Computer Network Optimization Using Queue Tree and Peer Connection Queue (PCQ) Method at SMK Negeri 1 Sumbawa for Learning Support

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Bandwidth struggles and non-optimal internet networks can result in connection problems, such as slow connections and allowing users not to connect to the internet. therefore it is necessary to optimize computer networks to be able to maximize service to users, both used to find information, download and upload data. This study uses the Queue Tree and PCQ methods which aim to optimize computer networks at SMKN 1 Sumbawa Besar and improve the quality of computer networks in terms of delay, jitter, throughput, and packet loss. This type of research is qualitative and quantitative research. Research methods include data collection (observation, interviews, literature study), analysis, design, implementation, and testing. Based on the test results after using the Queue Tree and PCQ methods, the average values of delay, jitter, throughput, and packet loss are more optimal than before applying the Queue Tree and PCQ methods. The delay measurement in data rate before applying the Queue Tree and PCQ methods is 1414925 m/s and after applying the Queue Tree and PCQ average delay is 3,165 ms. Test Jitter on the data rate before applying

Queue Tree and PCQ methods is 1414957 ms and after applying the queue tree and PCQ jitter is 3,164 ms, Throughput on data rates before applying the Queue Tree and PCQ methods is 5043 kbps and after applying the queue tree and PCQ throughput is 2486 kbps, Test packet loss on data rates before applying the Queue Tree and PCQ methods is 7,911% and after applying the queue tree and PCQ methods is 0,030%.

Keywords: Queue tree; PCQ (per connection queue); management bandwidth; delay; jitter; throughput; packet lost.

1. INTRODUCTION

Information and communication technology are combined in a computer network. This combination of technologies has resulted in computers that can be decentralized, using databases, software, and hardware at the same time, computers that were previously separate are now connected to each other to carry out their tasks. Such a system is called a computer network.

State Vocational High School (SMKN) 1 Sumbawa is one of the state vocational schools in Sumbawa Regency which is located at Jl. Durian No.3, Uma Sima, Sumbawa Besar. The use of internet network at SMKN 1 Sumbawa has very high mobility so resources are needed to support internet needs, therefore it is necessary to optimize computer networks that regulate resources so that they can be utilized to the fullest so that there are no disturbances to users when using the internet.

Bandwidth struggles and non-optimal internet networks [1] can result in problematic connections such as slow connections and allow users not to be connected to the internet, therefore it is necessary to optimize computer networks to be able to maximize service to users, both used to search for information, download and upload data.

In managing [2] the optimization of this computer network, a Mikrotik Router tool is needed to provide optimal internet services.

Mikrotik router [3] is also called a tool that does not need a lot of hardware, this is because the Mikrotik Router has many features, such as ease of configuration and also easy to download in various operating systems such as Windows, Linux, or Mac. Mikrotik OS as RouterOS has a lot of features and network support, both in terms of a wired network and wireless. Management Bandwidth is the most interesting of the many Mikrotik Router features. In terms of providing the best service for customers, Quality of Service (QOS) plays an important role. Therefore the importance of requiring bandwidth Management to manage all incoming and outgoing data.

From the description of the background above, the researcher chose to raise the research title "Computer Network Optimization Using the Queue Tree and Peer Connection Queue (PCQ) Method at SMK Negeri 1 Sumbawa for Supporting Learning as a medium for optimizing performance at SMK Negeri 1 Sumbawa.

2. BASIC THEORY

2.1 Computer Network

According to Malwin Syafrizal [4] in his introductory book on computer networks a computer network is a collection of "connections" that connect two or more separate computers via wired or wireless communication.

Another opinion was conveyed by Iwan Sofana [5] in his book titled build a computer network that is Specifically, the word internet comes from Internetworks. The concept of networking itself can be understood as a collection of networks that connect computers that run multiple operating systems. In short, the Internet is a collection of various global computer network systems that are interconnected and can communicate with each other.

2.2 Quality of Service (QoS)

Rika Wulandari [6] said that Quality of Service (QoS) is an attempt to determine the characteristics, nature, and methods of service to determine how good a network is. QoS measures a series of performance characteristics of certain services.

The QoS parameters used to measure network performance are listed below in the TIPHON standard:

2.2.1 Throughput

The number of network users, network topology, specifications of client/user computers, server computers, power induction, weather, and other factors all have an impact on bandwidth and throughput. The effective transfer rate (speed), also known as throughput, is measured in bps. The total number of packets successfully detected at a destination divided by the duration of the period is called throughput. The following is the formula for Throughput:

$$\text{Throughput} = \frac{\text{Data packet received}}{\text{Observation time}}$$

Following are the TIPHON throughput standards:

Table 1. Throughput

Throughput category	Throughput	Index
Bad	0 - 338 kbps	0
Poor	338 - 700 kbps	1
Fair	700 - 1200 kbps	2
Good	1200 kbps - 2,1 Mbps	3
Excellent	>2,1 Mbps	4

2.2.2 Packet loss

The amount of packet loss that can result from network collisions and congestion is referred to as packet loss. All applications are affected by this because retransmissions slow down the network as a whole, even if the application has sufficient bandwidth. The buffer will be full and no new data will be received if the backlog is long enough. The values for packet loss in the TIPHON version are as follows:

Table 2. Packet loss

Degradation Category	*Packet loss*	Index
Very good	0 %	4
Very nice	3%	3
Currently	15%	2
Bad	25%	1

Packet loss diukur dengan rumus berikut:

$$\text{Packet Loss} = \frac{(\text{Data packet sent} - \text{Data packet received})}{\text{Data packets sent}} \times 100\%$$

2.2.3 Jitter

Long queues, the time it takes to process data, and the time it takes to reassemble packets at the end of a jitter trip all vary. Jitter is also known as delay variation, and latency, or the amount of delay variation in network data transmission, is closely related to it. Jitter can be caused by queue delays in routers and switches. According to the TIPHON version, there are four categories of network performance degradation based on the peak jitter value.

