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Article

Comparative Simulation of Bandwitdh Management Using Queue Tree and PCQ Techniques

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A B S T R A C T

The IT services at PSP Pusri Building are equipped with adequate internet network facilities. However, the distribution of bandwidth across the network is uneven, which leads to bandwidth contention among users and consequently slows down internet connections. This issue arises due to the absence of specific upload and download limits for each room, which affects network stability. Managing upload and download speeds is crucial for efficient data transmission, and bandwidth management is needed to address this problem. This study employs an action research methodology, which includes the stages of Diagnosis, Action Planning, Action Taking, Evaluating, and Specifying Learning. The research focuses on improving network performance by implementing bandwidth management. The Per Connection Queue (PCQ) tree and queue techniques are applied to organize data flow based on priority, ensuring better distribution of bandwidth across all rooms. The results of simulations conducted during the bandwidth management application show significant improvement. The implementation effectively reduces the congestion issues in each room by providing an equal distribution of bandwidth. By using these management techniques, the IT services in the PSP Pusri Building can ensure a more stable and efficient network, improving the overall internet experience for users. This approach not only resolves existing bandwidth issues but also serves as a model for future network improvements. The study highlights the importance of careful bandwidth management in maintaining optimal network performance, especially in environments with multiple users and varying data demands.

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I. INTRODUCTION

With the rapid development of information technology, the desire to access information and communicate easily is getting higher [1]. The internet is something that is needed in today's modern information and computer era, because the internet cannot be kept away from daily life. More and more places provide internet every mall, café, eatery, park, and campus with wifi access and many more provide internet [2] The internet is often used to make it easier for us to communicate, find information and use other social media. We often use the internet even every day we really need the internet [3] Use of the internet network in the IT Service Building There are facilities with an internet network. However, if it is not monitored and controlled by policy, it will certainly cause violations. Illegal access, theft, and excessive bandwidth usage are some examples of breaches. It's the same with accessing sites that require bandwidth to do things like open online videos, play games, download videos, and so on. If in an office or workspace there are several computer users who do this, then other computers will experience problems accessing work. This can definitely lead to certain job processes becoming ineffective or efficient. The network in KP Room still uses a Local Area Network (LAN) with a bandwidth of 20 Mbps with many clients, which can interfere with download and upload speeds. There is a need to manage bandwidth, or bandwidth management, so that the data that is Passing can be divided equally, Large network bandwidth causes many problems [1]. Transfer data value consumption calculated in bits/second between a server and a client in a given time is called bandwidth (bps).

The researcher plans a solution that can monitor the network, that is, the researcher will do bandwidth management, Bandwidth Management is a way that can be used to manage and optimize various types of networks by implementing Quality of service (QoS) services to determine the type of network traffic. Qos is the ability to describe the level of achievement in a data communication system [5] Bandwidth management is an important thing in computer networks. Bandwidth management is a network management technique as an effort to provide fair and satisfactory network performance [6] Therefore, bandwidth management (network management) is very important to control uneven bandwidth usage [7]. With the optimal bandwidth distribution management, users who every time download and upload do not experience problems in the upload or download process [8] Untuk menjaga kelancaran penggunaan internet, manajemen bandwidth yang baik diperlukan dengan tujuan mengatur besaran bandwidth dan menjamin para pengguna jaringan mendapatkan bandwidth yang adil dan memuaskan [9] Management will be carried out on the mikrotik router in the room, Mikrotik is one of the hardware and software vendors that provides facilities to make routers [10] Currently, mikrotik products have been widely used by business people in the computer field, such as internet cafes, ISPs (Internet Service Providers), small to large companies, home businesses and so on [11].

The problem that occurs today is the absence of bandwidth management that regulates the distribution of bandwidth in the IT service department of PT. Pusri sriwidjaja Palembang which causes network instability in terms of speed in uploading and downloading which is very important In order to facilitate data transmission, this causes clients to consume too much bandwidth so that the distribution of data capacity flows is uneven, causing network disruptions.

