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Implementation of Bandwidth Management and Access Restrictions Using PCQ and Firewall Methods in SMP Tunas Bangsa Network

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Abstract*-- Internet virtual classes as a substitute for face-to-face learning are becoming common use in schools during the pandemic, which activities outside the home is restricted. SMP Tunas Bangsa has an internet hotspot to access Zoom as a virtual class while browsing activities carried out by the teachers. Diverse activities and high traffic loads cause internet traffic congestion and frequent connection failures. The hotspot requires bandwidth management and access restrictions in order to efficient internet usage. Bandwidth management is carried out by the method Per Connection Queue (PCQ), and access restrictions are carried out with the firewall mangle. Mikrotik router OS configuration in practice manages bandwidth starting with connection marks and packet marks to separate connections to the router, through the router, and from the router to the internet. The parameter used to distinguish the traffic is the IP address which is grouped in dst-address and src-address to fulfill the pcq-classifier. Meanwhile, the blocking of access to streaming activities and online games is intended so the teachers only access related to education matters. To determine the success of the configuration, the Quality of service was calculated both before and after configuration. The results of the QoS throughput parameter which increased from 4.39% to 84.99%, the delay decreased from 462.52 ms to 146.87ms, and packet loss decreased from 27.94% to 0% on the network.

Keywords— Bandwidth Management, Firewall, PCQ, QoS.

I. INTRODUCTION

SMP Tunas Bangsa has a bandwidth allocation of 5 Mbps, used for Zoom access, browsing, streaming, and online games at the same time so the internet gets slower. Each activity requires a different bandwidth result connection failure and traffic congestion which is caused by the unequal bandwidth used by the teacher. The available bandwidth that should be used for the benefit of the school at this time is not following the school hotspot purpose.

Previous research findings related to Bandwidth Management and Restricted Access have been widely used and developed before. In 2018, [1] has done network bandwidth management by using the queue tree function with PCQ, the research result show that network have been received an equal bandwidth of utilization network. In [2] has done PrioSDN Resource Manager (PrioSDN_RM), a resource management mechanism based on admission control for virtualized SDN-based networks, this research proposed combination imposes bounds on the resource utilization for the virtual slices, which therefore share the network links, while maintaining isolation from each other.

Then in [3] bandwidth management service procedures are mapped onto functionality of the control protocol between radio access network and core network. In [4] has an overview enhanced bandwidth management in cellular network, and having implemented the proposed enhanced

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bandwidth management, congestion in current cellular network can perform better. In [5] has done the evaluation of management bandwith in sustainable mobile wireless network using dynamic LSP tunneling and LDP MPLS.

Then in 2020 [6] have done bandwidth optimization by setting max-limit and limit-at using the Simple Queue method on the SDN 001 Sekupang internet network. In [7] they have restricted access to social media video streaming websites at SMP YADIKA 5 Jakarta, aims to make students focused during lessons. In [8] have done configuring firewall filter, NAT, Mangle for packet tagging, Queue (bandwidth management) in MikroTik. The results concluded that moving the configuration center point on the modem (giving the IP address down) to the MikroTik router made optimal network connection. In [9] the implementation of Rb941 proxy use on LAN networks for user authentication to avoid access to illegal internet, and increase the internet network for more stability due to bandwidth limitations. In [10] they have compared the bandwidth management using Class Basic Queue and Hierarchical Token Bucket Method for optimal internet access. In [11] they have analyzed network internet access using parameter QoS (Quality of Service) for Mikrotik configuration in SMK Tunas Harapan. In [12] they have Development of a Network Security System with Mikrotik in SMK Muhammadiyah 2 Kuningan. Based on the background mentioned above, this thesis will be implemented bandwidth management and access restriction using PCQ and firewall in Tunas Bangsa SMP Network.

