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Analysis of quality of service (QoS) wi-fi etwork in UNNES digital center building using wireshark

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ABSTRACT

The need for the internet is a very absolute target in today's all-digital era. The traffic of information that is so dense and always dynamic every second makes everyone want speed in capturing information circulating. The speed in gathering information in this all-digital era cannot be separated from the internet and networks. UNNES Digital Center is one of the facilities owned by Semarang State University which is used as a digital-based learning center to support the realization of the Smart Digital Campus. The availability of qualified network services at the UNNES Digital Center is needed to support the all-digital-based student learning process. This research was done to find out how fast and good the quality of the internet network provided by the UNNES Digital Center is. In the research conducted, the network analysis step uses the Quality of Service (QoS) method. In obtaining research data that will be used as a basis for analyzing throughput, packet loss, delay, and network jitter, Wireshark software is used as a tool. The research results show that the quality of the Digital Center's internet network is very good and very adequate for digital learning activities. This is evidenced by a network throughput value of 6122.37 /kbits/s, a packet loss value of 0.7%, a delay of 214 ms with a moderate or quite good value and jitter = 0.511 ms.

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1. Introduction

The need for the internet will certainly never be separated from human civilization today. Society 5.0, which makes all human activities digital-based, has a direct effect on the dense and fast exchange of information, making everyone really need and want a fast and stable internet so that they can easily get information quickly and accurately every day without missing anything at all. In fulfilling the need for internet access, we have seen a lot of various technologies that have been raised to support human convenience in getting qualified internet access anywhere and anytime. The installation of Wi-Fi and the availability of various providers who are always ready to provide various services are clear evidence of efforts to fulfil these needs which aim to keep people up to date with the dynamic changes in information in today's digital era.[1]

As a form of embodiment of digitalization in learning activities on campus, especially on the Semarang State University campus, there is no need to doubt the existence of Wi-Fi or access points. Almost all places for student activities are equipped with free internet access and are ready to use at any time. In addition, the embodiment of digitizing learning on the Semarang State University campus is also evidenced by the existence of the UNNES Digital Center building which functions as a support for smart digital campus learning. The functionality of the UNNES Digital Center building is supported by various technological facilities including internet access.

In this research, the authors conducted an analysis of the internet network connectivity found in the UNNES Digital Center building to determine how good the quality of the internet network is in the building that functions as a digital-based learning development center. Network connectivity analysis applies the Quality of Service (QoS) method which has service standards that guarantee performance and network quality measurement parameters. QoS itself is related to the network connected to the speed and reliability of providers of various types of data in communication. According to Wulandari (2016), Quality of Service (QoS) is a method for measuring network capacity and trying to define the characteristics and nature of a service. QoS is used to measure a predefined set of performance attributes assigned to a service [2].

The majority of problems that often occur in network protocols are network damage causing network quality to not work properly, therefore, to see how the network is performing, calculations are needed using the Quality of Service method.

In analyzing the network quality of the UNNES Digital Center building using the QoS testing method, Wireshark software is used to analyze a data packet on the network which functions to capture every packet that enters the network and displays information on all data packets in detail. All types of information packets can be viewed in IP (Internet Protocol) format which will be easy to analyze. With Wireshark, the process for analyzing internet network performance can easily get the results obtained.

1. Method

In network research at the UNNES Digital Center, research methods include research objects, research equipment, data collection techniques, and research steps. The research object in question is the wifi network on the 2nd floor of the UNNES Digital Center. The UNNES Digital Center is a building owned by Semarang State University which functions as a digitization building. This building consists of 3 floors where each floor has 2 rooms equipped with + 100 ready-to-use computers, wifi network access, toilets, recording room, elevator, kitchen, and so on.

