FO Lab of the AH Building of the State Polytechnic of Malang which can be used as a practicum for fiber optic network installation for telecommunication students [4].

In the early stages, the network infrastructure used in the Malang State Polytechnic environment was still dominated by conventional cable-based networks (copper). This type of network has limitations in data transmission speed, relatively small bandwidth capacity, and suboptimal quality of service (QoS) [5], so that it has not been able to support the increasing needs of data access and network services [6]. This condition encourages the need for the development of more reliable and high-speed network technology.

Fiber optics are a type of transmission media that has a speed of up to 1 Gbps, as well as a high level of reliability. This medium is used as a means of transmission for long distances. With highly reliable and fast transmission capabilities of up to several gigabits per second, fiber optics are perfect as a communication channel [7]. The technology that is often used in fiber optic networks is Gigabit Passive Optical Networ (GPON).

The use of fiber optic technology, especially GPON, is expected to overcome the limitations of conventional cable networks by improving data transmission speed, network stability, and overall service quality. GPON technology is able to provide greater bandwidth and lower latency, supporting increasingly complex data access and network service needs. With these characteristics, the implementation of GPON is a relevant solution to improve network performance, especially in educational environments that require high and reliable connectivity.

GPON is an optical network technology based on the Passive Optical Network (PON) which refers to the ITU-T G.984 standard. GPON provides high-speed service, reaching 2.4 Gbps downstream and 1.2 Gbps upstream. The distance that GPON signals can reach from the Optical Line Terminal (OLT) to the Optical Network Terminal (ONT) reaches 20 km. One of the unique features of this GPON technology is the use of distribution techniques that are carried out passively [8].

Although fiber optic network infrastructure and GPON have been developed at the State Polytechnic of Malang, especially in the Fiber Optic Laboratory of the AH Building, there are still

*Corresponding Author

obstacles in its utilization. Students of the Department of Electrical Engineering, especially the Telecommunications Study Program, experience limitations in accessing certain network services. These limitations are mainly related to access to local web servers that cannot be accessed optimally through the internet network, both from inside and outside the campus area.

The local web server used is on a GPON-enabled network, but access is still limited to the internal network. To overcome this problem, this study utilizes the port forwarding feature on MikroTik routers as a solution to open access to local server services. However, the implementation of port forwarding in GPON networks has its own challenges, one of which is related to the limitations of public IP [9].

The implementation of port forwarding in the GPON intranet network has aspects that need to be considered, such as limited Public IP resulting in Clients not being able to access campus services through the internet network. This is due to the Public IP obtained from the main provider being non-fixed or Dynamic IP Public, making Public IP static not the main solution, due to the high Public Static IP rental rate [10].

The novelty of this research lies in the integrated application of port forwarding on MikroTik routers and third-party remote VPN (tunnel.my.id) services as a practical solution to the limitations of dynamic public IP on GPON-enabled networks in educational laboratory environments. This study modifies the scheme of utilization and access to GPON network services, namely transforming local server access that was originally limited to intranet networks to be accessible through the internet network. This study directly implements local web server access on a real GPON infrastructure. In addition to proving the success of access, this study also analyzed network performance quantitatively based on the parameters of data transfer speed, bandwidth, and delay, resulting in an applicable, economical, and relevant GPON-based local server access implementation model for the needs of educational institutions without dependence on static public IP.

The researcher uses a VPN service from tunnel.my.id that provides a Remote VPN service that functions to access mikrotik over the internet without having to have a Static Public IP. A Virtual Private Network (VPN) is a communication system on a computer network that allows a device to connect to a local server network without having to connect directly to the public network infrastructure (internet) so that the local server can be accessed remotely [11]. By using the VPN service from tunnel.my.id, which is combined with the port forwarding method on mikrotik so that the client can easily access local server services over the internet. The function of port forwarding is to open access to devices on the local network to be accessed through a public network (internet).

II. METHODS

A. Block Diagram

The following is shown a block diagram image of the network topology used

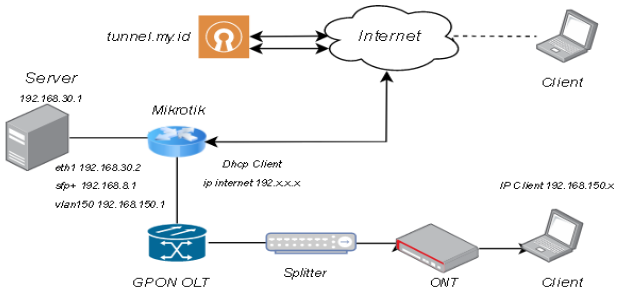


Figure 1 Intranet and Internet Network Topology Diagram Block

Figure 1 explain in this network system, several components are interconnected to support data communication and service access. The server functions as a device that provides data and services that can be accessed by the client, which acts as the end user receiving information from the server. Network traffic management is handled by the MikroTik router, which is responsible for routing, network configuration, and port forwarding to enable access to the local server. The internet serves as a bridge connecting the MikroTik router to the Tunnel My ID VPN service, allowing remote access to the local network without requiring a static public IP address. The network infrastructure utilizes GPON (Gigabit Passive Optical Network) technology, where the GPON OLT (Optical Line Terminal) manages and distributes optical signals through fiber optic cables. The optical signals are then divided using a splitter and transmitted to the ONT (Optical Network Terminal), which converts the optical signal into an electrical signal that can be connected to client devices via Ethernet. Through the integration of these components, the system enables efficient access to the local server through both intranet and internet networks.

