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Design of Network Device Placement and Bandwidth Allocation Using Simple Queue Method

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Abstract—Network usage that is not properly managed often leads to unfair bandwidth distribution and unstable internet connections. This problem causes slow internet connections and disruptions to activities that require internet connectivity. The solution to this problem is structured bandwidth management using Simple Queue. Network configuration is performed on the router to distribute bandwidth to all ports connected to the switch, and then PCQ (Per Connection Queue) can limit bandwidth for each user. The research methodology uses the Network Development Life Cycle (NDLC) with analysis, design, simulation, implementation, monitoring, and management phases. However, this research only covers the simulation phase and does not include the implementation, monitoring, or management stages. This research aims to design network topology and optimize the network, ensuring even and efficient bandwidth distribution to support all activities using internet connections properly. The testing results indicate that the download and upload speeds closely approach the bandwidth allocation set using the PCQ method, which is 10 Mbps, demonstrating optimal network performance. Bandwidth management using Simple Queue proves effective in managing and optimizing bandwidth usage in complex environments, providing fair bandwidth allocation to all users in the network. This reduces the possibility of network congestion and ensures all activities requiring an internet connection can run optimally.

Keywords— Simple Queue; Per Connection Queue; PCQ; Bandwidth Optimization; Bandwidth Management.

I. INTRODUCTION

The use of networks in modern life has become a vital element and significantly impacts various global aspects. Networks have become the main foundation for technological development as connectivity between individuals and organizations worldwide is becoming a human necessity due to the ease of access they provide. The rapid development of information technology is caused by the growing public demand for Internet networks [1]. Networks play a role in transferring information [2]. The need for information must be accessible through networks designed to obtain information quickly, easily, securely, and accurately. The presence of networks today ensures the rapid and efficient exchange of information and encourages innovation, economic exchange, and global collaboration. Data transfer between computers can be executed quickly and easily, achieving efficiency and effectiveness, resulting in high work productivity.

Networks facilitate access to services, information, and resources across various locations. The rapid development in the field of technology has had a significant impact, triggering societal changes in how people interact with each other [3]. Wireless networks offer greater flexibility at a lower cost [4]. Without a reliable network, the global exchange of information, which is the main pillar of the digital era, would not be effectively realized [5]. The world would revert to an era where communication and data transfer had to be done manually, taking considerable time, if networks did not exist. This would greatly impact operational efficiency across various sectors; for instance, real-time access to information would not be possible, such as transferring data between branch offices and headquarters, which would take an extended period.

The impact of the Internet on social life is substantial, and the Internet has been integrated into all areas of life [6]. Furthermore, it facilitates remote collaboration in the workplace and allows companies to operate globally. Computer network systems are designed to share resources that can be utilized collectively [7]. The presence of the Internet has established it as a main pillar for many institutions and organizations, serving as the foundation of the systems they possess to carry out various activities [8]. The Internet has become a human necessity in recent years due to its easy access [9]. The application of the Internet in developing increasingly advanced Information and Communication Technology has also led the government to utilize it as a primary source for future economic growth. The availability of Internet networks can enhance productivity and work efficiency. With a reliable network, individuals can collaborate with colleagues and clients from various parts of the world. Networks are no longer solely a matter of defense, as they were when this technology was first developed in the United States, but have now extended into many areas of life [10]. Networks can assist in completing tasks and work due to easy access to the necessary resources and information.

Several issues encountered by users within a network often hinder an institution's ability to grow [11]. The rapid advancement of network communication has made managing and maintaining networks increasingly complex [12]. As technology advances, the use of mobile devices continues to

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rise. This leads to an increasing demand for higher network quality [13][14]. A common issue is that, as user demand increases, network devices may become overloaded due to the need to handle many user requests [15]. High bandwidth usage leads to uncontrolled internet traffic [16]. As user activity within a network intensifies, the quality of bandwidth allocation among users becomes uneven [17]. Bandwidth refers to the volume of data that can be transferred within a specific period [18] or the calculation of data usage available within the network, measured in bits per second [19]. In addition, connectivity disruptions can hinder productivity and work efficiency due to slow internet access. Connection issues, such as signal interruptions, can obstruct the smooth operation of tasks.