During the research process, the author uses supporting equipment in the form of a laptop/PC to run the Wireshark application. The Wireshark application is a software used to analyze networks [3]. The author uses this application to obtain data for calculating throughput, packet loss, delay, and Wi-Fi network jitter at the 2nd floor of the UNNES Digital Center. The author uses the Nonprobability Sampling Design technique with purposive sampling for data collection when conducting research on the UNNES Digial Center internet network floor 2.This technique is a sampling technique from data sources that do not provide equal opportunities or opportunities for each member of the population to be selected as a data sample by certain considerations. Data samples to be taken in this research include throughput, packet loss, delay, and jitter of the UNNES Digital Center wifi network between 13.00 – 16.00 WIB. The author's purpose in choosing this time is because at that time it is a time with high or busy network traffic (the number of people using the network is quite high) in line with the lecture hours held at the UNNES Digital Center during these hours. The research was conducted on November 28, 2022.

The research steps with the focus of the object under study are network quality at the 2nd floor of the UNNES Digital Center is can be seen in Figure 1:

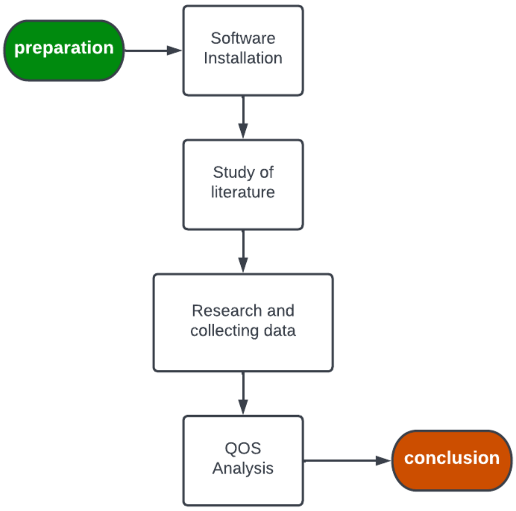

Figure 1. Research steps

The research step begins with the installation of the Wireshark software which is used as an assistant in capturing research data, namely internet network connectivity data at UNNES Digital Center floor 2. Wireshark can also be called a network packet analyzer. As the name implies, the use of this software is to capture data packets which will then display detailed information of all packets that are traffic on a network. Installation is done by first downloading the Wireshark set-up which can be obtained by searching on Google. [4]

The next step is a literatures′ study. In this step the author collects reference sources that are used as the basis for carrying out this research. The reference sources that the authors use include scientific journals, internet articles, and videos collected from various provider sites.

After the authors obtained the foundation for conducting network quality research, the authors conducted research with the object under study in the form of a wifi network on the 2nd floor of the UNNES Digital Center building. The details of the research implementation are the same as previously described. In the realization of the research implementation, the author did several network recordings. However, the author only performs network analysis on one of the recording results with consideration of the level of accuracy between the results of the network recording data obtained. In this stage the authors also collect research data that is used as a basis for analyzing network quality with the QoS analysis model.[5]

After the author obtained the research data regarding the desired quality of the wifi network at the UNNES Digital Center building, the 2nd floor, the author analyzed the data obtained by using an analysis model in the form of Quality of Service analysis. In the Quality of Service analysis, there are several parameters that the author analyzes:

- Throughput

Throughput is a parameter used to determine the amount of data that has been successfully received in good condition against the total transmission time required from source to recipient or subscriber[6]. Throughput is defined as the rate (speed) of the network in carrying out effective data transfers in units of bps (bits per second). The smaller the throughput value, the worse the quality will be. Throughput is the total number of packets that were successfully received (received) divided by the total observation time (timeframe). Therefore, the throughput calculation can be done using the following equation:

$$\text{throughput} = \frac{\text{datapacketreceive}}{\text{observationperio}}$$

The index or grouping of good and bad categories of networks based on throughput values is based on the following Table 1 [7]:

Table 1. Throughput category

Throughput categories	Throughput (bps)	Index
Very good	100	4
Good	75	3
Moderate	59	2
Bad	<25	1

