

# Bandwidth Management Analysis Using Proxy Server-Based Method Virtual Machine

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**Abstract:** Bandwidth is the most important part of internet network traffic. High bandwidth traffic results in slow internet access. This happens because internet users are increasing rapidly due to shifting habits in the technological era where everyone uses the internet in every activity meaning communication, business, and learning as well as expensive infrastructure to build proxy servers and bandwidth management. This problem arises within the Faculty of Medicine, Islamic University of North Sumatra in the lecture process because students often access streaming services in the lecture process which makes bandwidth consumption greater. The steps taken in overcoming this problem are to build a proxy cache and bandwidth management with the Per Connection Queue (PCQ) algorithm. The analysis was carried out using the Wireshark application based on Quality of Service (QoS) parameters of throughput, delay, jitter, packet loss, and efficiency as well as time differences. The test was carried out by accessing the youtube, dikti, and Facebook pages at peak times. Based on the analysis carried out, shows that there is a decrease in traffic and increased efficiency by up to 58.02analysis using Wireshark were carried out by monitoring the density experienced when searching so as to produce values in the Throughput QoS Parameter of 1982k, Packet loss of 0.0of 0.0063 and total jitter -0.00328 with an average jitter of -0.00021.

## 1 INTRODUCTION

Developments in the world of technology make the need for internet access very high. Even today, the internet has been considered a basic necessity for both personal and business in supporting work and information exchange media (Akmala, 2019).

The COVID-19 pandemic has had a huge impact on internet usage around the world. Due to social distancing and remote work orders, many people are forced to use the internet for various activities such as working, studying, and communicating. According to data from the Central Statistics Agency (BPS) in 2021, the percentage of Indonesians who use the internet is 62.10% in 2021 (Statistik, 2021). This increase is driven by factors such as increased accessibility and more affordable prices of technological devices such as computers and smartphones, as well as increased availability of internet networks both in cities and in rural areas. This is inseparable from the government's efforts to increase the accessibility and availability of the internet network throughout In-

onesia. Meanwhile, according to data from We Are Social and Hootsuite in 2022 (Social, 2022), there has been an increase in the time spent by internet users every day, the average time spent by internet users every day is about 6 hours and 37 minutes. And the most popular online activities in Indonesia are watching videos, browsing, and social media where this activity results in the use of large bandwidth, causing high traffic.

Currently, the Faculty of Medicine, Islamic University of North Sumatra (FK-UISU) is experiencing high network traffic caused by the increasing use of the internet in the teaching and learning process in the campus environment. On the other hand, the frequent access to video streaming services, video conferencing, and social media turned out to be a lot of burden on the bandwidth of the faculty's internet network, resulting in campus services that use internet access being hampered. The way that can be taken in reducing network performance decline is by doing bandwidth management and proxy servers with cache features in helping to ease large bandwidth loads (Tanwir and

Affandi, 2017). On the other hand, expensive infrastructure and devices are obstacles in providing server services in managing bandwidth and proxy caches. A virtual machine can be used in setting up and managing bandwidth and cache at a fraction of the cost (Mohammad, 2021).

Based on the above background, to overcome the large bandwidth consumption load, a bandwidth management mechanism, and proxy cache are needed to help reduce the bandwidth consumption load in the UISU medical school environment. The method proposed in this study is to use a virtual machine-based proxy server in optimizing stable, structured, and effective internet access to all clients.

## 2 LITERATURE REVIEW

### 2.1 Bandwidth Management

Bandwidth is a quantity to indicate how much data can be passed in a connection over a network (Nasir and Andrianto, 2018). Bandwidth is also called bandwidth or information channel capacity, which is the maximum ability of a tool to transmit information in units of time (Eko, 2017). It is usually denoted as bits per second (bps), or by some larger denomination of bits, such as Megabits per second (Mbps) or Kilobits per second (Kbps). It is now common for the word bandwidth to be used more to measure digital data streams (Iqbal and Tambunan, 2021).

### 2.2 Per Connection Queue (PCQ)

The Per Connection Queue (PCQ) algorithm is an algorithm used for a large number of clients, this algorithm adjusts the number of clients (Rifai, 2017). In the Mikrotik operating system, the PCQ method is a program to manage network traffic on Quality of Service (QoS) (Kusbandono and Syafitri, 2019). Bandwidth management that can be used or applied to the client is the PCQ method. PCQ is used for bandwidth management to improve system performance. PCQ shares the bandwidth from the ISP with all users using the network at the same time. Each sub-queue has a data rate limit based on PCQ and PCQ packet limit (D. Iswadi and Munadi, 2019). The total size of the PCQ queue should be smaller than the total limiting PCQ packet how PCQ works with PCQ-rate parameter = 0.