B. Flowchart Tool Working System

The following is a flowchart for the working system of the tools in this study.

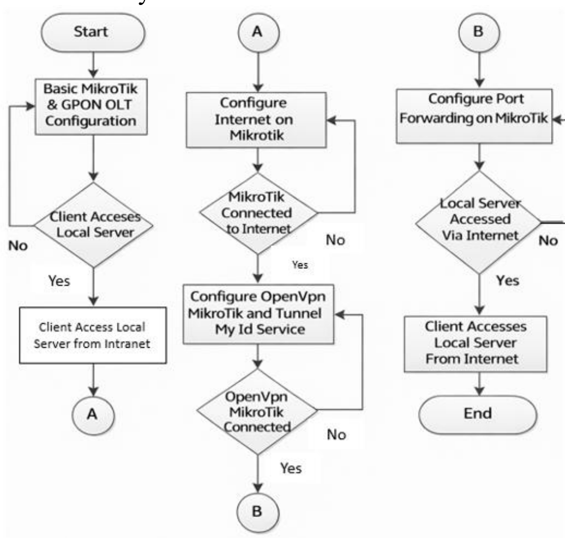


Figure 1 Flowchart Tool Working System

In the Figure 2 Flowchart, the stages that are passed as a working system of tools. The research process begins with the configuration of the GPON OLT and MikroTik router, including basic settings such as configuring the DHCP Server on both devices, which are then connected to the ONT through a splitter. After the initial setup, the client attempts to access the local server through the intranet by connecting to the ONT using an Ethernet cable in order to measure network performance parameters such as speed, bandwidth, and delay. The next stage involves configuring the internet connection on the MikroTik router by setting up the DHCP Client and conducting a connectivity test using a ping to Google. After the internet connection is established, an OpenVPN interface is added to the MikroTik router by creating a VPN account on the Tunnel My ID service and configuring the OpenVPN connection using the registered account credentials. Subsequently, port forwarding is configured on MikroTik by adding Netwatch IP and configuring NAT rules to enable external access to the local server. Finally, the client attempts to access the local server through the internet network to evaluate the network performance again, including speed, bandwidth, and delay.

C. Tools and Materials

The tools and materials needed in making the Implementation of the Forwarding Feature Using Mikrotik to Access Local Servers from the Internet in the Case Study of Intranet with GPON Technology in the FO Polinema Lab are as follows, in Table I.

TABLE I
RESEARCH TOOLS

No.	Tool Name	Remarks
1	*Router* Mikrotik	Functions to regulate *the bandwidth* that enters the *ONT WiFi* Router.
2	OLT	It functions to provide a network by transmitting light signals through fiber optic cables
3	Laptop	Functions to set up a network on WiFi *Router*, *Microtik Router, GPON devices and is used to be a* server *and* Client *on a network.*
4	*Splitter*	Serves to split the optical beam emitted by the GPON device.
5	ONT	Works for *Client connections* from ethernet cables

Table I presents the hardware devices used in this research to support the implementation of the network system. The MikroTik router functions as the main device for managing bandwidth and routing within the network. The GPON OLT is used to transmit data through fiber optic cables in the form of optical signals. A laptop is utilized to configure the network devices and also functions as both a server and a client during testing. In addition, a splitter is used to divide the optical signals from the GPON device, while the ONT serves as the device that connects the fiber optic network to the client through an Ethernet connection, in Table II.

TABLE II
RESEARCH MATERIALS

No.	Material Name	Remarks
1	Cable Fiber Optics	Data transmission media and light signals.
2	Cable RJ45	Data transmission media connected to the Server
3	Cable SFP+	Data transmission media connected from Mikrotik Router to GPON.

Table II shows the transmission media used in the network implementation. Fiber optic cables serve as the main medium for transmitting data in the form of light signals within the GPON network. RJ45 cables are used to connect the server to the network through Ethernet communication. Meanwhile, SFP+ cables are used to establish a connection between the MikroTik router and the GPON device, enabling high-speed data transmission within the network infrastructure, in Table III.

TABLE III
SOFTWARE

No.	Software Name	Remarks
1	Winbox	Configure the microtik device
2	Wireshark	Software to get Delay values
3	OpenSpeedTest	Useful for finding data transfer speeds in the local scope (intranet)
4	IDM	Apps that can show bandwidth when downloading data.

Table III lists the software applications used to configure the network and measure its performance. Winbox is used to configure and manage the MikroTik router. Wireshark is utilized to analyze network traffic and obtain delay values during testing. OpenSpeedTest is used to measure data transfer speeds within the local intranet network. In addition, Internet Download Manager (IDM) is used to observe bandwidth performance during the process of downloading data from the server.