Table 3. Jitter

Degradation Category	Peak Jitter	Index
Very good	0 ms	4
Very nice	0 s/d 75 ms	3
currently	75 s/d 125 ms	2
Bad	125 s/d 225 ms	1

Jitter is measured by the following equation:

$$\text{Jitter} = \frac{\text{Total delay variation}}{\text{Total packets received}}$$

$$\text{Total Delay Variation} = \text{Delay} - (\text{average delay})$$

2.2.4 Delay

The term delay refers to the amount of time it takes for data to travel from its source to its destination. Distance, physical disks, bottlenecks, and long processing times can all cause delays. The following are the delay components. The amount of delay can be classified as follows in the TIPHON version:

Table 4. Delay

Latency Category	Range *Delay*	Index
Very good	<159 ms	4
Very nice	150 s/d 300 ms	3
Currently	300 s/d 450 ms	2
Bad	>450 ms	1

The following equation is used to calculate the delay:

$$\text{Delay} = \frac{\text{Total data transmission time}}{\text{Total Data Packet -1}}$$

2.2.5 Router

According to Setiawan S.Ti, [7] data moving through the network can be filtered by routers based on certain protocols or rules. Routers can be used as connectors for LAN, MAN, and WAN models, such as hubs and switches.

Citing the Reliable Network Tutorial book with Mikrotik and Cisco the work of [8] Untung Suprihadi, S.Kom., to determine the most route efficient for IP packets from one system to another, a router which connected to each other via the Internet participate in the algorithm distributed routing.

The next opinion was raised by Melwin Syafrizal [9] in the book Introduction to computer networks, Data and information can be transferred between networks via a router. The bridge and router are almost identical. Despite evolution, the router is no smarter than the evolution of the bridge, it starts to fulfill and even beyond the expected technical requirements.

2.2.6 Mikrotik

According to Naufal Ilmi [10] in the best practice proxy book for beginners, Mikrotik is a company that makes computer network system hardware (RouterBoard) and software (RouterOS). Its head office is in Riga, Latvia. In 1995, Mikrotik was founded to develop Wireless Internet Service Provider (ISP) systems and routers. Arnis Riekstins and John Trully who made Mikrotik.

Towidjojo [11] offers the following point of view, Mikrotik Router can be designed graphically or using Command Line Interface commands (CLI). Winbox application or web browser can be used for performing a graphical configuration on the Mikrotik Router.

2.2.7 Bandwidth

According to Tanenbaum [12] in the book Computer Networks, 4th Edition explains that the distance of the emitted frequency which does not attenuate the signal is called bandwidth.

In the book Essential Cyber Security Handbook In Indonesian, Nam H Nguyen [13] explained that the relative speed of a network connection is called "bandwidth", and most dial-up modems available today can support a bandwidth of 56 kbps (thousands of bits per second).

2.2.8 Queue tree

According to Muhammad Hanafi [14] in his book on developing and optimizing the internet for citizens using a combination of Queue type and pihole systems, Queue Tree is a unidirectional queue configuration, which means that a queue configuration can only queue in one direction depending on the type of traffic. If the queue set is for download bandwidth, this setting does not queue download bandwidth and vice versa. So if you want to send and download traffic from client computers, you need to create two queue configurations.

The next opinion was expressed by M. Sigit Laksono [15] in the MTCNA teacher's proxy book that the Queue tree function is used for apply a more complex bandwidth limit on the proxy, where packet mark works better used to restrict connection download and upload only in one direction.

2.2.9 Peer connection queue (PCQ)

According to Dena Dewantara [16] in the MTCNA study guide, PCQ is a dynamic way to massively limit bandwidth using a simple configuration, PCQ works by creating sub-streams based on peq-classifier parameters. Only by defining the parameters (PCQ-Rate & PCQ-limit), each sub-stream will get the same Bandwidth limitation.

In addition, Adimas Ketut Nalenda [17] believes that PCQ can know the current bandwidth and also be used to divide the bandwidth evenly and massively. PCQ can be used on any proxy by using the Queue tree and Simple Queue features. Use PCQ even though the number of clients is not certain or very much we need to create one or two Queue roles.

2.2.10 Wireshark

In the book Computer Networks and Advanced Data, Leanna Vidya Yovita and Indrarini Dyah Irawati [18] explain Wireshark as an application that functions as a network analyzer by capturing data packets on a network using a network interface card (NIC) in their book Advanced Computer and Data Networks. Wireshark is a free tool for analyzing existing networks. Because it uses a graphical user interface (GUI).

2.2.11 Qualitative research

According to Sugiyono [19] in his book Research Methodology Quantitative, Qualitative, and R&D, Sugiyono explained that research qualitative

research is based on the philosophy of post-positivism and is used to study the state of natural objects rather than experiments. Method collection of information tested by triangulation (combined), data analysis are inductive/qualitative, and the findings of qualitative research are more emphasize meaning rather than generalization.

Meanwhile, Cresswell [20] in his book entitled Approach Qualitative, Quantitative and Mixed Methods state that the procedure of This qualitative research requires significant effort asking questions and following procedures, collecting specific information from the participants, analyzing the data inductively beginning from specific themes to universal themes and interpreting information. Participants in this kind of research are required to use the method inductive that focuses on the individual and conveyed the meaning of subject complexity.

