JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

Analysis of Bandwidth Management Using Hierarchical Token Bucket and Layer 7 Methods

Ahmad Syofian [1)*], Sumarlin[2)], Meiliyani Br Ginting [3)]
[1)2)3)]Institut Teknologi dan Bisnis Indonesia, Kab. Deli Serdang, Sumatera Utara, Indonesia
[1)]1ahmadsyofian22601@email.com, [2)]netcommmandiri@gmail.com, [3)]meiliyani.ginting@gmail.com

Submitted: 5 November 2025 | **Accepted**: 21 November 2025 | **Published**: 30 November 2025

Abstract: For bandwidth regulation on the internet network at PABAKU Stabat Private Vocational Schools, it is carried out by managing bandwidth using the Hierarchical Token Bucket method. Hierarchical Token Bucket is a method that is created hierarchically and divided into several classes or levels consisting of parent and child, so that it can optimize bandwidth by limiting download and upload ratings for clients, and can determine the priority of bandwidth sharing on clients. Bandwidth management will also affect QoS (Quality of Service) to ensure quality of service in the network. Layer 7 Protocol on Mikrotik routers is a very good firewall in limiting internet access, which is done by adding a regexp to block sites such as social media sites (Facebook, Instagram, TikTok, Youtube, Detik) and other sites that are inefficient during the learning process in the computer laboratory, because they interfere with students' concentration on learning.

Keywords: Bandwidth Management, Hierarchical Token Bucket Method, Layer 7 Protocol, Firewall, Mikrotik.

INTRODUCTION

SMK Pabaku Stabat is a vocational high school with 250 students and 20 faculty and staff. The school's internet access is limited to 40 Mbps. With such a large number of users, bandwidth overuse often occurs, resulting in slow or disconnected internet connections, especially during peak hours.

Therefore, this study aims to design and implement an efficient bandwidth management system using the Hierarchical Token Bucket (HTB) method on the school's Mikrotik router. With the HTB method, bandwidth can be hierarchically divided and prioritized according to the school's needs, such as prioritizing data traffic for teaching and learning activities, followed by administrative activities, and then internet access for students. Furthermore, this study will implement internet access restrictions using the Layer 7 Protocol feature on the Mikrotik router. This feature allows the school to restrict or block access to certain websites or applications deemed inappropriate for students during class hours. By implementing bandwidth management using the Hierarchical Token Bucket method and limiting internet access using the Layer 7 Protocol, SMK Pabaku Stabat is expected to utilize limited bandwidth resources more efficiently and create a more conducive learning environment for students by limiting access to irrelevant websites or applications during class hours.

A study titled "Design and Implementation of Bandwidth Management Using the Hierarchical Token Bucket Method and Limiting Internet Access Using the Layer 7 Protocol on a Mikrotik Router at SMP Negeri 1 Balige" explains that the Hierarchical Token Bucket method successfully manages bandwidth equitably in each room. Bandwidth sharing across LANs and WLANs allows for stable internet access. Restricting internet access using the Layer 7 Protocol successfully blocks social media sites using Regexp and network addresses, preventing students from accessing them during computer lab lessons(Rahmat et al., 2023).

A study titled "Bandwidth Management Using Hierarchical Token Bucket (HTB) (Case Study: PT. Orion Cyber Internet)" explains that research shows that the implementation of the Hierarchical Token Bucket (HTB) for bandwidth management works well at PT. Orion Cyber Internet. HTB has better download, upload, and QoS performance than simple queues. Future research could involve more users and other bandwidth management methods for more accurate and varied results(Simarmata & Widiasari, 2023).

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

The reserch, entitled "Utilizing Layer 7 Protocol Features for Website Filtering and Bandwidth Management," explains that the Layer 7 Protocol successfully implemented website filtering and bandwidth management, thus assisting the Palembang Class 1 Radio Frequency Spectrum Monitoring Center in providing recommendations for improving internet access. Test results showed that website filtering using a Layer 7 protocol firewall successfully blocked negative or illegal content, such as the film Layer 99. For bandwidth management, testing using a combination of Layer 7 protocol and queue tree successfully limited social media, video streaming, and file downloads(Kurniawan & Panjaitan, 2023).