III. RESULT AND DISCUSSION

A. Test Points

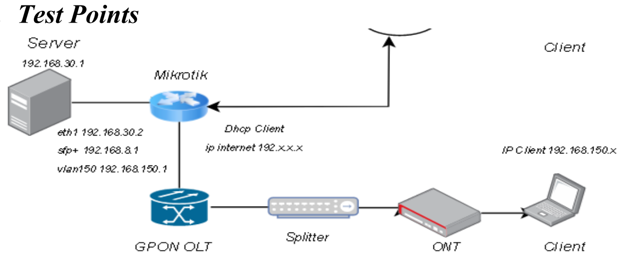


Figure 2 Titik Pengujian Jaringan Kabel LAN

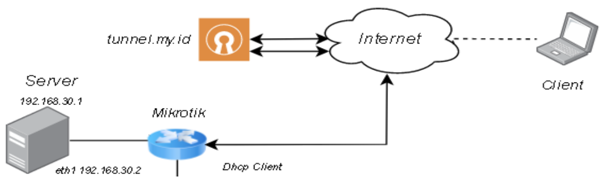


Figure 3 Wireless Network Test Points

Figure 2 and 3 explain the first test point that the client connected to ONT on an intranet line using a LAN cable, the ONT used in this study was the ZTE ZXHN F670L. The client connected to the ONT retrieves data from the server through the microtik path through the GPON OLT and to the ONT. The test is that both clients connect wirelessly and access the server address "polinema.id19.tunnel.my.id/gpon" that has been configured port forwarding on mikrotik.

B. Transfer Speed Testing

Speed testing performed by ONT-connected client laptops. Testing was also carried out 3 times. Here is the transfer speed test data, as shown in Table IV.

TABLE IV
TESTING TRANSFER SPEED PARAMETERS WITH INTERNET

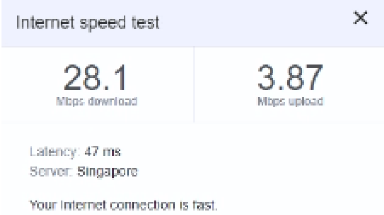
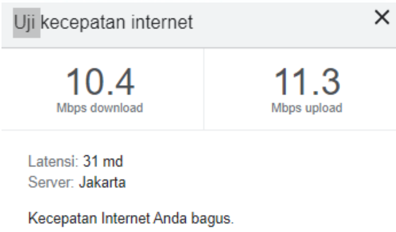
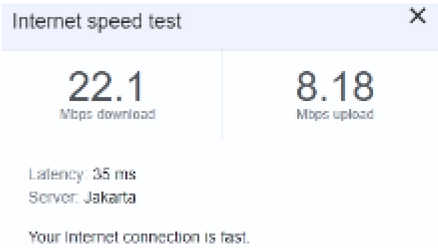
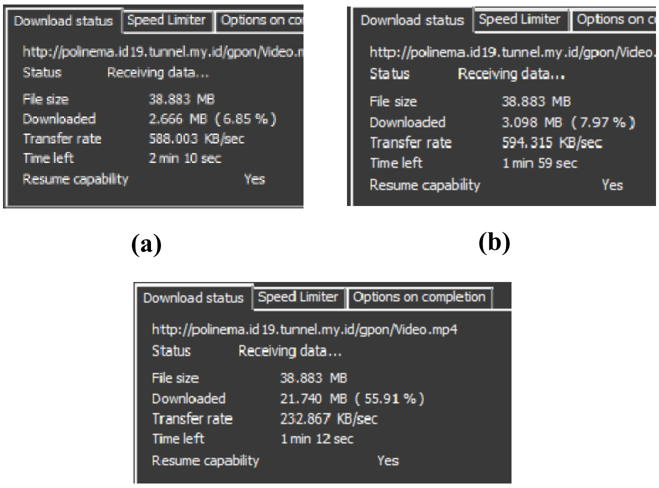
No.	Results	Speed
1		*Download*: 28.1 Mbps *Upload*: 3.87 Mbps
2		*Download*: 10.4 Mbps *Upload*: 11.3 Mbps
3		*Download*: 22.1 Mbps *Upload*: 8.18 Mbps
Average transfer speed	*Download* : 20.2 Mbps *Upload* : 7.78 Mbps	

Table IV presents the results of the data transfer speed testing conducted through the internet network. The testing was performed three times to obtain reliable measurement results for both download and upload speeds. The results show that the download speeds obtained were 28.1 Mbps, 10.4 Mbps, and 22.1 Mbps, while the upload speeds were 3.87 Mbps, 11.3 Mbps, and 8.18 Mbps. Based on these measurements, the average transfer speed achieved on the internet network is 20.2 Mbps for download and 7.78 Mbps for upload. These results indicate that the implemented network configuration allows the local server to be accessed through the internet with stable data transfer performance.