3. RESEARCH METHODS

In conducting this research with the title Computer Network Optimization Using Queue Tree and Peer Connection Queue (PCQ) Methods at SMKN 1 Sumbawa for Learning Support. Researchers used research analysis using descriptive qualitative analysis. The stages - stages of research as follows in Fig 1.
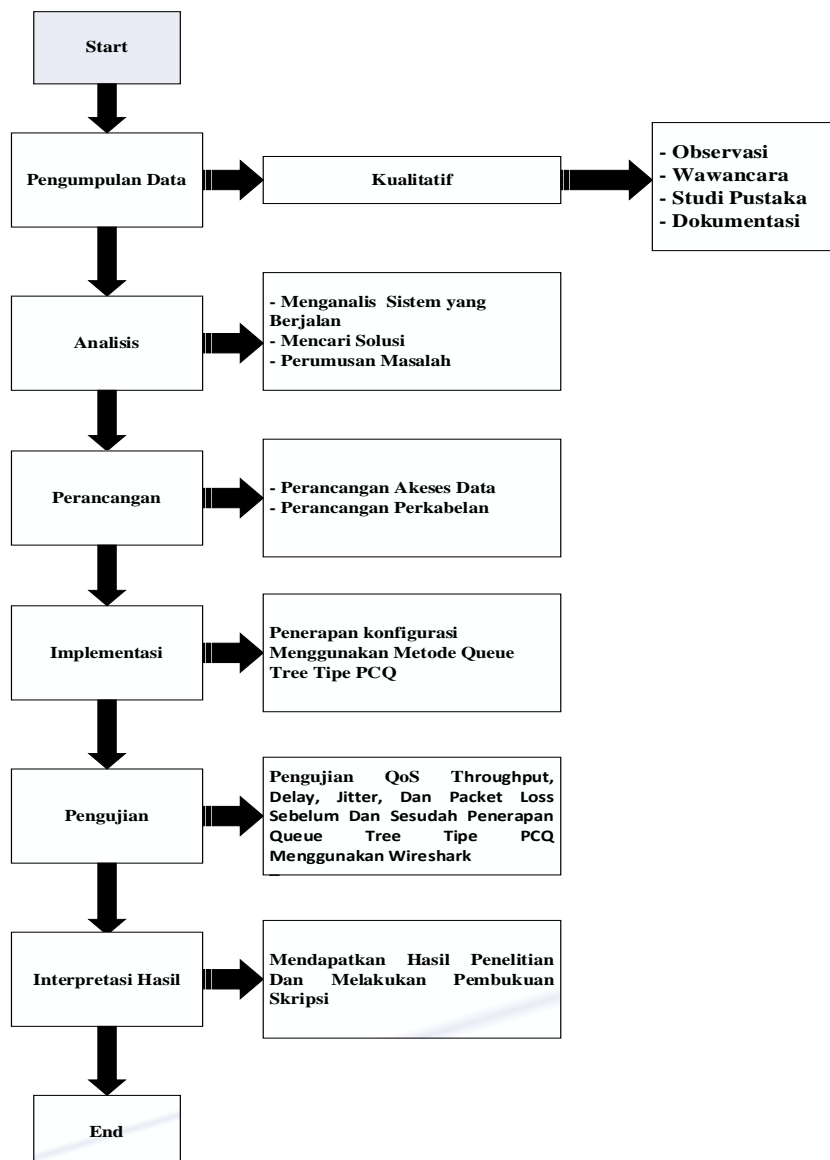
Fig. 1. Flow of research stages

The stages of the research to be carried out in this study are as follows:

3.1 Qualitative Data Collection Methods

a. Interview

At this stage, the researcher conducted interviews with those who manage IT at SMK Negeri 1 Sumbawa and provided questions related to the issues that the researcher would examine.

b. Observation (observation)

At the observation stage, the researcher conducted a direct visit to the field to obtain information related to computer network constraints at SMK Negeri 1 Sumbawa.

c. Literature review

At this stage, researchers look for data or references related to the thesis title. Data and information were obtained from previous journals, books, and theses to facilitate further research activities.

4. RESULTS AND DISCUSSION

4.1 Mikrotik Settings for Bandwidth Management

The amount of data that can be processed in one second is called bandwidth. Assuming the bandwidth will be shared between each client and PCQ (Peer Connection Queue), this study uses 100 MBps, with 30 MBps for download and 30 MBps for upload.konfigurasi *Mangle* pada mikrotik.

Mangle configuration is useful for marking packets passing through the route, and entering and leaving the route. In the Mangle Configuration, create 3 upload and download mangle, namely mangle ether2, ether3, and ether4 with each Address 192.168.10.0 (ether2), 192.168.20.0 (ether3), 192.168.30.0 (ether4). Done with the IP menu > Firewall > Mangle tab > Add button. Chain: Forward, Connection mark: no-mark.
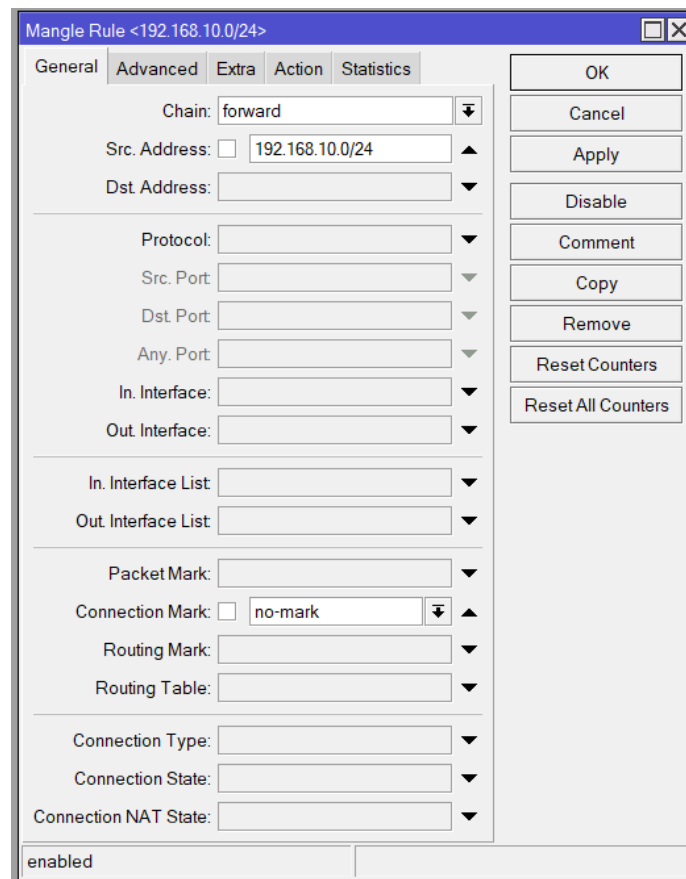
Fig. 2. Configure mangle uploads

