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ANALYSIS OF WIRELESS AND CABLE NETWORK QUALITY-OF-SERVICE PERFORMANCE AT TELKOM UNIVERSITY LANDMARK TOWER USING NETWORK DEVELOPMENT LIFE CYCLE (NDLC) METHOD

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ABSTRACT

There are some infrastructure problems in the Telkom University Landmark Tower building, which still lacks human resources to help troubleshoot the network when an interference happens. The second problem is that the TULT has a closed concept building, which will be an issue for the network stability. The last problem is the lack of information transparency when handling a network problem. In this research, the author uses the NDLC (Network Development Life Cycle) method as a step to solve the problem. The sequence of the NDLC methodology starts from the initial stage, the analysis stage, the design stage, the prototype simulation stage, and the final stage. Based on the analysis of the current wireless and wired network condition, it can be concluded that it is still in good condition, which only requires good and scheduled maintenance to prevent the internet connection from going down. The current wireless and wired connections are tested during peak and free times by adjusting the lecture conditions with the Hybrid Blended Learning (HBL) learning model, where not too many people use the internet connection from TULT building. Tests on wireless and cable networks during peak and off-peak hours revealed results for the 4th, 8th, 9th, and 18th floors with a very good delay index, a very good throughput index, and a very good packet loss index on all floors. All wireless and wired network test results have a very good index category.

***Keywords**: Quality of Service, Network Development Life Cycle, Delay, Throughput, Packet loss.*

I. INTRODUCTION

TELKOM University is a private university located in West Java, Indonesia. It has a few institutions combined under the auspices of the Telkom Education Foundation. There are seven faculties at Telkom University, namely the School of System and Industrial Engineering, Faculty of Electrical Engineering, Faculty of Informatics, Faculty of Economics and Business, Faculty of Communication and Business, Faculty of Creative Industries, and Faculty of Applied Science.

Telkom University also had its new 20-floor learning building named Telkom University Landmark Tower (TULT). Telkom University Landmark Tower is the tallest learning building currently in Bandung. Telkom University Landmark Tower carries the concept of smart building and go green. This building has 288 rooms that will be used for learning activities, academic activities facility, laboratory, research, and many more. Every floor in this building is already connected to the internet because this infrastructure is essential nowadays to help support the mobility and productivity of the lecturer and students.

There are some infrastructure problems in the Telkom University Landmark Tower, which still lacks human resources to help troubleshoot the network when an interference happens. The second problem is that the Telkom University Landmark Tower has a closed concept building. It makes the network stuck in every room, which will be an issue for the network stability. The last problem is the lack of information transparency when handling a network problem. That network infrastructure currently does not have an application to monitor the network troubleshooting.

The method that will be used in this research is the Network Development Life Cycle (NDLC) method. Network Development Life Cycle is a method used in developing or designing network infrastructure that allows monitoring to determine network statistics and performance. [1]

After identifying the problems, it can be concluded that the main problem currently being faced is that the devices and network topology design used at the Telkom University Landmark Tower did not support the "high availability" network connection. The troubleshooting handling was also hard to track, making the information not transparent for the other authorized personnel. To help solve the problems, the author will help suggest a Computer Network Design with a better Quality of Service performance for easy maintenance and monitoring at Telkom University

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Landmark Tower.