Some of previous research findings related to Bandwidth Management and Restricted Access have been widely used and developed before. In 2018, [1] has done network bandwidth management by using the queue tree function with PCQ, the research result show that network have been received an equal bandwidth of utilization network. In [2] has done PrioSDN Resource Manager (PrioSDN_RM), a resource management mechanism based on admission control for virtualized SDN-based networks, this research proposed combination imposes bounds on the resource utilization for the virtual slices, which therefore share the network links, while maintaining isolation from each other. Then in [3] bandwidth management service procedures are mapped onto functionality of the control protocol between radio access network and core network.

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A. Quality of Service

Quality of Service (QoS) is the ability of a network to provide good service by providing bandwidth, overcoming the many variations of delay (jitter) in data transmission on the network. Throughput is the ability of a network to transmit data per unit time. To calculate throughput, acknowledge the amount of data sent by the server to the client = Average Bytes/sec (bytes), time of sending data from the server to the client = time between first & last packet (sec). Delay is the time it takes for data to travel the distance from origin to destination. Delay is affected by distance, physical media, as well as the length of time to process queues on routers and switches. Packet loss can show the total number of lost packets, this happens because of collisions and congestion on the network [14]. The Quality of Service (QoS) parameter is measured based on the standardized version of TIPHON (Telecommunications and Internet Protocol Harmonization Over Network) for throughput shows in Table 1.

TABLE 1 . Throughput Category

Category	*Throughput*	*Index*
Best	100 %	4
Good	75 %	3
Middle	50%	2
Bad	<25 %	1

Standardized version of TIPHON (Telecommunications and Internet Protocol Harmonization Over Network) for delay shows in Table 2.

TABLE 2 . Delay Category

Category	*Delay*	*Index*
Best	<150 ms	4
Good	150 ms – 300 ms	3
Middle	300 ms – 450 ms	2
Bad	>450 ms	1

Standardized version of TIPHON (Telecommunications and Internet Protocol Harmonization Over Network) for packet loss shows in Table 3.

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TABLE 3 . Packetloss Category

Category	*Packetloss*	*Index*
Best	0 %	4
Good	3 %	3
Middle	15 %	2
Bad	25 %	1

B. Per Connection Queue (PCQ)

Per Connection Queue (PCQ) is a method provided by MikroTik to manage bandwidth for many client conditions and it works by grouping IP Address then create the pcq-classifier that used to distinguish between network traffic (sub-stream). And there is a parameter pcq-rate to limit the bandwidth per client. It can be concluded that PCQ makes sub-streams according to the number of clients or a number of IP addresses that want to use bandwidth allocation. For example, a bandwidth allocation of 1 Mbps is used for downloads, then the destination address parameter is the pcq-classifier, and if there are 4 clients in the network, each client gets a bandwidth of 256 Kbps [15].

C. Layer 7 Protocol in Firewall Mangle

Firewall Mangle has a function to mark a connection or data packet that passes through the router, enters the router, or exits the router. In its implementation, Mangle is used in combination with Bandwidth Management and Routing policy such as Layer 7 Protocol, this layer provides an alternative for blocking content. The method used is to look for patterns in ICMP/TCP/UDP streams or regex patterns. The way Layer 7 Protocol works are to match (matcher) the first 10 connection packets or the first 2 KB connection and look for data patterns that match the available ones. If this pattern is not found in the available data, the matcher does not check further and is considered unknown connections then drop the connections [16].

II. METHOD

Bandwidth management and access restrictions on the SMP Tunas Bangsa network are carried out to improve performance and efficiency in bandwidth usage as needed, which will be regulated through the Mikrotik router configuration. The research methodology used is the Network Development Life Cycle (NDLC) which is a method for developing or designing an infrastructure network by monitoring the existing network to know the value of network statistics and performance for improvement. Figure 1 shows flowchat of research metodology.

