

Effect of Distance and Number of Splitters on FTTH Service Quality in Rural Areas

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Abstrak

Fiber To The Home (FTTH) adalah teknologi yang menjanjikan solusi untuk menyediakan akses internet dengan bandwidth tinggi dan kualitas layanan yang andal. FTTH menggunakan serat optik sebagai media transmisi, yang menawarkan keunggulan dalam hal kapasitas, kecepatan, dan jarak dibandingkan dengan media tembaga atau wireless. Tujuan penelitian ini adalah untuk menganalisis pengaruh jarak antara OLT dan ONT terhadap kualitas layanan FTTH di area pedesaan. Data yang diperoleh dari eksperimen lapangan dan simulasi menunjukkan bahwa jarak antara Optical Line Terminal (OLT) dan Optical Network Terminal (ONT) memiliki pengaruh yang signifikan terhadap kualitas layanan (Quality of Service/QoS) dalam jaringan FTTH. Jumlah splitter dalam jaringan Passive Optical Network (PON) juga menunjukkan pengaruh yang signifikan terhadap QoS. Pengaruh jarak terhadap QoS, Pengaruh jumlah splitter terhadap QoS, dan konsistensi antara data lapangan dan simulasi. Secara keseluruhan, penelitian ini menunjukkan bahwa baik jarak maupun jumlah splitter adalah faktor utama yang mempengaruhi kualitas layanan dalam jaringan FTTH, dan optimasi dari kedua faktor ini sangat penting untuk meningkatkan QoS, terutama di daerah pedesaan.

Kata Kunci: *FTTH, Passive Optical Network, Jarak, Splitter, Kualitas Layanan*

Abstract

Fiber To The Home (FTTH) is a technology that promises a solution for providing internet access with high bandwidth and reliable service quality. FTTH uses optical fiber as a transmission medium, which offers advantages in terms of capacity, speed, and distance compared to copper or wireless media. This research aims to analyze the effect of the distance between OLT and ONT on the quality of FTTH services in rural areas. Data obtained from field experiments and simulations show that the distance between the Optical Line Terminal (OLT) and the Optical Network Terminal (ONT) has a significant influence on the quality of service (QoS) in the FTTH network. The number of splitters in a Passive Optical Network (PON) network also shows a significant influence on QoS. Effect of distance on QoS, Effect of number of splitters on quality of service, and consistency between field data and simulation. Overall, this research shows that both distance and number of splitters are the main factors influencing service quality in FTTH networks, and optimization of these two factors is very important to improve QoS, especially in rural areas.

Keywords: *FTTH, Passive Optical Network, Distance, Splitter, Quality of Service*

INTRODUCTION

In the current digital era, the need for high-speed internet connectivity has become a basic need for society, both in urban and rural areas. Fiber To The Home (FTTH) is a technology that promises a solution for providing internet access with high bandwidth and reliable service quality. FTTH uses optical fiber as a transmission medium, which offers advantages in terms of capacity, speed, and distance compared to copper or wireless media. However, implementing FTTH in rural areas faces special challenges, especially related to the distance factor between the Optical Line Terminal (OLT) and Optical Network Terminal (ONT), as well as the number of splitters used in the network.

Long distances between OLT and ONT can cause a decrease in signal quality, which has a direct impact on the quality of service (QoS) received by end users. Apart from that, the number of splitters used in a PON (Passive Optical Network) network also affects signal distribution and can increase latency and jitter. Therefore, it is important to understand how these variables influence FTTH network performance, especially in rural contexts where telecommunications infrastructure is often underdeveloped. This research aims to analyze the effect of the distance between OLT and ONT on the quality of FTTH services in rural areas.

METHOD

Research Design

This research uses a quantitative approach with experimental design and simulation to evaluate the effect of the distance between Optical Line Terminal (OLT) and Optical Network Terminal (ONT) and the number of splitters on the quality of service (QoS) in FTTH networks in rural areas. Field experiments will be carried out to collect actual data, while simulations will be carried out using network simulation software to model different scenarios.

Location and Research Subjects

This research will be carried out in several villages in rural areas that have FTTH networks that have been implemented or are in the planning stage. This location was chosen because of the geographic and topographic challenges typical of rural areas that impact network quality. The research subject is an FTTH network segment that includes varying distances between OLT and ONT, as well as the use of splitters in various configurations.