- Packet loss

Packet loss is a parameter that describes a condition that shows the total number of lost packets, which can occur due to collisions between packets and full data traffic on the network and this affects all applications because retransmission will reduce the efficiency of the network as a whole even though the number Sufficient bandwidth is available for the application [8]. The smaller the packet loss value, the better the quality will be. Packet loss is usually measured in % (percent). Calculation of packet loss can be done using the following calculation equation:

$$\text{Packetlos} = \frac{(\text{datapacketssent} - \text{datapacketsreceived})}{\text{totalpacketsen}} \times 100\%$$

The good and bad category of internet network quality when viewed from the packet loss value is classified as the following table:

Table 2. Packet loss category

Relegation categories	Packet loss (%)	Index
Very good	0	4
Good	3	3
Moderate	15	2
Bad	≥25	1

- Delay (latency)

Delay or also known as latency is the time lag required for a data packet to move from one source to another. The source in question can be the origin of the data packet and the destination of the data packet. In the calculation, delay / latency is defined in units of milliseconds (ms). Factors that can affect the delay / latency value include network hardware, remote server location, distance, and also processing time. The smaller the delay or latency, the better the quality of the internet network. Classification of network quality based on the value of the delay / latency is can be seen Table 3 [9]:

Table 3. Delay (Latency) category

Category	Delay (ms)	Index
Very good	<150	4
Good	150-300	3
Moderate	300-450	2
Bad	>450	1

Delay can be calculated by calculating the difference in reception between a packet and the next packet. Furthermore, there is the term average delay which is defined as the average delay between the delivery of each packet. To calculate the average delay, the following equation (1) is used:

$$\text{verage delay} = \frac{\text{total delay}}{\text{total packets received}} \quad (1)$$

- Jitter

Jitter or also known as the variation of data packet arrivals is easily interpreted as the difference between one delay and the next delay which is defined in units of milliseconds (ms). Jitter is called delay variation, because it is closely related to latency, indicating the amount of delay variation in data transmission on the network [11]. The amount of jitter can be affected by variations in queue length, in data processing time, and also in the reassembly time of packets at the end of the jitter trip [11]. Based on its definition, to calculate jitter, it is necessary to calculate the delay between data packets first. In addition, if you want to calculate the average jitter, then the calculation formula is used as follows:

$$\text{verage Jitter} = \frac{\text{total delay variatio}}{\text{total received packets} - 1} \quad (2)$$

The smaller the jitter value, the better the network speed and quality. Network classification based on its jitter value is presented in Table 4:

Table 4. Jitter category

Network categories	Jitter (ms)	Index
Very good	0	4
Good	0-75	3
Keep	75-125	2
Bad	125-225	1

2. Results and Discussion

Research that conducted by the author on November 28, 2022, at 13:47:44 – 13:48:15 WIB which took place in Laboratory 2A of the 2nd floor of the UNNES Digital Center Building on the available Wi-Fi network produced can be seen Figure 2 :

Statistics

Measurement	Captured	Displayed	Marked
Packets	143	143 (100.0%)	—
Time span, s	30.660	30.660	—
Average pps	4.7	4.7	—
Average packet size, B	164	164	—
Bytes	23464	23464 (100.0%)	0
Average bytes/s	765	765	—
Average bits/s	6122	6122	—

Figure 2. Data capturing from wireshark

Explanation:

1. Network packet capture is done at 13:47:44 – 13:48:15 (30 s)
2. Data that can be retrieved and will be used as material for QoS analysis from the results of the capture of the Wi-Fi network in the 2nd floor of the UNNES Digital Center building include:
    - Total captured packets = 143 packages
    - Capture time frame = 30,660 s
    - Bytes = 23464

3.1. Throughput Analysis

Throughput parameter data is obtained from the application software used. In calculating the throughput value, the author uses the total data packets received and the time span for sending packets. The data in question has the following values:

- Bytes = 23464
- Time = 30,660 s

$$\text{Throughput} = \frac{\text{number of data packets sent}}{\text{capture time frame}} \quad (3)$$

Throughput has units of bits per second, therefore data on the number of packets received from research is converted first from bytes to bits by multiplying the value by 8.

