JATAED
Journal of Appropriate Technology for Agriculture, Environment, and Development
email: jataed@lkppl.org
E-ISSN 3031-0903
Volume 2, **Number** 1, October 2024
https://doi.org/10.62671/jataed.v2i1.62

Installation and Activation of Fiber To The Home (FTTH) Network Using Gigabit Passive Optical Network (GPON) Technology and Quality of Service (QoS) Analysis

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Article History:
Submitted: 04-10-2024
Accepted: 08-10-2024
Published: 18-10-2024

Keywords:
Fiber to the Home; Gigabit Passive Optical Network; Network Activation; Quality of Service

ABSTRACT

This research discusses the design, implementation, and evaluation of Fiber to the Home (FTTH) networks using Gigabit Passive Optical Network (GPON) technology, including network topology design, device installation, activation, and quality of service analysis. Attenuation measurements were conducted before and after activation to ensure compliance with ITU-T G.984 standards, while Quality of Service (QoS) analysis using Wireshark application evaluated parameters such as throughput, packet loss, delay, and jitter. Results show an increase in network efficiency after activation, with a decrease in attenuation. QoS measurements showed excellent network performance, with high throughput (2,595 Kbps), no packet loss, low delay (3.106 ms), and minimal jitter (3.128 ms). This study provides a comprehensive overview of FTTH network implementation and the importance of quality of service evaluation to ensure optimal performance for end users. The systematic approach used can be a valuable guide for telecom operators and internet service providers in implementing reliable and efficient FTTH networks. The study also emphasizes the importance of continuous monitoring and evaluation of network performance, contributing to the technical understanding of FTTH implementation and highlighting the implications for end-user experience as well as the potential for future broadband service development.

INTRODUCTION

The rapid pace of digital evolution has triggered contemporary society's need for a fast and reliable internet connection for various activities. In response to this demand, Fiber to the Home (FTTH) technology integrated with Gigabit Passive Optical Network (GPON) emerged as an innovative solution. Significant digital transformation has revolutionized the way we conduct our work, pursue education, and establish social relationships, creating an urgency for greater bandwidth capacity and minimal latency.

The demand for fast and stable internet connection has increased over time. Responding to this need, the telecommunications industry continues to innovate in network technology development, with Fiber to the Home (FTTH) being one of the most significant recent breakthroughs (Syahrin 2023). A comprehensive study has been conducted to evaluate the performance of FTTH networks, by comparing the results of direct measurements in the field and simulations using OptiSystem software. The study focused on analyzing three key parameters: rise time budget, Bit Error Rate, and Signal-to-Noise Ratio (SNR). The findings of the simulation revealed that all parameters tested successfully met the standards set for Gigabit Passive Optical Network (GPON) technology, confirming the reliability and efficiency of FTTH in meeting modern connectivity needs(Afrizal Yuhanef, Aprinal Adila Asril 2023).

The evolution of technology from EPON to GPON in FTTH network implementation aims to optimize Fiber to the Home infrastructure. Research shows that the majority of GPON users are in new residential areas, with network quality strongly influenced by attenuation levels between 15 to 28 dB. FTTH network feasibility evaluation is conducted through Quality of Service (QoS) analysis to ensure compliance with applicable standards (Nur Ikhsanto and Setiawan 2024).

In the context of specific applications, a study analyzed live video streaming services in FPV aeromodelling. This research involved distance measurement, evaluation of environmental conditions, and QoS analysis using Wireshark. The results showed that the delay, jitter, and throughput parameters met ITU-T standards, confirming the reliability of this technology in supporting applications that demand high performance (Suhendar 2021).

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This research focuses on designing an FTTH network using EPON technology, with special emphasis on the activation process and connection loss analysis on a 10-meter dropcore cable. The main objective is to examine the impact of the number of connections on FTTH performance and data transmission efficiency through network activation. Referring to the IEEE 802.3ah standard, the attenuation tolerance for fiber optic networks is set between 20-29 dB, which becomes a reference in network performance evaluation(Asril, Maria, and Setiawan 2024). This study provides important insights into FTTH network optimization in the context of EPON technology implementation.

LITERATURE REVIEW

Fiber to the Home (FTTH) is a network technology that uses optical fiber to transmit high-speed data directly to users' homes.