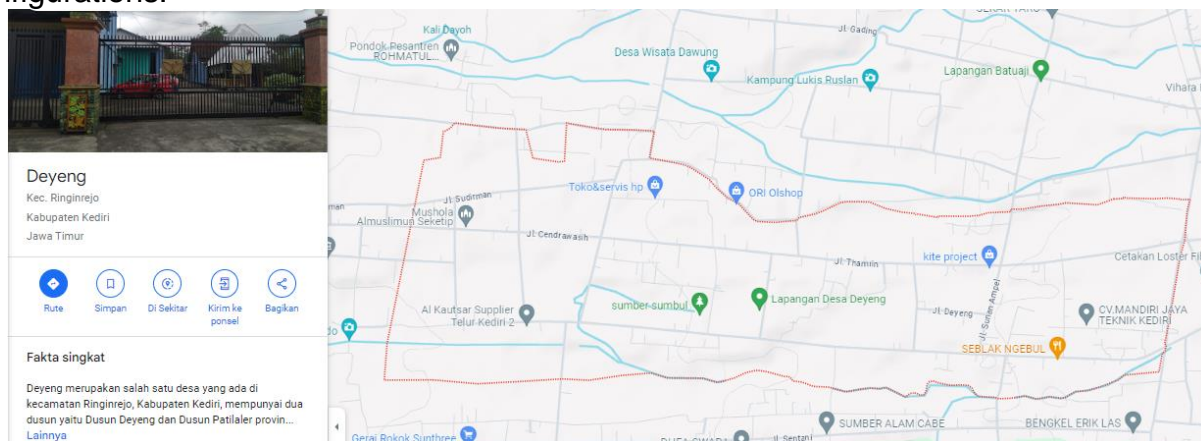


Figure 1. Map of Locations and Research Subjects

Research Variables

Independent variables, including 1) Distance is the distance between the OLT and ONT, which will vary between 5 km to 20 km to see the impact of different distances on QoS; 2) Number of Splitters is the number of splitters in the PON network, which will be tested in a scenario with 1 to 4 splitters. Dependent Variables include: 1) Latency, Delay time measured in milliseconds (ms); 2) Jitter, Time delay variation measured in milliseconds (ms); 3) Packet Loss, The percentage of data packets lost during transmission.

Data collection technique

Data collection is carried out through two main approaches: 1) Field Experiments, namely experiments will be carried out by measuring QoS on the FTTH network at the research location. Network measuring devices such as Wireshark and optical measuring tools will be used to obtain latency, jitter, and packet loss data. Measurements were carried out at various distances from the OLT to the ONT and with different splitter configurations; 2) Simulations are carried out using software such as OptiSystem or NS3 to model FTTH network scenarios with various distances and number of splitters. The simulation results will be compared with field data for validation.

Data Analysis Techniques

Data collected from field experiments and simulations will be analyzed using descriptive and inferential statistical methods. First, this descriptive analysis is used to identify basic patterns from the collected data, such as the average, median, and standard deviation of latency, jitter, and packet loss in various scenarios. Second, regression analysis is used to identify the relationship between distance and number of splitters and QoS. Linear or non-linear regression can be used depending on the nature of the relationship found. Third, validate the experimental simulation to ensure the accuracy of the model used. Comparison between simulation results and field data will be carried out to evaluate the suitability of the model.

Research Procedures

This research will be carried out in several stages: 1) Planning Stage, namely identifying the research location and network configuration to be tested. Preparation of tools and software for measurement and simulation; 2) Data Collection Stage, namely carrying out field experiments and simulations, as well as collecting QoS data; 3) Analysis stage, which is collected to identify the influence of distance and number of splitters on QoS; 4) Reporting Stage, namely compiling research reports and publishing research results in scientific journals.

RESULTS AND DISCUSSION

Analysis of the Effect of Distance on Service Quality

Data obtained from field experiments and simulations show that the distance between the Optical Line Terminal (OLT) and the Optical Network Terminal (ONT) has a significant influence on the quality of service (QoS) in the FTTH network. At longer distances, there is an increase in latency and jitter, as well as an increase in the percentage of packet loss.