- Bytes to bits = 23464 x 8 = 187712
- Throughput = 187712 : 30,660

  = 6122.37 bits /s

Based on the calculation results, the throughput value of the Wi-Fi network in the 2nd floor of the UNNES Digital Center building is 6122.37 bits / s. In real terms the throughput value of the Wi-Fi network is > 100 ms. Based on the network quality classification table based on throughput value, the Wi-Fi network has an index of 4 and is included in the very good category.

3.2. Packet Loss Analysis

To search for packet loss, after opening the network packet recording file, in Wireshark a search filter is added tcp.analysis.ack_lost_segment or tcp.analysis.lost_segment which functions to display whether or not data packets are not captured / lost packets.

In capturing the Wi-Fi network of the UNNES Digital Center Building floor 2 on November 28, 2022 at 13:47 – 13:48 for 30 seconds, a packet was found that was not captured can be seen in Figure 3 [11].

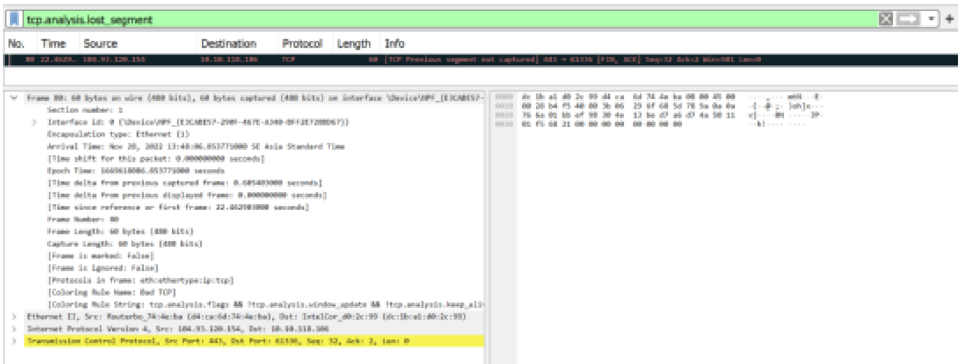

Figure 3. Capture packet loss

Based on the search results, the number of uncaptured packets found is 1. So the packet loss calculation for the wifi network UNNES Digital Center Building floor 2 is as follows:

- Packet send = 143
- Uncaptured = 1
- Packet received = (143 - 1) = 142
- Packet loss

$$\text{Packet Loss} = \frac{\text{Uncaptured packet(s)}}{\text{Total packets}} \times 100\% \quad (4)$$

$$\text{packet loss} = \frac{(143 - 142)}{143} 100\%$$

$$= \frac{1}{143} 100\%$$

$$= 0{,}7\%$$

Based on the calculation results, it was found that the packet loss value of the Wi-Fi network in the UNNES Digital Center building on the 2nd floor was 0.7%. Based on the packet loss value, the Wi-Fi network is in the very good category with an index of 4.

3.3. Delay Analysis

In the network delay analysis, the authors filter the network activity capture that has been obtained with the TCP filter. It is intended that the capture view only shows the log section with the TCP protocol. The results of the capture with the TCP protocol obtained by the author are as follows:

No.	Time	Source	Destination	Protocol	Length
2	0.267156	10.10.118.106	170.114.15.93	TLSv1.2	84
3	0.650919	170.114.15.93	10.10.118.106	TCP	60
5	0.694614	170.114.15.93	10.10.118.106	TCP	66
10	2.1026	10.10.118.106	170.114.15.93	TLSv1.2	271
11	2.660171	10.10.118.106	170.114.14.69	TLSv1.2	89
12	2.663286	170.114.15.93	10.10.118.106	TCP	60
13	2.664217	170.114.15.93	10.10.118.106	TLSv1.2	249
14	2.704907	10.10.118.106	170.114.15.93	TCP	54
15	3.355231	10.10.118.106	170.114.14.69	TCP	89
16	3.358607	170.114.14.69	10.10.118.106	TCP	60
17	3.358914	170.114.14.69	10.10.118.106	TLSv1.2	85
18	3.400115	10.10.118.106	170.114.14.69	TCP	54
19	3.656544	10.10.118.106	35.186.224.47	TLSv1.2	89
20	4.338302	170.114.14.69	10.10.118.106	TCP	66
21	4.374462	35.186.224.47	10.10.118.106	TCP	60
22	4.374462	35.186.224.47	10.10.118.106	TLSv1.2	85
23	4.42487	10.10.118.106	35.186.224.47	TCP	54
24	5.15749	52.108.195.3	10.10.118.106	TLSv1.2	87
25	5.208117	10.10.118.106	52.108.195.3	TCP	54
26	6.898216	52.108.195.3	10.10.118.106	TLSv1.2	87
27	6.946871	10.10.118.106	52.108.195.3	TCP	54
47	9.121144	13.107.138.9	10.10.118.106	TCP	60
52	12.12558	35.186.224.25	10.10.118.106	TLSv1.2	127
55	12.17848	10.10.118.106	35.186.224.25	TCP	54
56	12.17849	13.107.138.9	10.10.118.106	TCP	60
57	14.16841	13.107.138.9	10.10.118.106	TCP	60
60	16.83227	35.186.224.25	10.10.118.106	TLSv1.2	110
61	16.83227	35.186.224.25	10.10.118.106	TCP	60
62	16.83238	10.10.118.106	35.186.224.25	TCP	54
63	17.5946	10.10.118.106	118.97.159.42	TCP	55
64	17.59479	10.10.118.106	118.97.158.160	TCP	55
67	18.43338	52.108.195.3	10.10.118.106	TLSv1.2	87
70	18.43338	52.108.195.3	10.10.118.106	TCP	87
71	18.43338	118.97.158.160	10.10.118.106	TCP	66
72	18.43363	10.10.118.106	52.108.195.3	TCP	66
73	18.43639	118.97.159.42	10.10.118.106	TCP	66
74	19.08312	52.108.195.3	10.10.118.106	TLSv1.2	87
75	19.13225	10.10.118.106	52.108.195.3	TCP	54
77	21.28598	10.10.118.106	104.93.120.154	TCP	55
78	21.6247	104.93.120.154	10.10.118.106	TCP	66
79	21.8575	10.10.118.106	35.186.224.39	TLSv1.2	97
80	22.4629	104.93.120.154	10.10.118.106	TCP	60
81	22.46297	10.10.118.106	104.93.120.154	TCP	54
82	22.46391	35.186.224.39	10.10.118.106	TCP	60
83	22.46499	35.186.224.39	10.10.118.106	TLSv1.2	94
84	22.51987	10.10.118.106	35.186.224.39	TCP	54
85	23.07848	104.93.120.154	10.10.118.106	TCP	85
86	23.07857	10.10.118.106	104.93.120.154	TCP	54
87	23.70655	10.10.118.106	20.198.119.84	TLSv1.2	97
88	23.72203	157.240.218.61	10.10.118.106	TCP	119
89	23.72759	10.10.118.106	157.240.218.61	TCP	274
90	23.7278	10.10.118.106	157.240.218.61	TCP	101
92	24.11252	20.198.119.84	10.10.118.106	TLSv1.2	228
94	24.11593	157.240.218.61	10.10.118.106	TCP	60
95	24.11639	157.240.218.61	10.10.118.106	TCP	60
96	24.1582	10.10.118.106	20.198.119.84	TCP	54
97	25.06661	157.240.218.61	10.10.118.106	TCP	1003
99	25.08868	10.10.118.106	157.240.218.61	TCP	93
100	25.19383	157.240.218.61	10.10.118.106	TCP	1003
101	25.19392	10.10.118.106	157.240.218.61	TCP	66
102	25.63878	157.240.218.61	10.10.118.106	TCP	60
103	25.63907	157.240.218.61	10.10.118.106	TCP	963
104	25.68332	10.10.118.106	157.240.218.61	TCP	54
112	27.53817	10.10.118.106	118.98.116.35	TCP	66
114	27.84975	118.98.116.35	10.10.118.106	TCP	66
115	27.84987	10.10.118.106	118.98.116.35	TCP	54
116	27.85178	10.10.118.106	118.98.116.35	TLSv1.3	553
120	28.04067	118.98.116.35	10.10.118.106	TCP	60
121	28.04333	118.98.116.35	10.10.118.106	TLSv1.3	266
122	28.04344	10.10.118.106	118.98.116.35	TCP	54
123	28.04646	10.10.118.106	118.98.116.35	TLSv1.3	118
124	28.05493	10.10.118.106	118.98.116.35	TLSv1.3	134
125	28.06627	10.10.118.106	118.98.116.35	TLSv1.3	244
126	28.68962	10.10.118.106	118.98.116.35	TCP	388
127	28.69267	118.98.116.35	10.10.118.106	TLSv1.3	237
128	28.69267	118.98.116.35	10.10.118.106	TLSv1.3	128
129	28.69267	118.98.116.35	10.10.118.106	TLSv1.3	85
130	28.69267	118.98.116.35	10.10.118.106	TLSv1.3	157
131	28.69281	10.10.118.106	118.98.116.35	TCP	54
132	28.6946	10.10.118.106	118.98.116.35	TLSv1.3	85
135	28.72119	10.10.118.106	36.91.231.224	TCP	66
136	28.7295	52.108.195.3	10.10.118.106	TLSv1.2	87
137	28.7821	10.10.118.106	52.108.195.3	TCP	54
140	29.12806	10.10.118.106	118.98.116.35	TCP	85
141	29.72982	10.10.118.106	36.91.231.224	TCP	66
142	30.20313	10.10.118.106	118.98.116.35	TCP	85
143	30.65959	52.108.195.3	10.10.118.106	TLSv1.2	87