II. Literature Review and Research Method

A. Conceptual Model

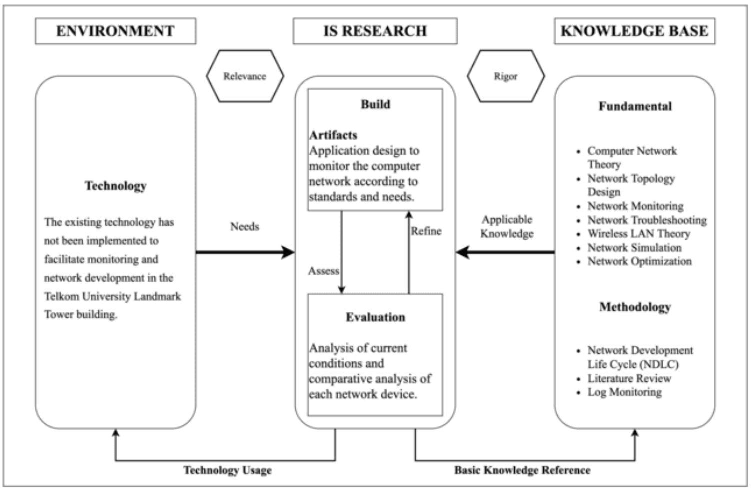

Figure 1. Conceptual Model

It can be seen on the Figure 1 that the conceptual model is a concise and precise presentation of all goal-relevant structural and behavioral features of the SUI in a predefined format. It serves as the foundation for the simulation program's development [2]. The conceptual model on Figure 1 illustrates design science research that aims to ease the troubleshooting of existing network topology at Telkom University Landmark Tower. The conceptual model has three main processes or three main elements, namely input, process, and output. In analyzing and optimizing the network topology in this research, input is needed in the form of network conditions and the current condition of the topology, especially the existing infrastructure conditions at Telkom University Landmark Tower as well as data from direct interviews with the party responsible for network infrastructure at Telkom University, which is Pusat Teknologi dan Informasi (PuTI) Telkom University

B. Computer Network

According to Cisco, the communication of connected computing devices (such as laptops, desktops, servers, smartphones, and tablets) as well as an ever-expanding array of IoT devices is referred to as computer networking. [3].

C. Types of Computer Network

According to Cisco, while their overall goals are similar, different types of networks serve different functions. Nowadays, networks are classified into the broad categories listed below.

1) Local Area Network (LAN)

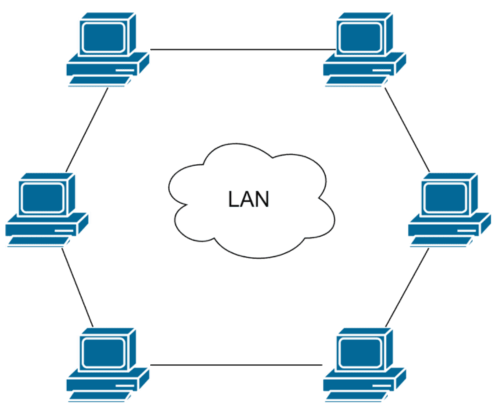

Figure 2 Local Area Network (LAN)

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A local area network (LAN) on the Figure 2 is a collection of connected devices in a single physical location, such as a home or office. A local area network (LAN) can be small or large, ranging from a single user's home network to an extended enterprise network with thousands of users and devices. A LAN can consist of both wired and wireless devices. A LAN, regardless of size, is distinguished by the fact that it connects devices in a single, constrained area. [3]

2) Metropolitan Area Network (MAN)

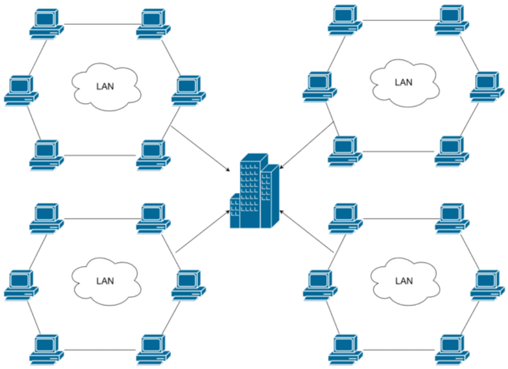

Figure 3 Metropolitan Area Network (MAN)

A metropolitan area network (MAN) on the Figure 3 is similar to a local area network (LAN). However, it extends across an entire city, campus, or municipal or organizational territory. Multiple LANs are connected to form MANs. Thus, MANs are more extensive than LANs but smaller than wide-area networks (WANs), which cover large geographical areas and sometimes connect users worldwide.

MANs are typically highly efficient and capable of providing rapid communication via high-speed carriers such as fiber optic cables. However, the rise of wireless and subsequent networking technologies has resulted in a proliferation of modalities for transmitting signals across a larger MAN area.