Given the existing issues, Reliable network design is essential to ensure optimal internet distribution [20]. Implementing bandwidth management to optimize network usage is crucial, as the amount of bandwidth will affect transmission speed. [21]. High network speeds ensure seamless content access without interruption [22]. The implementation of bandwidth management has been shown to improve throughput, reduce packet loss, and decrease delay in local area networks [23]. Bandwidth management serves to regulate user priorities. With the continuous advancement of technology and its application in various daily activities, it is crucial to optimize network performance quality [24] effectively. To efficiently control and allocate bandwidth usage, each user must receive optimal network performance and fair access. Slow connections and network disruptions can be minimized through effective bandwidth management. Bandwidth management refers to the policies implemented to ensure optimal network performance.

One effective method for bandwidth optimization is a Simple Queue. Simple Queue is widely applied in various institutions and industries to manage bandwidth optimization. Several studies have shown that implementing the Simple Queue model optimizes bandwidth across all devices, ensuring stable network quality [25]. Implementing Simple Queue is successful because the upload and download bandwidth limits will not exceed the predetermined speeds [26]. The simple queue method of bandwidth management has a major impact on download and upload connections because bandwidth utilization is more evenly distributed, following the users' requirements [27]. Moreover, its configuration process considers the Simple Queue method more straightforward. Another advantage of using Simple Queue in bandwidth management is its ability to adjust the bandwidth size required by users, thus enabling an equitable bandwidth distribution to clients [28]. Implementing the simple queue method is highly beneficial in maintaining stable internet speeds for each user, as users receive a predetermined bandwidth allocation, eliminating competition for bandwidth usage. PCQ (Per Connection Queue) is added to the configuration to optimize the simple queue method further. The PCQ method automatically and evenly shares bandwidth among all active network users.[29]. Previous studies have focused on bandwidth management without considering the structural conditions of the building. The main contribution of this article is the proposal of a network distribution design tailored to the physical characteristics of buildings with thick concrete structures, including the strategic placement of Access Points, to ensure more optimal signal distribution and meet the specific needs of each area.

Based on this, managing bandwidth to optimize network performance is crucial, allowing users to work more efficiently. This study focuses on the design of network device placement and bandwidth allocation using the Simple Queue method. Each user or group will receive a bandwidth allocation that suits their needs.

II. Research Methodology

This research was conducted at the Faculty of Medicine building, Muhammadiyah University of Kendari, using the Network Development Life Cycle (NDLC) approach. The NDLC method is a systematic approach designed to optimize the development and management of network systems in a planned manner [30], ensuring that network planning and implementation processes run systematically and efficiently.

Fig.1 illustrates the NDLC research methodology with sequential phases: analysis, design, simulation, implementation, monitoring, and management. This research limits its scope to the simulation process, thus excluding the implementation, monitoring, and management phases from its discussion.

Fig.1. NDLC method

A. Analysis

The analysis phase begins with conducting observations of the physical conditions of the Faculty of Medicine building at Muhammadiyah University of Kendari. These observational activities aim to gain a comprehensive understanding of the physical state and environment of the building. The primary objective is to obtain factual information regarding room

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arrangements, distance between spaces, and environmental aspects affecting network quality. The observational data assesses the building's physical conditions and determines strategic positions for network equipment installation, including Access Points, Switches, and Routers. The analysis also identifies bandwidth requirements adjusted to user quantities and the variety of services needed.

B. Design

The network topology design was developed as a reference for future implementation based on the results of the completed analysis. This design includes establishing network device locations (router, switch, access point) accompanied by structured cable pathway planning. The design also involves Simple Queue configuration for bandwidth management, with bandwidth allocation based on room priority levels. Applied configurations encompass maximum download and upload speed limits and PCQ settings to ensure equitable and fair bandwidth distribution.

