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Design and Development of FTTH Network Infrastructure Using GPON Technology in Sukoharjo Regency

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***Abstract*— The increasing demand for high-speed, reliable internet access in the digital era has led to the decline of conventional copper-based networks and the rise of fiber-optic-based solutions. This study focuses on the design and development of a Fiber To The Home (FTTH) network using Gigabit Passive Optical Network (GPON) technology in Banaran Subdistrict, Sukoharjo Regency, an area with growing economic activity, particularly in the Micro, Small, and Medium Enterprises (MSME) sector. The implementation of GPON is seen as a critical infrastructure enhancement that supports regional development, education, and digital connectivity. The research methodology began with site surveys using Google Earth Pro and QGIS to collect spatial data such as household coordinates and pole locations. This data was then processed using Setics Sttar Planner version 2.3.12, enabling automatic calculation of optimal cable routes, equipment locations, and required component specifications. The resulting FTTH design covers four neighborhood units (RW 1, RW 2, RW 4, and RW 5), serving a total of 630 homepasses. Key components of the network include 1 Optical Line Terminal (OLT), 2 Fiber Distribution Terminals (FDTs), 46 Fiber Access Terminals (FATs), and 125 poles. The power link budget calculation, essential to determining signal feasibility, produced theoretical receive power values between -15.089 dBm and -14.144 dBm. Field implementation and post-deployment measurements were conducted in RW 1 and RW 2 to validate the theoretical model. Adjustments were made due to site constraints, including reductions in splitter and FAT counts, as well as cable length modifications. Measured receive power values ranged from -16.71 dBm to -16.22 dBm, which still fall within acceptable standards defined by PT. iForte Solusi Infotek (between -10 dBm and -21 dBm). The differences between calculated and actual measurements were attributed to splicing quality, variations in cable deployment, and environmental factors. Overall, the study successfully demonstrates the feasibility and efficiency of deploying GPON-based FTTH infrastructure in semi-urban regions like Sukoharjo. The integration of digital tools for planning and field validation ensures optimal network performance, supporting the goal of bridging the digital divide and enhancing socio-economic development in the area.**

***Keywords*— FTTH, GPON, Setics Sttar Planner, Sukoharjo, Optical Fiber**

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I. Introduction

The limitations of copper access networks are considered insufficient to support the large bandwidth and high-speed demands of modern communication technologies. This limitation led to the operation of the Palapa telecommunications satellite and, subsequently, the adoption of the Optical Fiber Communication System (SKSO) in Indonesia [1]. These steps were taken as part of efforts to adopt the latest advancements in telecommunications. To improve service quality and capacity, optical fiber was chosen as the main transmission medium due to its advantages in supporting high-speed and stable communication.

Optical fiber is a type of cable made from glass or plastic that is extremely fine—smaller than a strand of hair—and is capable of transmitting light signals from one point to another [2], with a diameter of approximately 120 micrometers [3]. Unlike other telecommunications media, optical fiber uses light waves as carriers instead of electromagnetic or electrical signals. The light remains confined within the fiber due to the difference in the refractive index between the fiber and the surrounding air. A laser is used as the light source because it produces a very narrow spectrum. Due to its high transmission speed, optical fiber is highly suitable for communication channels [4].

Sukoharjo Regency, particularly Grogol District, has a population with strong economic potential, especially among communities engaged in Micro, Small, and Medium Enterprises (MSMEs), which are increasingly shifting toward digital systems. As a result, sufficient bandwidth is needed to support these developments [5].

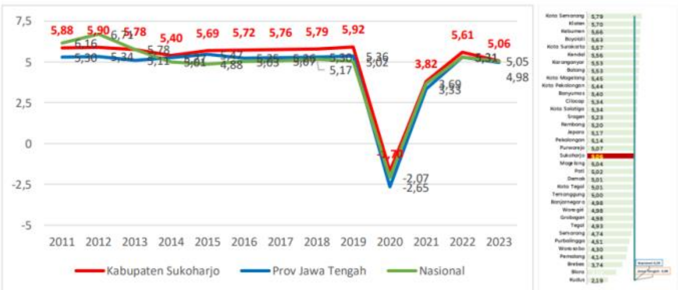

Fig. 1 Economic Growth Chart of Sukoharjo Regency from 2011 to 2023

Figure 1 shows that in 2023, Sukoharjo Regency experienced an accelerated economic growth of 5.06%. This acceleration indicates that the region's economy has begun to recover steadily since the Covid-19 pandemic. Sukoharjo's economic growth rate was relatively higher than the average of Central Java Province (4.98%) and the national average (5.05%) [5]. Therefore, it is necessary to design a network that includes determining the path and number of devices to be used in the access network, which will then be analyzed for its feasibility.