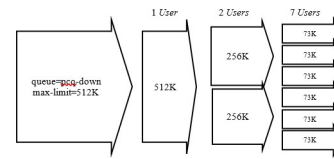


Figure 1: How PCQ Works.

### 2.3 Simple Queue

Simple Queue is a simple way to limit bandwidth based on the client's IP address, either download or upload bandwidth. The simple queue is a queuing technology in the bandwidth management system on the proxy router. This queuing technique can be easily configured, and bandwidth allocation is the simplest among other methods used to perform bandwidth management (Arya, 2020).

### 2.4 Mikrotik

Mikrotik is an operating system specialized in handling routing on computer networks (T. Rahman and Nurdin, 2020). Mikrotik router is a hardware router made by Mikrotik that runs the RouterOS system. Mikrotik can be used as a Firewall, Routing, Hotspot for plug-and-play access, remote Winbox GUI, and Virtual Private Network (VPN) Mikrotik RouterOS bandwidth type simple queue can control the throughput or upload and download rate of each client on the network (Ayubih and Kuswanto, 2021).

### 2.5 Quality of Service

Quality of Service is the ability to describe a level of achievement in a data communication system (Sarmah and Sarma, 2019). Quality of Service is a network mechanism that allows an application or service to operate on an implementation basis. The goal of Quality of Service (QoS) is to use the same infrastructure to meet different service requirements (Jang and Lin, 2017). Performance refers to the speed and reliability of sending different types of data loads in communication. The following are some QoS parameters that are often used to measure network performance, namely Throughput, Packet loss, Delay, and Jitter (M. C. Breaban and Balan, 2018) (Wisesa, 2018).

### 2.6 Throughput

Throughput is the actual bandwidth measured at any given time to transfer data. Unlike bandwidth, although the unit is equal to bps, throughput also represents the actual bandwidth at a time and on certain

conditions and networks used to download a file of a certain size (Mukti and Dasmen, 2019). Throughput can be divided into four categories according to the TIPHON version (D. Iswadi and Munadi, 2019).

Table 1: Troughput.

Throughput Categories	Throughput	Table of Contents
Perfect	100%	4
Good	75%	3
Medium	50%	2
Poor	<25%	1

## 2.7 Packet Loss

Packet loss is a parameter used to describe a situation that represents the total number of packets lost that may occur due to collisions and congestion on the network. Collision and congestion will affect all applications, even if the bandwidth is sufficient for the application. The packet loss value according to the TIPHON version is divided into four parts (D. Iswadi and Munadi, 2019).

Table 2: Packet Loss.

Relegation Categories	Packet	Index Loss
Perfect	0%	4
Good	3%	3
Medium	15%	2
Bad	<25%	1

## 2.8 Delay

Delay is the time it takes to send data packets from one computer to another. Delays in the process of sending data packets on a computer network can be caused by long queues or the use of other routes to avoid route congestion (Sari and Sukri, 2018). Delays can be affected by distance, physical media, congestion, or long processing times. According to the TIPHON version, the magnitude of the delay can be classified (D. Iswadi and Munadi, 2019).

## 2.9 Jitter

Jitter or delay variation is a change in delay or difference between the first delay and the subsequent delay. If the transmission delay changes too much, it will affect the quality of the transmitted data. Jitter is a data packet delay known as QoS which is very important,

Table 3: Delay.

Latency Category	Delay	Index Amount
Perfect	<150 ms	4
Good	150 – 300 ms	3
Medium	300 – 450 ms	2
Poor	>450 ms	1

especially for real-time applications. There are four categories of network performance reduction based on jitter magnitude values according to the TIPHON version (D. Iswadi and Munadi, 2019).

Table 4: Jitter.

Categories Jitter	Jitter	Index Magnitude
Perfect	< 0 ms	4
Good	0 – 75 ms	3
Medium	75 – 125 ms	2
Poor	125 – 225 ms	1

## 2.10 Wireshark

Wireshark is a software application used to be able to view and try to capture network packets and try to display all the information in the package in as much detail as possible. Open Source from Wireshark using Graphical User Interface (GUI) (S. Sandhya and Deep, 2017). Wireshark is used to view, capture, and analyze data packets to help troubleshoot wireless network administrators. It can also help capture traffic from the air and decrypt it into a format that helps administrators to track down issues causing poor performance, and intermittent connectivity using appropriate driver support (Jain and Anubha, 2021).