The Simple Queue method is a bandwidth management technique that allocates and limits bandwidth usage in the network. Bandwidth management using Simple Queue ensures that each client receives an appropriate and fair bandwidth allocation according to their requirements. By incorporating PCQ into the simple Queue, bandwidth is automatically divided among active users for both downloads (PCQ-download) and uploads (PCQ-upload), thereby ensuring that no single user consumes excessive bandwidth that could result in slow connections for other users and guaranteeing fair bandwidth distribution as the available bandwidth can be evenly distributed across all devices within the network.

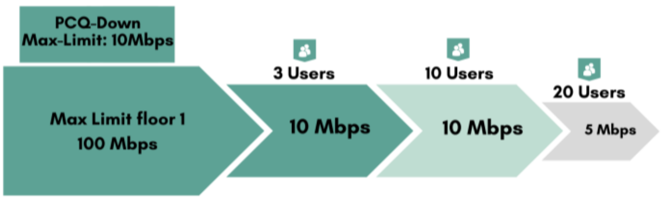

Fig.2. PCQ Operation

Fig.2 illustrates that in the 1st-floor scenario, a maximum bandwidth of 100 Mbps is conFig.d through Simple Queue on the router. PCQ manages bandwidth allocation by limiting the speed of each connection to 10 Mbps. With this configuration, if there are 3 active users in the network, each receives 10 Mbps; if there are 10 users, they still receive 10 Mbps each; and if the number of users increases beyond that, the bandwidth is distributed equally. For instance, if there are 20 active users, each user receives 5 Mbps of bandwidth. This method ensures efficient and fair bandwidth distribution, prioritizing each connection according to the predetermined allocation.

C. Simulation

The simulation process is carried out to evaluate the effectiveness of the network topology design before the implementation phase. This simulation activity includes a series of tests on bandwidth allocation by implementing Simple Queue and PCQ, accompanied by network performance analysis based on speed test results under user traffic load. The simulation results data is then analyzed to ensure the network design aligns with the previously identified requirements.

III. Result and Discussion

A. Network Requirements Identification Results

1) Physical Building Observation: A survey was conducted to assess the building structure and determine the placement planning for network devices. Access Points are installed in each room to optimize network coverage. The Faculty of Medicine building at Universitas Muhammadiyah Kendari consists of two floors. Table I describes the details of a two-story building with a total area of 5,992 M2, comprising various rooms designed to support academic and administrative activities. The 1st-floor contains a Computer Laboratory, 2 Practice Rooms for student practicum activities, 1 Service Room for administration, a lobby as a public area, a Faculty Room, a Cadaver Room specifically for practicum activities, and a Server Room for server and switch equipment. On the 2nd floor, there are twelve Practice Rooms for student practicum activities, one Practice Control Room for supervision and practice management, six Work Units that serve as workstations for various units and personnel, five Classrooms conducive to teaching and learning activities, and one library.

TABLE I
ROOM DETAILS

Floor	Room Names	Quantity
1st Floor	Computer Laboratory	1
	Practice Room	2
	Service Room	1
	Lobby	1
	Faculty Room	1
	Cadaver Room	1
	Server Room	1
2nd Floor	Practical Room	12
	Practical Control Room	1
	Work Unit	6
	Classroom	5
	Library	1

2) Number of Devices Used: The number of network devices used in the Faculty of Medicine building is presented in the details of Table II. The building employs one router with 16 ports, which connects the Internet Service Provider (ISP) to all switches. Four switches, each with 48 ports, distribute the network from the router to computers and all access points on the first and 2nd-floors. A total of 26 access points are spread across all building areas.

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TABLE II
NETWORK DEVICES USED

Device	Quantity	Specification
Router	1	16 Ports LAN
Switch	4	48 Ports LAN
Access Point	26	RUIJIE RG-AP720-L

B. Design

1) Network Topology Flow: The network topology of the Faculty of Medicine, Universitas Muhammadiyah Kendari, employs a star topology model, where network devices are connected through a central controller, namely the primary router. The Star topology connects all devices to a central device, enhancing reliability and enabling easier network expansion [31].