Figure 4. Capture delay

From the results of the capture of the wifi network at the UNNES Digital Center Building floor 2 with the TCP protocol above, the calculation for network delay is obtained by finding the difference between Time 2 (next time) and Time 1 (current time). The result of the calculation is as follows:

Delay	3.004435	0.001083	0.001917
0.383763	0.052898	0.054879	0.188885
0.043695	1.7E-05	0.558608	0.002661
1.407986	1.989912	8.5E-05	0.00011
0.557571	2.663864	0.627979	0.003026
0.003115	0	0.015483	0.008469
0.000931	0.000107	0.005562	0.011333
0.04069	0.762223	0.000212	0.623355
0.650324	0.000186	0.38472	0.003048
0.003376	0.838597	0.003406	0
0.000307	0	0.000457	0
0.041201	0	0.041816	0
0.256429	0.00025	0.90841	0.00014
0.681758	0.002754	0.022064	0.001788
0.03616	0.646735	0.105154	0.026589
0	0.049127	9.1E-05	0.008317
0.050408	2.153727	0.444855	0.052596
0.73262	0.338727	0.00029	0.545958
0.050627	0.232797	0.044257	0.401767
1.690099	0.605403	1.854845	0.473303
0.048655	6.8E-05	0.311582	0.456461
2.174273	0.00094	0.000116	

Figure 5. Capture delay

Based on these data, the total delay and average delay time of the UNNES Digital Center 2nd floor Wi-Fi network are obtained as follows:

- Total delay= 30.39 s

$$\text{Delay} = \frac{\text{Capture time frame}}{\text{Total packets received}} \tag{5}$$

- Average delay

= Total delay : (total packets received – 1)

= 30.39 : (143 – 1)

= 0.214 s

= 214 ms

The average delay can also be calculated by the following calculation formula:

- Mean delay = capture time frame : packet received

= 30,660 : 143

= 0.214 s

Based on the calculation of the two different formulas, the delay from the Wi-Fi network in the UNNES Digital Center building on the 2nd floor produces the same value of 214 ms. This value is included in the category of networks with good quality index 3 if it is based on the network quality classification table based on its delay or latency value.