In Figure 1 it can be seen that the research begins in Network Existing Observation to identify the main problem, then design Network Topolgy to make sure the Bandwidth Management and Firewall work properly to the network. There are 3 main problem at SMP Tunas Bangsa Hotspot, which is:

a) The existing configuration is still at a basic stage without any bandwidth limitations caused unequal bandwidth internet usage.
b) There is no Firewall to limit access, besides online learning activities via zoom, teacher do streaming and gaming at the same time caused high congestion network.
c) There was several lost connection when teacher's laptops accessed Zoom Meeting in the implementation of online learning.

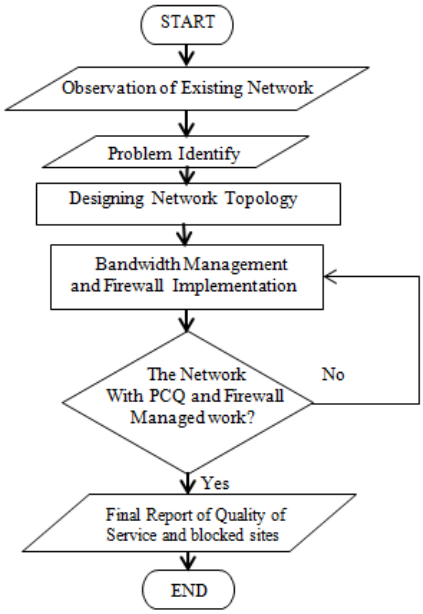

Fig 1 . Flowchart Research Methodology

The solution of these problem is fixed netwok topology need to be implemented to separate the connection between zoom and others. Manage bandwidth priority for the Zoom connection and the rest bandwidth for other activity. Furthermore, the role of pcq configuration as bandwidth limitation is carried out with the steps for implementing bandwidth management using Per Connection Queue as follows:

1. *Set Zoom traffic as priority and add it to IP>Firewall>Address List*

```
/ip firewall mangle
    add chain=prerouting dst-address-
list=!zoom_ip dst-port=80, 443 Protocol=tcp
action=add-dst-to-address-list address-
list=zoom_ip;

    add chain=prerouting dst-address-
list=!zoom_ip dst-
port=3478,3479,5090,5091,8801-8802
Protocol=tcp action=add-dst-to-address-list
address-list=zoom_ip;

    add chain=prerouting dst-address-
list=!zoom  ip dst-
port=3478,3479,5090,5091,8801-8802
Protocol=udp action=add-dst-to-address-list
address-list=zoom_ip;
```


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2. *Through winbox, configure IP>Firewall>Mangle which serves to mark incoming traffic and zoom packets to Address list.*

```
/ip firewall mangle
Add chain=prerouting src-address-list=zoom_ip
action=mark-connection new-connection-
mark=koneksi_zoom passthrough=yes

/ip firewall mangle
add chain =forward connection-
mark=koneksi_zoom action=mark-packet new-
packet-mark=zoom_paket passthrough=no;
```

3. *Also configure IP>Firewall>Mangle which serves to mark traffic and browsing packets.*

```
/ip firewall mangle
Add chain=prerouting Protocol=tcp dst-
port=80,443 action=mark-connection new-
connection-mark=koneksi_browsing
passthrough=yes

/ip firewall mangle
add chain =forward connection-
mark=koneksi_browsing action=mark-packet
new-packet-mark=browsing_paket
passthrough=no;
```

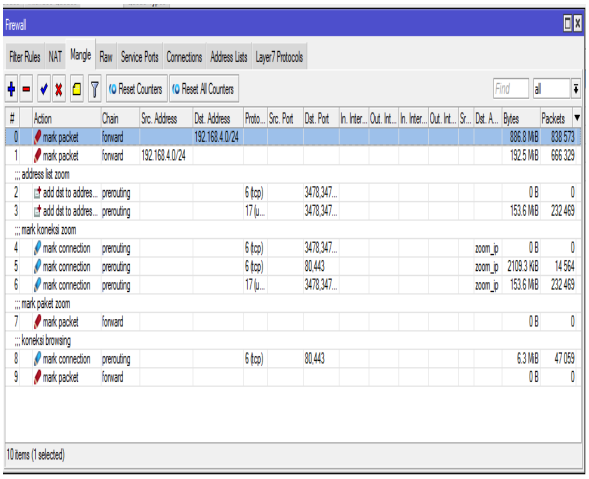

Fig 2 . Connection Mark and Packet Mark

4. *Create a global parent "parent download" and "parent upload" on the Queue Tree tab which functions to separate zoom and browsing packages.*