C. Bandwith

Bandwidth testing is performed using the Internet Download Manager application by an internet-connected client and accessing the "pollinema.id19.tunnel.my.id/gpon" address on the browser with the video download. The following are the results of the measurements made.



(a) **(b)**

(c)

Figure 4 Video Download Testing

Figure 4 will be ecxplained by point. Figure (a) shows the test of downloading video files using the Download Manager application which was carried out 3 times at different times. It can be seen that the video file size of 38,883 MB has a transfer speed of 588.00 KB/sec. Figure (b) shows a 38,883 MB video file with a transfer speed of 594,315 KB/sec. And in figure (c) shows a video file measuring 38,883 MB with a transfer speed of 232,867 KB/sec. This shows bandwidth limitations because when downloading large files, it will leave little bandwidth for other online activities. This can result in decreased performance when performing online tasks such as, streaming videos or playing online games. So that the average speed of video download files using an internet connection from 3 attempts was 471,727 KB/sec.

D. Delay

The data obtained to calculate the delay was obtained from the wireshark application. By conducting tests on the network monitored by wireshark and after network testing, wireshark stops the capturing process and data will be obtained when opening the captured file. The data needed for delay calculation are the timespan(s) and packets. Testing through the internet network and intranet was also carried out 3 times. Delay calculation is done with the following formula.

$$Delay(ms) = \frac{Total\ time\ (s)}{Total\ Packets\ Received}$$

Here is the data delay at the time of downloading the captured video.

Statistics

Measurement	Captured	Displayed	Marked
Packets	52086	52086 (100.0%)	—
Time span, s	294.351	294.351	—
Average pps	177.0	177.0	—
Average packet size, B	913	913	—
Bytes	47547415	47547415 (100.0%)	0
Average bytes/s	161 k	161 k	—
Average bits/s	1292 k	1292 k	—

(a)

Statistics

Measurement	Captured	Displayed	Marked
Packets	40322	40322 (100.0%)	—
Time span, s	376.213	376.213	—
Average pps	107.2	107.2	—
Average packet size, B	950	950	—
Bytes	38306617	38306617 (100.0%)	0
Average bytes/s	101 k	101 k	—
Average bits/s	814 k	814 k	—

(b)

Statistics

Measurement	Captured	Displayed	Marked
Packets	40322	40322 (100.0%)	—
Time span, s	376.213	376.213	—
Average pps	107.2	107.2	—
Average packet size, B	950	950	—
Bytes	38306617	38306617 (100.0%)	0
Average bytes/s	101 k	101 k	—
Average bits/s	814 k	814 k	—

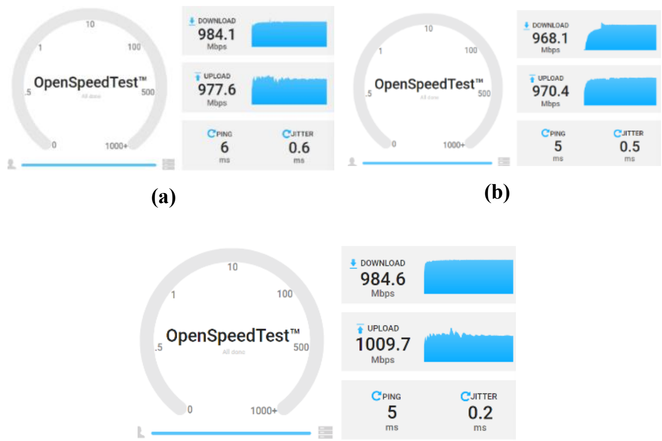
(c)

Figure 5 Testing Video Download Delay with Internet Connection

Figure 5 shows the Delay test of downloading a video file using the Wireshark application which was carried out 3 times at different times. Figure (a) shows a delay of 5.67 ms. Figure (b) has a delay of 9.33 ms. Figure (c) has a delay of 9.33 ms. So that the average delay of downloading videos using an internet connection from 3 attempts is 8.11 ms.

E. Transfer Speed Testing

Speed testing performed on ONT-connected clients. Testing was also carried out 3 times. Here is the transfer speed test data.



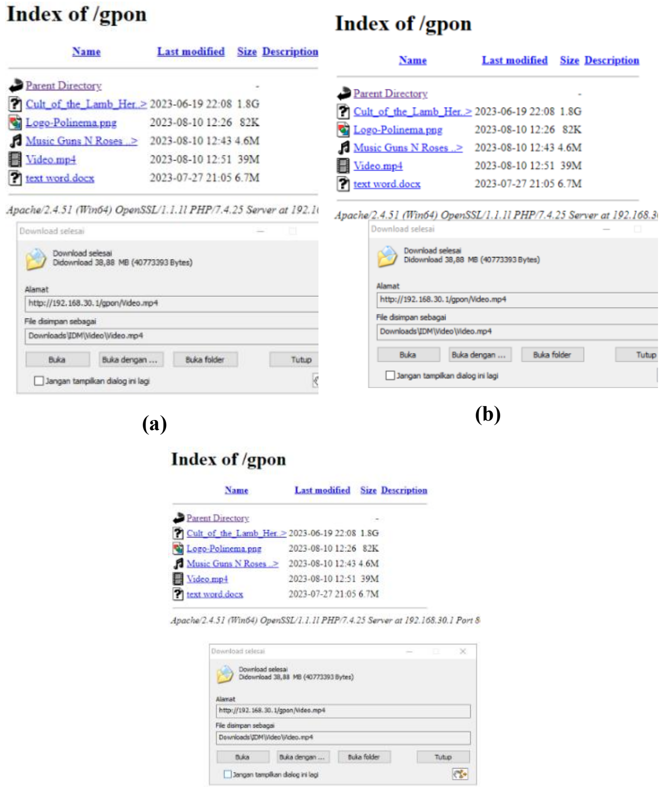
(c)

