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Four-Layer QoS Analysis for Multimedia Traffic over Wi-Fi Network at UPNVJ Laboratory

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Abstract — One technique to evaluate and enhance the quality of telecommunications services is to monitor and measure the Quality of Service (QoS) and the user's Quality of Experience (QoE). This method is suitable to be performed in an area that provides public Wi-Fi for multi-user, such as Wi-Fi at the UPN Veteran Jakarta Electrical Engineering Laboratory. The survey results show that there are still many issues experienced by users regarding the availability, accessibility, retainability, and stability of the network and application services accessed. The multimedia application services analyzed in this study are WhatsApp Desktop Call (voice traffic), Zoom Meeting (video traffic), and the UPNVJ LeADS web (data traffic). The tools used for data collection are Wireshark, PRTG, router admin panel web, and Command Prompt. Based on the monitoring, it was found that: network quality degrades when connected to more than 5 devices at the same time, frequent downtime conditions can reach 54% in a day, and the average data packet traffic speed across one device is 4,34 Mbps. Based on the average calculation of the QoS parameters measured: the highest throughput value is obtained on the UPNVJ LeADS web which reaches 102,09 Kbps, the highest delay value is obtained in the WA Desktop Call which reaches 521,39 ms, the highest jitter value is obtained in the WA Desktop Call which reaches 1,21 ms, and the highest packet loss value is obtained in Zoom Meeting which reaches 2,16%. The most common issue experienced by users is the "no internet" condition on the Wi-Fi network. The solution for network optimization in this condition can be done by administration setting and network management.

Keywords – Quality of Service (QoS), Quality of Experience (QoE), Multimedia Traffic, Wi-Fi, Wireshark, PRTG.

I. INTRODUCTION

Networks and multimedia data communication services continue to develop into a system that connects people, devices, and information in a converged network environment. One of the network implementations is the Wireless Local Area Network (WLAN), such as Wi-Fi. As a group of interconnected computer networks, a reliable network and equipment are needed to guarantee the connectivity of the telecommunication process by all of its users. Therefore, services and network infrastructure in all scales and layers need to be designed according to standards set by internet standards organizations.

One of the basic characteristics that form the network architecture design is Quality of Service (QoS). QoS determines service delivery priorities according to the type of communication and its importance in the organization when congestion in traffic occurs. QoS is an important parameter in improving multimedia telecommunication services because it is a factual service that is experienced directly by its users. Therefore, monitoring and measuring the quality of telecommunication services, including Quality of Service (QoS) and Quality of

Experience (QoE) can be a solution in dealing with problems when using the internet through Wi-Fi (Kementerian Komunikasi dan Informatika, 2020).

The UPN Veteran Jakarta Electrical Engineering Laboratory as a facility in higher education is an example of a strategic area where the internet is often used for various purposes. Based on the survey results of 100 Electrical Engineering Students, 86% of students had used Wi-Fi at the UPN Veteran Jakarta Electrical Engineering Laboratory. However, overall, based on the survey results, as many as 64% of students had experienced some issues when accessing Wi-Fi at the UPN Veteran Jakarta Electrical Engineering Laboratory.

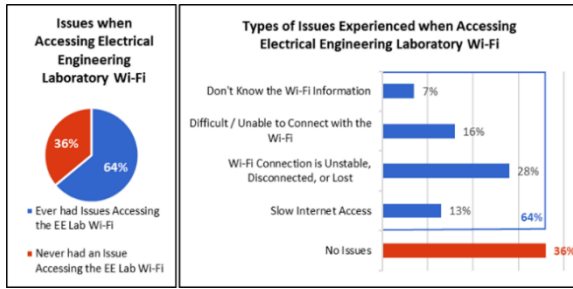


Fig. 1. Survey Results Chart: Number and Types of Issues

II. RESEARCH METHOD

The flow of each stage and the framework for this research are discussed in this section.

A. Identification of Problems

Problem identification is carried out to explore and determine research boundaries at research location. This was explored by observing field conditions, literature review, and conducting a survey of Electrical Engineering Students' Experience regarding the quality of Wi-Fi internet services at the Electrical Engineering Laboratory in the Building of Engineering Faculty of UPN Veteran Jakarta.

