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Article

Bandwidth Management Using the Hierarchical Token Bucket Method to Enhance Server Network Performance

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Abstract: Villa Nomada, as an accommodation in Kuta, Central Lombok, is experiencing internet network instability due to uneven and uncontrolled bandwidth distribution, which disrupts user comfort, especially for foreign guests who require an optimal connection. The solution implemented is bandwidth management using the Hierarchical Token Bucket (HTB) method to allocate bandwidth fairly and efficiently. This research contributes to improving quality of service (QoS) by optimizing network performance through HTB. The method used is HTB configuration to allocate bandwidth based on user categories (VIP, Regular, and Office). Network performance was evaluated before and after implementation to measure improvements in speed and stability. The research results showed that HTB successfully distributed bandwidth evenly, with VIP users receiving priority, while regular and office users obtained stable connections without interruptions. Network efficiency improved, reducing congestion and increasing user satisfaction. We rated the HTB method as "Good" for optimizing network performance. In conclusion, the implementation of HTB successfully addressed the bandwidth management issues at Villa Nomada, ensuring fair distribution and optimal network performance for all users.

Keywords: Hierarchical Token Bucket; Quality of Service; Enhancing Server Network; Bandwidth Management; Packet Loss

1. Introduction

In this rapidly evolving digital era, stable and fast internet access is a crucial factor in maintaining network performance [1], [2], [3]. The internet, as an interconnected network, is a global computer network system that connects various devices [4], [5]. The high demand for access and communication requires the network to operate optimally, with sufficient bandwidth to provide quality and convenient services to users [6], [7], [8]. However, without proper management, bandwidth usage can become unbalanced, causing differences in access speeds between users, and even access failures. One effective solution to this problem is the implementation of bandwidth management [9], [10].

Villa Nomada, a guesthouse in Kuta, Central Lombok, needed a stable network to meet the needs of internet users, especially foreign guests accustomed to high-quality connections. The main issue they encountered was network instability due to uncontrolled bandwidth allocation, which disrupted the user experience. Previous research shows that the implementation of Hierarchical Token Bucket (HTB) can reduce delay and increase throughput on the network [11].

In addition, a comparative study between HTB and the PCQ method proves that HTB is superior in terms of throughput, delay, packet loss, and jitter [12], [13], [14]. Another analysis on the SMK Negeri 22 network also shows that HTB is able to reduce packet loss significantly [15]. This study aims to implement bandwidth management using the HTB method to optimize network performance at Villa Nomada. The contribution of this study is to improve Quality of Service (QoS) through fair and efficient bandwidth sharing. Some QoS parameters include Throughput (the amount of data that can be passed at one time), Packet loss (loss of data packets), Delay (Latency) or delay in data delivery, and Jitter (variation in data delivery delay [16], [17], [18]. With HTB, each user will get a bandwidth allocation according to their needs, thereby increasing the stability and speed of internet access [19].

2. Research Method

The implementation of bandwidth management as a means of optimizing server network performance has been explored through the application of the Network Development Life Cycle (NDLC) method, which provides a systematic framework for improving computer network infrastructure [20], [21]. In this context, the NDLC approach is integrated with the concept of Virtual Local Area Network (VLAN), enabling the segmentation of a Local Area Network (LAN) into multiple subnetworks. Such segmentation facilitates more effective control and management of network resources, thereby addressing performance constraints in an optimal manner. At Villa Nomada, this implementation is illustrated in Figure 1.

2.1. Analysis

Based on the data in the field according to the request from the Villa owner, there is 300 Mbps Broadband Business (Indibiz) which will be managed using the Hierarchical Token Bucket (HTB) method so that each user gets the speed they need and the point is to optimize server performance so that it provides optimal speed. assist in the planning process, needs analysis, design, prototype simulation, and network monitoring to ensure the success of network system development.

2.2. Design

At this stage, system design is carried out based on the analysis results. To present an overview of research needs, a system workflow design drawing will be created that has been obtained from the analysis results. At this stage, creating a network topology design using tools from UniFi or others to provide information before carrying out the next stage. The network devices used are Mikrotik RB-3011 2, TP-Link 16 Port Switch Type TL-SG1016D / 2, TP-Link 110 Indoor Celingmoon Access Point / 14 Access Point. There are three focal points here for bandwidth distribution, namely for VIP Guests, General Workers (Regular) and Office (Administration). At this stage the researcher will show the network topology in Figure 2.

3. Simulation prototyping

To evaluate the initial performance of the network on which bandwidth management will be built, a system workflow design drawing will be created that has been obtained from the analysis results to provide an overview of research needs, such as topology. The purpose of using this application is as a simulation so that testing can be carried out without using the hardware currently in use [10].