Figure 6 Transfer Speed Testing with Intranet

Figure 6 shows the results of transfer speed testing conducted on a client connected to the ONT through the intranet network using the OpenSpeedTest application. The testing was carried out three times to evaluate the stability and performance of the network. In test (a), the download speed reached 984.1 Mbps and the upload speed 977.6 Mbps with a ping of 6 ms. In test (b), the download speed was 968.1 Mbps and the upload speed 970.4 Mbps with a ping of 5 ms. In test (c), the download speed reached 984.6 Mbps and the upload speed 1009.7 Mbps with a ping of 5 ms. These results indicate that the intranet network using GPON technology provides very high and stable data transfer speeds close to 1 Gbps, demonstrating the effectiveness of the implemented network configuration.

F. Bandwidth

Bandwidth testing is performed using the Internet Download Manager application by an internet-connected client and accessing the "pollinema.id19.tunnel.my.id/gpon" address on the browser with the video download. The following are the results of the measurements made.



(c)

Figure 7 Video Download Testing

Figure 7 explain by some point. Figure (a) shows the test of downloading video files using the Download Manager application which was carried out 3 times at different times. It can be seen that the video file size of 38,883 MB has a transfer speed of 984.1 Mb/sec. Figure (b) shows a 38,883 MB video file with a transfer speed of 968.1 Mb/sec. And in figure (c) shows a video file measuring 38,883 MB with a transfer speed of 984.1 Mb/sec. This shows bandwidth limitations because when downloading large files, it will leave little bandwidth for other online activities. This can result in decreased performance when performing online tasks such as, streaming videos or playing online games. So that the average speed of video download files using the internet connection from 3 attempts was 978.9 Mb/sec.

G. Delay

The data obtained to calculate the delay was obtained from the wireshark application. By conducting tests on the network monitored by wireshark and after network testing, wireshark stops the capturing process and data will be obtained when opening the captured file. The data needed for delay calculation are the timespan(s) and packets. Testing through the internet network was also carried out 3 times. Delay calculation is done with the following formula.

$$Delay(ms) = \frac{Total\ time\ (ms)}{Total\ Packets\ Received}$$

Here is the data delay at the time of downloading the captured video.

Statistics

Measurement	Captured	Displayed	Marked
Packets	95	95 (100.0%)	—
Time span, s	3.195	3.195	—
Average pps	29.7	29.7	—
Average packet size, B	74	74	—
Bytes	7052	7052 (100.0%)	0
Average bytes/s	2207	2207	—
Average bits/s	17 k	17 k	—

(a)

Statistics

Measurement	Captured	Displayed	Marked
Packets	148	148 (100.0%)	—
Time span, s	7.358	7.358	—
Average pps	20.1	20.1	—
Average packet size, B	74	74	—
Bytes	10982	10982 (100.0%)	0
Average bytes/s	1492	1492	—
Average bits/s	11 k	11 k	—

(b)

Statistics

Measurement	Captured	Displayed	Marked
Packets	73	73 (100.0%)	—
Time span, s	4.284	4.284	—
Average pps	17.0	17.0	—
Average packet size, B	76	76	—
Bytes	5544	5544 (100.0%)	0
Average bytes/s	1294	1294	—
Average bits/s	10 k	10 k	—

(c)

Figure 8 Testing Video Download Delay with Intranet Connection

Figure 8 above shows the Delay test of downloading a video file using the Wireshark application which was carried out 3 times at different times. Figure (a) shows a delay of 33.63 ms. Figure (b) has a delay of 49.71 ms. Figure (c) has a delay of 58.68 ms. So that the average video download delay using an internet connection from 3 attempts is 47.34 ms.

H. Transfer Speed

The transfer speed obtained 3 times of testing that has been carried out on the internet network is as Table V.

TABLE V
DATA TRANSFER SPEED ON THE INTERNET NETWORK

No	Transfer Speed	
	Download	***Upload***
1	28,1 Mbps	3,87 Mbps
2	10,4 Mbps	11,3 Mbps
3	22,1 Mbps	8,18 Mbps
Average transfer speed		*Download*: 20,2 Mbps *Upload*: 7,78 Mbps

Table V shows the results of transfer speed testing conducted on the internet network. The testing was carried out three times to measure both download and upload speeds. The results indicate that the average download speed obtained was 20.2 Mbps, while the average upload speed reached 7.78 Mbps. These results demonstrate that the network configuration allows the local server to be accessed through the internet with stable data transfer performance. Then the transfer speed obtained 3 times of testing that has been carried out on the intranet network is as follows.