Therefore, the researcher uses the Queue Tree and PCQ methods because Using Queue Tree and PCQ provides a comprehensive approach in traffic management, optimizes bandwidth usage, and ensures better network performance. Both are highly beneficial depending on the specific needs of the network and the type of traffic being managed. The solution to this problem is to manage bandwidth by using the Queue Tree and PCQ methods on the mikrotik router to optimize the use of existing data. The Queue Tree method itself is one of the most flexible and complicated features of microtics, because this restriction must activate the Mangle feature on the Firewall to provide tagging of the packets to be restricted [12]. Queue Tree is a very complicated limit because this limit is based on protocol, ports, IP Address, even we have to activate the Mangle feature on the Firewall if we want to use the Queue Tree Queue Tree functions to limit the Bandwidth on mikrotik

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that has two internet connections because the mark package is more functional than in Simple Queue [13]

In addition to the Queue Tree method, the PCQ method is a method that serves to recognize the trend of the flow and is applied to distribute the bandwidth fairly and evenly for use with the Queue Tree [14].

The purpose of this study is to manage bandwidth in the IT service department of PT. Pusri Sriwidjaja Palembang by using the Queue Tree and PCQ methods, where the amount of bandwidth will later be divided according to the subclass or subqueue for each user to optimize the utilization of existing data. The Queue Tree method itself is one of the features in Mikrotik that is flexible and quite complex. Queue Tree has a one-way nature, meaning that the Queue Tree configuration can only handle one type of directional traffic. If the configuration is intended to manage download bandwidth, it will not queue the upload traffic.

II. METHODS

The research method used is Action Research which is a method that aims to test, develop, discover, and create new actions with the aim of improving performance or overcoming problems in a context [15]. This method has several stages, namely those that start from the Diagnosis, Action Planning, Action Taking, Evaluation and Learning stages. The stages can be seen in the picture below.

In this study, Python programming was utilized to support the analysis and visualization of network performance data obtained during the bandwidth management implementation. The primary libraries employed included Pandas for data manipulation, Matplotlib for graphical visualization of bandwidth usage and speed test results, and NumPy for numerical operations related to throughput calculations.

Data analyzed consisted of network traffic logs and speed test results collected from the MikroTik router over a period of two weeks, capturing multiple daily samples to reflect variations in upload and download speeds before and after the implementation of Queue Tree and PCQ techniques. The dataset comprised approximately 1,000 records, including timestamps, bandwidth measurements (in Mbps), and user or room identifiers.

The data acquisition was performed using MikroTik's logging and monitoring features, exported in CSV format for subsequent processing in Python. Analysis focused on descriptive statistics, time-series trend analysis, and comparative visualization to assess the impact of bandwidth management on network stability and fairness.

This approach allowed for rigorous, reproducible examination of network performance metrics and provided empirical evidence supporting the efficacy of the applied bandwidth management strategies.

Diagnosing

Diagnosis in the Action Research method refers to the process of collecting data and analyzing it to better understand the problems or challenges that are being faced in the context of the research or improvement being made. The Action Research method itself is an active and action-oriented research approach, which aims to formulate practical solutions to problems faced by groups or organizations. At this stage, the author monitors and diagnoses the problems that occur in the IT Service Section of PT. Pusri Palembang.to collect data and information related to the problems faced.

Bandwidth Problems

The author identifies the existing problem by performing bandwidth management. The research limits bandwidth to 10 Mbps download speed and 5 Mbps upload speed for avp and employees while kp is divided by 10 mbps for upload and 10.