3) Wide-area Network (WAN)

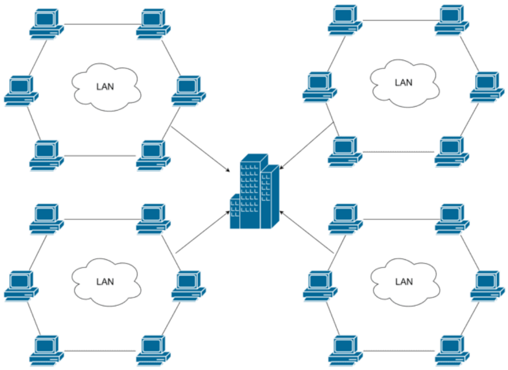

Figure 4 Metropolitan Area Network (MAN)

A WAN on the figure 4 connects individual users or multiple LANs over a large geographical area. The internet is a type of WAN. Large organizations use WANs to connect their various sites, remote employees, suppliers, and data centers so that applications and data can be run and accessed. Leased lines, cellular connections, satellite links, and other methods can provide physical connectivity in WANs. [3]

D. Types of Network Topology

Administrators can choose from various logical and physical network topologies to build a secure, robust, and easily maintainable topology. The following are the most common configurations:

1) Bus Network Topology

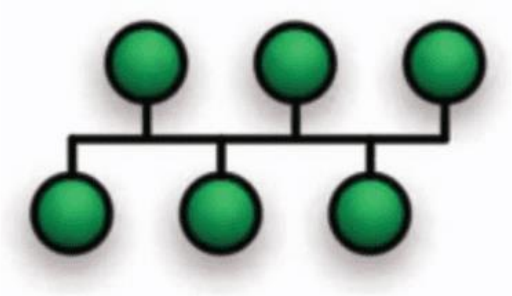

Figure 5 Bus Network Topology *[4]*

The bus network topology on Figure 5, also known as the backbone network topology, connects all devices to the main cable via drop lines. The benefits of bus network topology stem from its simplicity, as less cable is required than in other topologies, allowing for easy installation. [5]

2) Mesh Network Topology

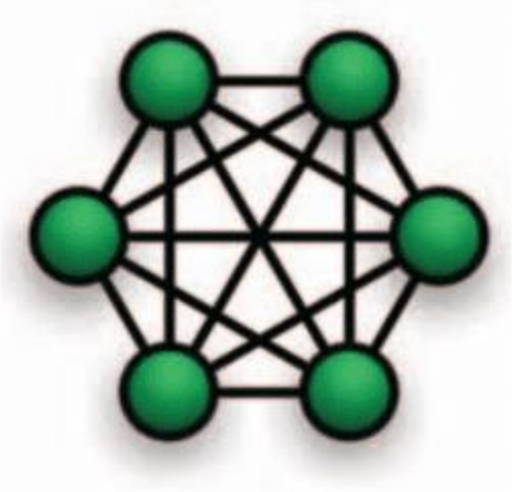

Figure 6 Mesh Network Topology *[4]*

Mesh network topology on the Figure 6 is a dedicated point-to-point link that connects each device to another device on the network, carrying only data between the two devices. [5]

3) Ring Network Topology

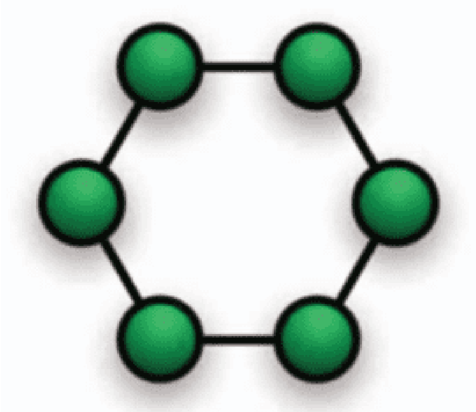

Figure 7 Ring Network Topology *[4]*

The Figure 7 shows two dedicated point-to-point links connect a device to the two devices on either side of it, forming a ring of devices through which data is forwarded via repeaters until it reaches the target device. [5]

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4) Star Network Topology

Figure 8 Star Network Topology *[4]*

The most common network topology is a star topology, as shown on the Figure 8, which connects each device in the network to a central hub. The central hub is the only way for devices to communicate with one another. [5]

5) Tree Network Topology

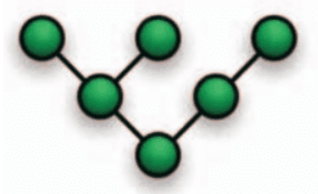

Figure 9 Tree Network Topology *[4]*

The Figure 9 shows a topology which comprises a parent-child hierarchy in which star networks are linked together by bus networks. Nodes branch out linearly from a single root node, and two connected nodes share only one mutual connection. [5]