FTTH infrastructure consists of several key components:

1. Optical Line Terminal (OLT): A termination point that connects the fiber optic network with user devices.
2. Optical Distribution Cabinet (ODC): A fiber optic cable collection center for a specific area.
3. Optical Distribution Point (ODP): Connects the core network to the end-user access network.
4. Optical Network Terminal (ONT): A user-side device in a PON network.
5. Rosette: The connection point between the main fiber optic cable and the user device.
6. Passive Splitter: Splits the optical signal into multiple paths.
7. Optical Time Domain Reflectometer (OTDR): A tool for evaluating optical fibers and analyzing losses.
8. Optical Power Meter (OPM): Measures optical signal power and identifies power loss in transmission.
9. Each of these components plays an important role in ensuring the efficiency and reliability of FTTH networks, enabling fast and stable internet access for users.

Network activation

The FTTH network activation process is a series of structured and interrelated steps. Starting with OLT configuration, the process includes basic IP and management system settings. The next stage involves comprehensive network configuration, including VLAN, interface, and routing settings. Supporting devices such as a proxy or router are configured for efficient network management.

Service profile settings on the OLT are the next focus, covering the configuration of lines, T-CONT, GEM, and service ports. The process continues with ONU configuration customized to the customer's specific needs, including WAN parameter settings, port bindings, and SSIDs.

The final stage of activation involves a series of tests and verifications to ensure optimal connectivity, speed, and quality of service. While the details of the process may vary depending on device specifications and network requirements, this framework provides a systematic approach to effective and reliable FTTH network activation.

Quality of Service (QoS)

Quality of Service (QoS) is a fundamental concept in computer networking that measures the ability to manage data quality. QoS focuses on four main parameters:

1. Throughput: Describes the amount of data successfully received at the destination within a certain time interval, reflecting the actual capacity of the network in transmitting data.
2. Packet Loss: Indicates the number of data packets lost during transmission, often caused by collisions or congestion in the network.
3. Latency (Delay): Measures the time it takes for data to travel from source to destination. Factors such as distance, physical media, and computing processes can affect latency.
4. Jitter: Indicates variations in the arrival time of data packets, which can have a significant impact on transmission quality, especially for high-speed data.

The primary goal of QoS is to optimize the use of network infrastructure to meet diverse service requirements. By monitoring and managing these parameters, QoS enables the provision of more efficient and reliable network services, adapting to the demands of different applications and users.

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METHOD

This research uses simulation methods related to FTTH network installation, measuring attenuation before and after activation, and testing network quality using wireshark application. after FTTH network activation. The simulation can be seen in the research flow below:

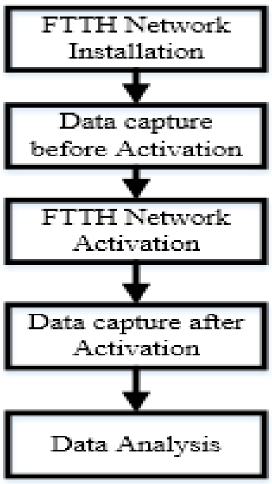

Figure 1. Research Flow

The method carried out in this study can be seen in Fig 1 which explains the research flow. In this research, the first stage is a literature study to find and find references related to this research that will be carried out. Then, design the FTTH Network with GPON technology. Then the FTTH network installation starts from installing OLT to ONT devices and connecting cables in each device used. Then taking data before and after activation and entering the Quality of Service (QoS) data analysis stage which is discussed from Troughput, packet loss, letency (Delay) then jitter. Then the conclusion of the data analysis taken by the researcher.