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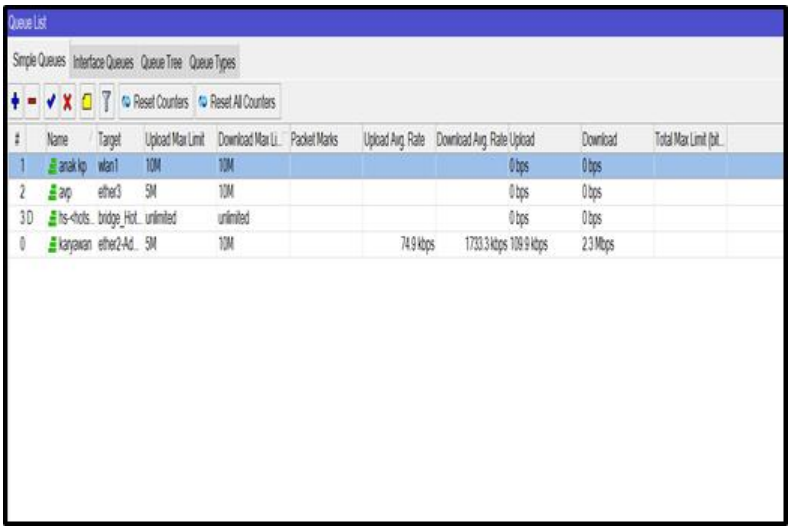

Figure 1. Action Research Methods

The researcher conducted bandwidth management using a MikroTik router, employing the Queue Tree and PCQ methods of the IT Service Section, as illustrated in Figure 1.

Action Planning

The At this stage, the writing manages a system that is used to solve network problems in the IT service section of PT Pusri Palembang by utilizing the mikrotik router device in accordance with the proposed network scheme design, then with the addition of a mikrotik router and a Queue Tree system where internet services from ISPs (Internet Service Providers) are managed so that the internet connection is much more optimal.

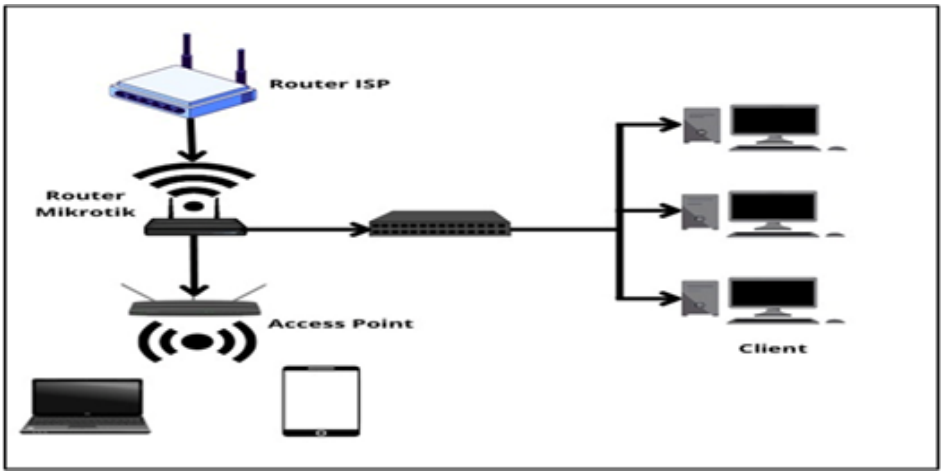

Figure 2. Topologi Jaringan

Figure 2 illustrates a simple network topology utilizing a MikroTik router as the main device for network management and bandwidth control. The internet connection originates from the ISP Router and is then forwarded to the MikroTik router. The MikroTik router acts as the primary controller within the network, managing bandwidth distribution and data traffic using Queue Tree and PCQ methods according to the implemented policies. From the MikroTik router, the network connects to a switch that links several client devices via wired connections, as well as to an access point that provides wireless connectivity for mobile devices such as laptops and tablets. This configuration combines both wired and wireless connections, allowing all client devices to efficiently access the local network and the internet. The topology enables structured traffic management and optimal bandwidth allocation for all users within the network, as shown in Figure 2.

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Researchers divided 10 Mbps in each room so that the bandwidth in each room could be allocated evenly, ensuring smoother and more stable internet access. The results obtained after bandwidth management for each room are presented in Table 1.