B. Survey of UPN Veteran Jakarta Electrical Engineering Students

The survey was conducted on UPN Veteran Jakarta Electrical Engineering Students as a population with a sample size of 100 respondents. The sampling technique used is stratified random sampling method. The data was collected online using Google Forms.

This survey is divided into 4 (four) main sections that refer to the Quality of Service (QoS) and Quality of Experience (QoE) indicators (Jalil Piran et al., 2020). First, regarding the number of students who have used Wi-Fi in the Electrical Engineering Laboratory. Second, regarding the experience when connected to Wi-Fi in the Electrical Engineering Laboratory. Third, regarding the experience when accessing application services via Wi-Fi at the Electrical Engineering Laboratory. Fourth, regarding the issues experienced when using Wi-Fi in the Electrical Engineering Laboratory.

C. Four-Layer QoS Model

According to ITU-T Rec. E.800, Quality of Service (QoS) is the totality of the characteristics of telecommunications services that depend on their ability to meet the stated or implied needs of service users (ITU-T, 2008), (Eckert & Bryant, 2021). QoS is a measurement of network performance that determines the degree of user satisfaction with telecommunications services, and defines the characteristics and characteristics of these services (Taruk et al., 2018), (Charisma et al., 2019).

The Quality of Service (QoS) model for wireless networks includes 4 (four) layers as follows (Jalil Piran et al., 2020):

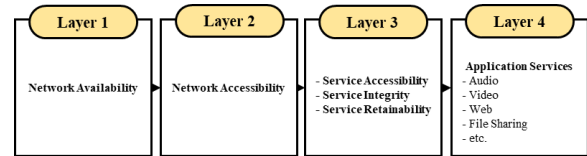


Fig. 2. Four-Layer QoS Model for Wireless Network

Layer 1, Network Availability, is a layer that defines the availability of network infrastructure including devices, media, and drivers that build telecommunication networks.

Layer 2, Network Accessibility, is a layer that defines internet access paths to establish connectivity through the telecommunication network.

Layer 3, is a layer that defines the quality of data transmission of communication services, such as speed, volume, and resilience. This layer includes Service Accessibility, Service Integrity, and Service Retainability.

Layer 4, Application Services, is a layer that defines the various types of services received and experienced directly by end users.

These four layers are interrelated and are indicators of the quality of the user experience when using the network to access application services.

D. Research Theoretical Framework

This is a theoretical framework that connects each variable in this research.

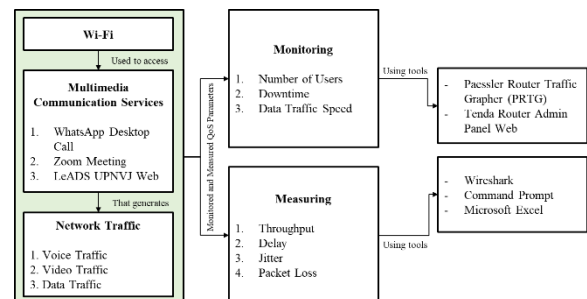


Fig. 3. Research Theoretical Framework

Wi-Fi under this study is used to access multimedia communication services (Ikhwannul et al., 2020), which are divided based on the type of the network traffic: WhatsApp Desktop Call (voice traffic), Zoom Meeting (video traffic), and Google Chrome: UPNVJ LeADS Web (data traffic). This system is then monitored and measured based on the QoS parameters.

The QoS parameters that are monitored are the number of users, downtime, and data traffic speed. The tools used for this monitoring are PRTG Network Monitor and router admin panel web. Meanwhile, the QoS parameters that are measured are throughput, delay, jitter, and packet loss. The tools used for this measurement are Wireshark, Command Prompt, and Microsoft Excel.

E. Data Collection

The Wi-Fi in the Electrical Engineering Laboratory under this study has the SSID “LabElektro” and operates in repeater mode. The measurement and monitoring is carried out in the range of 08.00 – 17.00 for 10 working days (Monday – Friday).