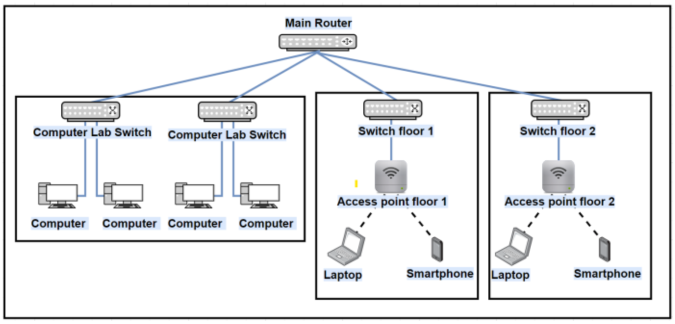

Fig.3. Network Topology

The router is the primary control centre in this topology that manages data distribution to connected devices. The advantage of the star topology lies in its ease of network management, as a failure in one device does not affect other devices as long as the router remains operational. Fig.3 shows that the main router is connected to four switches. The Switch for Computer Laboratory 1 and the Switch for Computer Laboratory 2 connect all computers in the laboratory. The switch for the 1st floor connects all access points on the 1st floor, while the switch for the 2nd floor connects all access points on the 2nd floor.

2) Network Topology Design: The network topology design includes the placement of router and switch devices and the arranging of cable pathways to ensure even signal distribution and minimize interference. Fig.4 illustrates the network topology at the Faculty of Medicine, which spans two floors. The 1st-floor comprises 7 rooms with three switches, one connecting seven access points distributed across each room, while the other two switches are utilized for the computer laboratory. The 2nd floor contains 25 rooms, 12 practicum rooms with six access points, and 13 other rooms, each equipped with one access point. This building, with a total area of 5,992 m², features thick concrete wall structures that can affect signal quality. Considering the building's condition with thick wall partitions, the RUIJIE RG-AP720-L device, which has a range of 10-15 meters in unobstructed conditions, was selected to optimize the network. The placement of access points in each room serves as a solution to overcome signal attenuation due to the building structure, thereby ensuring stable network connectivity throughout the area.