Table 1. Management Division

NO	Room	Bandwidth Dowload	Bandwidth Upload
1	Kp/Magang	10M	10M
2	Employee	5M	10M
3	AVP	5M	10M

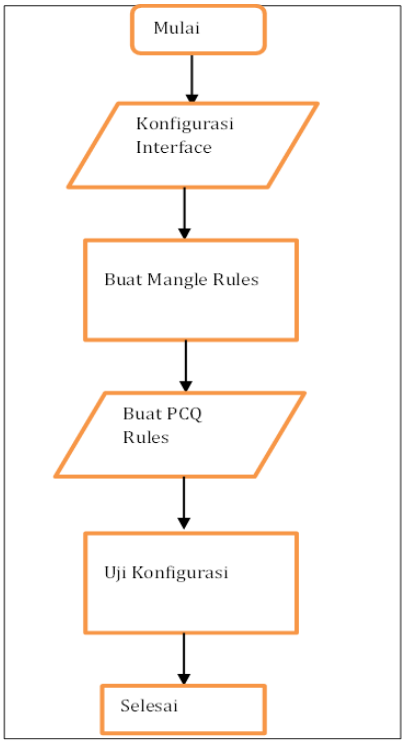

Figure 3. Flowchart

The following is an explanation of the stages of configuring bandwidth management using Queue Tree and PCQ on MikroTik; the following stages must be followed as shown in Figure 3. Do not mix complete spellings and abbreviations of units:

1. Identify how much bandwidth the service will be regulated, such as browsing, streaming, and downloading.
   Define the maximum speed allowed for each user and service.
2. Configuration Interface
   - Make sure that the interface that will be used to manage the bandwidth is configured correctly.
3. Create Mangle Rules
   - Create mangle rules that mark packages based on service type and interface.
4. Create Queue Tree
   - Create a child Queue Tree to set the bandwidth of each service and a master Queue Tree to divide the total bandwidth.
5. Create PCQ (Per Connection Queue)
   - Create PCQ rules to split bandwidth between connections or users.
6. Configuration Test
   - Test the configuration to ensure that the bandwidth is divided according to the objectives of the research conducted. The suitability of the conclusion with the objectives supported by the

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data of the research results. Suggestions can be given after the conclusion of the study is presented.

III. RESULT

Action Taking

At this stage, the action research method is action taking which is the process of taking steps or actions to achieve certain goals. This includes decision-making, planning, and implementation of the necessary actions to realize the desired results, the researcher at the initial stage will perform a configuration on Mikrotik, as one of the efforts in optimizing the computer network in the IT service department and after the configuration is carried out the author will show the results of the bandwidth management configuration.

Configuration

Before configuring, in the early stages we must first log in to winbox. In the image above is the initial display of the mikrotik login. At this stage, the research uses the MAC Address connected to the router, it can be seen that the MAC Address used is 78:9A:18:16:72:26, the MAC Address (Media access controll) is the MAC Address connected to the ISP (Internet service provider) router when you want to configure the network. MAC Address address or identity.

<After Winbox successfully logs in, the next step before configuring the DHCP Client IP is >then click the "+" sign then select the ether1 input interface>click apply>ok.

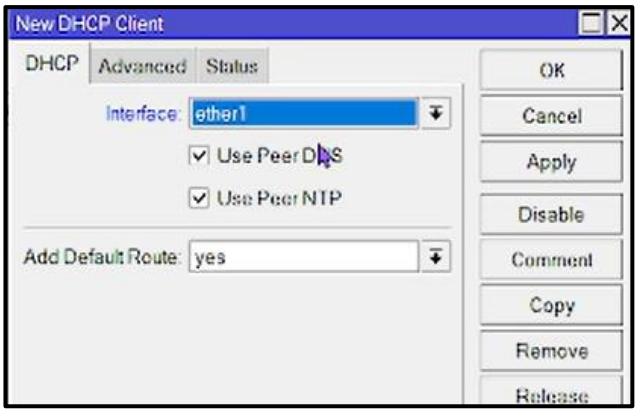

Figure 4. DHCP Client

The next step is to configure the IP Address by clicking on the IP Address and clicking on the "+" sign. then type the IP Address 192.168.10.1/24 >either2 as admin > then click.