E. Wireshark

Wireshark is a network protocol analyzer that captures packets from a network connection, for example, when accessing an internet network from our devices. A packet is a unit of data in a typical Ethernet network. Wireshark is the world's most popular packet sniffer. Wireshark, like any other packet sniffer, performs three functions:

- **Packet Capture:** Wireshark listens in real-time to a network connection and then captures entire traffic streams, potentially tens of thousands of packets at a time.
- **Filtering:** Wireshark can use filters to slice and dice random live data. We can get only the information needed by using a filter.
- **Visualization:** Wireshark lets us enter the middle of a network packet like any packet sniffer. It can also display entire conversations and network streams.

F. Network Development Life Cycle (NDLC)

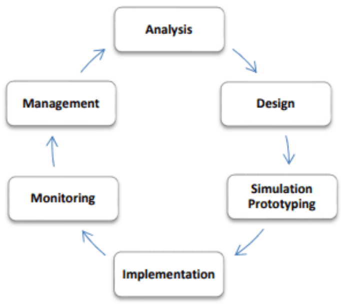

Figure 10 Network Development Life Cycle Stages *[6]*

The network development life cycle on Figure 10 is the key model underlying the network design process (NDLC). The term "cycle" is a key descriptive term of the network development life cycle because it emphasizes the continuous nature of network development. A network built "from the ground up" must undoubtedly begin somewhere, namely with an analysis phase. Existing networks, on the other hand, are constantly moving from one phase of the network development life cycle to the next. Monitoring existing networks, for example, would generate management and performance statistics, possibly using a network management protocol such as SNMP. Qualified

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network analysts would then examine the existing network's performance statistics. Based on the analysis of these performance statistics, design changes may or may not be implemented. Physical or logical network designs are possible. Physical network designs are concerned with the arrangement and interconnection of physical network circuits and devices, whereas logical network designs are concerned with the configuration and definition of services that will run over that physical network, such as addressing schemes, routing schemes, traffic prioritization, security, and management. Before being deployed or implemented, proposed network design changes are frequently simulated using sophisticated network simulation software packages or prototyped in a test environment, safely removed from a company's production network. This monitoring, management, analysis, design, simulation, and implementation cycle is ongoing. Just as network demands are constantly changing due to changes in business, application, or data requirements, so must network design itself be dynamic in order to successfully support these changing requirements. The network development life cycle provides a logical framework for this dynamic network design to thrive in. [7]

1) Analysis Stage

Identifying the problem is the first step in the early stages of this research. Furthermore, there is a background problem that contains a summary of the problem and refers to the study of literature in solving the problem. Following the creation of the background, the writer determines the formulation of the problem to conduct this research, and the problem boundaries are determined based on the research conducted. Then, based on the results of the problem formulation, determine the research objectives, which are limited by the problem boundaries.

At this stage, data collection from stakeholders is carried out for analysis of the condition of the computer network at Telkom University Landmark Tower (existing), so that further identification can be carried out for network design and network monitoring application design to make troubleshooting easier.

2) Design Stage

At this stage, the design of the network monitoring application begins, the author design based on the conditions from the analysis stage whose needs have been identified.

3) Simulation Prototyping Stage

At this stage, a comparison is made after the design of the network monitoring application design that has been made. So that it can be seen the advantages and disadvantages of the proposed application, and updates or revisions can be made to the design of the application design. If the design has received recommendations from stakeholders, it can be implemented based on prior approval, and if the application design is not approved, the design will be revised again.

G. Quality of Service (QoS)

Quality of Service (QoS) is a set of technologies that work on a network to ensure its ability to run high-priority applications and traffic reliably. Quality of service achieves this by providing differentiated handling and capacity allocation to specific flows in network traffic and allowing the network administrator to specify the order in which packets are being handled and the amount of bandwidth available to that application or traffic flow.

Quality of service measurements includes bandwidth (throughput), latency (delay), jitter (latency variation), and error rate. This makes the quality of service especially important for high-bandwidth, real-time traffic like voice over IP (VoIP), video conferencing, and video-on-demand, which are sensitive to latency and jitter. These applications are called "inelastic" because they have low bandwidth requirements and high latency limits.