The implementation of Gigabit Passive Optical Network (GPON) technology in Sukoharjo Regency has significant potential to drive local economic growth. The enhancement of telecommunication infrastructure, such as GPON networks, can strengthen connectivity and information access, which in turn opens new business opportunities and improves the operational efficiency of Micro, Small, and Medium Enterprises (MSMEs) in the area. This aligns with findings that the development of telecommunication infrastructure contributes positively to regional economic growth [17].

In this context, the development of Grogol District—especially Banaran Subdistrict, which covers an area of 1.37 square kilometers and has a total population of 8,225 residents [6]—is particularly relevant. This includes a substantial number of students, making the need for fast and stable internet access essential. The implementation of GPON networks is expected to fulfill this need, support digital learning processes, and improve the quality of education in Sukoharjo Regency. Better access to online educational resources helps students develop their skills and knowledge, ultimately contributing to the improvement of local human resources (HR) [18].

Based on this need, network operators aim to improve service quality by developing a new infrastructure based on optical fiber that reaches customer premises, known as Fiber To The Home (FTTH). With this technology, telecommunication services can be delivered more swiftly and reliably compared to traditional cable access networks.

One of the final outcomes of this research is to create an FTTH network design from the central office to end-users by determining the equipment usage, distances, and specifications. This study aims to design an FTTH network in accordance with the standards of PT. iForte Solusi Infotek. The network design process depends on prior development stages, such as business strategy planning, application development lifecycle, and data distribution analysis.

Google Earth and Setics Sttar Planner are used in the design process to determine location, distance, and device specifications. The output from Setics provides automatic planning. In the implementation phase, FTTH installation will be carried out by a third-party contractor of PT. iForte Solusi Infotek, namely PT. Buana Menara Indonesia, to install the optical fiber in Banaran Subdistrict, Sukoharjo Regency.

II. Literature Review and Method

A. *Optical Fiber Technology*

Optical fiber is a transmission medium made of glass or plastic that is extremely thin finer than a strand of hair and is used to transmit light signals from one location to another. In optical fiber technology, electrical signals are converted into light signals, which are then transmitted through the optical fiber. At the receiving end, the light signals are converted back into electrical signals [8].

B. *Fiber To The Home (FTTH)*

FTTH is an access network that uses optical fiber cables extending from the service provider's central office directly to the customer's home. Its advantages include high bandwidth, low latency, and high reliability. The main components in this network include the Optical Line Terminal (OLT), Optical Distribution Frame (ODF), Fiber Distribution Terminal (FDT), Fiber Access Terminal (FAT), and distribution cables.

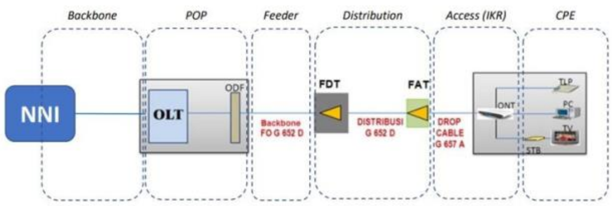

Fig. 2 FTTH Network Segments

C. *Power Link Budget*

The power link budget is an analytical parameter used to determine the feasibility of a network design. It calculates the power loss across a link to ensure that the designed power does not exceed the acceptable threshold. According to PT. iForte's standards, the acceptable receiver power range is between -10 dBm and -21 dBm, and the total allowable attenuation is between 15 dB and 26 dB. The formula for power link budget [10] is:

$$atot = L.\alpha serat + Nc.\alpha c + Ns.\alpha s + Nasp.\alpha asp \quad .....(1)$$

Meanwhile, the received power (Prx) in a GPON optical fiber network is calculated using the following formula:

$$Prx = Ptx - \alpha tot \quad \text{...(2)}$$

D. Setics Sttar Planner

Setics Sttar Planner is a specialized software application designed for FTTH (Fiber to the Home) network planning. It simplifies the design, optimization, and analysis processes of fiber optic networks. This software allows users to efficiently plan the network architecture from the Optical Line Terminal (OLT) to the Optical Network Terminal (ONT), incorporating components such as optical fiber cables, splitters, and connectors.

Figure 2 displays the main interface of Setics Sttar Planner Version 2.3.12. The visualized map shows a portion of the fiber network layout in the Banaran Subdistrict, including the routing of optical cables and the positioning of distribution components. This interface provides a comprehensive view of the network design, enabling accurate placement of elements based on geographic and infrastructure data.