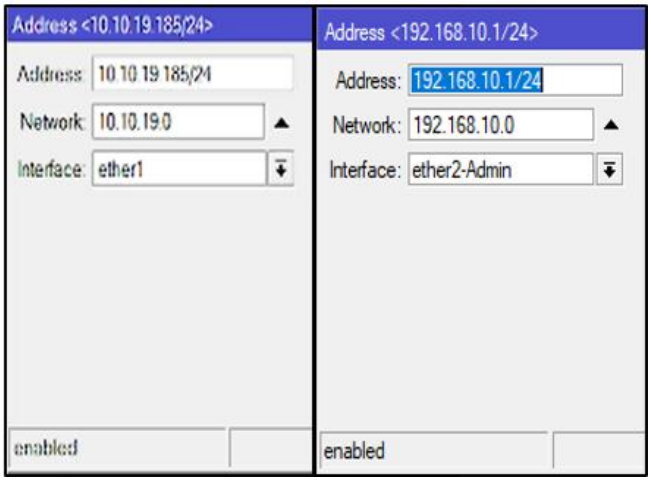

Figure 5. Setting IP Address

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In Figure 6 above is the interface on the Mikrotik network that has been created, in either 2 is the local network connected between the laptop to the Mikrotik router with the IP Address 192.168.10.1/24 and in either 3 is also the local network connected between Mikrotik to the PC with the IP address 192.168.20.1/24.

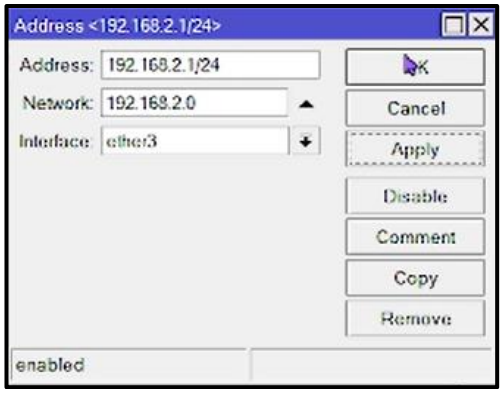

Figure 6. Setting IP Address

Furthermore In Figure 7 is an interface on a WLAN network that functions to connect the internet network through.

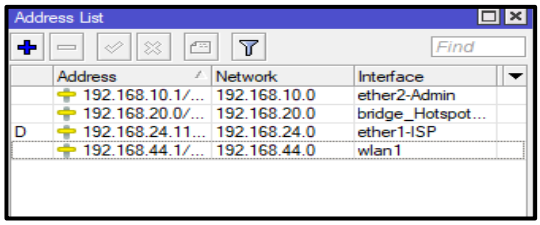

Figure 7. Address List

Configuration Firewall Mangle

The mangle firewall feature works by flagging packets that pass through, enter, or exit the router. Mangle settings can be configured from the firewall menu on the Mangle tab to create packet markers and flags for each client. In the mangle configuration, this can be done by accessing the firewall menu on the Mangle tab and then creating a packet connection mark, as illustrated in Figure 8.

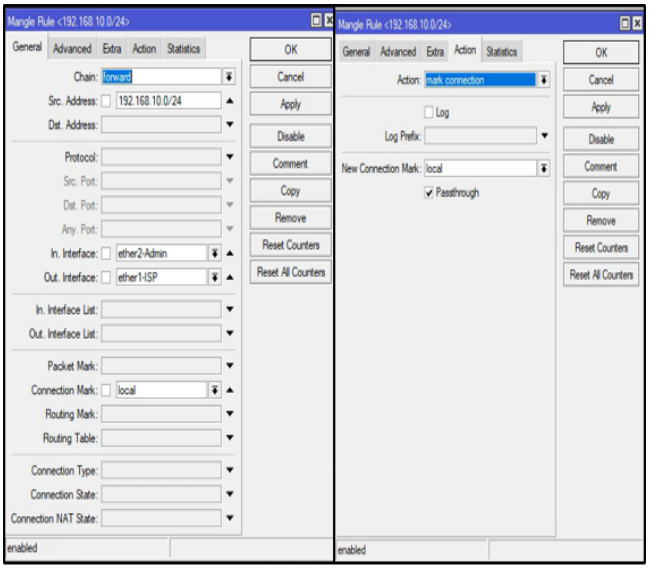

Figure 8. Mangle Firewall Configuration

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In the image above is the result of the Mangle firewall configuration that has been successfully configured, which can.