23
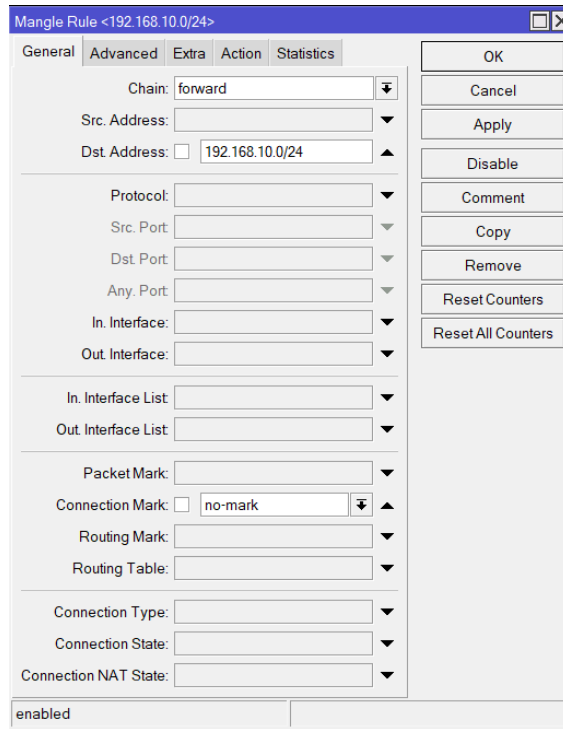
Fig. 3. Configure mangle download

Click the Action tab, then replace Action: packet mark, New Packet Mark: (according to the name of the ether interface). Then select OK.
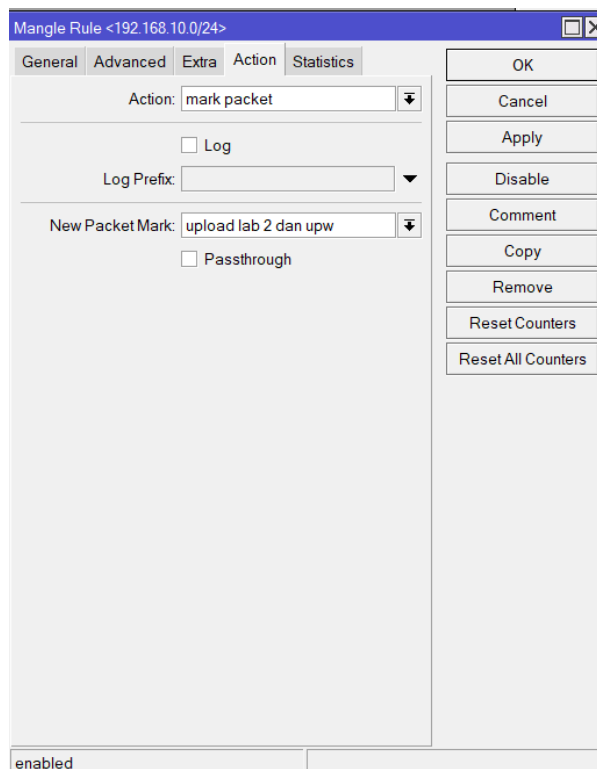

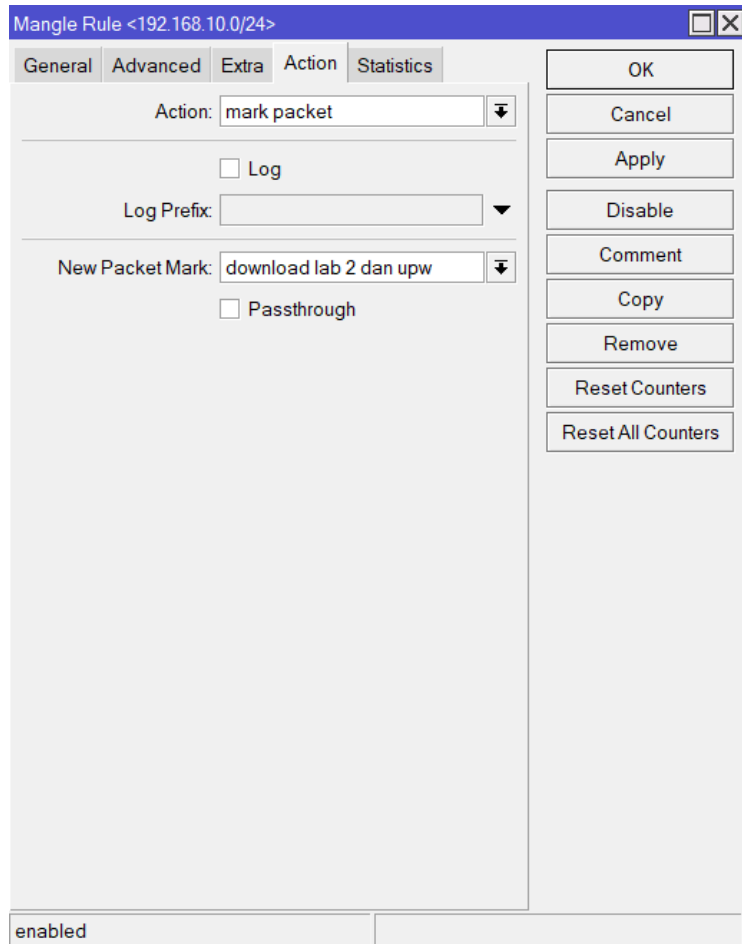**Fig. 4. Configure Mangle tab action upload**

Fig. 5. Configure mangle tab action download

When you've finished making the mangle, give the Download and Upload Labels and the results are as follows.
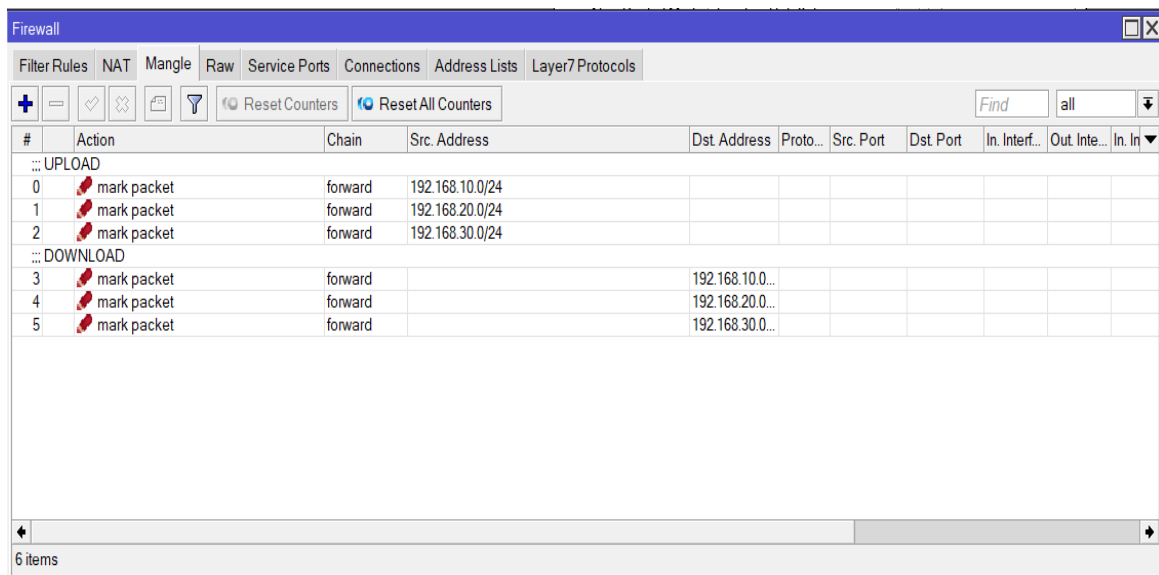