Based on the problems that exist in previous studies, the author in this case wants to create a system that works automatically as a whole, by connecting the system to Android to make it easier to serve coffee drinks to the public, so based on this background the author raised the research title, namely "Analysis and Design of Bandwidth Management with the Hierarchical Token Bucket (HTB) Method and Limitation of Internet Access Using Layer 7 Protocol on Mikrotik Routers at SMK PABAKU Stabat".

LITERATURE REVIEW

Design is the primary foundation for creating a system, with the goal of providing a clear, complete picture of what will be created. Design is a series of procedures for translating the results of a system analysis into a detailed description of how the system's components are implemented (Widiyaningrum, 2020).

Analysis is an activity to find a pattern. Analysis is also a way of thinking related to the systematic examination of something to determine its parts, the relationships between them, and their relationship to the whole (Sari et al., 2021).Bandwidth is the amount of internet capacity at the highest data transfer rate between a server and a client, measured in bits per second (bps). A bit, or binary number, is a base consisting of the digits 0 and 1, and this unit describes how many bits can flow from one location to another per second (Daulay, 2020).

Bandwidth is also a measure of the amount of information that can flow from one location to another in a given time span. Digital and analog data flows can be measured using bandwidth (Ichwan et al., 2019). Hierarchical Token Bucket (HTB) is a method for grouping queues and managing traffic types. The implementation of Quality of Service (QoS) on MikroTik routers relies heavily on the Hierarchical Token Bucket (HTB) queuing system (Putra et al., 2020).

The function of HTB is to generate a hierarchical queue structure and manage relationships between hierarchical classes. HTB consists of three types of classes: root, inner, and leaf. The root class is the top-level class through which all outgoing traffic passes, the inner class distributes bandwidth to its child classes, and the leaf class controls traffic queues directly (Simarmata & Widiasari, 2023).

Layer 7 Protocol is a feature on MikroTik routers used to detect patterns in data packets transmitted via ICMP, TCP, and UDP. This feature allows the use of regular expressions (regexp) to filter traffic at the application layer (Kurniawan & Panjaitan, 2023).

Layer 7 Protocol operates at the application layer and functions as an interface between applications and network services. It regulates application access to the network and processes protocol data such as HTTP, FTP, SMTP, and NFS. The Layer 7 matcher examines the first packets of a connection to identify traffic patterns (Shomad et al., 2022).

MikroTik is an operating system specifically designed for network routers and can transform a standard computer into a powerful routing device (Pratomo, 2023). MikroTik is widely used due to its ease of use and suitability for both small-scale and complex network administration (Rahmat et al., 2023).

A computer network is a collection of interconnected computers that communicate and exchange data to share resources and services (Widiyaningrum, 2020). Computer networks are used not only for organizational needs but also for personal activities such as internet banking and social media access (Jayanti et al., 2020).

METHOD

1. Research Stage.

In collecting data, information, and designing the program needed for this thesis, the author used several methods, namely:

1. Observation (Observation Research)
   Observation methods can be used to collect data on how students and school staff use the internet, the types of applications they use, the duration of use, and other internet usage patterns. In addition, researchers will also pay attention to the quality of network services, such as internet speed, latency, and connection stability.
2. Literature Research

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

The literature study method is used to gather information and knowledge from existing scientific literature related to the Hierarchical Token Bucket (HTB) method, bandwidth management, Layer 7 protocols, and internet access limitations. The author will review previous research, articles, books, and other theoretical sources to understand the theoretical basis and concepts relevant to the research topic.

3. Design Method
   The design method chosen for this research involves a structured and detailed approach to designing a bandwidth management and internet access limitation system at SMK PABAKU Stabat. A comprehensive analysis was conducted to understand the school's specific needs for managing internet usage. This included a thorough understanding of how the network is used by students and staff, the types of applications most frequently used, and daily internet usage patterns.