In Figure 3. it can be seen that on ether 1 on the mikrotik router is connected to the ISP (Internet Service Provider) which has an internet network of 300 Mbps Broadband Business and on Ether 2 is specifically for mikrotik configuration with IP Address 10.34.10.10/24 for ether 3 is specifically for the Villa Nomada hotspot with IP Address 10.10.1.1/24 and on ether 9 is specifically for Villa Susoro with IP 10.25.10.1/24, connected to the Switch as a connector to the client User using an Outdoor FTP cable, which is connected to the access point device via a Wireless network, the server computer acts as a configurator where the mikrotik router configuration will be carried out with Winbox as a supporting application, then on all client devices QoS testing will be carried out using Wireshark and Speed Test as supporting applications.

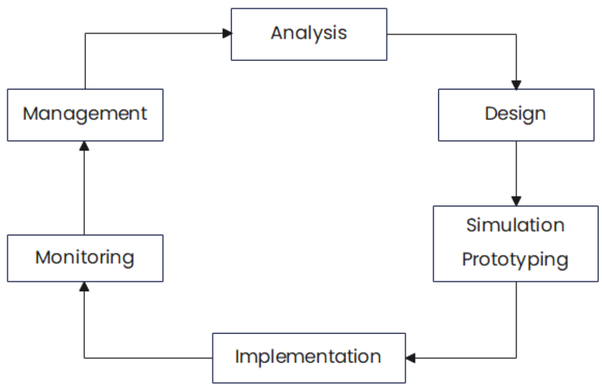


Figure 1. Research Flow.

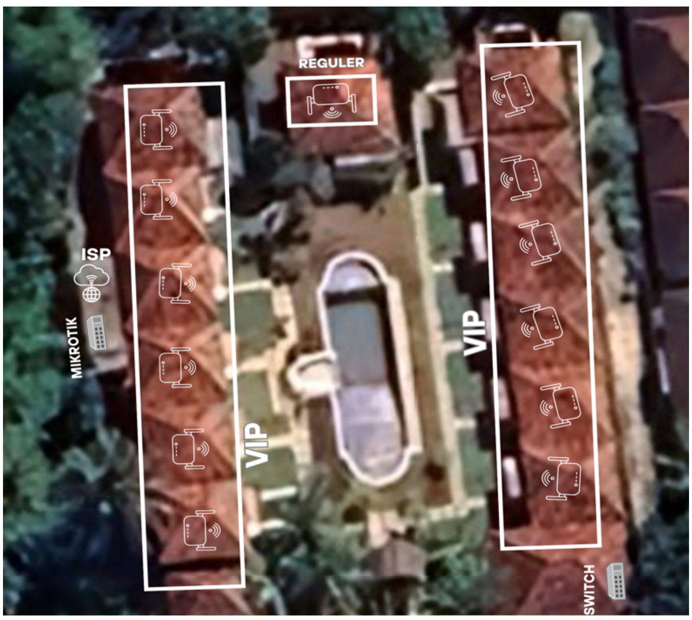


Figure 2. Design.