Table VI
Data Transfer Speed on Intranet Network

No	Transfer Speed	
	Download	***Upload***
1	984,1 Mbps	977,6 Mbps
2	968,1 Mbps	970,4 Mbps
3	984,6 Mbps	1009,7 Mbps
Average transfer speed		*Download*: 978,9 Mbps *Upload*: 985,8 Mbps

Table VI presents the transfer speed results obtained from testing on the intranet network. The measurements were conducted three times to evaluate network performance. The results show significantly higher speeds compared to the internet network, with an average download speed of 978.9 Mbps and an average upload speed of 985.8 Mbps, indicating that the intranet network provides very high data transmission capability.

I. Bandwidth

Bandwidth testing is done to find out the extent to which the network can send and receive data. The bandwidth obtained 3 times tested at different times on the internet network is as Table VII.

TABLE VII
BANDWIDTH ON THE INTERNET NETWORK

No	Video File Size	*Bandwidth*
1		588,003 KB/Sec
2	38,883 MB	594,315 KB/Sec
3		232,867 KB/Sec
Average *bandwidth* obtained		471,727 KB/Sec

Table VII shows the bandwidth testing results on the internet network using a video file of 38.883 MB. The test was conducted three times at different times to observe variations in network performance. The results show bandwidth values of 588.003 KB/sec, 594.315 KB/sec, and 232.867 KB/sec, with an average bandwidth of 471.727 KB/sec. This indicates that bandwidth performance on the internet network may fluctuate depending on network conditions.

The bandwidth obtained 3 times of testing that has been carried out on the intranet network is as Table VIII.

TABLE VIII
BANDWIDTH ON INTRANET NETWORK

No	Video File Size	*Bandwidth*
1	38,883 MB	984,1 Mbps
2		968,1 Mbps

No	Video File Size	*Bandwidth*
3		984,6 Mbps
	Average *bandwidth* obtained	978,9 Mbps

Table VIII presents the bandwidth testing results on the intranet network. The testing was performed three times using the same video file size. The results show bandwidth values of 984.1 Mbps, 968.1 Mbps, and 984.6 Mbps, with an average bandwidth of 978.9 Mbps. These results indicate that the intranet network provides significantly higher and more stable bandwidth compared to the internet network.

J. Delay

Delay level testing is necessary to measure the time it takes for data or information to move from source point to destination. The delays obtained from 3 tests that have been carried out on the internet network are as Table IX.

Table IX
Delays on the Internet Network

No	*Delay Download* Video		
	Package	*Time span*	*Delay (ms)*
1	52086	294,351	5,67
2	40322	376,213	9,33
3	40322	376,213	9,33
Average delay obtained			8,11

Table IX presents the results of delay testing on the internet network during the video download process. The testing was conducted three times to determine the average delay value based on the number of packets and the time span captured. The results show delay values of 5.67 ms, 9.33 ms, and 9.33 ms, resulting in an average delay of 8.11 ms. These results indicate that the internet network provides a relatively low latency level during data transmission.

The delays obtained from 3 tests that have been carried out on the intranet network are as Table X.

Table X
Intranet Network Delays

No	*Delay Download* Video		
	Package	*Time span*	*Delay (ms)*
1	95	3,195	33,63
2	148	7,358	49,71
3	73	4,284	58,68
Average delay obtained			47,34

Table X shows the delay testing results on the intranet network obtained during the video download process. Similar to the internet testing, the measurements were conducted three times using packet capture data. The results show delay values of 33.63 ms, 49.71 ms, and 58.68 ms, with an average delay of 47.34 ms. Although the delay value on the intranet network is higher than on the internet network, it still indicates acceptable network performance for data transmission.

Delay testing is carried out to determine the level of delay in sending data packets from server to client on intranet networks and internet networks. The delay value is obtained from the results of packet capture using the Wireshark application during the video file download process. The parameter is one of the main indicators in Quality of Service (QoS) because it affects the speed of response and user comfort in accessing network services.

Based on the test results, the average value of internet network delay was 8.11 ms, while the average intranet network delay was 47.34 ms. To determine the quality of network service produced, the delay value was compared with the QoS standards set by TIPHON and ITU-T, as shown in Table IX and Table X.

According to the TIPON standard, the delay category is divided into four levels: very good (< 150 ms), good (150–300 ms), medium (300–450 ms), and bad (> 450 ms). Meanwhile, based on the ITU-T standard, the delay category is divided into good (< 150 ms), medium (150–400 ms), and bad (> 400 ms).

When compared to the TIPON standard, the average delay value on the internet network of 8.11 ms and the intranet network of 47.34 ms is included in the very good category, because it is well below the maximum limit of 150 ms. Based on the ITU-T standard, both delay values are also included in the good category, because they are still below the threshold of 150 ms.