2. **Design Tools**

The tools used to build this system are as follows:

1. Crimping Tool
   Crimping is the process of converting the cable you've installed into a network transmission medium. Without the crimping process, the cable is simply a non-functional cable. There are no connectors to connect the network to the device used to install the internet, such as a switch, access point, or other device.
2. UTP Cable
   UTP cable is a type of cable consisting of pairs of insulated copper wires woven together to transmit digital or analog signals. The word "Unshielded" in UTP means this type of network cable lacks the aluminum shielding of other types of twisted pair cables.
3. RJ-45 Connector
   The RJ-45 connector is a type of connector used to connect Ethernet cables in LANs (Local Area Networks) and other network topologies.
4. MikroTik Router
   MikroTik is an operating system used to turn a computer into a network router. With this software, you can manage your network without special equipment.
5. Access Point
   An access point is a computer networking hardware device that connects wireless devices to a local network using technologies such as Wi-Fi, Bluetooth, wireless, and so on.
6. UTP Tester
   A UTP tester is a tool used to inspect and identify the condition of a computer network. This tool can help identify network connection problems, such as damaged cables, loose connectors, or other issues.

3. **Research Design**

The research design is illustrated in the form of a flowchart, as shown in the figure below:1. Microcontroller-Based Automation

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

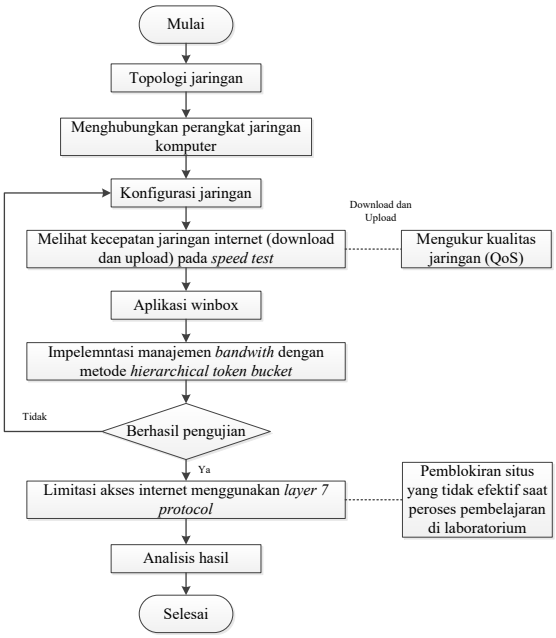


Figure 1. System flowchart

4. System Design

1. Network Topology

The network topology of the current system and the network topology of the system to be built in this system implementation are shown in Figures 2 and 3.

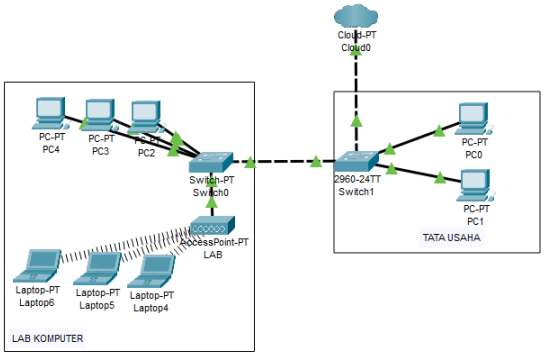


Figure 2. Network Topology of the Current System

This network topology design consists of several main interconnected components: access from the ISP (Internet Service Provider), router, switch, access point, client computer, and client laptop. Internet access is obtained from the ISP (Internet Service Provider). The access point, which uses a WLAN network connection, is a device used to connect the network to the computer/laptop device so that the device can connect to the internet.