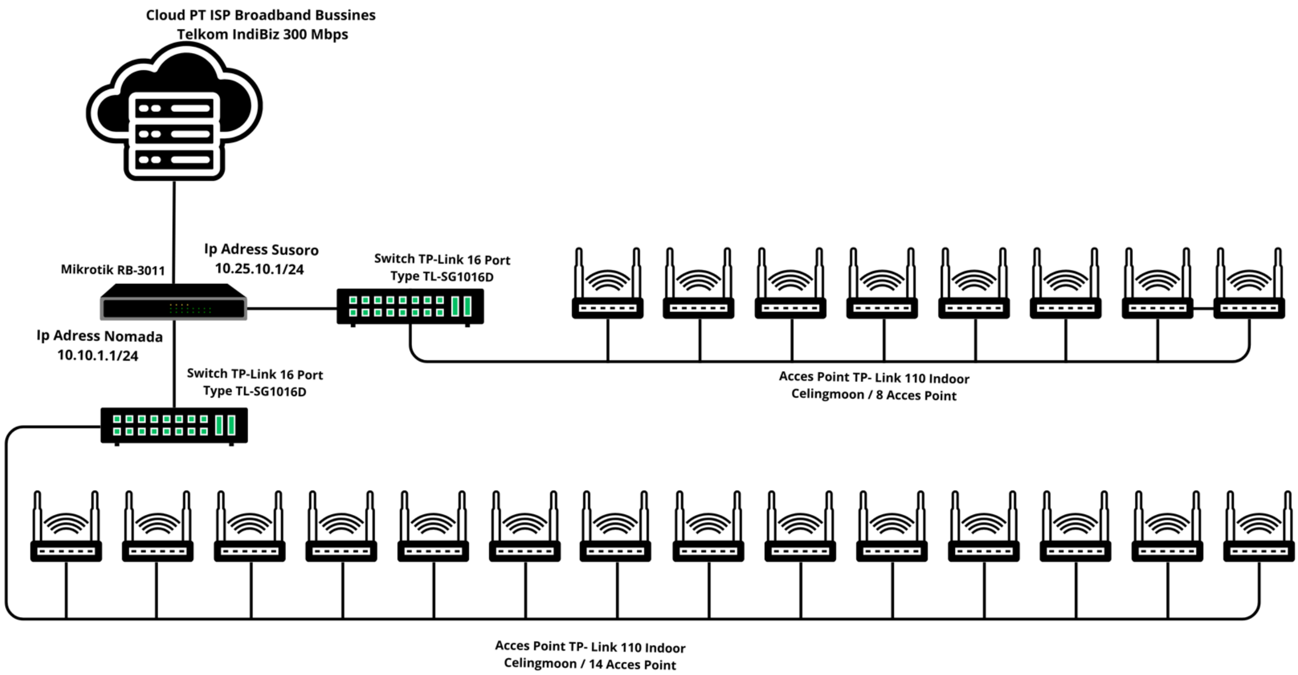


Figure 3. Simulation Prototyping.

Each client and network has a Class A IP address. The following is the IP addressing for each client and network: IP Address on ether 3 Villa Nomada IP 10.10.1.1/24 – IP 10.10.1.2/254 IP Address on ether 9 Villa Susoro IP 10.25.10.1/24 – IP 10.25.10.2/254.

3.1. Implementation

This implementation stage applies the Hierarchical Token Bucket (HTB) method to regulate bandwidth distribution hierarchically to maintain network stability, optimize bandwidth allocation, and meet the needs of internet users at Villa Nomada.

3.2. Monitoring

The monitoring stage is carried out by evaluating network performance using Wireshark for network specification analysis and speed tests to measure actual performance, to ensure that the applied method has achieved the expected results. monitoring the network that was built to see the success of the previous stage.

3.3. Management

The system management phase includes physical, BIOS, and software security to ensure optimal network operation in the future.

3.4. Result

In the final stage, namely making decisions based on the results obtained in the field based on the tests that have been carried out previously.

4. Results and Discussion

4.1. Management Implementation

The network configuration on the Mikrotik router is implemented by creating a bridge interface named Nomada, which connects the local devices within the LAN. This interface is assigned the IP address 10.10.1.1/24 with the network 10.10.1.0, serving as the local gateway. A DHCP Server is then enabled on the Nomada interface to automatically lease IP addresses to clients. The server is configured with a lease time of one hour and an address pool corresponding to the Nomada network. To allow local devices to access the Internet, a NAT (Network Address Translation) rule with the masquerade action is applied. This translates private IP addresses into a public IP address through the ether1 interface, which is connected to the WAN. As a result, all local clients appear to use a single public IP address when communicating with external networks. The overall configuration workflow is illustrated in Figure 4.

4.2. Setting Simple Queues

At this stage, the Simple Queues bandwidth management configuration is applied to Villa Nomada with the target network 10.10.10.0/24, where the allocated limit is 100 Mbps upload and 100 Mbps download. In addition, a Premium Villa queue is created for VIP guests, also within the same network, with 100 Mbps upload and 150 Mbps download, along with a 125 Mbps maximum limit.

To further optimize distribution, different user profiles are defined through the IP Hotspot configuration. Regular Nomada guests receive 30 Mbps with a 75 Mbps maximum limit and support up to 25 user logins. Staff Susoro are allocated 10 Mbps with a 15 Mbps maximum limit for up to 10 users, while Susoro staff receive 50 Mbps with a 100 Mbps maximum limit for 35 users. Premium Villas (Villa 1–4 Nomada) are assigned 50 Mbps with a 125 Mbps maximum limit for 8 user logins each, as shown in Figure 5a and 5b.