These results show that the implementation of port forwarding combined with VPN services on GPON-enabled networks does not cause significant data transmission delays, both on intranet networks and internet networks. Although the delay value on intranet networks is greater than on internet networks, the difference is still in the category of excellent service quality and does not negatively impact the performance of local server service access. Based on a comparison of the TIPHON and ITU-T QoS standards, it can be concluded that the quality of delay in the implemented system has met excellent network service standards, so the system is feasible to support local server access through intranet networks and the internet.

Based on the results of the tests that have been carried out, the average value of internet network delay is 8.11 ms, while the average intranet network delay is 47.34 ms. The difference in the delay value shows that there is a variation in performance between the two types of networks. The internet network in this test showed a lower delay value than an intranet network, which indicates a lower level of latency. The delay parameter is one of the main indicators in Quality of Service (QoS) used to assess network performance, as it has a direct effect on service response speed and user comfort. The QoS standard set by TIPHON places delay as a critical parameter in network performance evaluation [12].

TIPHON provides a QoS assessment framework that can be applied to various types of network services, including cloud computing-based services that are generally connected via internet networks and intranets. In that context, latency values greatly affect the user experience, especially in time-sensitive applications, such as multimedia services, streaming video, and teleconferencing. Relatively higher delay values on intranet networks indicate the potential for service quality disruptions, especially in applications that require real-time interaction and fast response times [13].

Evaluation of network service quality can also be done by comparing test results against standards set by international organizations, such as the International Telecommunication Union-Telecommunication Standardization Sector (ITU-T). The ITU-T formulates network delay tolerance limits for different types of communication services. In the ITU-T standard document, it is stated that for real-time communication, the ideal delay value is in the low range so that the transmission quality is well maintained [14]. Thus, the higher delay value of intranet networks compared to internet networks indicates the need for special attention to intranet network management and optimization.

Based on the analysis, it can be concluded that although intranet networks have the potential to support high data transmission speeds, the real implementation conditions show that there are factors that need to be improved, such as bandwidth regulation and data traffic route optimization. This is in line with recommendations from several previous studies that suggest the application of more optimal QoS control mechanisms and algorithms to improve overall network performance [15]. These improvement efforts are important to ensure reliable network service quality and in accordance with the demands of evolving digital communication needs.

To determine the level of network service quality produced, the delay value of the test results is compared to the Quality of Service (QoS) standard set by TIPHON. This comparison aims to classify the quality of delays on internet networks and intranets based on the applicable standard categories, as shown in Table XI.

Table XI
Comparison of Research Results with Standards

Types of Networks	Delay Average (ms)	Delay Category according to TIPHON	Remarks
Internet	8,11 ms	**Very Good** (< 150 ms)	Delays are very low and well below the TIPHON threshold
Intranet	47,34 ms	**Very Good** (< 150 ms)	Delay is still in the very good category even though it is higher than the internet network

Based on the Table XI, it can be seen that the average delay value on the internet network of 8.11 ms and the intranet network of 47.34 ms are both below the threshold of 150 ms. Referring to the TIPON standard, the two delay values are included in the very good category, which shows that the delay in data transmission on both types of networks is at a very low level. Although the delay value on intranet networks is higher than on internet networks, the difference is still within the limits of excellent service quality and does not have a significant impact on local server access performance. This confirms that the implementation of port forwarding and VPN on GPON-enabled networks is still able to maintain the quality of network services according to the set QoS standards.

IV. CONCLUSION

On mikrotik routers, in order to connect to the internet, it is necessary to configure DHCP Client and NAT. In the OpenVPN tunnel My ID you need to create an account first which includes Username, Password, IP netwatch, server and port. In order for mikrotik to connect to the My ID tunnel, it is necessary to configure the interface of openVPN and ip netwach in mikrotik. From the experiments that have been carried out, mikrotik can run well, which is shown to be able to connect to the internet as well as the OpenVPN tunnel My ID. From the experiments that have been carried out on the configuration of the forwading port on microtik, the addition of the NAT Rule is required. This is done so that the local web can be publicly accessed by the Client. So that the Client can take advantage of the web facility to download data. From the tests that have been carried out on the internet network, the average data transfer speed is 20.2 Mbps, the video bandwidth size is 471,727 KB/sec with an average delay of 8.11ms. Meanwhile, tests on intranet networks obtained an average data transfer speed of 978.9 Mbps, video bandwidth size of 978.9 Mbps with an average delay of 47.34ms. This shows that the quality of intranet network service is superior to that of the internet network.

REFERENCES

[1] T. Mahirani, M. D. Atmadja, Waluyo, and H. Darmono, "Comparative Analysis of Fiber Optic Networks Using Converter Devices with Splitters and Without Splitters in AI Building Malang State Polytechnic," *JURNAL JARTEL: Jurnal Jaringan Telekomunikasi*, vol. 15, no. 3, pp. 264–272, 2025, doi: 10.33795/jartel.v15i3.6301.