Fig. 6. Mangle list upload dan download

a.   Queue Tree Configuration and Peer Connection Queue (PCQ)

Configuration is done on the Queues menu > Queue types tab > add (at this stage separate upload and download). Type Name: PCQ uploaded user, kind: PCQ, classifier: Src. Address, Dst. Address Click OK.
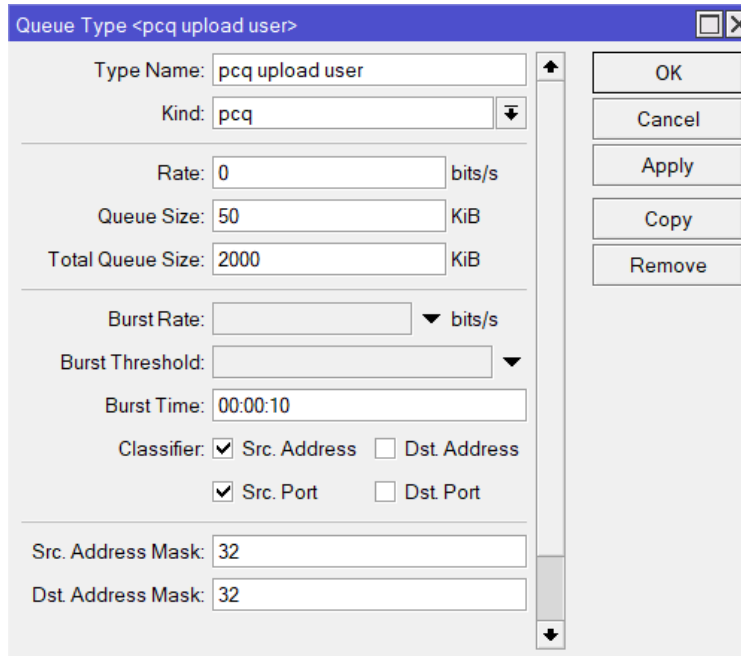
Fig. 7. Configure PCQ Uploads

Select add, then change the Type Name: PCQ download user, Kind: PCQ, Classifier: Etc. Addresses, Etc. Port then press OK.
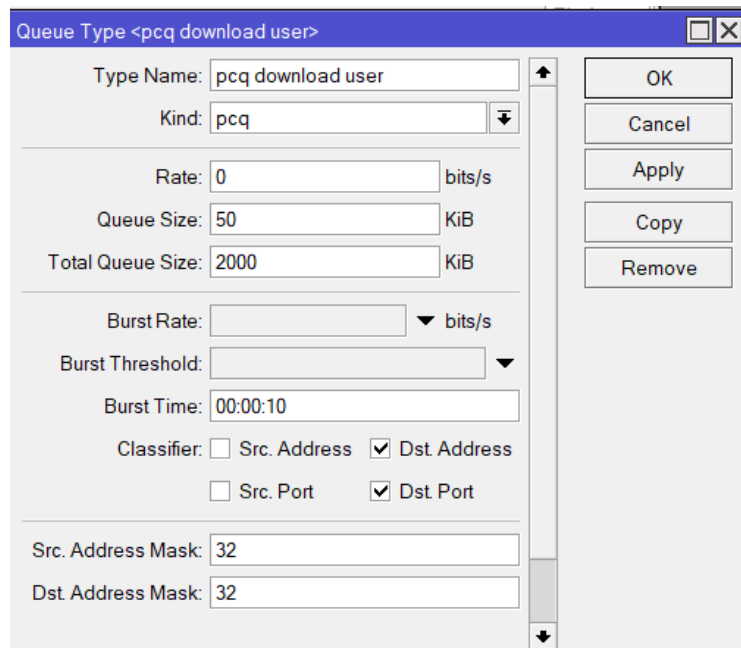
Fig. 8. Download PCQ configuration and the results in the queue list

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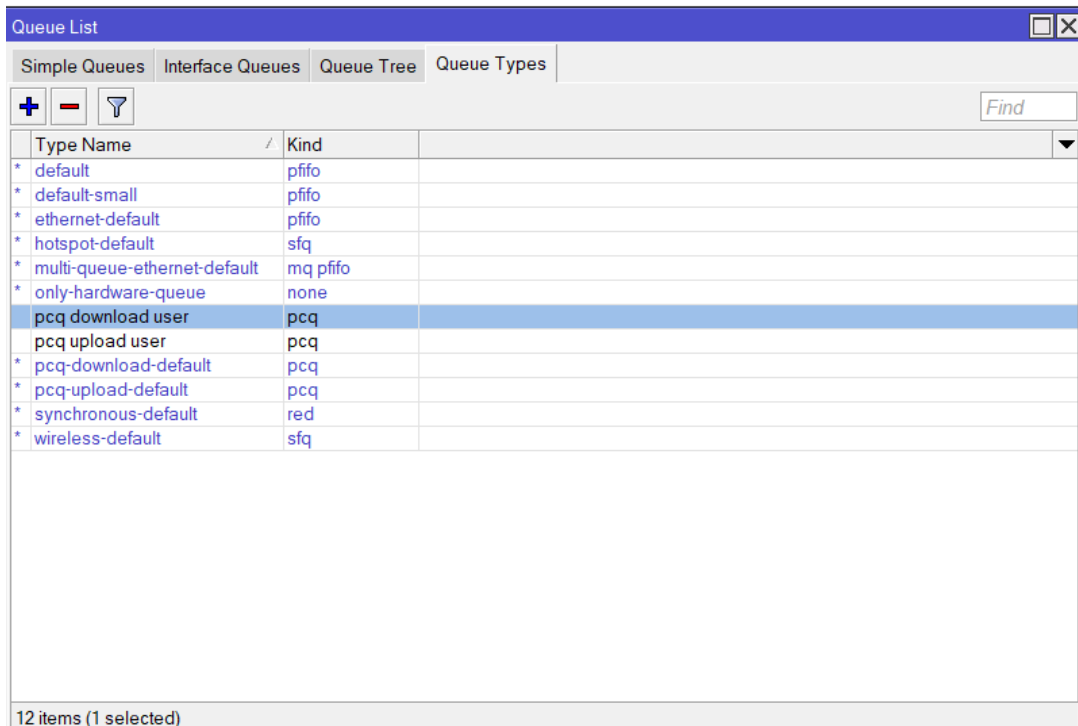
Fig. 9. PCQ configuration results