Figure 9. Mangle Configuration Results

Be seen that there are several packets to perform Bandwitch management as seen in the image below.

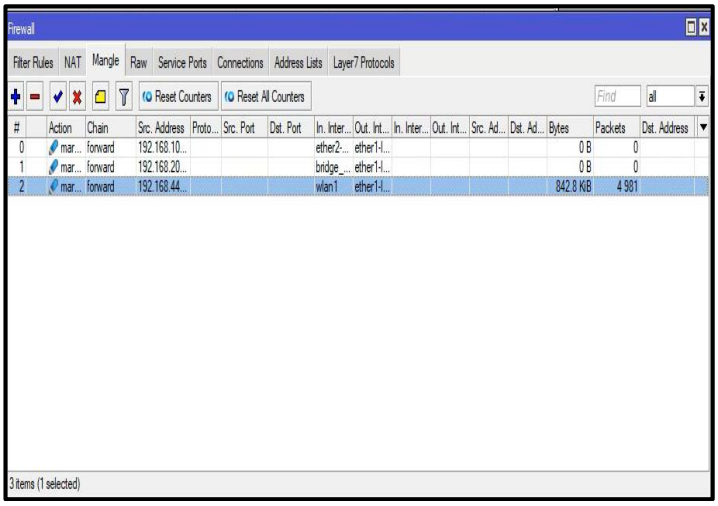

Figure 10. Test DNS Connection

Next stages, test the connection by entering Google's DNS in the image below and it is successfully configured which can be seen below. In Figure 10 above, a test has been carried out by entering DNS (Domain Name System) in the MikroTik terminal using the command "ping 8.8.8.8". The address 8.8.8.8 is Google's DNS and serves to check the quality of the network to ensure that the configuration runs well and optimally.

Evaluating

The next stage is that the researcher will conduct a speed test on the network before Bandwitch management is carried out using the queue tree and PCQ methods to see the amount of Bandwitch received at the IT service department.

For Example:

1. Initial bandwidth speed test results

   You can see in the image below is the upload and download speed in the IT service department Before applying bandwitch management with queue tree and pcq methods with download speed.

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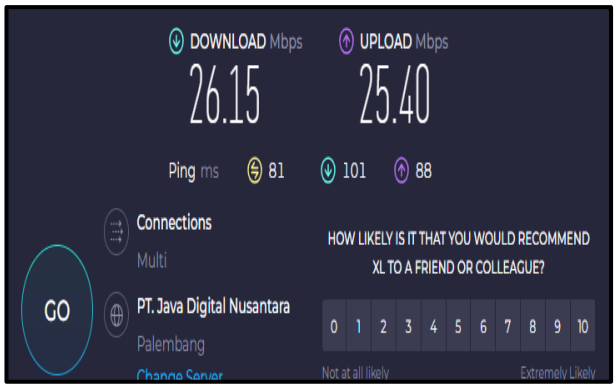

Figure 11. Speed test result before restriction

2. Management Bandwidth Configuration
   In the next stage, the author will do bandwitch management to limit and divide bandwitches so that their use is regular and not wasted in their use. The following configuration is done by clicking on the queue menu then select pcq then click the "+" sign then click general then click type name then enter "bandwitch-download" and enter "bandwitch- upload "select kind > pcq then check dst address then ok.