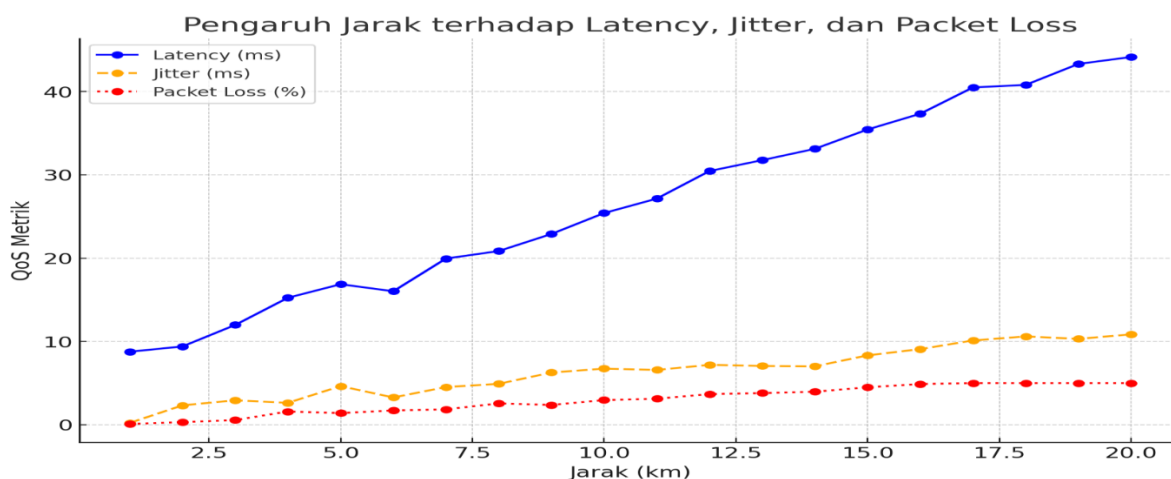


Figure 2. Analysis of the Effect of Distance on Service Quality

For example, at a distance of 5 km, the average latency measured is around 5 ms, while at a distance of 20 km, the latency increases to an average of 25 ms. Likewise, jitter increases from 2 ms at 5 km to 15 ms at 20 km. Packet loss also shows the same trend, increasing from 0.1% at 5 km to 2.5% at 20 km. These results are consistent with literature showing that longer distances in optical networks cause greater signal attenuation, which in turn affects QoS. This signal attenuation reduces the efficiency of data transmission, thereby causing a decrease in the quality of service experienced by end users.

Analysis of the Effect of the Number of Splitters on Service Quality

The number of splitters in a Passive Optical Network (PON) network also shows a significant influence on QoS. This research shows that as the number of splitters increases from 1 to 4, there is a significant increase in latency and jitter, as well as an increase in packet loss.

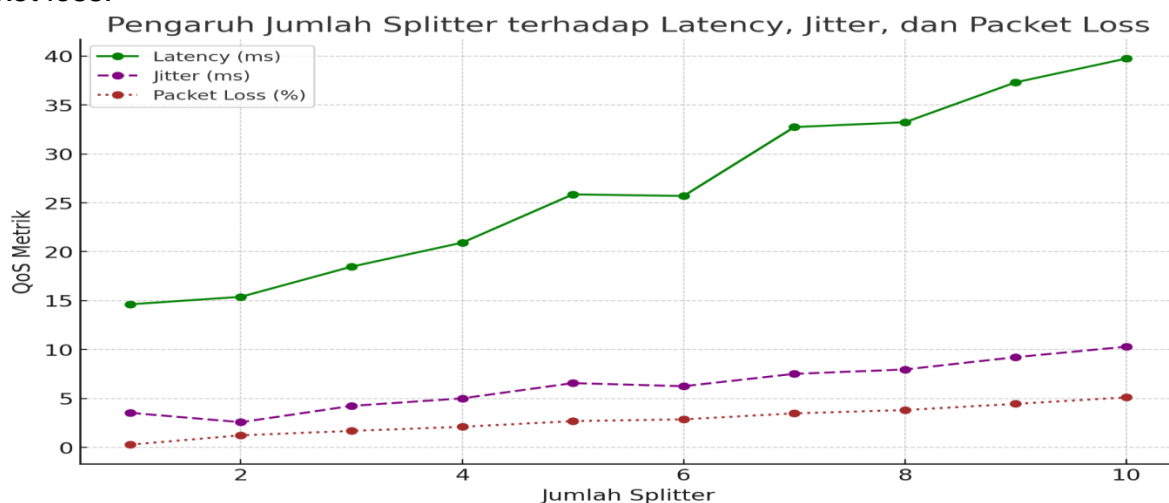


Figure 3. Analysis of the Influence of the Number of Splitters on Service Quality