FTTH Network Installation

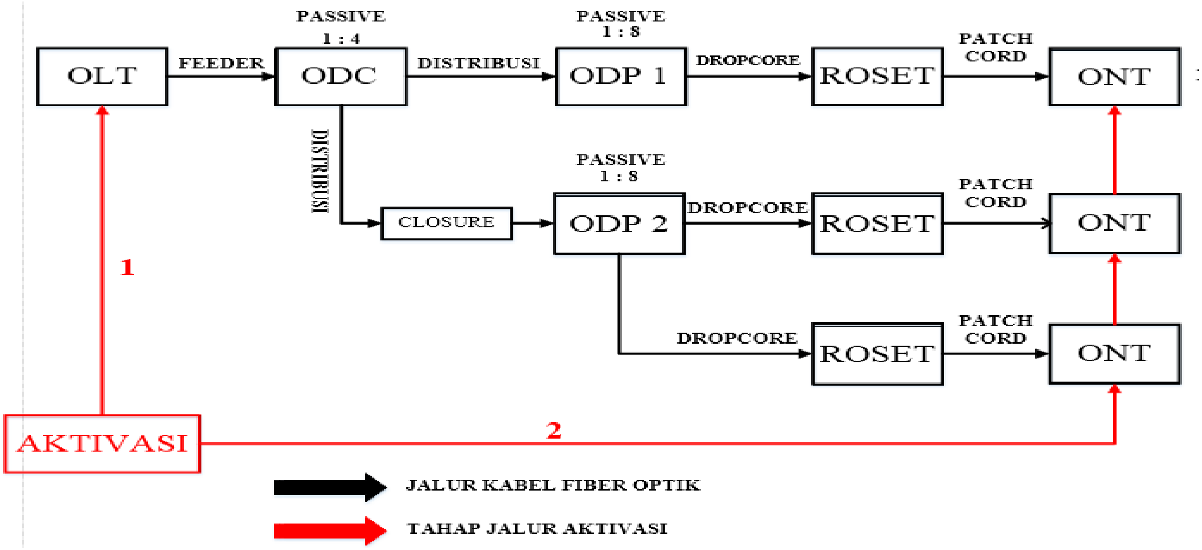

Figure 2. Fiber To The Home (FTTH) Network Block Diagram

During installation it is necessary to understand the devices to be installed starting from OLT, ODC, ODP, ROSET, ONT and CLOSURE during the installation process, the installation and use of fiber optic cables must be in accordance with the FTTH installation standards so that the FTTH network installation is in accordance with the standards, the next step is after all the devices have been installed, continue to activate the network starting from the

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configuration on the OLT using the help of microtik after the OLT and microtik parts have been configured, continue to activate / configure ONT so that the configurations from microtik, OLT and ONT are in sync if everything has been activated, then test the internet connection.

RESULT

FTTH Network Circuit Measurement Before Activation.

1. Hls Calibration

In the FTTH Network circuit, measurements are taken with HLS input at the end of the feeder cable and the output is measured with OPM at each end of the segment, where these measurements are taken before activation which aims to determine whether the attenuation in the FTTH network does not exceed the maximum recommended attenuation limit for activation can be seen in table 1.

Table 1. HLS Calibration Measurement Results

Trial to	Calibration result (dBm)
1	-7,31
2	-7,28
3	-7,28
Mean	-7,28

2. FTTH Network Attenuation Measurement Results Before Activation

In this measurement, it is measured starting from the feeder cable to the ODC using passive 1: 4 and continuing to ODP 1 which uses passive 1: 8 and so does ODP 2 and continues measurements on the rosette using drop core cables from 20 meters, 30 meters, 65 meters. Therefore the measurement results can be seen in table 2.

Table 2. measurement results

Devices	λ (nm)	Ptx (dBm)	Prx (dBm)	Redaman (dB)
Feeder			-8,38	1,1
ODC 1:4			-14,68	7,4
ODP 1			-24,90	17,62
ODP 2	1310	-7,28	-25,63	18,35
Drop core 65 m			-30,63	22,78
Drop Core 20 m			-25,63	18,35
Drop Core 30 m			-26,72	19,44

Measurement of FTTH Network Circuit After Activation

1. Sfp Calibration

In SFP calibration this time using SFP type HSGQ-C+++ 8 dB with transmit power emitted 2.5G/1.25G Tx 1490 nm Rx 1310 nm DDM for calibration in 3 measurement trials in order to get the results or average attenuation that can be stable can be seen in table 3.

Table 3. SFP Calibration Measurement Results

Trial to	Calibration result (dBm)
1	7,48
2	7,45
3	7,38
Mean	7,43

2. Results of FTTH Network Attenuation Measurement After Activation

Measurement after activation and before activation is the same which distinguishes it from the source used before activation using a source from HLS while after activation using a source from OLT using SFP so that you can see the difference in measurement values obtained as in table 4.