## 2.11 Squid

Squid is a high-performance proxy caching server for web clients, which already supports FTP, gopher, and HTTP data objects. Unlike the old caching software, squid handles all nonblocking single requests and I/O-driven processes. Squid supports SSL, lots of access control, and full request logging (Wahyudi, 2017).

## 2.12 Virtual Machine (VM)

A virtual machine (VM) is a software engineer that has the same functions as a physical computer. The VM is a standalone operating environment that behaves as if it were a separate computer (Amarudin and Yuliansyah, 2018). There are so many popular vir-

tualization technologies available such as VMWare, VirtualBox, Parallels, QEMU, UML, and Xen (Naik, 2016).

### 3 METHOD

This research was conducted by bandwidth management using a virtual machine-based proxy server method in optimizing bandwidth. The flow of this study is presented in Figure 2.

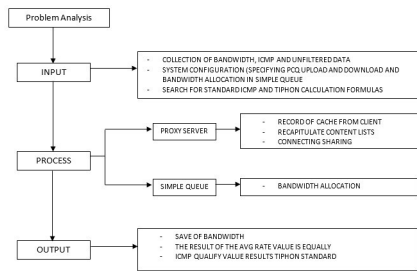


Figure 2: Research Flow Chart.

In Figure 2. There is a research flow chart which is an illustration of the research carried out along with an explanation of the research flow chart. The inter-relationships of problem analysis, inputs, processes, and outputs lie at the time of the process Optimizing proxy server and simple queue methods. In the input process, unfiltered data collection is carried out, and configures the system using the Per Connection Queue (PCQ) algorithm which determines pcq upload and download and allocates bandwidth in a simple queue. In the process of research flowchart, the proxy server functions as a connection sharing, recording the cache of the client and recapitulating the list of content to be created.

The output results will be proven using the avg rate parameter as well as using the Internet Control Message Protocol (ICMP) packet parameters throughput, delay, jitter, and packet loss. Provides effective bandwidth management improvements by meeting TIPHON value standards and saving available bandwidth on the UISU Faculty of Medicine campus.

The process in this study was carried out by building an external proxy server based on a virtual machine using the Debian operating system and Mikrotik routers as a Quality of Service (QoS) using the PCQ algorithm which is in apply it to a simple queue. The topology used in this study is presented in Figure 3.

Bandwidth Management is a method used to manage and optimize various types of QoS (Quality of Service) to determine various types of existing net-

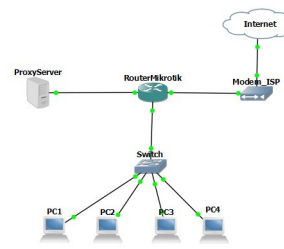


Figure 3: Topology.

work traffic. The proxy server is connection sharing and caches the client. There is also a proxy caching that will be done, namely, the browsing client computer will be processed to the proxy to retrieve the related site that has been saved if the related site is not in the proxy then it will be in the process of directly fetching from the web server page, if the related site is already on the proxy server then it can be directly retrieved and then finished. As presented in Figure 4.

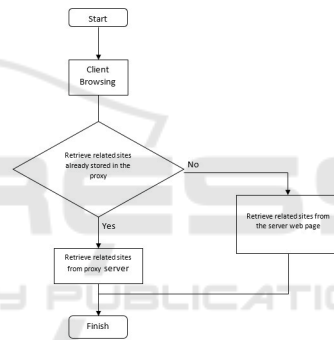


Figure 4: Flowchart Caching Proxy.

The analysis in this study was carried out based on the following TX / RX speed test data and avg rate values from Mikrotik OS in the queue, Traffic type data and the most frequently accessed by clients, Data results from Internet Control Message Protocol such as throughput, delay, jitter, and packet loss. The analysis was performed using the Wireshark application based on the standard formula of the ICMP packet itself. The formula is as follows:

- Throughput

$$Throughput = \frac{Packet\ data\ sent}{Data\ delivery\ time} \times 8 \quad (1)$$

- Delay

$$Average\ delay = \frac{Total\ Delay}{Total\ packets\ received} \quad (2)$$

- Jitter

Judging from the variation in the time delay in the

Command Line Interface where the delay value from time 1 to the following time is stable.