5. Set pcq-*upload :*
Choose *Queues> Queue Types>* + > fill the cloumn *Type name*: *Pcq_Down*; *Kind*: *pcq> classifier src-address checklist (√)*

6. Set pcq-*download :*
Choose *Queues> Queue Types>* + > fill the cloumn *Type name*: *Pcq_Upl*; *Kind*: *pcq> classifier dst-address checklist (√)*

7. Configuration result shows in Figure 3

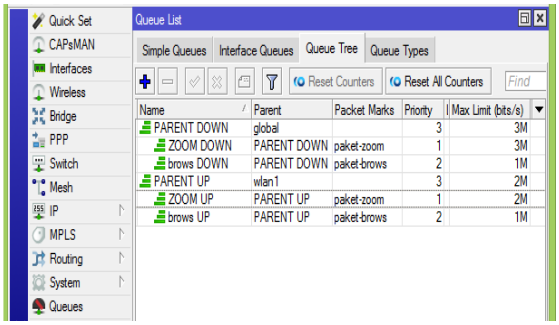

Fig 3 . Separating Connection Upload and Download

8. In Figure 3 means access zoom has become a priority with bandwidth allocation of 3 Mbps which is divided automatically through PCQ which is 614.4 Kbps/user (3072 Kbps divided by 5 zoom users), browsing traffic is also divided into bandwidth allocation of 2 Mbps which is divided equally. automatically by PCQ. So if there are 15 clients doing browsing activities, the bandwidth used is 136.5 Kbps/user.

9. Access to heavy traffic in the network such as online gaming and streaming is also blocked. This is done by configuring the Firewall at Layer 7 Protocol, via the Winbox Command Line Interface (CLI). An example of the syntax used is "Ip firewall layer7 add name = youtube regex ^.+(. youtube.).*$ firewall rules add chain = foward Protocol = 6(tcp) dst-port = 80,443 advanced layer7Protocol = youtube action = drop "

Result appears in Quality of Service (QoS) calculations performed before and after configuration to see the changes and improvements in network performance.

III. Results And Discussion

The results of the Quality of Service (QOS) analysis carried out on the network at SMP Tunas Bangsa are compiled into a table based on measurements for 10 minutes of zooming and other activities such as browsing. QoS measurements are carried out within a week before and a week after the Per Connection Queue (PCQ) configuration.

A. Quality of Service (QoS) Data Processing Results Before Configuring Per Connection Queue (PCQ) on Hotspot

The testing involves 20 clients in 3 conditions at the same time, there are 5 clients in Zoom, 7 clients in download, and 8 clients in browsing activity. Results of the average calculation shows in Table 4.

TABLE 4 . QoS Result Before PCQ Implementation

Category	*Through put* (%)	*Delay* (ms)	*Packet loss* (%)
Download	4,70	464,26	27,35
Zoom	2,72	468,22	28,89
Browsing	5,83	461,11	27,58

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In Table 4 results seen is the average of two weeks calculation of QoS Parameter before configuration of Per Connection Queue (PCQ) implemented on the network Hotspot SMP Tunas Bangsa. Results throughput for download = 4.70%, delay = 464.26 ms, and packetloss = 27.35%. Results throughput for Zoom = 2.72%, delay = 468.22 ms, and packet loss = 28.89%. Results throughput for browsing = 5.83%, delay = 461.11 ms, and packet loss = 27.58%. Result throughput = 4.39%, delay = 462.52 ms, packet loss = 27.94% for all activities carried out. So the conclusions obtained are based on the standard TIPHON category, the hotspot network at SMP Tunas Bangsa, Rohil is included in index 1 or "bad" before bandwidth management.