The next step is Configuring the parent download Queue Tree by opening the Queues menu > Queue Tree tab > add Name: DOWNLOAD, Parent: global, Queue Type: PCQ download user, select OK.
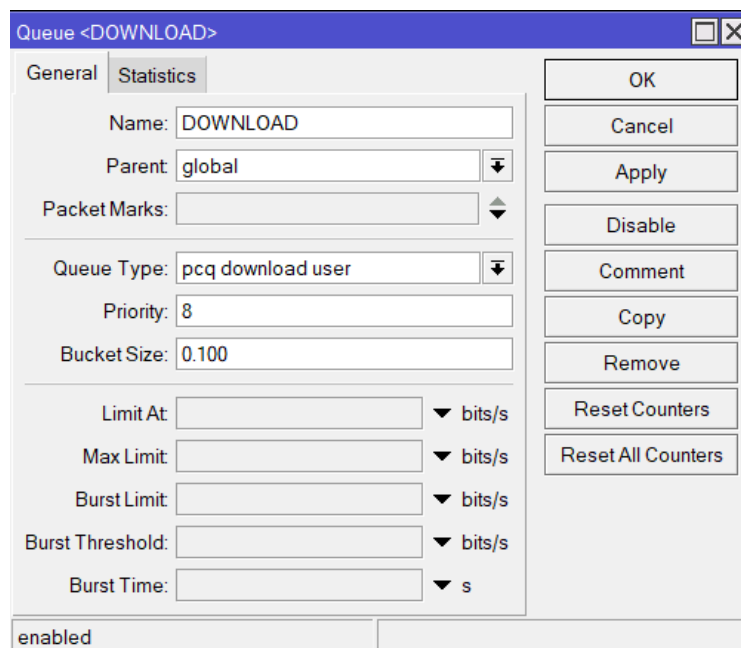

Fig. 10. Configure queue tree parent download

Click the add button and change the Name: download lab 2 and upw, Parent: DOWNLOAD, PacketMarks: download lab 2 and upw, Queue Type: PCQ download user, Limit At: 5M, Max Limit: 30M, Burst Limit: 100M, Burst Threshold: 23M, Burst Time: 2.
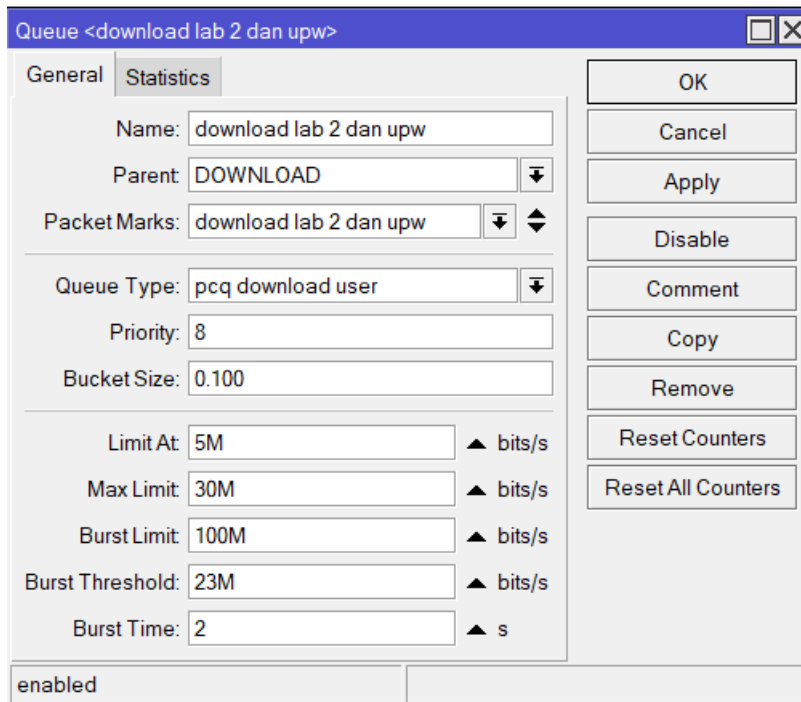
Fig. 11. Queue tree configuration download lab 2 and upw

The next step is Configuring the parent upload Queue Tree by opening the Queues menu > Queue Tree tab > add Name: UPLOAD, Parent: internet, Queue Type: PCQ upload user, click OK.
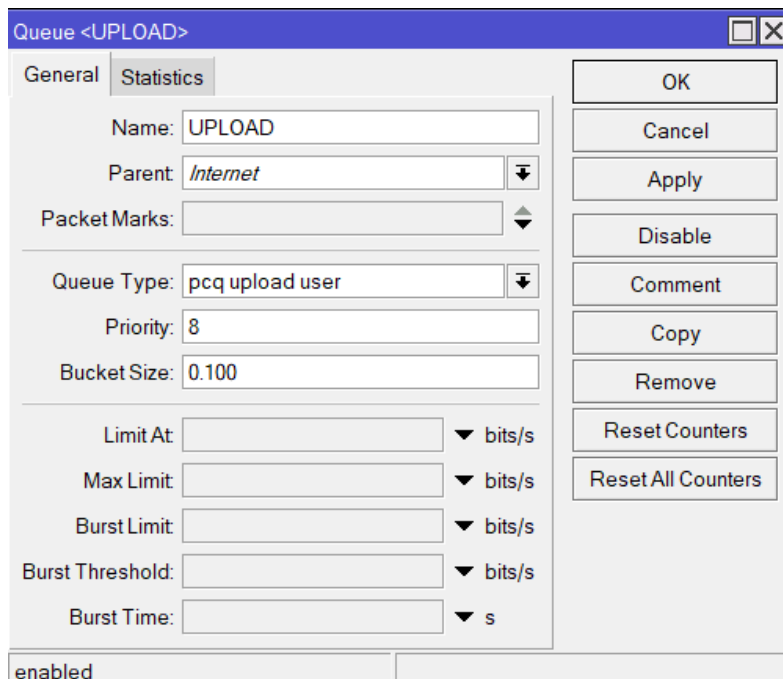