- Packet Loss

$$Packet\ loss = (Dataset - Datareceived) \times 100\% \quad (3)$$

- Efficiency and Time Difference

The analysis in this study was carried out based on the following TX / RX speed test data and avg rate values from Mikrotik OS in the queue, Traffic type data and the most frequently accessed by clients, Data results from Internet Control Message Protocol:

$$Ef = \frac{(Before\ cache - After\ cache)}{Before\ cache} \times 100\%$$

$$Difference = (Before\ cache - After\ cache) \quad (4)$$

## 4 SIMULATION AND RESULTS

### 4.1 Proxy Server Configuration

This research was conducted by building a virtual machine-based proxy server by implementing the squid3 application and the Debian operating system with a memory capacity of 4 GB as a connection sharing and storing cache from the client. The proxy cache configuration is presented in Figure 5.



Figure 5: Configuring a Proxy Server with Squid3.

### 4.2 PCQ Configuration

Meanwhile, bandwidth management is carried out using a Mikrotik router using the PCQ algorithm. Bandwidth allocation is accomplished by using a Queue List. In the Queue List we select the simple queue tab, then click + (Add) Before starting to limit internet bandwidth with Mikrotik, first make sure how much Internet bandwidth you get from the ISP you are using. So that later the Bandwidth value that is limited does not exceed the Bandwidth allocation from the ISP, and provides limitations to other users in accordance with the Target-Address as happened in Figure 6.

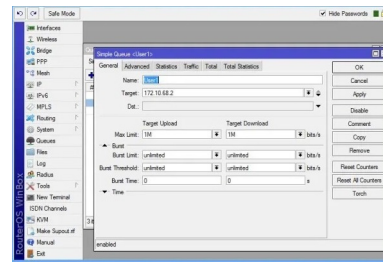


Figure 6: Target queue list.

### 4.3 Analyze with Wireshark

After configuring the proxy server and bandwidth management, an analysis is then carried out using the Wireshark application to monitor data communication that can be seen from sources and destinations that always exchange places with the protocol used as shown in Figure 7.

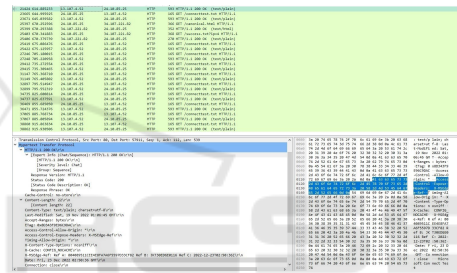


Figure 7: Analyze with Wireshark.

Testing and analysis were performed using QoS Throughput parameters, QoS Packet Loss Parameters, QoS Delay Parameters, and QoS Jitter Parameters. In the Troughtput QoS Parameter, testing was carried out by accessing the youtube page where the result of the Number of Bytes: Time Span was 247.75429851888 b, then multiplied by the Bytes Result where 8 is the Byte count, and resulting in 1982k which is well categorized in the Tiphon formula. The QoS Throughput catch is presented in Figure 8.

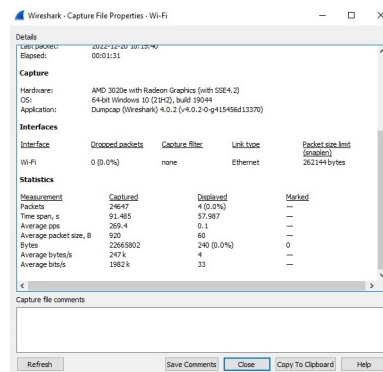


Figure 8: Capture File Throughput.



The next analysis is carried out based on the QoS Packet Loss Parameter. A parameter used to describe a situation that represents the total number of packet losses that may occur due to collision and congestion in the network of packet loss on 4 packet loss.

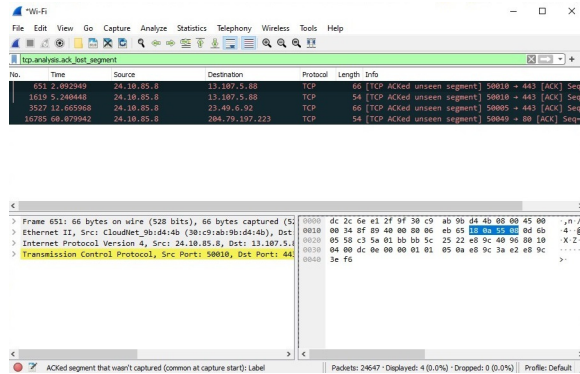


Figure 9: Capture Packet Loss.