B. *Quality of Service (QoS) Data Processing Results After Configuring Per Connection Queue (PCQ) on Hotspot*

The testing involves 20 clients in 3 conditions at the same time, there are 5 clients in Zoom, 7 clients in download, and 8 clients in browsing activity. Results of the average calculation shows in Table 5

TABLE 5 . *QoS Result After PCQ Implementation*

Category	*Through put* (%)	*Delay* (ms)	*Packet loss* (%)
Download	85,55	158,58	0
Zoom	85,94	154,17	0
Browsing	84,82	126,26	0

In Table 5 results seen is the average of two weeks calculation of QoS Parameter after configuration of Per Connection Queue (PCQ) implemented on the network Hotspot SMP Tunas Bangsa. Results throughput for download = 85.55%, delay = 158.58 ms, and packetloss = 0%. Results throughput for Zoom = 85.94%, delay = 154.17 ms, and packet loss = 0%. Results throughput for browsing = 84.82%, delay = 126.26 ms, and packet loss = 0%. Result throughput = 84,99%, delay = 146,87ms, packet loss = 0% for all activities carried out. So the conclusions obtained are based on the standard TIPHON category, the hotspot network at SMP Tunas Bangsa, Rohil is included in index 3 or "good" after bandwidth management.

C. *Comparison Result Quality of Service (QoS)*

The following is graphs comparison of the QoS parameter values for each activity carried out in the Tunas-Bangsa SMPhotspot network, namely before and after the implementation of bandwidth management with the Per-Connection Queue (PCQ) method. Throughput value for all activities shows in Figure 4.

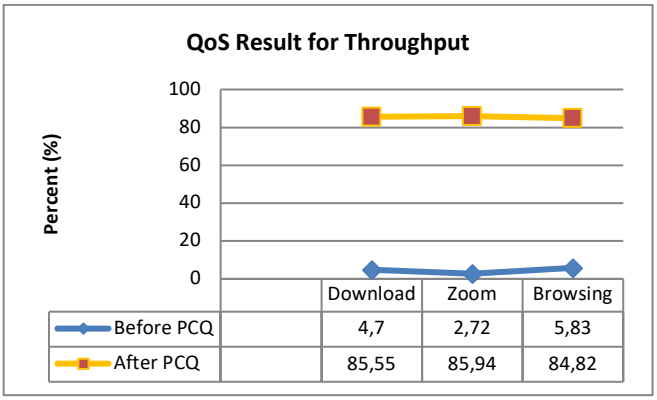

Fig 4 . Comparison of QoS Result Throughput

Based on Figure 4 can be seen significant changes for throughput on Tunas Bangsa Hotspot network traffic. Before bandwidth management using PCQ implemented, the throughput value of each activity is low caused the average allocation bandwidth for user unequal. After bandwidth management using PCQ implemented, stage of the trafic Zoom carried out as the priority, Then access for downloading and browsing is not interrupted because every activity has its own traffic flow.

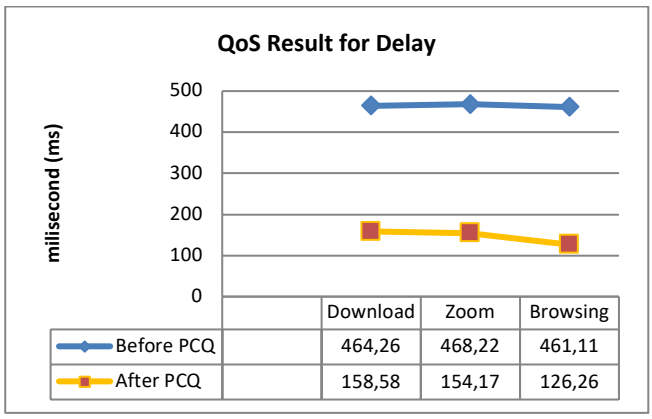

Fig 5 . Comparison of QoS Result Delay

Based on Figure 5 can be seen significant changes for delay on Tunas Bangsa Hotspot network traffic. Before bandwidth management using PCQ implemented, the delay value of each activity is high caused the diverse traffic connection can be imply the congestion of the network. After bandwidth management using PCQ implemented, stage of the trafic congestion decreased, Then access for every activity has its own bandwidth allocation so the delay can be shrink.