Queuing and bandwidth management are quality of service mechanisms for ordering packets and allocating bandwidth. However, before they can be implemented, traffic must be classified using classification tools. Organizations can ensure resource consistency and adequate availability for their most critical applications by categorizing traffic according to policy. Traffic can be classified crudely by port or IP or, more sophisticatedly, by application or user. The latter parameters allow for more meaningful identification and data classification. [8]

1) Packet Loss

The percentage of packets lost during data transmission is referred as packet loss. Many factors contribute to this, including signal degradation in network media, network hardware errors, and radiation from the surrounding environment. Packet loss is a parameter that describes a condition that shows the total number of lost packets that can occur due to network collision and congestion. This impacts all applications because retransmission reduces overall network efficiency even when sufficient bandwidth is available for the application. The following equation can be used to calculate the value of packet loss.

$Packet\ loss\ = ((sent\ packets - received\ packets))/(sent\ packets) \times 100$ [9]

The Table 1 is used to categorize Packet Loss:

TABLE I
PACKET LOSS CATEGORY

Packet Loss Category	Packet Loss (%)	Index
Very Good	0-2%	4
Good	3-14%	3
Medium	15-24%	2
Bad	>25%	1

2) Average Delay

Delay is the amount of time it takes for a packet to be sent from one computer to another. A long queue or taking another route to avoid routing congestion causes a delay in the packet transmission process in a computer network. Distance, physical media, and congestion can cause delays. To calculate the delay in a transmitted packet, divide the time span by the sent packets. The following equation can be used to calculate the average delay value.

$$Average\ delay = (time\ span)/(packets\ received)\ [9]$$

The Table 2 is used to categorize Average Delay:

TABLE II
AVERAGE DELAY CATEGORY

Delay Category	Delay Amount	Index
Very Good	<150ms	4
Good	150 – 300ms	3
Medium	300 – 450ms	2
Bad	>450ms	1

3) Throughput

Throughput is the actual bandwidth measured during the transmission of a file. Unlike bandwidth, which has the same units of bits per second (bps), throughput describes the actual bandwidth at a given time and under specific conditions and networks that are used to download a file of a specific size. Throughput is calculated by dividing the total number of successful packet arrivals observed at the destination during a given time interval by the duration of that time interval. The following equation can be used to calculate the throughput value.

$$Throughput = (bytes\ sent)/(time\ span) \times 8\ [9]$$

The Table 3 is used to categorize Throughput:

TABLE III
THROUGHPUT CATEGORY

Throughput Category	Throughput	Index
Excellent	>2.1 Mbps	4
Good	1200 kbps – 2.1 Mbps	3
Fair	700 – 1200 kbps	2
Poor	338 – 700 kbps	1

III. CURRENT WIRELESS AND CABLE NETWORK ANALYSIS

A. Telkom University Landmark Tower Existing Network Topology

The current network plan is in the form of a map showing four floors in the Telkom University Landmark Tower building that are part of the School of Industrial and System Engineering. The switch core from Pusat Teknologi dan Informasi connects to the distribution switch on the 1st floor of Telkom University Landmark Tower using fiber optic cable to provide internet access to the whole building on every floor. The distribution switch on the 1st floor then connects to the switch at the panel room on every floor to provide internet access to the access point for wireless internet access. The Figure 11 shows the existing wireless and cable network condition at Telkom University Landmark Tower.

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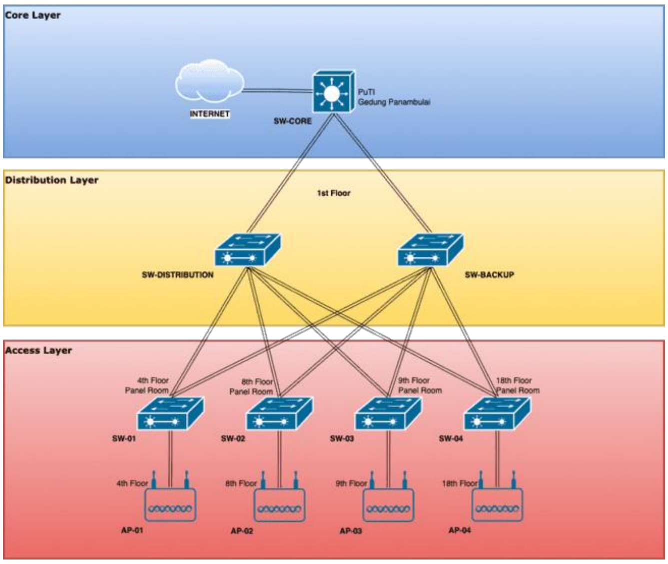

