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COMPARISON OF FIBER TO THE HOME NETWORK ATTENUATION USING OPTICAL POWER BUDGET AND LINK POWER BUDGET

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Abstract

Cileungsi Hijau Residential Area in Bogor Regency has adopted Fiber To The Home (FTTH) technology to meet the increasing demand for high-speed internet access. However, high attenuation remains a technical issue that may affect service quality. This study aims to compare signal attenuation in FTTH networks using two approaches: direct measurement with an Optical Power Meter (OPM) and theoretical estimation using the Link Power Budget (LPB) method. Measurements were conducted at nine Optical Distribution Point (ODP) locations to assess network feasibility based on the EPON standard threshold (-28 dBm). The results showed that eight of the nine ODP points were above the minimum threshold and deemed feasible. Several points, such as ODP B1, B3, C1, and C2, even had better OPM results than LPB estimates, indicating optimal physical installation. However, ODP D1 showed a received power of -28.99 dBm, falling below the standard and declared unfit. This comparison indicates that while LPB is effective as an initial reference, OPM measurements provide more accurate, real-time insights into actual network performance and are essential for early detection of potential disruptions.
Keywords**:** *FTTH, attenuation, Optical Power Meter (OPM), Link Power Budget, EPON.*

Abstrak

Perumahan Cileungsi Hijau merupakan kawasan permukiman di Kabupaten Bogor yang telah menggunakan teknologi *Fiber To The Home* (FTTH) sebagai solusi kebutuhan akses internet berkecepatan tinggi. Namun, ditemukan permasalahan redaman tinggi yang dapat menurunkan kualitas layanan jaringan. Penelitian ini bertujuan untuk membandingkan redaman jaringan FTTH dengan dua pendekatan, yaitu pengukuran langsung menggunakan *Optical Power Meter* (OPM) dan perhitungan estimasi melalui metode *Link Power Budget* (LPB). Penelitian dilakukan pada sembilan titik Optical Distribution Point (ODP) untuk menganalisis kelayakan jaringan berdasarkan standar EPON (-28 dBm). Hasil menunjukkan bahwa delapan titik ODP masih berada di atas batas minimum dan dinyatakan layak. Beberapa titik seperti ODP B1, B3, C1, dan C2 bahkan menunjukkan hasil OPM lebih baik dari perhitungan LPB. Namun, ODP D1 menunjukkan nilai OPM -28,99 dBm dan dinyatakan tidak layak. Hasil komparasi ini menunjukkan bahwa LPB efektif sebagai acuan awal, namun pengukuran OPM lebih akurat dalam menilai kondisi jaringan aktual dan mendeteksi potensi gangguan di lapangan.
Kata kunci: FTTH, redaman, Optical Power Meter (OPM), Link Power Budget, EPON

I. INTRODUCTION

As the public's need for fast, stable, and high-quality internet access increases, fiber-optic network technology has become a key solution in modern communication systems. One implementation of this technology is Fiber To The Home (FTTH), which enables high-speed internet connectivity directly from the distribution center to the customer's home without the use of copper transmission media. FTTH technology offers various advantages, such as large bandwidth capacity, wide coverage distance, and resistance to electromagnetic interference. "FTTH is a derivative of FTTx technology, which functions to provide triple play services from the provider center to the user's area using fiber optic cables as the transmission medium.

One of the technical challenges often encountered in FTTH implementations is high attenuation. Attenuation (loss) occurs when the power of the light signal transmitted through the optical cable decreases, and this is a significant factor affecting overall network performance. High levels of attenuation can impact service quality, such as slow internet connections, interruptions during streaming, and even sudden network outages. Therefore, further understanding and analysis of the causes of attenuation are needed, one of which is through measurement approaches such as the Link Power Budget, to ensure the optimal functioning of FTTH systems.

To ensure the quality of the FTTH network, attenuation measurements were performed using two methods: direct measurement using an Optical Power Meter (OPM) and estimation using the Link Power Budget (LPB) method. The OPM provides actual data on received optical power in the field, while the LPB is used as a theoretical approach based on the total attenuation of each network element, such as cables, splitters, and connectors. Therefore, this study aims to compare the two methods on the FTTH network in the Cileungsi Hijau housing complex.

The comparison results were then analyzed based on the IEEE 802.3ah EPON feasibility standard, which stipulates that the maximum attenuation of a passive network (ODN) must be within a specific range, generally between 15 and 28 dB.

This high attenuation problem is a significant problem in the Cileungsi Hijau housing complex, a residential area in Bogor Regency that has implemented an FTTH network. With appropriate comparison and analysis based on applicable methods and standards, it is hoped

that the FTTH network in the Cileungsi Hijau housing complex can ensure stable and efficient service quality according to community needs.