F. Data Analysis

Furthermore, all data that has been collected and processed is analyzed. Some of the parameters, such as delay, jitter, and packet loss are analyzed using each parameter classification standard. The following tables are the standardization for each of the measured QoS parameters based on previous studies [6].

Table 1. Delay Parameter Standard

Delay Category	Value (ms)
Excellent	< 150
Good	150 – 300
Normal	300 – 450
Bad	> 450

Table 2. Latency Parameter Standard

Jitter Category	Value (ms)
Excellent	0
Good	0 – 75
Normal	75 – 125
Bad	125 – 225

Table 3. Packet Loss Parameter Standard

Packet Loss Category	Percentage (%)
Excellent	0 – 2
Good	3 – 14
Normal	15 – 24
Bad	> 25

III. RESULT AND DISCUSSION

A. Number of Connected Devices

The number of devices connected to “LabElektro” Wi-Fi is monitored every hour via the Wi-Fi router admin panel web to see the availability and accessibility of the Wi-Fi network by users.

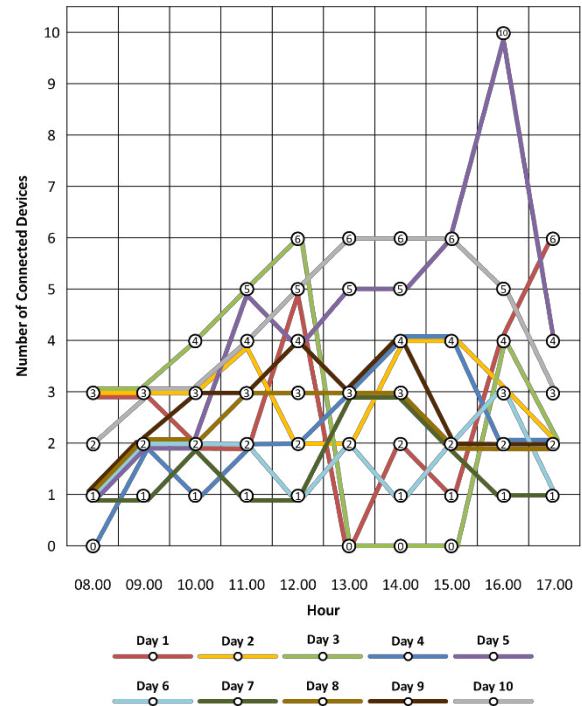


Fig. 4. Graph of Number of Devices Connected to the Wi-Fi

Based on the data collected as in Fig. 4, the highest number of devices that can connect to the “LabElektro” Wi-Fi router is 10 devices. However, all devices connected to the “LabElektro” Wi-Fi may not necessarily have internet access (no internet). Moreover, based on observations, the internet network via “LabElektro” Wi-Fi can experience a decrease in quality when connected to more than 5 devices simultaneously.

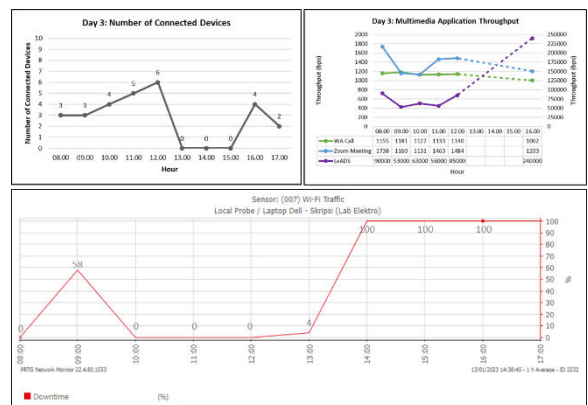


Fig. 5. Graph of the Relationship between Number of Devices and Internet Quality

In the Fig. 5 there are 3 (three) graphs, namely: a graph of the number of connected devices, a graph of the multimedia application services throughput, and a graph of the “LabElektro” Wi-Fi traffic downtime. Based on these graphs, the highest number of connected devices reached 6 devices at 12.00. But after that, there was an overload which caused the internet disconnection on the device at 13.00 – 15.00, so that users could not access the internet. This

condition is also illustrated in the graph of the “LabElektro” Wi-Fi downtime which reaches 100% (not operating) at the same time. Therefore, in addition to other variables, the number of connected devices is one of the factors that affect the quality of the “LabElektro” Wi-Fi.