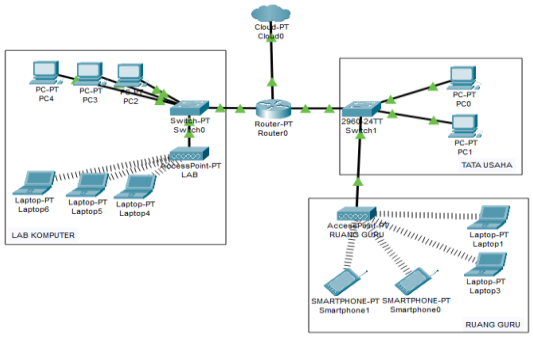


Figure 3. Network Topology of the System to be Built

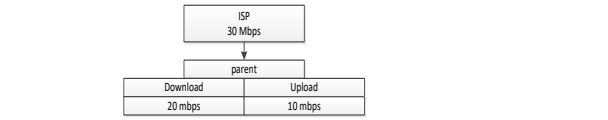
JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

The network topology above is divided into several different rooms. One is the "COMPUTER LAB" room, which consists of several desktop computers and laptops connected to a switch. The other rooms visible are the "ADMINISTRATION" room, which has two connected computers, and the "TEACHER'S ROOM," which has a laptop and smartphone connected wirelessly.

Connectivity in this network uses two methods: wired and wireless. Wired connections are indicated by green lines connecting devices to the switch and router. Meanwhile, wireless connections are represented by wavy white lines connecting laptops and smartphones to the network.

2. Bandwidth Limitation Scenario Using the Hierarchical Token Bucket Method

The bandwidth classification or limitation uses the hierarchical token bucket method to be distributed among users in three rooms: the computer lab, the teacher's room, and the administration room, as can be seen in the image:



Nama ruangan	Child		User / komputer	Jenis jaringan
	Download	Upload		
Laboratorium Komputer	Max-limit : 10 mbps Limit-at : 5 mbps Priority : 10	Max-limit : 5 mbps Limit-at : 3 mbps Priority : 10	10 unit komputer	LAN Menggunakan kabel
Ruang Guru	Max-limit : 15 mbps Limit-at : 10 mbps Priority : 10	Max-limit : 5 mbps Limit-at : 3 mbps Priority : 10	10 user	Wireless
Ruang Tata Usaha	Max-limit : 5 mbps Limit-at : 3 mbps Priority : 5	Max-limit : 5 mbps Limit-at : 3 mbps Priority : 5	2 Unit Komputer	LAN Menggunakan kabel

Figure 4. Bandwidth Limitation Scenario

3. Internet Access Limitation Scenario Using Layer 7 Protocol

To implement the Layer 7 protocol, it is necessary to define scenarios for site names and regular expressions (regexp) that are useful for detecting sites to be blocked. The scenarios for site names and regular expressions can be seen in the table:

Table 1
Internet Access Limitation Scenario

No	Nama Situs	Regexp
1	facebook	^.+(facebook.com).*$
2	instagram	^.+(instagram.com).*$
3	TikTok	^.+(TikTok.com).*$

RESULT

1. Analysis of the Existing System

According to an analysis of the bandwidth management system and internet access limitations, SMK Pabaku Stabat only has a simple network infrastructure connecting computers in the computer lab and administration room to the internet. There is no well-organized network management system. Available internet bandwidth is allocated flat, without any specific division or prioritization. All devices and users have equal access to the available bandwidth.

All users, both students and teachers, have unlimited access to the internet. They can access all types of websites and download various types of content without restrictions or filters. Without a bandwidth management system and access limitations, SMK Pabaku Stabat may face several problems. One of these is slow internet when many users access the internet simultaneously due to uncontrolled bandwidth. Furthermore, bandwidth may be wasted on unproductive activities, such as streaming videos or downloading large files unrelated to education.

2. Bandwidth Management Using the Hierarchical Token Bucket Method

Hierarchical Token Bucket is a hierarchical or tiered bandwidth management method that creates parent and child tiers and prioritizes users so that users receive bandwidth according to predetermined bandwidth allocations. The following are the steps for configuring Bandwidth Management using the Hierarchical Token Bucket Method.