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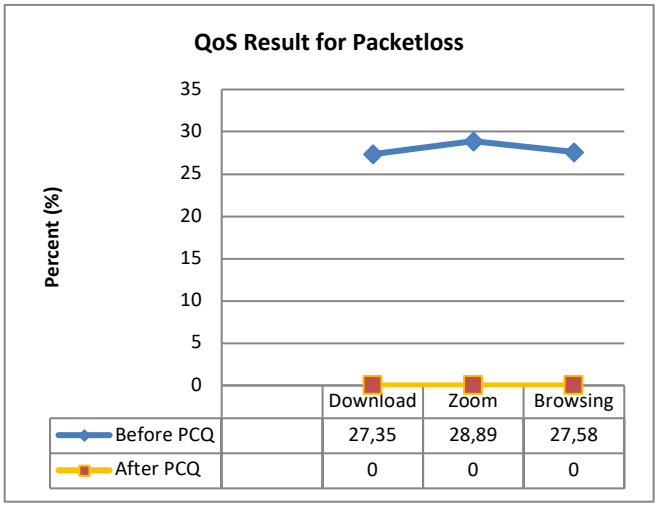

Fig 6 . Comparison of QoS Result Packetloss

Based on Figure 6 can be seen significant changes for packetloss on Tunas Bangsa Hotspot network traffic. Before bandwidth management using PCQ implemented, the packetloss value of each activity is up to 25%. After bandwidth management using PCQ implemented, stage of the reduced delay has overcome the traffic congestion flow on the network so the buffer can be minimized for losing packet during the delivery process.

D. Blocking Streaming Video Sites and Online Game

Blocking of video streaming sites and online games are done through the Firewall > Layer 7 Protocol feature configured on Mikrotik. Blocked streaming site such as Youtube shows in Figure 7

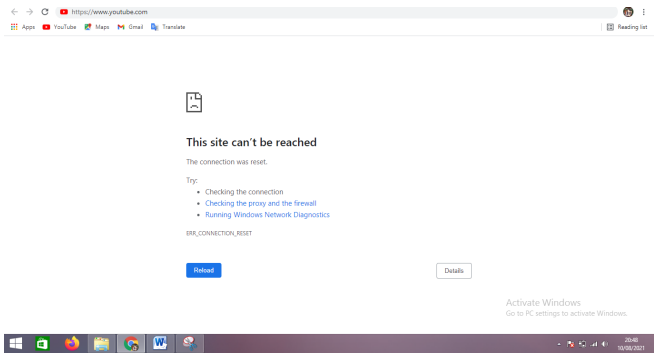

Fig 7 . Blocked Youtube Streaming site

In Figure 7 can be seen the network is well connected, but the user cannot access the youtube site because it is blocked through the Mikrotik Firewall. Then the blocking of streaming has been successfully done. In Figure 8 can be seen online game site stops on the loading screen, so users cannot access online games because they are blocked through the Mikrotik Firewall. So the blocking of online games has been successfully carried out.

Fig 8 . Blocked MobileLegends Online Game

IV. CONCLUSION

By implementing PCQ on bandwidth management in the SMP Tunas Bangsa network, the QoS of the network are better than without PCQ. The results of the QoS throughput parameter which increased from 4.39% to 84.99%, the delay decreased from 462.52 ms to 146.87ms, and packet loss decreased from 27.94% to 0% on the network. In addition, access to streaming sites and online games was successfully blocked through the Firewall Layer 7 Protocol feature.

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