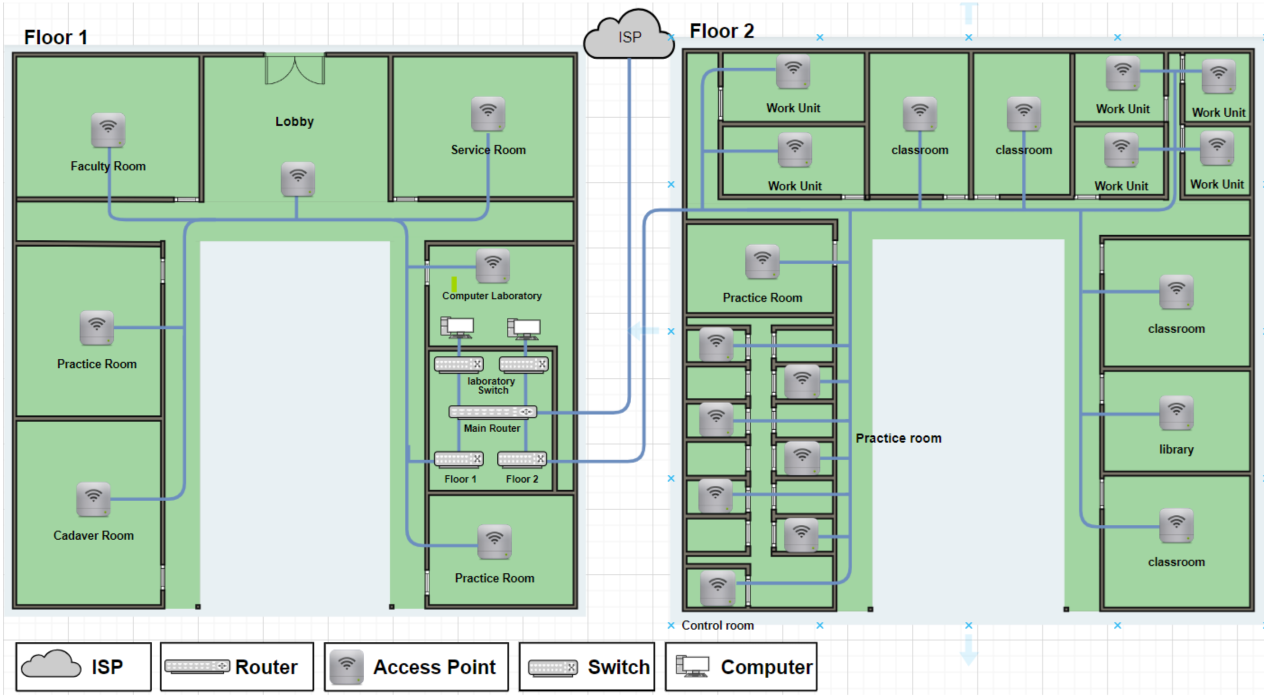

Fig.4. Network Topology Design

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3) Bandwidth Management: The bandwidth management design utilizes four switches connected to the ISP router, with a total bandwidth of 200 Mbps distributed equally. Table III demonstrates that each switch receives bandwidth commensurate with the device requirements in their respective areas. Additionally, to allocate bandwidth on the router, a Simple Queue method is implemented with PCQ queue type for both download and upload, allocating 10 Mbps per user. This PCQ method facilitates equitable bandwidth distribution, ensuring each user receives bandwidth proportionate to their allocation. Consequently, this approach optimizes overall network performance.

TABLE III
BANDWIDTH MANAGEMENT

Switch	Bandwidth (Mbps)
Floor 1 Switch	100
Floor 2 Switch	100
Computer Laboratory 1 Switch	50
Computer Laboratory 2 Switch	50

C. Network Simulation and Testing

The network testing was carried out with a straightforward topology, as depicted in Figure 5, to verify the efficiency of the suggested bandwidth control.

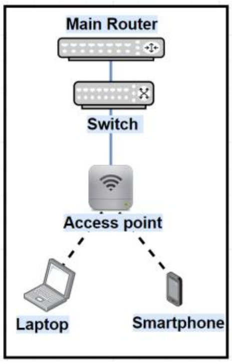
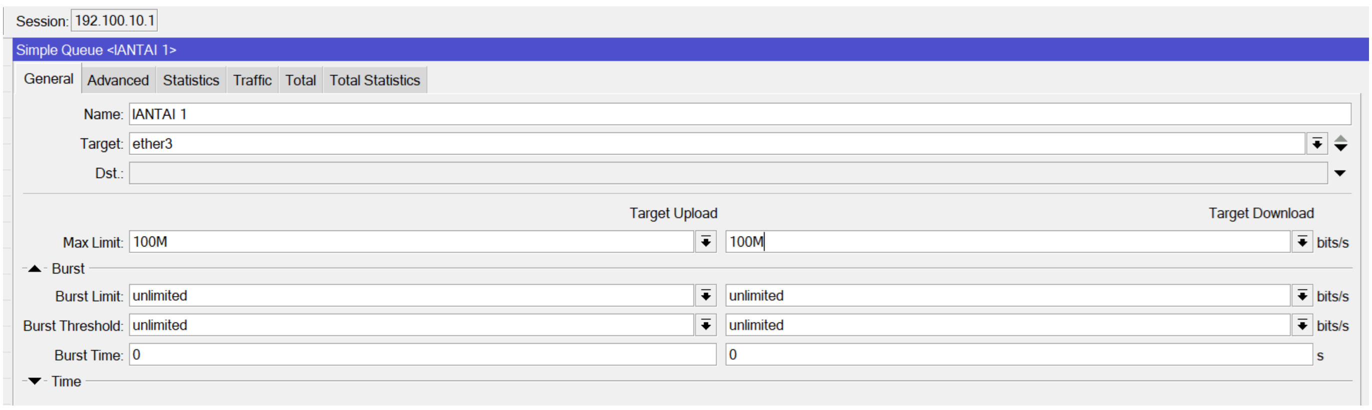