Table 4. difference in measurement values

Devices	λ (nm)	Ptx (dBm)	Prx (dBm)	Redaman (dB)
Feeder			7,28	0,15
ODC 1:4			0,45	6,98
ODP 1			-9,64	17,07
ODP 2	1310	7,43	-9,65	17,08
Drop core 65 m			-17,63	25,06
Drop Core 20 m			-10,20	17,63
Drop Core 30 m			-10,51	17,94

3. Hasil Quality of Service (QOS)

In this QoS result, which is where to achieve a good or bad signal quality, it is necessary to measure the quality of the signal that is built with the help of the Wireshark application in this QoS includes parameters such as Throughput, packet loss, Delay, and Jitter if these parameters have obtained their respective values and can be categorized as in table 5.

Table 5. Throughput, packet loss, Delay, and Jitter

No	QoS parameters	Average value	Index	Category
1	Througput (Kbps)	2592 Kbits/s	4	Very good
2	Packet Loss	0%	4	Very good
3	Delay (ms)	3,106 ms	4	Very good
4	Jitter (ms)	3,127 ms	4	Very good

DISCUSSION

Analysis Before Activation

The measurement results before activation can be seen in Table 2 where measurements are taken on each FTTH network device, starting from the feeder cable, ODC, ODP, to the end of the drop core cable on the rosette. Measurements are made using HLS as input and OPM to see the output power (Pr). Before taking measurements, OPM and HLS must be calibrated 3 times as shown in Table 1, and the calibration results will be the input power (Pt) of the FTTH network.

Feeder cable measurements with a length of 1 km were carried out by attaching HLS to the input end of the feeder cable on a white core and OPM to the output end of the feeder cable with a white core connected with a patch cord to the OPM. This feeder cable has an attenuation of 1.1 dB, which is relatively low and suitable for optical transmission systems. The 1310 nm wavelength was used because it has low intrinsic attenuation in standard optical fibers, making it suitable for medium-distance transmission.

Measurements from the feeder cable to the ODC were made by connecting one of the Passive Splitter 1:4 outputs. One of the Passive Splitter outputs was connected to the OPM using a patch cord, while the HLS was at the input of the feeder cable. The result of the output power at ODC is -14.68 dBm, which is reduced by the input power of -7.28 dBm, so the attenuation is 7.4 dB.

Measurements at ODP 1 were made by connecting one of the Passive Splitter 1:4 outputs to the Passive Splitter 1:8 input, and one of the Passive Splitter outputs was connected to the OPM using a patch cord, while the HLS was at the feeder cable input. The result of the output power is -24.90 dBm, which is then reduced by the input power of -7.28 dBm, so the attenuation on the ODP is 17.62 dB. Measurements on ODP 2 were carried out in the same way as on ODP 1, and obtained an output of -25.63 dBm, which was reduced by the input power of -7.28 dBm, so the attenuation on ODP 2 was 18.35 dB. Measurements on the rosette were taken from the ODC input to ODP 1 and ODP 2.

At ODP 1, a 20-meter drop core cable was used from the ODC input to the end of the rosette, then the output of the rosette was connected to OPM, resulting in a rosette output power of -25.63 dBm. After subtracting the input power, the attenuation on the rosette was 18.35 dB. Repeated measurements were made on the rosette with 15 meters and 30 meters of drop core cable length connected to ODP 2.

The attenuation of the 65-meter drop core cable is -30.06 dBm, which is reduced by the input power of -7.28 dBm, so the attenuation result on the 15-meter rosette is 22.78 dB. In the 30-meter drop core cable, the attenuation obtained is -26.72 dBm, which is reduced by the input power of -7.28 dBm, so the attenuation result in the 30-meter

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rosette is 19.44 dB. Therefore, to find out that the FTTH network that has been built is feasible and ready to be activated, the author calculates the power link budget first with the following conditions: the length of the cable used at ODC is 1000 meters and the length of the ODP1 (5.5 m) and ODP2 (12.5 m) Drop cores 20, 30 and 65 meters

Analysis After Activations

The data measurement during activation is done in a similar way to the data measurement before activation. The main difference between the measurement results before and after activation is the input power source (Pt) used. Before activation, the input power came from HLS, while after activation, the input power came from OLT using an 8 dB SFP which resulted in an input power (Pt) of 7.43 dBm. The results of network attenuation measurements after activation can be seen in Table 3 and Table 4.