B. Downtime

The following table contains a summary of the average daily monitoring results of downtime obtained from the “Wi-Fi Traffic SNMP Service” sensor using PRTG Network Monitor.

Table 4. Monitoring Results of SNMP Services Wi-Fi Traffic: Downtime

	Downtime (%)
Day 1	0,33
Day 2	54
Day 3	51
Day 4	5
Day 5	13
Day 6	12
Day 7	0
Day 8	24
Day 9	26
Day 10	2

Based on the measurement results presented in Table 4, the lowest downtime value was 0% and the highest downtime value was 54%. The higher the downtime value, the more it indicates the instability of the availability and accessibility of the network. Several factors affect this downtime, including: the condition of the hardware used, the number of connected devices, and the volume of traffic across the network.

C. Data Traffic Speed

The following table contains a summary of the average daily monitoring results of data traffic speed obtained from the “Wi-Fi Traffic SNMP Service” sensor using PRTG Network Monitor.

Table 5. Monitoring Results of SNMP Services Wi-Fi Traffic: Data Traffic Speed

	Traffic In (Mbps)	Traffic Out (Mbps)	Traffic Total (Mbps)
Day 1	3,57	3,53	7,10
Day 2	7,24	3,63	11
Day 3	0,34	0,05	0,38
Day 4	0,23	0,05	0,28
Day 5	7,25	7,18	14
Day 6	2,17	3,28	5,45
Day 7	1,93	2,03	3,97
Day 8	0,42	0,05	0,47
Day 9	0,11	0,04	0,15
Day 10	0,56	0,03	0,59
Average	2,38	1,99	4,34

Table 5 presents the results of measuring the traffic speed of data packets crossing the network on one device. The average value of “LabElektro” Wi-Fi traffic in speed is 2,38 Mbps with a value range of 0,11 Mbps to 7,25 Mbps. The average value of “LabElektro” Wi-Fi traffic out speed is 1,99 Mbps

with a value range of 0,03 Mbps to 7,18 Mbps. The average value of “LabElektro” Wi-Fi traffic total speed 4,34 Mbps with a value range of 0,15 Mbps to 14 Mbps.

The speed of data traffic across the “LabElektro” Wi-Fi network has a various value because it is affected by several factors such as the services accessed, the number of users, device conditions, and various other factors. The higher the value of the data traffic speed, the better the quality because more data is sent and received in a shorter time.

D. Measurement Results of Quality of Service (QoS) Parameters for Multimedia Applications

The Quality of Service (QoS) is measured to define the quality of data transmission for various types of communication services received and experienced directly by end users (Ikhwannul et al., 2019). This measurement is carried out using the Wireshark application and the Command Prompt. The three multimedia applications that are measured are: WhatsApp Desktop Call (voice traffic), Zoom Meeting (video traffic), and UPNVJ LeADS website via Google Chrome (data traffic).

a) WhatsApp Desktop Call

The average throughput value of the WhatsApp Desktop Call application is 2563,76 bps or the equivalent of 2,56 Kbps.

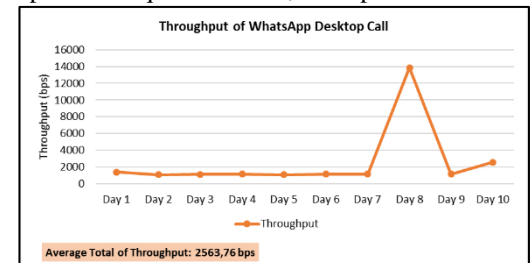


Fig. 6. Graph of WhatsApp Desktop Call Throughput Measurement

The average delay value of 521,39 ms is categorized as “bad”. The average jitter value of 1,21 ms is categorized as “good”.