Fig.5 Network Simulation Topology

The simulation analyzed the system's capability to perform bandwidth regulation under controlled traffic conditions. The simulation network arrangement consists of one router connected to a switch, which channels the connection to an Access Point. This Access Point provides wireless connectivity for two client devices, such as laptops or mobile devices. This simulation helps test the effectiveness of the Simple Queue configuration and PCQ method in fair bandwidth distribution.

1) Simple Queue Configuration: The initial step in configuring the Simple Queue is creating a single Simple queue and assigning the name of the 1st floor, as illustrated in Fig.6(a). In the target field, the port connecting devices on the 1st floor in the simulation, ether3, is selected. Subsequently, the maximum speed limit is input; in this simulation, 100M is entered to represent 100 Mbps for both download and upload speeds for all devices connected to ether3. Fig.6(b) demonstrates the creation of PCQ Download in the Queue Type. The initial step involves entering a name for the queue type in the Type Name field. In the Kind field, PCQ is selected. The Rate field is populated with the maximum speed per user, for instance, 10M to represent 10 Mbps and Dst.Address check. Fig.6(c) illustrates that after creating PCQ Download, the next step is to create PCQ Upload. In the Rate field, the maximum speed per user is entered; for example, 10M represents 10 Mbps and Src checks.Address. Fig.6(d) depicts the subsequent phase, where we return to the Simple Queue, inputting the previously created PCQ Download and PCQ Upload into the Queue Type field. Configuring Simple Queue with PCQ Download and PCQ Upload aids in distributing bandwidth equitably among all users, ensuring that no single user dominates bandwidth usage. This approach facilitates improved download and upload traffic management, delivering consistent network performance and enhancing overall efficiency. The same procedure is applied to configure subsequent simple queue targets.