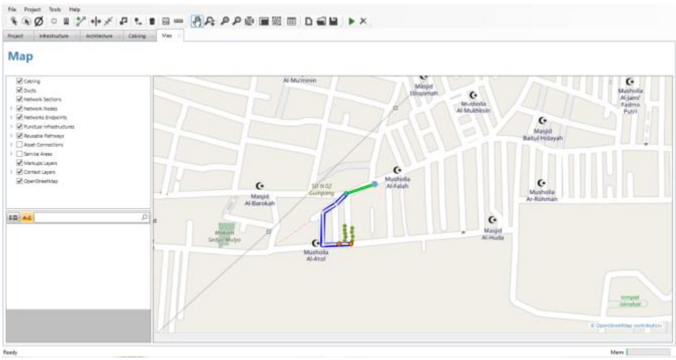

Fig. 3 Desktop Interface of Setics Sttar Planner Version 2.3.12

E. Method

This study was conducted through the following stages:

1. Site Survey
   Google Earth Pro and QGIS were used to obtain coordinate points for locations such as homes, cable paths, and utility poles.
2. Data Processing
   Spatial data were processed using Setics Sttar Planner version 2.3.12 to design distribution routes, determine the locations of FDTs and FATs, and calculate the required cable lengths.
3. Design Output
   The resulting design provides an optimized and efficient network layout.

III. Results And discussion

A. Design Results

The design results for RW 1, RW 2, RW 4, and RW 5 in Banaran Subdistrict, with a total of 630 homepasses, are as follows:

TABLE I
THE DESIGN RESULTS OF ALL NEIGHBORHOOD UNITS (RW) IN BANARAN SUBDISTRICT

Material	Quantity (pcs) / Length (m)
96-Core Cable (Feeder)	892 meters
48-Core Cable (Distribution)	343 meters
24-Core Cable (Distribution)	5,698 meters
96-Core Closure	2 pcs
FDT	2 pcs
FAT	46 pcs
1:4 Splitter	21 pcs
1:8 Splitter	84 pcs
Poles	125 pcs

B. Power Link Budget Calculation

The power link budget calculations for RW 1, RW 2, RW 4, and RW 5 in Banaran Subdistrict are as follows:

TABLE II
RECEIVE POWER AT FATS IN ALL NEIGHBORHOOD UNITS (RWS)

Banaran Subdistrict	Nearest / Farthest FAT Receive Power (dBm)
RW 1 Banaran	-14.576 / -15.144
RW 2 Banaran	-14.574 / -14.870
RW 4 Banaran	-14.667 / -15.089
RW 5 Banaran	-14.783 / -15.111

C. Field Implementation and Measurement

The network implementation in RW 1 and RW 2 of Banaran underwent several adjustments. The OLT was removed (reduced from 1 to 0), FAT units were reduced from 14 to 13, 1:4 splitters from 7 and 4 units to 4 and 2 units, and 1:8 splitters from 25 and 19 units to 13 and 10 units, respectively. The number of poles was decreased from 39 and 28 to 24 and 18. The 96-core cable was omitted; the 48-core cable increased from 130 meters to 2,662 meters, and the 24-core cable increased slightly from 1,539 meters and 1,137 meters to 1,787 meters and 1,238 meters, respectively.

D. Comparison of Calculated and Measured Receive Power

TABLE III
COMPARISON OF CALCULATED AND MEASURED RECEIVE POWER IN RW 1 AND RW 2 OF BANARAN SUBDISTRICT

Cluster	Calculated Receive Power (dBm)		Measured Receive Power (dBm)	
	FAT 1	FAT 12	FAT 1	FAT 10
RW 1 Banaran	-14.576	-15.144	-16.22	-16.71
RW 2 Banaran	-14.574	-14.870	-16.27	-16.31

Based on the ratio between theoretical calculations and actual measurements after implementation, it can be concluded that the attenuation values of the FTTH network for RW 1 and RW 2 in Banaran are still within acceptable limits. There is a difference between the calculated and measured values. In general, the appropriate attenuation standard for FTTH ranges from -15 dBm to -25 dBm. Therefore, the measured values ranging from -16.22 dBm to -16.71 dBm are still within the acceptable range used in FTTH systems, as are the calculated values ranging from -15.144 dBm to -14.87 dBm. However, the differences may be caused by factors such as splice quality, cable length, and environmental conditions that can affect the received power. This is evident from the number of splices and the actual cable length compared to the initial design.

IV. Conclusion

Based on the research conducted from the design phase to implementation, it can be concluded that the FTTH network design in Banaran Subdistrict covers RW 1, RW 2, RW 4, and RW 5, with a total of 630 homepasses. The design was carried out using Google Earth Pro and processed with Setics Sttar Planner version 2.3.12 to generate the Bill of Materials (BOM) for each RW. The link budget calculation shows that the receive power at the nearest to the farthest FAT remains within the standards of PT. iForte Solusi Infotek, ranging from -14.574 dBm to -15.144 dBm.

The implementation in RW 1 and RW 2 required adjustments such as feeder relocation and a reduction in the number of FATs and poles due to field conditions. Post-implementation measurements indicate good network quality, with receive power ranging from -16.22 dBm to -16.71 dBm in RW 1, and from -16.27 dBm to -16.31 dBm in RW 2, which are still within the feasibility standards set by PT. iForte Solusi Infotek.

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