Figure 11 Existing Network Condition

The distribution switch on the 1st floor of Telkom University landmark Tower is connected using fiber optic cables behind the wall with access switches on the 4th floor, 8th floor, 9th floor, and 18th floor panel room. Access switches on each floor are connected directly to the distribution switch using a Small Form-factor Pluggable (SFP) cable. Then, the switch from the panel room connects to the access point using an STP CAT6 cable.

B. Current Wireless and Cable Network Testing Analysis

Analysis of the test on this wireless and cable network design is done by measuring delay, throughput, and packet loss by streaming video via Netflix, which the client accesses during peak time (2 PM – 3PM) and free time (4 PM – 5 PM). However, this peak and free time test analysis uses the assumption of peak and free time testing results with traffic adjusted to the Hybrid Blended Learning (HBL) conditions set by Telkom University. Only specific courses are held on-site at Telkom University Landmark Tower, where not many students and lecturers will connect and use the TelkomUniversity Wi-Fi at Telkom University Landmark Tower during peak and free time. The conclusions will be drawn and compared later with the free time testing. The following are the test results on wireless and cable networks on 4th floor of the School of Industrial and System Engineering, Telkom University Landmark Tower:

1) TelkomUniversity Wi-Fi Testing During Peak Time on TULT 4th Floor

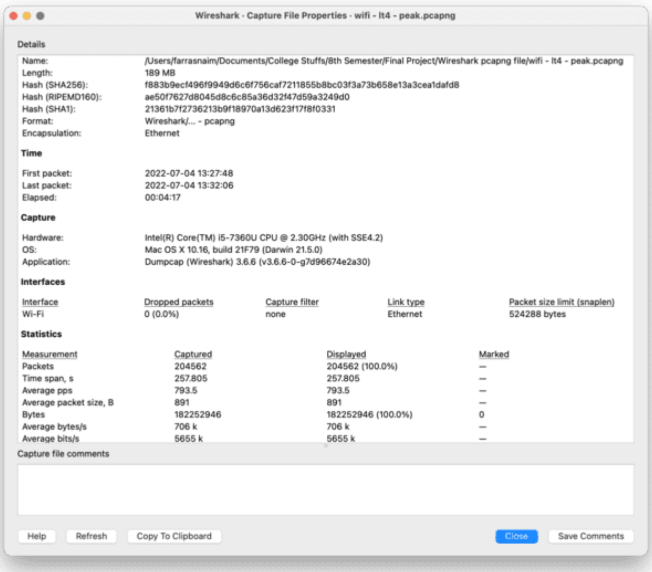

Figure 12 Analysis of TelkomUniversity Wi-Fi During Peak Time on 4th Floor Telkom University Landmark Tower

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Based on the tests that have been carried out and the analysis of the packet capture results using Wireshark and shown on the Figure 12, the parameters of delay, throughput, and packet loss values obtained for the 4th floor of the Telkom University Landmark Tower building during peak times are as follows:

$$Packet\ loss\ = ((204562 - 204364))/204562 \times 100\ = 0{,}1\%$$
$$Average\ delay = \ 257.805/204562\ \ = 0{,}00126028\ second$$
$$Throughput = \ 182252946/257.805\ \ \times\ 8\ = 5.655\ KBps$$