(a) Configuration-1

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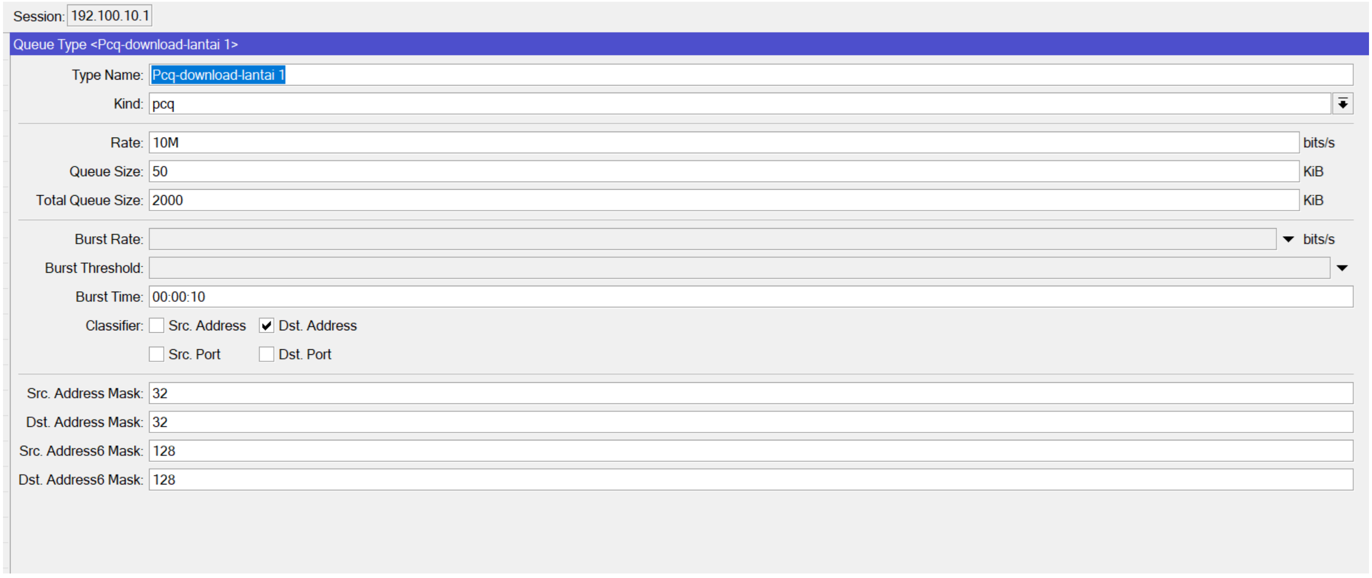
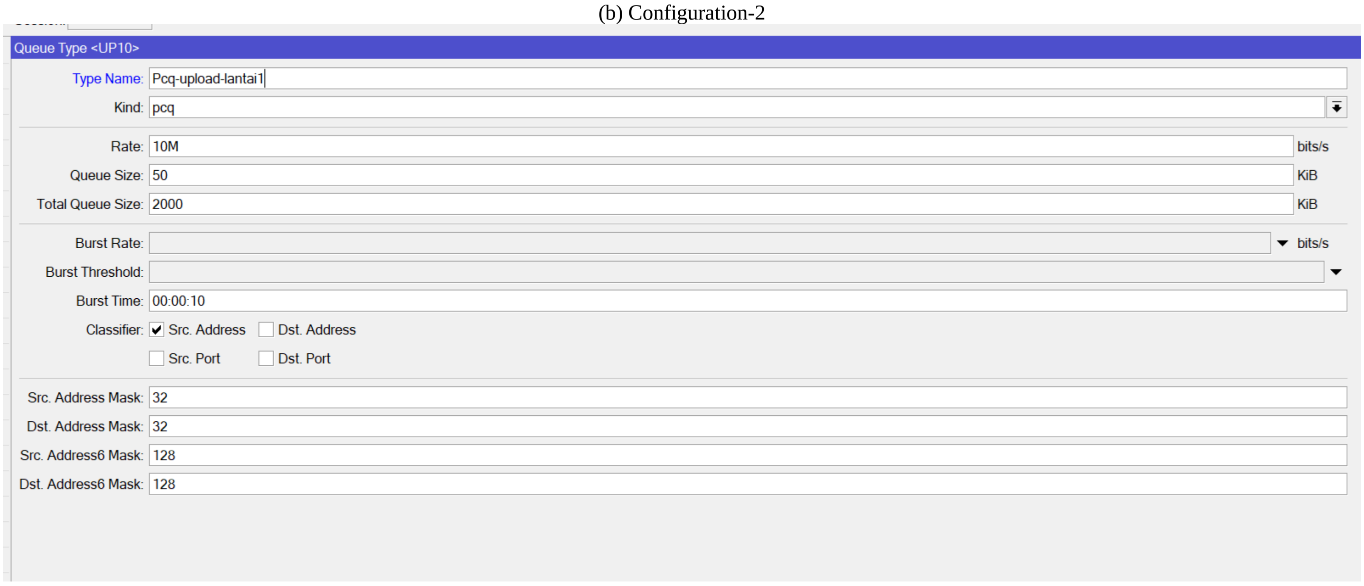
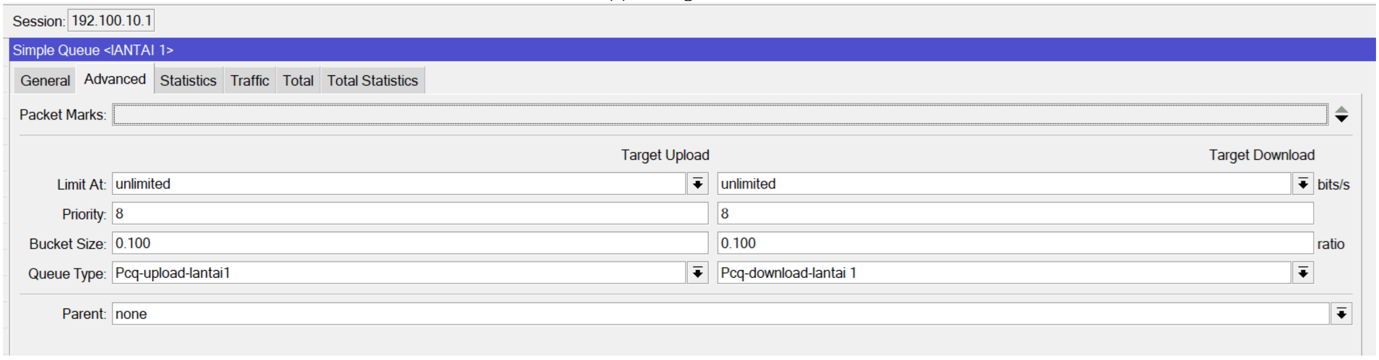