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

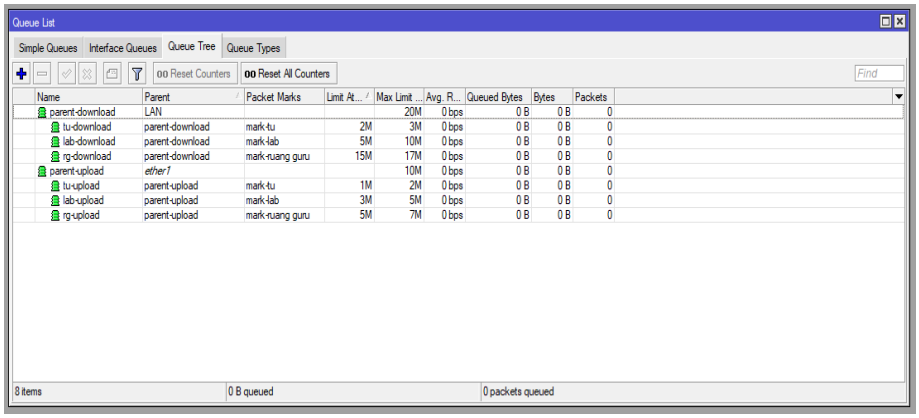


Figure 4. Bandwidth management using the HTB method

3. Layer 7 Protocol Implementation

Layer 7 Protocol is used to limit internet access, such as blocking websites. In this process, the author will block social media sites like Instagram, Facebook, and TikTok. This site blocking will be implemented on student computers in the computer lab before the learning process begins. The following is the configuration result for implementing the Layer 7 Protocol, which can be seen.

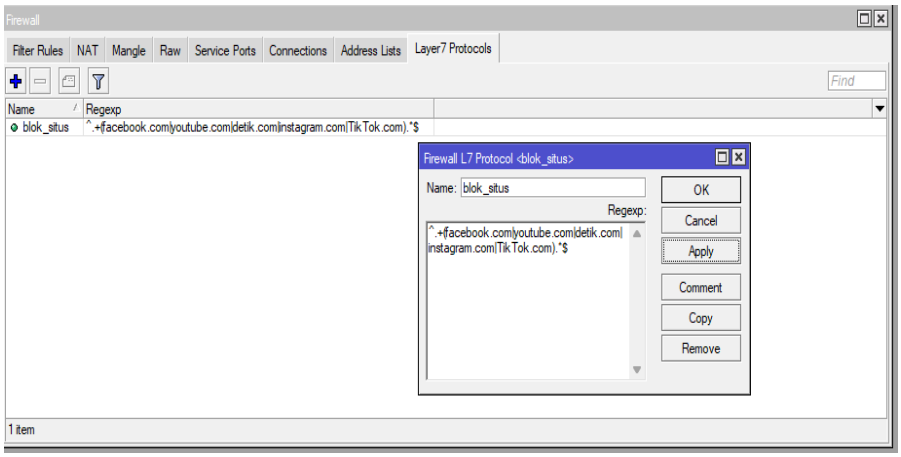


Figure 5. Layer 7 Protocol Implementation

4. System Testing

a. Testing before using the hierarchical token bucket method.

The results of the download and upload speed tests of the network that was created can be seen in the image below.