2) TelkomUniversity Wi-Fi Testing During Free Time on TULT 4th Floor

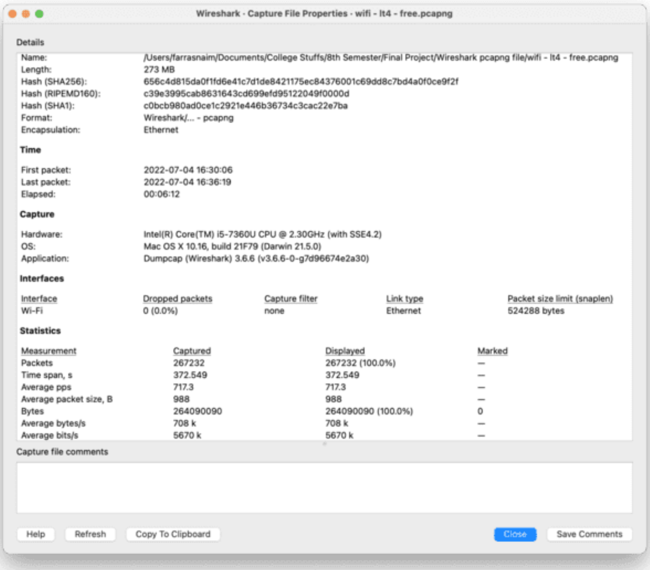

Figure 13 Analysis of TelkomUniversity Wi-Fi During Peak Time on 4th Floor Telkom University Landmark Tower

Based on the tests that have been carried out and the analysis of the packet capture results using Wireshark, the parameters of delay, throughput, and packet loss values obtained for the 4th floor of the Telkom University Landmark Tower building during free times are as follows:

$$Packet\ loss\ = ((267232 - 267067))/267232 \times 100\ = 0{,}1\%$$
$$Average\ delay = \ 372.549/267232\ \ = 0{,}0013941\ second$$
$$Throughput = \ 264090090/372.549\ \ \times\ 8\ = 5.670\ KBps$$

3) Cable Network Testing During Peak Time on TULT 4th Floor

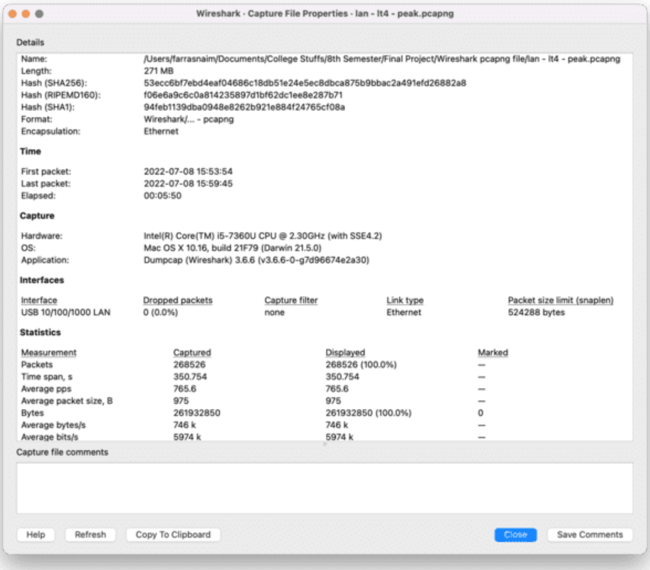

Figure 14 Analysis of Telkom University Landmark Tower 4th Floor Cable Network Connection During Peak Time

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Based on the tests that have been carried out and the analysis of the packet capture results using Wireshark and shown on the Figure 14, the parameters of delay, throughput, and packet loss values obtained for the 4th floor of the Telkom University Landmark Tower building cable network connection during peak times are as follows:

$$Packet\ loss\ = ((268526 - 266707))/268526 \times 100\ = 0{,}6\%$$
$$Average\ delay = \ 350.754/268526\ \ = 0{,}00130622\ second$$
$$Throughput = \ 261932850/350.754\ \times 8\ = 5.974\ KBps$$

4) Cable Network Testing During Free Time on TULT 4th Floor

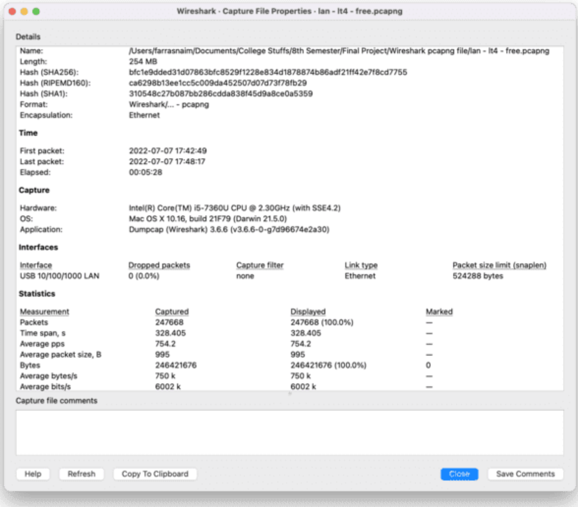

Figure 15 Analysis of Telkom University Landmark Tower 4th Floor Cable Network Connection During Free Time