Based on the analysis carried out through the results in Figure 9, it is stated:

Packet loss :

$$\begin{aligned} & \text{Packet sent} - \text{Packet received} : \text{Packet sent} * 100 \\ & = (24647 - 24644) : 24647 * 100 \\ & = (3 : 24644) * 100 \\ & = 4 (0.0\%) \end{aligned}$$

In analyzing packet loss from the test results using Youtube states where the number of packets sent – packets received divided by packets sent times 100 and based on the test results (0.0formula). The analysis was carried out using a sample of 23 of 2501 total delays based on the capture of network traffic that was carried out so as to find the total delay to determine the total jitter of the delay obtained. The delay analysis obtained is presented in Table 5.

Table 5: Total QoS Delay.

No	Time	...	Delay	...	Delay2
1	0	...	0.000393	...	-0.00564
2	0.000393	...	0.003677	...	0.009011
3	0.00407	...	0.009315	...	-0.00112
4	0.013385	...	0.000304	...	-0.00417
...	...	...	...	...	...
23	0.076403	...	0.00521	...	0.006815

In Table 5, time1-time2 will produce a delay of 1, from a delay of 1 minus a delay of 2, from a total delay of 2501 delays resulting in a total delay of 15.925747 with an average delay of 0.0063.

The next analysis is carried out based on Jitter parameters by looking at the change in delay or the dif-

ference between the first delay and the subsequent delay. If the transmission delay changes too much, it will affect the quality of the transmitted data. Jitter is a data packet delay known as QoS which is very important, especially for real-time applications. The result of QoS with jitter parameters is presented in Table 6.

Table 6: QoS Jitter.

No	Time	...	Delay	...	Jitter
1	0	...	0.000393	...	0.002354
2	0.000393	...	0.003677	...	-0.01465
3	0.00407	...	0.009315	...	0.010127
4	0.013385	...	0.000304	...	0.003057
...	...	...	...	...	...
23	0.076403	...	0.00521	...	-0.00864

Based on the calculations presented in Table 6. obtained delay1-delay2 will produce a jitter, from the overall delay of the total capture file of 2501 delay produces a total jitter of -0.00328 with an average jitter of -0.00021. Furthermore, the test was carried out based on the time parameter before using the cache and after using the squid cache by accessing the youtube page. Based on the analysis done to access the youtube page before using the proxy cache resulted in a time of 65.352 seconds. Meanwhile, after using the proxy cache, the time forged was 30,310, resulting in a time difference of 35,042 seconds. The test was carried out by accessing 3 pages, namely youtube, dikti, and Facebook. Results based on efficiency and difference are presented in Table 7.

Table 7: Response Time Comparison Results.

URL	Before Cache	After Cache	Difference	Efficiency
Dikti	91.485	40.245	51.240	56.01%
Youtube	65.352	30.310	35.042	53.62%
Facebook	14.440	5.134	9.306	64.44%

Based on Table 7. above there is a difference between URLs that are before being cached and after being cached, the difference is said to show efficiency numbers, efficiency numbers show 58.02% response time by an average of 58.02%.

## 5 CONCLUSIONS

Based on the results of the analysis carried out, it can be seen that the proxy server has run according to the wishes that the author expects and can access the internet, the client of this proxy server can also access

the internet. For website blocks that have been determined by the author, the proxy server can block websites with the HTTP protocol, while for websites that use the HTTPS protocol, proxies cannot block it except all websites that use the HTTPS protocol are also blocked. So in this study, the author only blocked websites with the HTTP protocol, in this article, the web was blocked <http://www.youtube.com>. Virtual machines can be applied in building proxy servers and are able to work optimally.

From the research, the test results using Wireshark were obtained with the density experienced when searching so that the value determined based on the rules using the packet loss value according to the version TIPHON is divided into the four parts QOS Throughput parameters of 1982k, Packet loss of 0.0 with an average of 0.0063 and total jitter of -0.00328 with an average jitter of -0.00021. Testing response time against sites using a squid proxy server as a metadata cache can provide better response time results than without using a proxy server with a virtual machine.

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