Fig. 12. Configure parent upload queue tree

Click the add button and change the Name : upload lab 2 and upw, Parent : UPLOAD, PacketMarks : upload lab 2 and upw, Queue Type : PCQ download user, Limit At : 5M, Max Limit : 30M, Burst Limit : 100M, Burst Threshold : 23M, Burst Time : 3
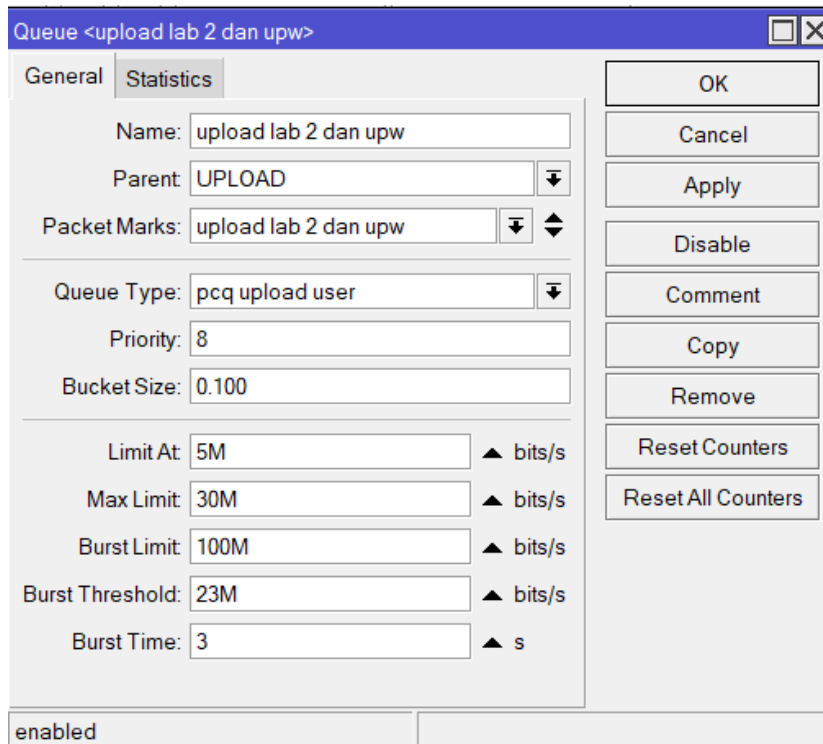
Fig. 13. Configure queue tree upload lab 2 and upw

b. Connection or parameter testing

Bandwidth management when applying the Queue Tree and PCQ methods is proven to be more efficient, stable and optimal than not using these methods. When testing, the researcher will show the QoS results after testing the Queue Tree and PCQ methods.

To observe the actual difference in bandwidth speed efficiency between Queue Tree and PCQ implementations with the previous state. After that, delay, jitter, throughput and packet loss are considered when calculating the parameters. Researchers will use the Wireshark application to carry out this test. Data will appear automatically, processed, and then presented in table form with a comparison chart at the end.

1. Delay

From the analyzed data obtained:

a. Delay measurement in data rate before applying the Queue Tree and PCQ methods
Based on the data obtained from Wireshark, the average delay is obtained with the following calculation:

Average Delay = Total Delay / Total packets received

= 4759811 s / 3364
= 1414,925 s = 1414925 ms

b. Testing the delay in data speed by applying the Queue Tree and PCQ methods

From the data obtained when using Wireshark, the average is obtained with the following calculation:
Average Delay = Total Delay / Total packets received

= 10,468948 s / 3307
= 0,003165 s
= 3,165 ms

To get the total delay, that is by adding up the overall delay between one packet and another.

Based on the tests that the researchers did, the delay value was obtained before applying the Queue Tree and PCQ, which was 1414925 ms, and after implementing the Queue Tree and PCQ, which was 3.165 ms. If the two test results are compared, the bandwidth management without applying the Queue Tree and PCQ is greater when compared to after implementing the Queue Tree and PCQ methods.
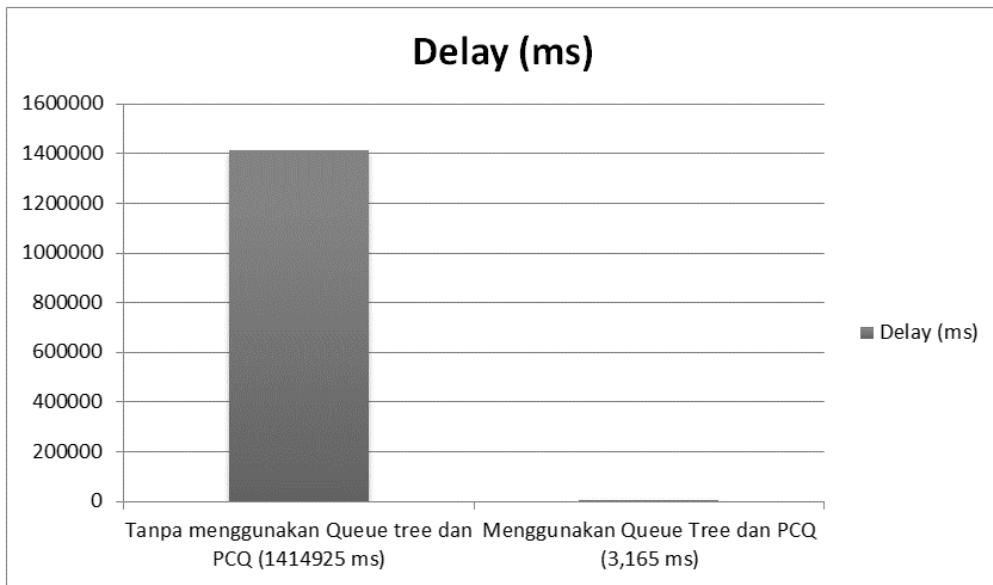
Fig. 14. Diagram hasil perbandingan delay

1. Jitter

a. Test Jitter on data rate before applying Queue Tree and PCQ methods

Capture data from the Wireshark application is obtained on average with the following calculation:

Jitter = Total delay variation / Total received packets:

 = 4759914 / 3364
 = 1414,957 s
= 1414957 ms

The total delay variation is obtained by adding up the difference in total delay between one packet and another. Table 3 shows the value of Jitter based on calculations on data transfer rates before applying the Queue Tree and PCQ methods.

b. Test Jitter on data rate by applying Queue Tree and PCQ methods

From the data capture using Wireshark, the average is obtained with the following calculations:

Jitter = Total delay variation / Total received packets

=10,46327 / 3307
= 0,003164 s
= 3,164 ms

Research conducted by researchers obtained jitter values when bandwidth management before using the Queue Tree method was 1414957 ms, and when implementing Queue Tree and PCQ it was obtained 3.164 ms. When applying the Queue Tree and PCQ methods the jitter value is better than before applying the Queue Tree and PCQ methods because the bandwidth of each internet user has been divided equally.