Based on the tests that have been carried out and the analysis of the packet capture results using Wireshark, the parameters of delay, throughput, and packet loss values obtained for the 4th floor of the Telkom University Landmark Tower building cable network connection during free times are as follows:

$$Packet\ loss\ = ((247668 - 246783))/247668 \times 100\ = 0{,}3\%$$
$$Average\ delay = \ 328.405/247668\ \ = 0{,}00132599\ second$$
$$Throughput = \ 246642676/328.405\ \times 8\ = 6.008\ KBps$$

C. Proposed Wireless and Cable Network Design

The proposed network design in this research uses the Cisco Three-Layer Hierarchical Model, which consists of three layers: the core layer, distribution layer, and access layer, so that each existing device can work optimally according to its function. The Figure 16 below shows the proposed network topology.

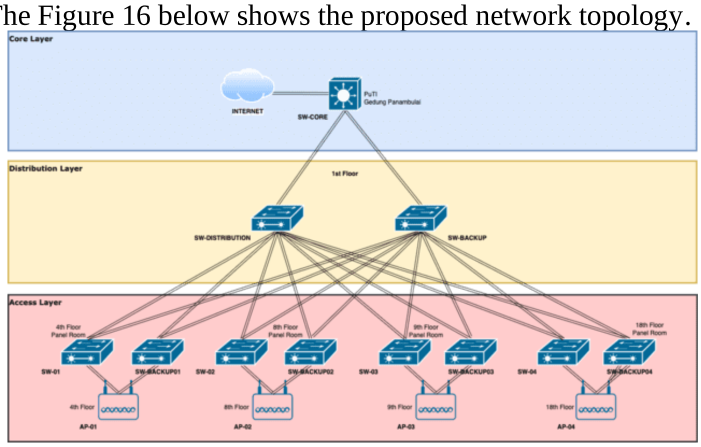

Figure 16 Proposed Network Topology

The core layer in this proposed network topology is not much different from the existing network topology, where one router is connected to the internet, and one switch on the third layer is connected to the main switch and a backup switch at the distribution layer. The core switch on the third layer functions to forward packets to the distribution switch, and then the distribution switch will forward them to the access switch. In contrast to the existing topology, where the access point on each floor in the access layer does not have a backup switch, for this

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proposed topology, a backup switch is made on each floor to cover the access point if the access switch goes down. In order to prevent damage or errors due to unwanted things, a backup switch on the access layer is suggested so that the communication links on each floor can still run when unwanted things happen and maintain high availability.

IV. CONCLUSION

Based on the research that has been done, the results of the analysis and design of wireless and cable network optimization at the School of System and Industrial Engineering Telkom University using the Network Development Life Cycle (NDLC) method, it can be concluded that:

1) There is no backup switch in the distribution layer at the current network condition, so if the main line is interrupted, it will impact network users. Then the proposal design uses the Network Development Life Cycle (NDLC) method up to the simulation prototyping stage as a reference. This method can be used to develop the network further continuously. The proposed design uses the Cisco Three-Layered Hierarchical Model, which consists of the core, distribution, and access layers.

2) In the proposed design, it is necessary to analyze both in terms of costs and terms of maintenance. The cost factor will increase slightly due to adding a backup switch. However, with the addition of a backup switch, the level of network availability will increase.

3) The test scenario of this research uses Quality of Service performance measurement parameters, namely delay, throughput, and packet loss, where the results of these measurements are analyzed based on standards from ETSI TIPHON. The test results of current wireless and wired connections during peak and free times are carried out by adjusting the lectures' conditions with the Hybrid Blended Learning (HBL) learning model, where not too many people use the internet connection from Telkom University Landmark Tower. Tests in both peak and free times on wireless and cable networks showed results for the 4th, 8th, 9th, and 18th floors with a very good delay index on all floors, a very good throughput index on all floors, and a very good packet loss index on all floors. All test results on wireless and wired networks have a very good index category.

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