3.4. Jitter Analysis

Jitter analysis is based on network delay time data that has been obtained. according to the initial definition, jitter is obtained by calculating the difference between network delays. In this study, Microsoft Excel software was used to find jitter value data to speed up the data calculation process. The results of jitter calculations for the UNNES Digital Center 2nd floor Wi-Fi network are presented in the following table:

JITTER	-2.95154	0.053796	0.186968
-0.34007	-0.05288	0.503729	-0.18622
1.364291	1.989895	-0.55852	-0.00255
-0.85041	0.673952	0.627894	0.002916
-0.55446	-2.66386	-0.6125	0.005443
-0.00218	0.000107	-0.00992	0.002864
0.039759	0.762116	-0.00535	0.612022
0.609634	-0.76204	0.384508	-0.62031
-0.64695	0.838411	-0.38131	-0.00305
-0.00307	-0.8386	-0.00295	0
0.040894	0	0.041359	0
0.215228	0.00025	0.866594	0.00014
0.425329	0.002504	-0.88635	0.001648
-0.6456	0.643981	0.08309	0.024801
-0.03616	-0.59761	-0.10506	-0.01827
0.050408	2.1046	0.444764	0.044279
0.682212	-1.815	-0.44457	0.493362
-0.68199	-0.10593	0.043967	-0.14419
1.639472	0.372606	1.810588	0.071536
-1.64144	-0.60534	-1.54326	-0.01684
2.125618	0.000872	-0.31147	
0.830162	0.000143	0.001801	

Figure 6. Capture jitter

Based on the Jitter calculation data above, the total Jitter and the average network Jitter are obtained as follows:

- Total Jitter = 0.0726 s
- Average Jitter = Total Jitter : (total packets received – 1)

  = 0. 0726 : 142

  = 0.000511 s

  = 0.511 ms

It is known that the average jitter value is 0.511 ms. Based on the network quality classification based on jitter value, this number is included in index 3 and is close to zero. Therefore, based on the jitter, the quality of the wifi network in the 2nd floor of the UNNES Digital Center building is in the good category, close to very good.

3. Conclusion

Based on the results of the Quality of Service analysis on the internet network in the 2nd floor of the UNNES Digital Center building, it can be concluded that the value of network quality when retrieving the data: (1) Measured from the Quality of Service at the UNNES Digital Center, the parameters used are throughput, jitter, delay, and packet loss with the help of the Wireshark application. (2) The time required for data packets is calculated from the data transmission by the transmitter received by the receiver (throughput) at 13: 47:44 – 13: 48: 15 (30 s) with an index value of 6122.37 bits / s (Very Good). (3) Difference in time interval for delivery between packets to destination terminals (delay) at 13:47:44 –

13:48:15 (30 s) with an index value of 214 ms (Good). (4) The number of packets that have been lost during the transmission process to the destination (packet loss) at 13:47:44 – 13:48:15 (30 s) with an index value of 0.7% (Very Good). (5) The number of bits obtained during the communication process of a system per second in sending data (jitter) at 13:47:44 – 13:48:15 (30 s) with an index value of 0.511 ms (Good). By knowing the magnitude of the calculation value for each QoS parameter above, it can be concluded that the quality of the internet network on the 2nd floor of the UNNES Digital Center building is included in the good category close to very good. Thus, the internet access in the building is sufficient to be used as a support for digital-based learning processes.

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