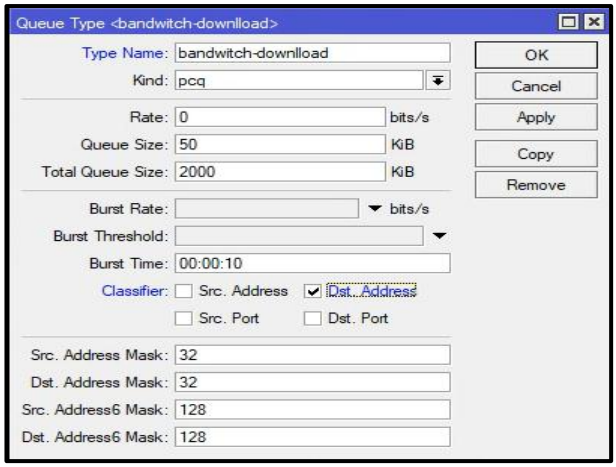

Figure 12. Bandwitdh Management Configuration

The next step is to enter the queue tree menu then select general then type the name as you want to enter such as "IT employee" and avp with a target of either 2 and either 3 and give the limit with an upload target of 10mbps and a download target of 10mbps then click apply and ok.

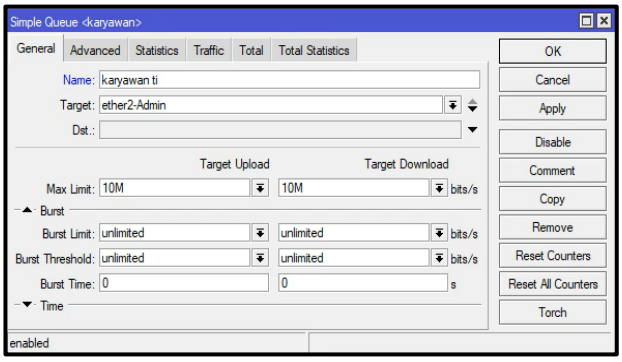

Figure 13. Configuration With the Queue Tree Employee

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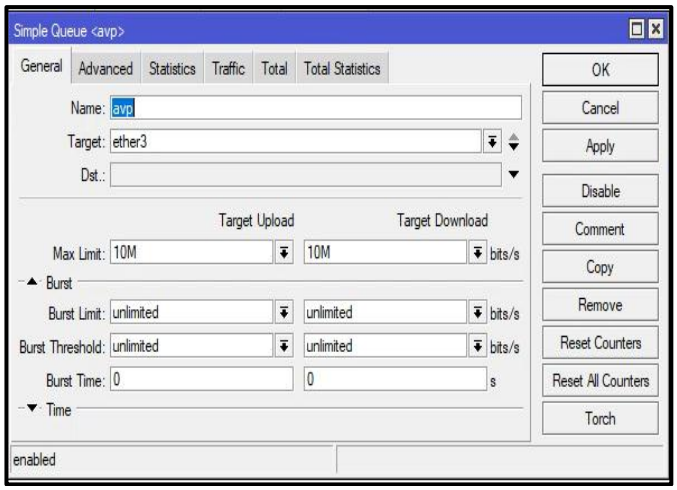

Figure 14. Configuration With the Queue Tree AVP

Learning

The following is a discussion of the differences between before the bandwitdh is managed and after the management, which has been configured as follows.

1. Bandwidth Before managemen
   The bandwidth speed in the IT service department at the time when the bandwidth has not been divided is 26.15 Mbps for downloading, and 25.40 Mbps for uploading.
2. Bandwitdh after management
   The bandwidth speed in the IT service department at the time of management has been carried out using the queue tree and pcq tree methods, along with the download speed of 9.48 Mbps and the download speed of 9.33 Mbps.