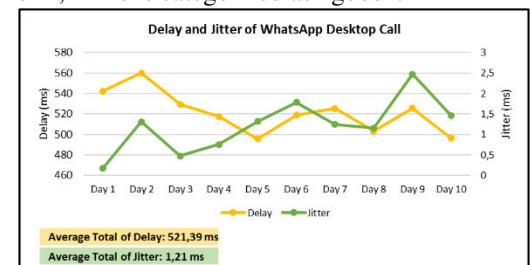


Fig. 7. Graph of WhatsApp Desktop Call Delay and Jitter Measurements

The average packet loss value of 1,43% is categorized as “excellent”.

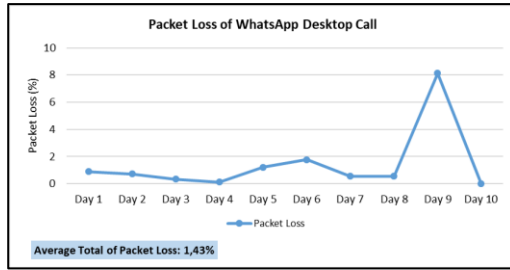


Fig. 8. Graph of WhatsApp Desktop Call Packet Loss Measurement

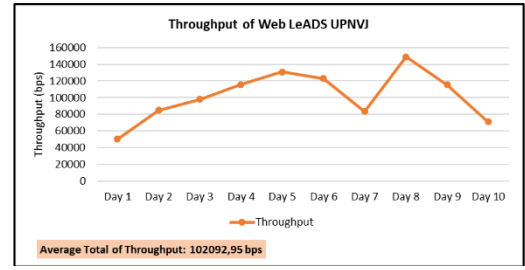


Fig. 12. Graph of UPNVJ LeADS Web Throughput Measurement

b) Zoom Meeting

The average throughput value of the Zoom Meeting application is 1367,27 bps or the equivalent of 1,37 Kbps.

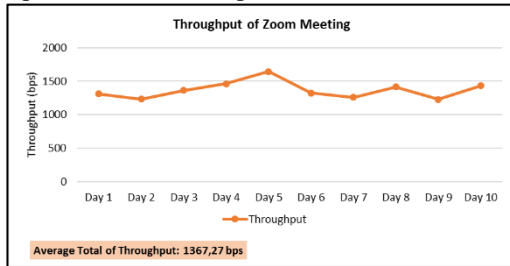


Fig. 9. Graph of Zoom Meeting Throughput Measurement

The average delay value of 93,57 ms is categorized as “excellent”. The average jitter value of 0,20 ms is categorized as “good”.

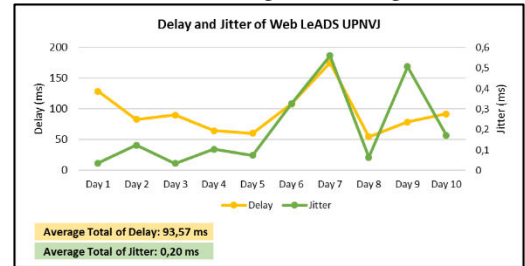


Fig. 13. Graph of UPNVJ LeADS Web Delay and Jitter Measurements

The average delay value of 428,21 ms is categorized as “normal”. The average jitter value of 0,80 ms is categorized as “good”.

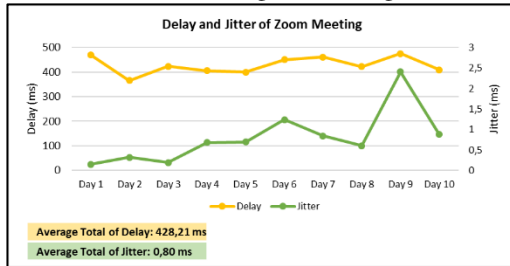


Fig. 10. Graph of Zoom Meeting Delay and Jitter Measurements

The average packet loss value of 1,43% is categorized as “excellent”.