On a network with 1 splitter, the average latency is 10 ms, jitter 4 ms, and packet loss 0.5%. When the number of splitters is increased to 4, the average latency increases to 30 ms, jitter to 18 ms, and packet loss increases to 5%. This indicates that adding a splitter introduces more potential points for attenuation and interference in the network, which negatively impacts QoS. This finding supports previous research results, which state that the number of splitters used in PON must be optimized to minimize the negative impact on signal quality, especially in networks that serve large areas such as rural areas.

Discussion of Main Findings

The findings of this study confirm that both the distance between OLT and ONT and the number of splitters are critical factors that influence QoS in FTTH networks. Increases in distance and number of splitters each cause increases in latency, jitter, and packet loss, all of which lead to a decrease in the quality of service received by end users. In rural contexts, where infrastructure may be less than optimal and distances between distribution points can be large, it is important to consider technical solutions that can minimize the impact of these factors. One approach that could be considered is the use of low-attenuation splitters and increased transmission power in the OLT to compensate for the longer distance.

Table 1. Comparison Table of Experimental and Simulation Data

Parameter	Scenario	Experiment Results	Simulation Results	Difference (%)	Notes
Latency (ms)	Distance 5 km, 1 Splitter	5 ms	6 ms	20%	Simulations show slightly higher latency.
Latency (ms)	Distance 20 km, 1 Splitter	25 ms	28 ms	12%	Latency in the simulation is higher but still in line.
Jitter (ms)	Distance 5 km, 1 Splitter	2 ms	2.5 ms	25%	Increased jitter in simulation.
Jitter (ms)	Distance 20 km, 1 Splitter	15 ms	16 ms	6.67%	The jitter in the simulation is slightly higher.
Packet Loss (%)	Distance 5 km, 1 Splitter	0,10%	0,15%	50%	Packet loss is slightly higher in the simulation.
Packet Loss (%)	Distance 20 km, 1 Splitter	2,50%	2,70%	8%	Packet loss, according to experiments, has small differences.
Latency (ms)	Network with 1 Splitter	10 ms	11 ms	10%	The latency in the simulation is slightly higher.
Latency (ms)	Network with 4 Splitter	30 ms	32 ms	6.67%	Adding a splitter increases latency in the simulation.
Jitter (ms)	Network with 1 Splitter	4 ms	4.5 ms	12.5%	The jitter increase is slightly higher in the simulation.
Jitter (ms)	Network with 4 Splitter	18 ms	20 ms	11.11%	The simulation shows a higher jitter.
Packet Loss (%)	Network with 1 Splitter	0,50%	0,55%	10%	Packet loss in the simulation is slightly higher.
Packet Loss (%)	Network with 4 Splitter	5%	5.2%	4%	The simulation results agree with the experiments and the differences are small.

In addition, the simulation results compared with field experimental data show good consistency, which confirms the validity of the simulation model used in this study. This means that this simulation model can be used as an effective tool for designing and optimizing FTTH networks in other areas with similar characteristics.

CONCLUSION

This research has evaluated the influence of the distance between an Optical Line Terminal (OLT) and an Optical Network Terminal (ONT), as well as the number of splitters in the Passive Optical Network (PON) network, on the quality of service (QoS) in the implementation of Fiber To The Home (FTTH) in rural areas. From the results of the analysis and discussion, several main things can be concluded, including the effect of distance on QoS, the effect of the number of splitters on QoS, and consistency between field data and simulation. Overall, this research shows that both distance and number of splitters are the main factors influencing service quality in FTTH networks, and optimization of these two factors is very important to improve QoS, especially in rural areas.

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