The difference between the FTTH network that has been activated and before activation can be seen from the indicator on the ONT. Before activation, the internet indicator on the ONT is off After activation, the internet indicator on the ONT is on, If the internet indicator light is on, then the ONT is ready to use.

The power link budget calculation is as follows:

$\alpha total = (L \cdot \alpha \text{ fiber}) + (\cdot \alpha c) + (Ns \cdot) + (Na \cdot \alpha a) + Sp$

Description:
αtotal = Total attenuation (dB)
αfiber = Optical fiber attenuation
αc = Connector attenuation (dB / piece)
αs = Splice attenuation (dB/splice)
αa = Adapter attenuation (dB/piece)
L = Optical fiber length (km)
Sp = Splitter attenuation (dB)
Ns = Number of splices
Nc = Number of Connectors
Na = Number of Adapters
PTx = Optical source output power (dBm)
PRx = Power received at the device (dBm)
SM = Safety margin 3 dB

ROSET 1 (20 m) power link budget calculation

L = 1,0225 km
Nc = 7 buah
Ns = 6 buah
Na = 5 buah
Sp 1: 4 = 7,25 dB
Sp 1 : 8 = 10,38 dB

$\alpha total = (L \cdot \alpha serat) + (NC \cdot \alpha c) + (Ns \cdot \alpha s) + (Na \cdot \alpha a) + (Sp\ 1{:}4 + Sp\ 1{:}8)$

= (1.0255 .0,35) + (7 .0,25) + (6 .0,1) + (5 .0,5) + (7,25 + 10,38)
= 0,358925 + 1,75 + 0,6 + 2,5 + 17,63
= 22,83 dB

ROSET 2 (30 m) power link budget calculation

L = 1,0425 km
Nc = 7 buah
Ns = 6 buah
Na = 5 buah
Sp 1: 4 = 7,25 dB
Sp 1 : 8 = 10,38 dB

$\alpha total = (L \cdot \alpha serat) + (NC \cdot \alpha c) + (Ns \cdot \alpha s) + (Na \cdot \alpha a) + (Sp\ 1{:}4 + Sp\ 1{:}8)$

= (1,0425.0,35) + (9 .0,25) + (8 .0,1) + (6 .0,5) + (7,25 + 10,38)
= 0,364875 + 2,25 + 0,8 + 3 + 17,63
= 24,04 dB

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ROSET 3 (65 m) power link budget calculation
L = 1,0775 km
Nc = 7 buah
Ns = 6 buah
Na = 5 buah
Sp 1: 4 = 7,25 dB
Sp 1 : 8 = 10,38 dB
$\alpha total = (L . \alpha serat) + (NC . \alpha c) + (Ns . \alpha s) + (Na . \alpha a) + (Sp\ 1{:}4 + Sp\ 1{:}8)$
= (1,0775.0,35) + (9 .0,25) + (8 .0,1) + (6 .0,5) + (7,25 + 10,38)
= 0,377125 + 2,25 + 0,8 + 3 + 17,63
= 24,05 dB

CONCLUSION

Activation of the FTTH network and data collection before and after activation, followed by measuring the network quality (QoS) designed using the Wireshark application with parameters such as Throughput, packet loss, delay, and Jitter.

1. The design of the FTTH network with GPON technology starts with creating a sketch that includes the placement and configuration of devices such as Optical Line Terminal (OLT), Optical Distribution Cabinet (ODC), Optical Distribution Point (ODP), and Optical Network Terminal (ONT).
2. Attenuation measurements before and after activation showed an increase in network efficiency. HLS calibration of -7.28 dBm and SFP of 7.43 dBm, and attenuation decreased after activation, resulting in more stable connectivity.
3. The performance of the FTTH network was rated excellent based on QoS measurements. High throughput (2,595 Kbps), no packet loss, low delay (3.106 ms), and minimal jitter (3.128 ms) indicate excellent network quality.

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