Table 2. Management Results Table

No	Room	Planned Bandwidth	Bandwidth Successfully Allocated in SPP
1	AVP	10 Mbps	9.48 Mbps
2	EmployeeTI	10 Mbps	9.48 Mbps
3	Kp/Magang	10 Mbps	9.48 Mbps

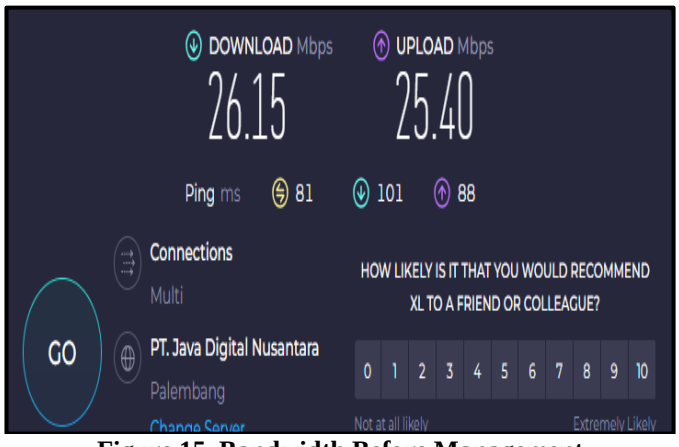

Figure 15. Bandwidth Before Management

The bandwidth speed in the IT service department at the time of management has been carried out using the queue tree and pcq tree methods, along with the download speed of 9.48 Mbps and the download speed of 9.33 Mbps.

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Figure 16. Bandwidth After Management

In each room in the IT service department gets the same bandwidth after bandwidth management, the planned bandwidth can be seen in table 2 where the planned bandwidth is 10 Mbps and after testing on the speed test, which is 9.48 Mbps, Here are the results.

IV. CONCLUSION

This study provides a comprehensive examination of bandwidth management within the IT services environment of PSP Pusri Palembang by deploying the Queue Tree and Per Connection Queue (PCQ) techniques on a MikroTik router platform. Utilizing the action research methodology, which encompasses diagnosis, planning, implementation, evaluation, and reflective learning, the research effectively identified and addressed critical network performance challenges caused by uneven bandwidth distribution and consequent congestion among multiple users.

The empirical findings demonstrate that the combined use of Queue Tree and PCQ methods enables an equitable and efficient allocation of available bandwidth across different user groups or network segments. Specifically, the deliberate capping of bandwidth at 10 Mbps per designated room resulted in a more stable network environment, reducing congestion and balancing data transmission rates. Post-implementation speed tests revealed download and upload speeds averaging 9.48 Mbps and 9.33 Mbps respectively, closely aligning with the targeted bandwidth limits and indicating minimal loss due to overhead or configuration inefficiencies.

This outcome substantiates that deploying Queue Tree and PCQ techniques not only enhances bandwidth utilization but also significantly improves Quality of Service (QoS) by minimizing bottlenecks and ensuring fair bandwidth sharing. Such improvements are critical in environments where multiple users with diverse data demands coexist, and where network resource contention can degrade operational efficiency and user experience. The findings thus contribute to the growing body of research emphasizing the necessity of proactive and sophisticated bandwidth management solutions in modern network infrastructures.

From a methodological perspective, this research validates the efficacy of the action research approach for iterative problem solving in applied network management contexts. The cyclical process of diagnosing issues, planning interventions, implementing solutions, and evaluating results facilitates continuous improvement and real-time adaptation to changing network conditions. Moreover, the practical insights gained underscore the importance of integrating both technical configurations and user demand analysis to achieve optimal network performance.

The implications of this study extend beyond the immediate case, offering a replicable framework for organizations seeking to optimize bandwidth distribution without incurring substantial infrastructure upgrades. Future research could build on this work by exploring the integration of more advanced QoS protocols, machine learning algorithms for dynamic bandwidth allocation, or the performance of these techniques under varying network loads and service types.

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Comparative studies involving alternative bandwidth management strategies such as Hierarchical Token Bucket (HTB) or Simple Queuing could further elucidate the relative strengths and weaknesses of Queue Tree and PCQ in diverse operational environments.

In conclusion, this research affirms that deliberate bandwidth management using Queue Tree and PCQ on MikroTik routers is a viable and effective strategy to enhance network stability, fairness, and user satisfaction. It serves as a practical model for similar institutional networks facing bandwidth contention issues and contributes to the broader discourse on optimizing network resource management in increasingly data-intensive environments.

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