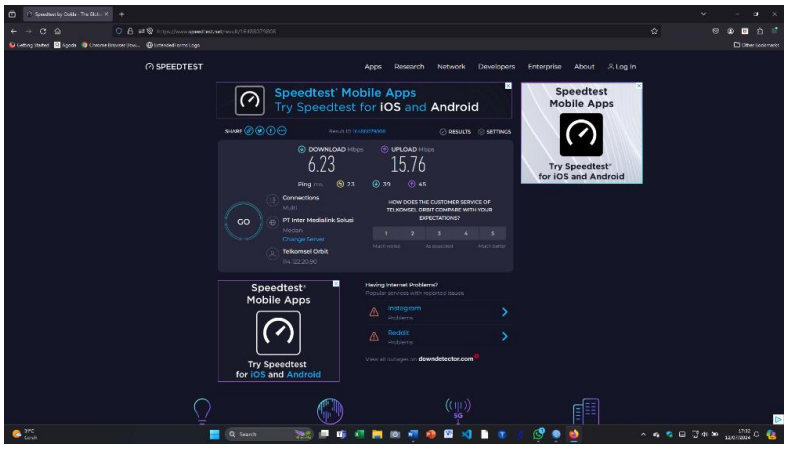


Figure 6. Testing before using the HTB method

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

In the image above, the download speed was recorded at 6.23 Mbps, while the upload speed was recorded at 15.76 Mbps. This download speed indicates how quickly data can be downloaded from the internet to your device. With this speed, you can perform various online activities such as streaming video, downloading files, or browsing the web quite smoothly. Although activities requiring high bandwidth, such as streaming 4K video or downloading large files, may experience some slowdowns.

b. Testing after using the Hierarchical Token Bucket method.
After using the hierarchical token bucket method, the network speed changed to 5.06 Mbps for download and 6.72 Mbps for upload.

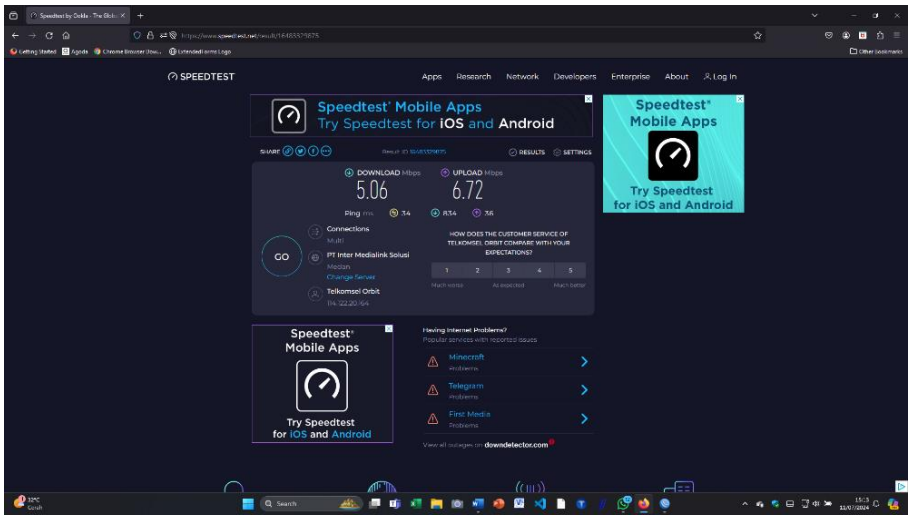


Figure 7. Testing after using the HTB method

Before implementing HTB, there was a significant difference in download and upload speeds. However, after implementing HTB, there was a better balance between download and upload speeds. Download speeds were recorded at 5.06 Mbps, while upload speeds reached 6.72 Mbps. HTB works by prioritizing and limiting data rates for different types of network traffic. This method allows for more structured and fair bandwidth management. In this case, HTB appears to have optimized bandwidth usage by distributing network resources more evenly between download and upload traffic.

c.of internet access limitation testing using Layer 7 protocols
The image below shows an internet access limitation where YouTube has been successfully blocked from the internet network.