II. THEORETICAL STUDIES

In a Fiber-To-The-Home (FTTH) network, fiber optic cables are run directly from the central office to the user's home or business. The connection to the device is then distributed via coaxial, wireless, or fixed fiber optic lines, depending on the installation type.

The EPON architecture is designed to transmit Ethernet-based data traffic while maintaining the characteristics of the IEEE 802.3 specifications.

Calculating attenuation in a Fiber-To-The-Home (FTTH) network plays a crucial role in assessing network transmission quality. Calculating attenuation allows for determination of whether the attenuation value remains within the established acceptable limits, which are between 15 dB and 28 dB. If the attenuation value exceeds this threshold, the network is at risk of transmission disruption, which can impact service stability for customers.

An Optical Power Meter (OPM) is a measuring instrument used to detect and measure the amount of energy in the form of optical signals in a fiber optic transmission system.

Link Power Budget calculations are used as a reference to ensure that the power on the designed link exceeds the minimum threshold required for proper transmission. To calculate the Link Power Budget, the following formula is used:

$$atotal = L.afiber + NC.a\ c + Ns.as + a\ sp$$

Description:

atotal = total loss (db)

L = length of fiber optic cable (KM)

afiber = Fiber optic cable attenuation/km (dB/km)

Nc = number of connectors

Ns = number of splices (dB)

a c = Connector attenuation (dB)

a s = Splice attenuation (dBm)

a sp = Splitter attenuation (dB)

$$M = (Pt - Pr) - atotal - SM$$

Description:

Pt = Optical Source Output Power (dBm)

Pr = Maximum Detector Power Sensitivity (dBm)

total = Total Loss (dB)

SM = Safety Margin

$$Prx = Pt - atotal - SM$$

Description:

Prx = Received Power (dBm)

Pt = Transmitted Power

a total = Total System Attenuation (dBm)

SM = Safety Margin

III. RESEARCH METHODS

This research is a quantitative study that focuses on collecting numerical data and statistical analysis of FTTH network performance in Cileungsi Hijau Housing, with the main data in the form of optical attenuation values measured using an Optical Power Meter (OPM) and manual calculations using the Link Power Budget method. Both data are then compared with the IEEE 802.3ah EPON-based optical network feasibility standards to assess the suitability of network performance to technical standards. The quantitative approach was chosen because it is able to provide an objective, measurable, and retestable picture according to field conditions. The data collection method is carried out through direct observation of the FTTH network infrastructure to observe the physical condition of the installation, identify potential attenuation, and record device specifications; interviews with field technicians and internet service providers (CITRA-NET) to obtain information on technical constraints, frequency of interference, and troubleshooting steps; and literature studies by reviewing various scientific references such as journals, articles, books, and EPON standard documents related to FTTH technology, attenuation, as well as OPM measurement methods and Link Power Budget calculations. The flowchart used in this research is as follows:

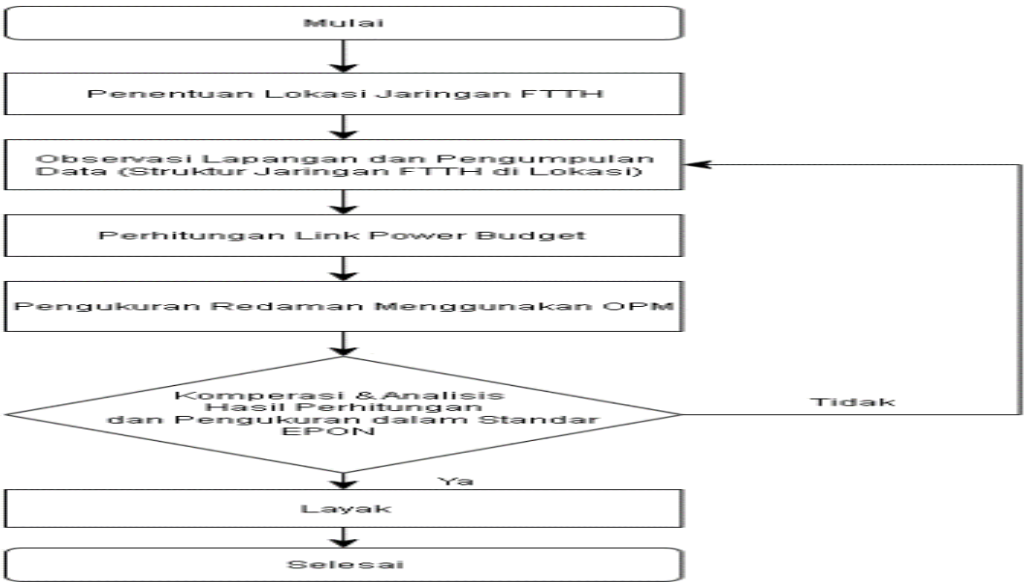

Figure 1. Research Flowchart

Source: Personal Documentation

IV. RESEARCH RESULTS

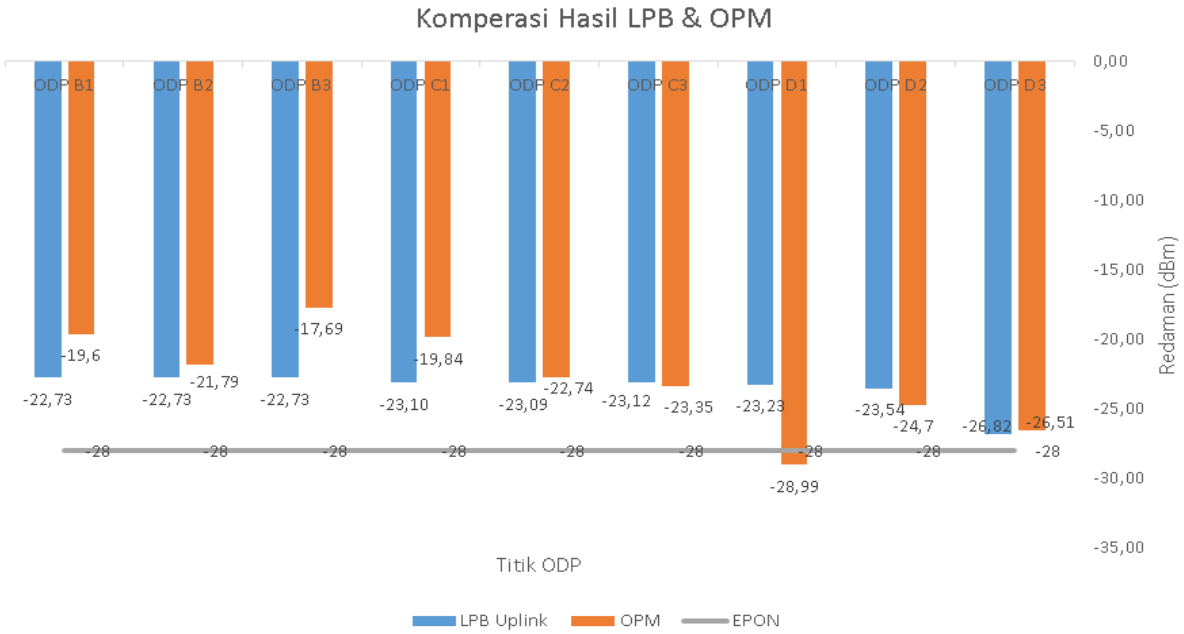

Figure 2. Link Power Budget & Optical Power Meter Comparison Results Diagram

Source: Personal Documentation

Based on a comparative analysis of received power measurements using an Optical Power Meter (OPM) and calculations using the Link Power Budget (LPB) method at nine ODP points in the Cileungsi Hijau Housing FTTH network, eight of the nine points remained above the minimum EPON threshold of -28 dBm, thus being declared operationally viable.

Several points, such as ODP B1, B3, C1, and C2, showed better OPM measurements (less attenuation) than the LPB calculations, indicating that the network was well-installed and no significant additional attenuation was present.

However, at ODP points B2, C3, D2, and D3, the OPM results showed lower power than the LPB estimates, which could indicate a decline in network quality due to factors such as loose connectors, suboptimal splicing, or environmental conditions. Meanwhile, ODP point D1 showed power below the minimum standard (-28.99 dBm), indicating that the network at that point was unsuitable and required immediate maintenance.

From these results, it can be concluded that although the Link Power Budget method is effective as an initial reference in network planning, measurements using the OPM tool are much more effective in the context of evaluating and maintaining existing networks, because it is able to provide real-time data that shows the actual condition of optical signals in the field. Therefore, in the case study at Cileungsi Hijau Housing, the OPM method is considered more accurate and relevant for analyzing network performance comprehensively and detecting potential disruptions before they impact user services.

V. CONCLUSION

Comparison of attenuation results between measurements using OPM and Link Power Budget calculations shows a difference in values, where OPM provides actual data in the field, while Link Power Budget produces estimates based on network design parameters. At some points, the OPM attenuation value tends to be higher than the calculated results, which indicates a possible degradation of the cable or connector quality. The OPM method has proven to be more effective in evaluating the quality of FTTH networks directly because it is able to capture actual conditions and potential physical disturbances that are not detected in theoretical calculations. In general, the FTTH network in Cileungsi Hijau Housing has met the EPON IEEE 802.3ah signal eligibility standards with received power values on the customer side above the minimum threshold of -28 dBm, except at the ODP D1 point which exceeds the threshold so that it requires periodic evaluation and maintenance to prevent performance degradation.

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