2. Throughput

a. Throughput on data rates before applying the Queue Tree and PCQ methods

From capturing data using Wireshark, the results are obtained with the following calculations:
Throughput = Data packets received / Observation time

 = 3000616 Bytes / 4,760 s
 = 630381,512 dalam bytes/s (1 bytes = 8 bit)
 = 630381,512 x 8
 = 5043 kbps

b. Test the throughput at data rates after applying the Queue Tree and PCQ methods

From Capture data using the Wireshark application, the results are obtained with the following calculations:

Throughput = Data packets received / Observation time

= 3254367 Bytes / 10,469 s
= 310857,484 dalam bytes/s (1 bytes = 8 bit)
= 310857,484 x 8
= 2486 kbps

Based on the tests that the researchers did, the throughput value with the Queue Tree and PCQ method was obtained at 2486 kbps, whereas before using the Queue Tree and PCQ method the throughput value was obtained at 5043 kbps. From the throughput value obtained, it can be concluded that by applying the Queue Tree and PCQ methods, the resulting throughput value will decrease.

3. Packet loss

a. Test packet loss on data rates before applying the Queue Tree and PCQ methods

Capture data from the Wireshark application is obtained on average with the following calculation:

Packet loss = (((packets sent - packets received) / packets sent) x 100%)

= ((3653 - 3364) / 3653) x 100%
= (289 / 3653) x 100%
= 7,911%

b. Test packet loss on data rates by applying the Queue Tree and PCQ methods

Capture data from the Wireshark application is obtained on average with the following calculation:

Packet loss = (((packets sent - packets received) / packets sent) x 100%)

= ((3308 - 3307) / 3308) x 100%
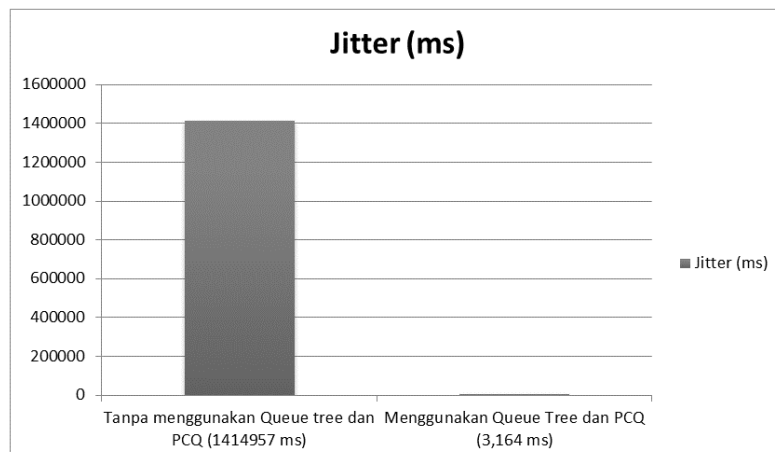= (1 / 3308) x 100%
= 0,030 %

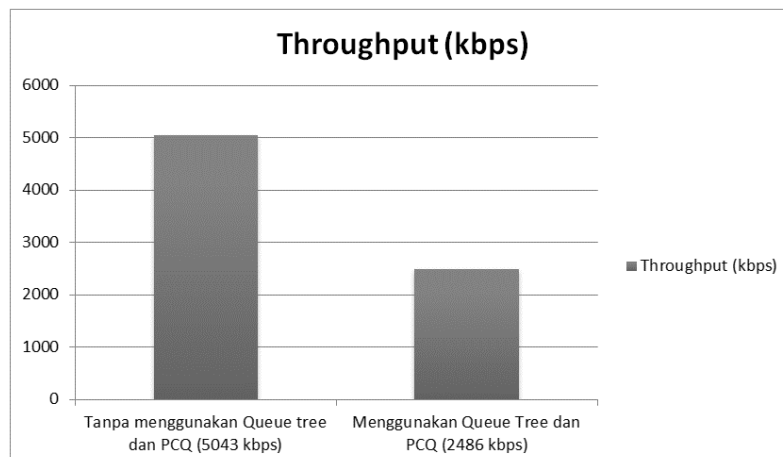**Fig. 15. Jitter comparison result chart**

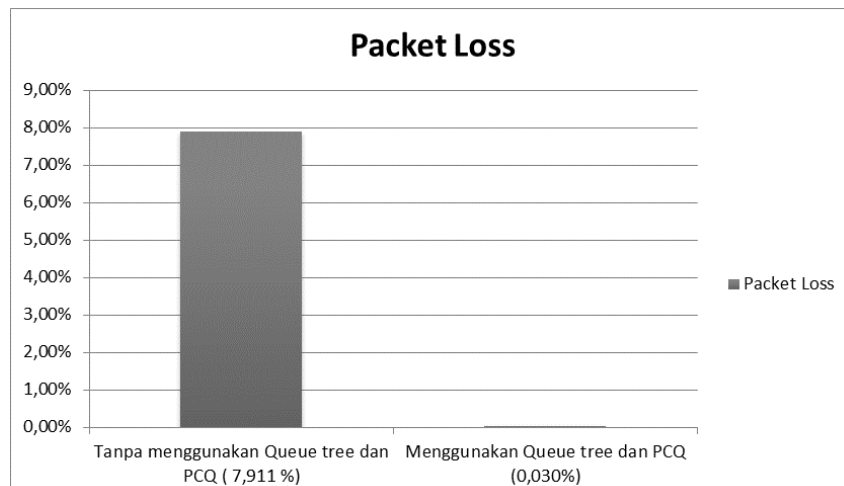**Fig. 16. Throughput comparison result diagram**

Fig. 17. Diagram of packet loss comparison results

From the test results, it was found that the results of packet loss in bandwidth management before applying the method were 7.911% and when implementing the method, the packet loss value was 0.30%. Judging from the value of each packet loss, the researcher can conclude that when applying the Queue Tree and PCQ methods the packet loss value is smaller than before applying the method.

5. CONCLUSION

The conclusions from the computer network optimization research conducted at SMK Negeri 1 Sumbawa are as follows:

1. Based on the results of delay, packet loss, throughput, and jitter before applying the Queue Tree and PCQ methods for bandwidth management, it was still less effective than afterwards.
2. Based on the test results it can be concluded that applying the Queue Tree and PCQ methods has better network quality because bandwidth is divided according to bandwidth management parameters and does not interfere with other bandwidth.

6. SUGGESTION

Suggestions from researchers for further research development can apply different optimization methods so they can find out the differences between one method and another.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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