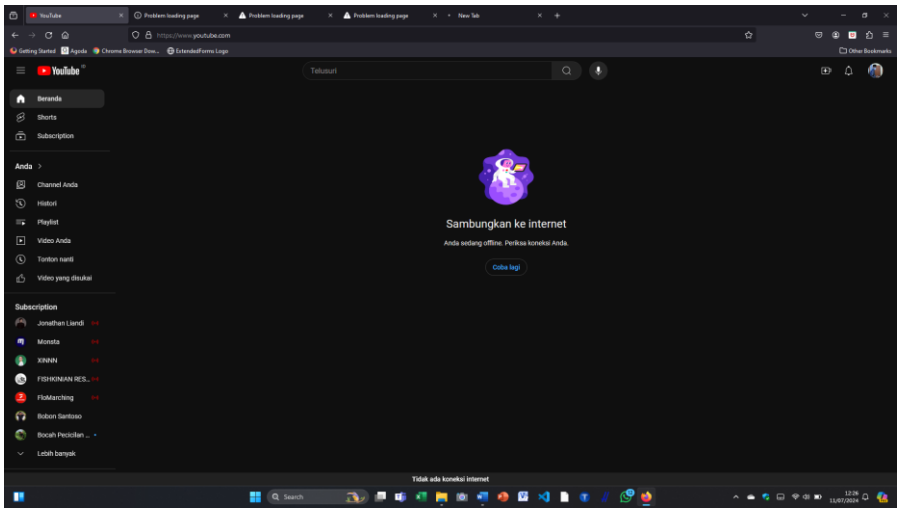


Figure 8. Internet access limitation testing

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025
Page: 32-40
ISSN 3089-106X
(online)

The image above shows a situation where access to YouTube has been blocked using the Layer 7 protocol blocking method. This blocking is a sophisticated technique that targets specific applications or services at the application level of the OSI model.

DISCUSSIONS

To address these limitations, a new system was designed using a more sophisticated and structured approach. The implementation of the Hierarchical Token Bucket (HTB) method on MikroTik routers forms the core of the bandwidth management solution. HTB enables more flexible and efficient bandwidth allocation, ensuring a fair distribution of network resources tailored to the needs of various users within the school. This method allows for data traffic prioritization, ensuring that applications and services critical to education are allocated adequate bandwidth. In addition to bandwidth management, the new system also implements the Layer 7 Protocol for internet access limitation. This approach allows for more granular control over internet traffic, allowing schools to restrict access to specific sites or services deemed unproductive or inappropriate for an educational environment. The Layer 7 Protocol implementation involves pattern matching to identify and control access to specific applications or websites, such as social media or video streaming platforms, that are unrelated to education.

The system design involves structured bandwidth allocation across various areas of the school, including the computer lab, the teachers' lounge, and the administration room. Each of these areas is allocated bandwidth according to its needs and priorities. For example, a computer lab might receive a larger portion of bandwidth to support technology-based learning activities, while an administration room might receive a smaller but stable allocation for administrative tasks.

The implementation of this system is supported by the use of a MikroTik router as the primary platform. MikroTik was chosen for its ability to handle complex network management and its flexibility in accommodating various configurations. The MikroTik configuration process encompasses various aspects, from interface settings, security profiles, WLAN, IP addresses, DHCP clients and servers, to firewall, queue, and hotspot configurations.

The internet access limitation scenario is designed with educational needs and school policies in mind. Several websites and applications deemed unproductive or potentially disruptive to the learning process, such as Facebook, Instagram, TikTok, YouTube, and news sites like Detik, are restricted using the Layer 7 Protocol. However, this system also allows flexibility in restrictions, for example, by allowing limited access at certain times or for specific users who require it for educational purposes.

CONCLUSION

The research conclusions may highlight the effectiveness of combining these two methods in optimizing school bandwidth usage and controlling student and staff internet access. The use of HTB likely allows for more efficient and equitable bandwidth allocation among network users, while throttling using Layer 7 Protocol provides more granular control over the types of internet traffic permitted or restricted. The study may also conclude that there is an improvement in overall network performance, a reduction in internet access abuse, and a potential increase in student and staff productivity following the implementation of this system. Conclusions may include recommendations for implementing similar systems in other educational institutions or suggestions for further development to improve network management in educational settings.

REFERENCES

Al Kautsar, D., & Nulhakim, L. (2020). Pengelolaan management bandwidth dengan menggunakan metode simple queue di Toko Subur Graphic Jakarta Pusat. Jurnal Teknik Informatika STMIK Antar Bangsa, 2(1).