(b) Configuration-2



(c) Configuration-3



(d) Configuration-4

Fig.6. Simple Queue Configuration

2) Testing: The testing phase is conducted to evaluate the performance of the designed network. This evaluation uses the Speedtest tool to measure download and upload speeds. Fig.7(a) illustrates the speed test results for the laptop device. The download speed was recorded at 9.25 Mbps, while the upload speed reached 9.37 Mbps. These results are close to

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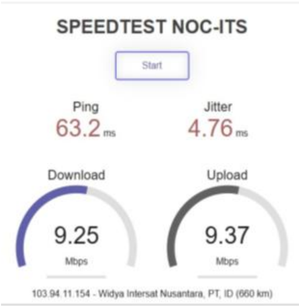
the maximum bandwidth allocation of 10 Mbps per user, as conFig.d using the (PQ) method. Fig.7(b) illustrates the speed test results for the smartphone device. The download speed was recorded at 9.20 Mbps, while the upload speed reached 9.58 Mbps. These values are also close to the maximum bandwidth allocation of 10 Mbps per user, as established through the PCQ method.



(a) Laptop

(b) Smartphone

Fig.7. Device Testing

The testing results for both devices demonstrate that the Simple Queue configuration and the PCQ method effectively manage bandwidth allocation, ensuring 10 Mbps for each user for both download and upload speeds. It is important to note that these results may vary as the number of network users increases. When more devices are connected, the network load will rise, potentially causing a decrease in overall download and upload speeds.

Based on this research, the network design at the Faculty of Medicine, Muhammadiyah University of Kendari, demonstrates that the distribution of network devices, such as routers, switches, and Access Points, has been well-planned to ensure optimal network coverage throughout the building. The placement of Access Points in each room on the 1st and 2nd floors aims to provide stable and uniform wireless connectivity, supporting academic and administrative activities in various spaces such as laboratories, classrooms, and workspaces. The bandwidth management implemented using Simple Queue and PCQ methods successfully distributed bandwidth allocation fairly among users, allocating 10 Mbps per device for download and upload. This configuration ensures that no single user dominates the bandwidth, maintaining connection quality throughout the building area.

IV. Conclusion

The research results indicate that the network design for the Faculty of Medicine building at Universitas Muhammadiyah Kendari, covering an area of 5,992 m², was successfully optimized using 1 router, 4 switches, and 26 access points, ensuring uniform signal distribution throughout the building. Bandwidth management through the Simple Queue and PCQ methods effectively distributed bandwidth fairly and evenly, preventing any single user from dominating the network. This research has achieved its initial objective of designing an efficient and well-structured network to support academic and administrative activities. For further development, it is recommended that the network be implemented directly and field tests conducted to evaluate performance under real-world conditions. Additionally, exploring more advanced bandwidth management technologies should be considered to meet the evolving needs of the network.

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