[2] M. N. Zakaria, S. W. Dali, A. S. Cyrillafitri, and F. D. Distien, "Implementation of Wireless Sensor Technology Based on LoRa for River Water Quality Monitoring System to Detect Water Pollution," *JURNAL JARTEL: Jurnal Jaringan Telekomunikasi*, vol. 15, no. 4, pp. 485–493, 2025, doi: 10.33795/jartel.v15i4.8646.

[3] L. Febriarti, A. M. Imammuddin, and D. Suprianto, "Analysis of Coverage Range and Data Transmission Success Rate of LoRaWAN in the Implementation of an Electrical Power Monitoring System," *JURNAL JARTEL: Jurnal Jaringan Telekomunikasi*, vol. 15, no. 4, pp. 479–484, 2025, doi: 10.33795/jartel.v15i4.8716.

[4] M. A. Al Maruf, Darman, and Z. Razilu, "Rancang Bangun Manajemen Bandwidth Jaringan Pada Laboratorium Teknik Komputer dan Jaringan," *Decode: Jurnal Pendidikan Teknologi Informasi*, vol. 3, no. 2, pp. 246–256, 2023, doi: 10.51454/decode.v3i2.177.

[5] H. Khatimi, E. S. Wijaya, A. R. Baskara, and Y. Sari, "Performance Comparison Between Copper Cables and Fiber Optic in Data Transfer on Banjarmasin Weather Temperature Conditions," *MATEC Web of

Conferences*, vol. 280, p. 05022, 2019, doi: 10.1051/matecconf/201928005022.

[6] Z. Abdellaoui, Y. Dieudonne, and A. Aleya, “Design, Implementation and Evaluation of a Fiber To The Home (FTTH) Access Network Based on a Giga Passive Optical Network GPON,” *Array*, vol. 10, p. 100058, 2021, doi: 10.1016/j.array.2021.100058.

[7] B. A. Budiman and E. Yundra, “Pengembangan Trainer Penerapan Rangkaian Elektronika Pada Kelas TEI di SMKN 1 Jabon,” *Jurnal Pendidikan Teknik Elektro*, vol. 9, no. 3, pp. 541–548, 2020, doi: 10.26740/jpte.v9n03.p541-548.

[8] P. Mahrifatika, I. Maulana, K. M. Fauziah, and D. Aribowo, “Perencanaan Jaringan Akses Optik FTTH Menggunakan Teknologi GPON (Gigabit Passive Optical Network),” *Jurnal Sistem Informasi dan Ilmu Komputer*, vol. 1, no. 2, pp. 52–58, 2023, doi: 10.59581/jusiik-widyakarya.v1i2.333.

[9] H. Pratama and N. F. Puspitasari, “Penerapan Protokol L2TP/IPSec dan Port Forwarding untuk Remote Mikrotik pada Jaringan Dynamic IP,” *Creative Information Technology Journal*, vol. 7, no. 1, pp. 51–62, 2021, doi: 10.24076/citec.2020v7i1.253.

[10] W. O. Zamalia, L. M. F. Aksara, and M. Yamin, “Analisis Perbandingan Performa QoS, PPTP, L2TP, SSTP dan IPsec pada Jaringan VPN Menggunakan MikroTik,” *SemanTIK: Teknik Informasi*, vol. 4, no. 2, pp. 29–36, 2018, doi: 10.5281/zenodo.1444898.

[11] V. Phang and E. Setyaningsih, “Perancangan Virtual Private Network dengan Protokol PPTP Menggunakan MikroTik untuk Kebutuhan Remote Access,” *Jurnal POLEKTRO: Jurnal Power Elektronik*, vol. 10, no. 2, pp. 68–71, 2021, doi: 10.30591/polektro.v10i2.2573.

[12] R. N. Aziza, J. Adilman, K. Djunaidi, M. Y. D. Sudirman, and M. D. Yusra, “Comparative Study of Cloud Computing Network Services Based on QoS Analysis Using TIPHON Standard,” *Jurnal Teknik Informatika (JUTIF)*, vol. 4, no. 5, pp. 1201–1209, 2023, doi: 10.52436/1.jutif.2023.4.5.1411.

[13] M. Mbise and F. Simba, “Performance Evaluation of UDSM Network to Deliver Multimedia eLearning Contents: Case of CoICT,” *Tanzania Journal of Engineering and Technology*, vol. 41, no. 4, pp. 205–218, 2022, doi: 10.52339/tjet.v41i4.860.

[14] M. Murakami, “Optical Network Technology for Future Ultra-High-Capacity Communications in the Beyond 5G and Big Data Era,” *NTT Technical Review*, vol. 20, no. 6, pp. 43–51, 2022, doi: 10.53829/ntr202206gls.

[15] D. Mourtzis, J. Angelopoulos, and N. Panopoulos, “Smart Manufacturing and Tactile Internet Based on 5G in Industry 4.0: Challenges, Applications and New Trends,” *Electronics*, vol. 10, no. 24, p. 3175, 2021, doi: 10.3390/electronics10243175.