Daulay, O. L. (2020). Analisis quality of services (QoS) pada manajemen bandwidth menggunakan metode hierarchical token bucket (HTB) pada sistem jaringan. JISTech (Journal of Islamic Science and Technology), 5(2).

Husnaini, M., Bagye, W., & Ashari, M. (2019). Implementasi fitur Layer 7 protocols Mikrotik RB750 di SMKN 1 Narmada. Jurnal Informatika dan Rekayasa Elektronik, 2(1). https://doi.org/10.36595/jire.v2i1.94

Ichwan, M. I., Sugiyanta, L., & Yunanto, P. W. (2019). Analisis manajemen bandwidth hierarchical token bucket (HTB) dengan Mikrotik pada jaringan SMK Negeri 22. PINTER: Jurnal Pendidikan Teknik Informatika dan Komputer, 3(2). https://doi.org/10.21009/pinter.3.2.6

JCEIT: Journal of Computer Engineering and Information Technology
Volume 2, Number 1, November 2025 ISSN 3089-106X
Page: 32-40 (online)

Jayanti, R., Rachman, S., & Irfan, L. A. S. (2020). Management bandwidth dan analisis QoS menggunakan metode hierarchical token bucket (HTB) pada topologi star. Repository Universitas Mataram.

Kurniawan, B., & Panjaitan, F. (2023). Pemanfaatan fitur Layer 7 protocol untuk filter website dan manajemen bandwidth. Jurnal Jupiter, 15(1).

Pratomo, A. B. (2023). Pengembangan sistem firewall pada jaringan komputer berbasis Mikrotik RouterOS. Bulletin of Network Engineer and Informatics, 1(2). https://doi.org/10.59688/bufnets.v1i2.10

Putra, K. G. W. P., Santyadiputra, G. S., & Kesiman, M. W. A. (2020). Penerapan manajemen bandwidth menggunakan metode hierarchical token bucket pada layanan hotspot Mikrotik Undiksha. CESS (Journal of Computer Engineering, System and Science), 5(1). https://doi.org/10.24114/cess.v5i1.14959

Rahmat, E., Hulu, J., Naibaho, J. F., & Purba, M. J. (2023). Perancangan dan implementasi manajemen bandwidth dengan metode hierarchical token bucket dan limitasi akses internet menggunakan Layer 7 protocol pada router Mikrotik di SMP Negeri 1 Balige. Methotika. https://ejurnal.methodist.ac.id/index.php/methotika

Sari, I. P., Siska, S. T., & Budiman, A. (2021). Perancangan aplikasi pelayanan gangguan TV kabel berbasis web dan SMS gateway. Jurnal Pusat Akses Kajian Teknologi Artificial Intelligence, 1(1).

Shomad, A., Akbar, Y., & Mulyana, D. I. (2022). Implementasi pembatasan akses sosial media menggunakan Layer 7 protocol pada perangkat Mikrotik di SMK IDN. Informatics for Educators and Professional: Journal of Informatics, 7(1). https://doi.org/10.51211/itbi.v7i1.1998

Simarmata, H. S., & Widiasari, I. R. (2023). Manajemen bandwidth menggunakan hierarchical token bucket (HTB) (Studi kasus: PT Orion Cyber Internet). Technomedia Journal, 8(2SP). https://doi.org/10.33050/tmj.v8i2sp.2078

Syahputri, C. N., Anggraini, C., Anugerah, H. F., Zufria, I., & Nahwi, M. I. (2023). Penerapan kinerja filter rule dengan metode raw dan Layer 7 protocol di router Mikrotik. Jurnal Kridatama Sains dan Teknologi, 5(2). https://doi.org/10.53863/kst.v5i02.969

Widiyaningrum, I. (2020). Rancangan sistem jaringan LAN (local area network) di satuan kerja staf operasi Mabesau. Jurnal Online Mahasiswa Sistem Informasi dan Manajemen Informatika, 2.