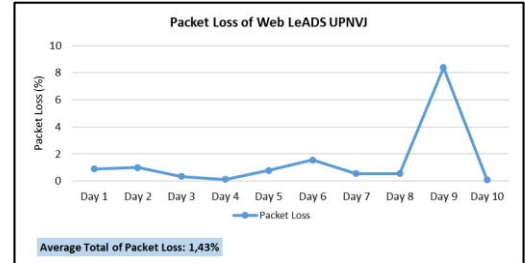


Fig. 14. Graph of UPNVJ LeADS Web Packet Loss Measurement

The average packet loss value of 2,16% is categorized as “excellent”.

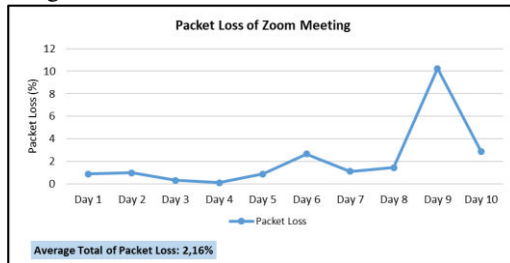


Fig. 11. Graph of Zoom Meeting Packet Loss Measurement

c) Google Chrome: LeADS UPN Veteran Jakarta

The average throughput value of the UPNVJ LeADS website via Google Chrome is 102092,95 bps or the equivalent of 102,09 Kbps.

E. Issues and Solutions to the Use of “LabElektro” Wi-Fi Network

The following table contains issues that occur when using “LabElektro” Wi-Fi along with short-term solutions that users can do to overcome them.

Table 6. Issues and Solutions

No.	Issues	Solutions
1.	Device is unable to connect with Wi-Fi.	<ul style="list-style-type: none"> - Rebooting and resetting the router. - Using mobile hotspot mode from a device that has been successfully connected to Wi-Fi.
2.	The device is connected to Wi-Fi, but there is no internet connection.	<ul style="list-style-type: none"> - Check and repair the connection between the repeater and the upstream router. - Using mobile hotspot mode from a device

		that has been successfully connected to Wi-Fi.
3.	The Wi-Fi connection is slow, unstable, and lost while in use.	Perform user management of devices connected to Wi-Fi.

the equivalent of 102,09 Kbps. The delay value of 93,57 ms is categorized as “excellent”. The jitter value of 0,20 ms is categorized as “good”. The packet loss value of 1,43% is categorized as “excellent”.

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In addition, there are long-term solutions that can be done through network settings by administrators:

- 1) Provide network administration access to the UPN Veteran Jakarta Faculty of Engineering to monitor the internet network in the UPN Veteran Jakarta Faculty of Engineering.
- 2) Set the capacity of the maximum number of devices connected to Wi-Fi in the Electrical Engineering Laboratory.
- 3) Subscribe to an additional ISP (Internet Service Provider) as a backup internet service provider at the Electrical Engineering Laboratory.

IV. CONCLUSSION

The following is the conclusion of this research.

- 1) Quality of Service (QoS) analysis based on a four-layer model is suitable for a simple construction of wireless local area network. This analysis model includes network availability, network accessibility, quality of data transmission from communication application services, and user experience when using application services.
- 2) “LabElektro” Wi-Fi may experience a decrease in quality when connected to more than 5 devices simultaneously.
- 3) The highest downtime value is 54% in a day.
- 4) The average value of “LabElektro” Wi-Fi traffic total speed 4,34 Mbps with the average value of “LabElektro” Wi-Fi traffic in speed is 2,38 Mbps and the average value of “LabElektro” Wi-Fi traffic out speed is 1,99 Mbps.
- 5) The throughput value of the WhatsApp Desktop Call application is 2,56 Kbps. The delay value of 521,39 ms is categorized as “bad”. The jitter value of 1,21 ms is categorized as “good”. The packet loss value of 1,43% is categorized as “excellent”.
- 6) The throughput value of the Zoom Meeting application is 1367,27 bps or the equivalent of 1,37 Kbps. The delay value of 428,21 ms is categorized as “normal”. The jitter value of 0,80 ms is categorized as “good”. The packet loss value of 2,16% is categorized as “excellent”.
- 7) The throughput value of the UPNVJ LeADS website via Google Chrome is 102092,95 bps or

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