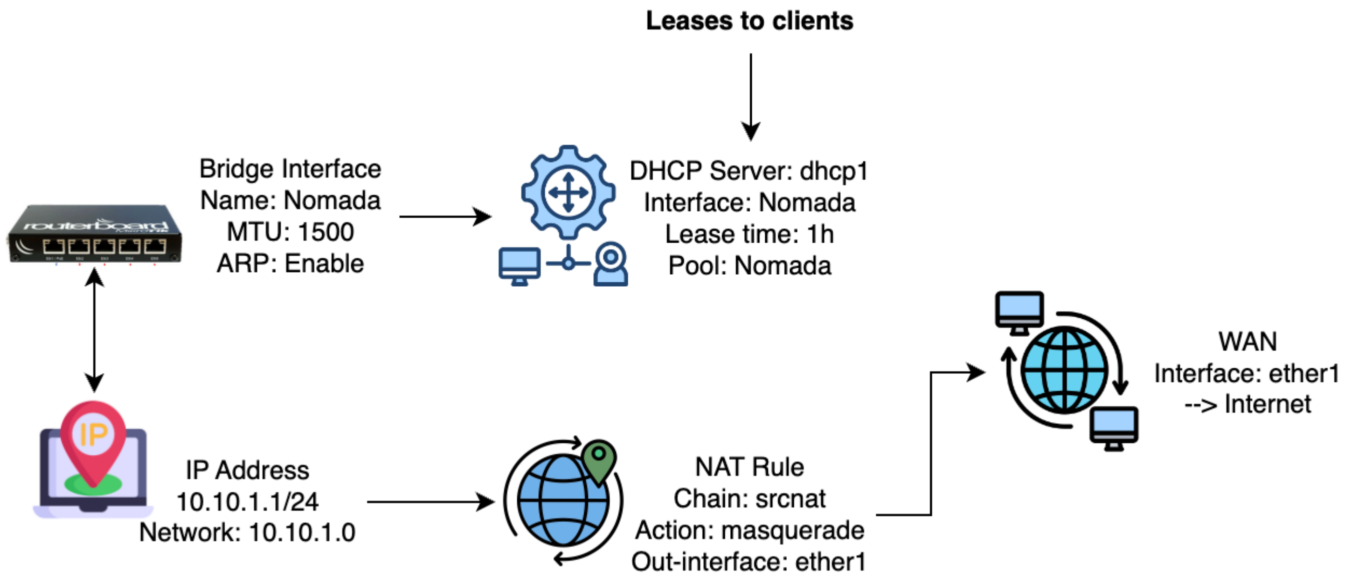
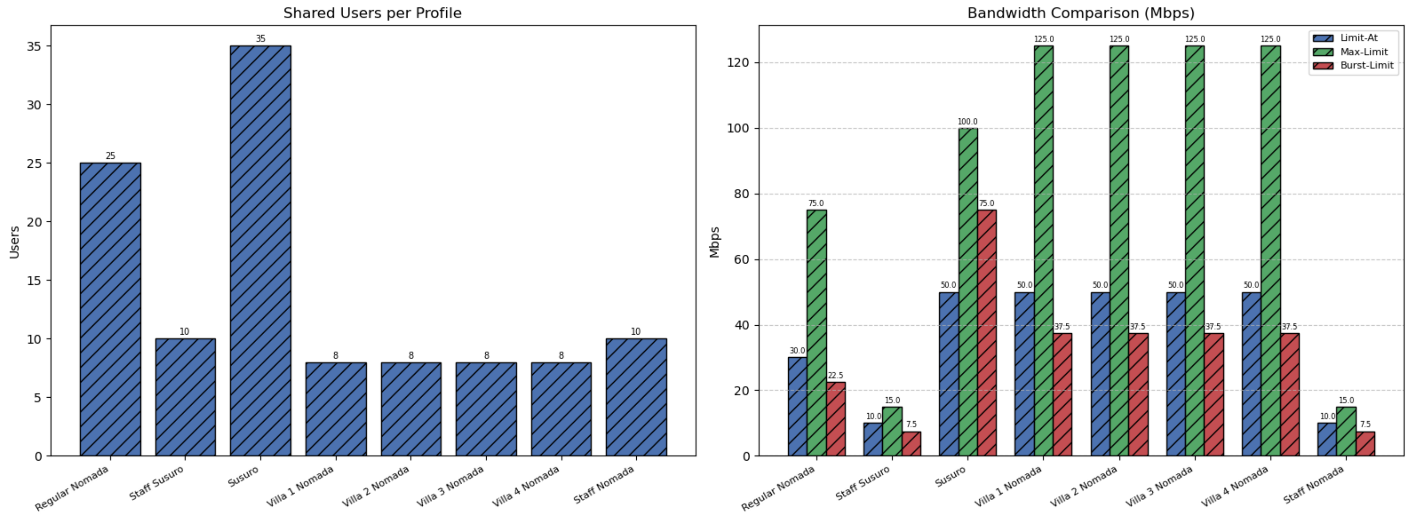


Figure 4. Overall configuration workflow.



(a) (b)

Figure 5. (a) Shared users and (b) bandwidth comparison per Profile.

After completing the configuration, wireless speed tests were conducted to confirm the allocated bandwidth for each group. The results show that Regular Nomada (VIP Guests) received the expected distribution (Figure 6a), Villa Nomada 1–4 consistently obtained 50 Mbps (Figure 6b), and the Nomada Office (Administration) was limited to 10 Mbps (Figure 6c).

4.3. Measurement Using Wireshark Application

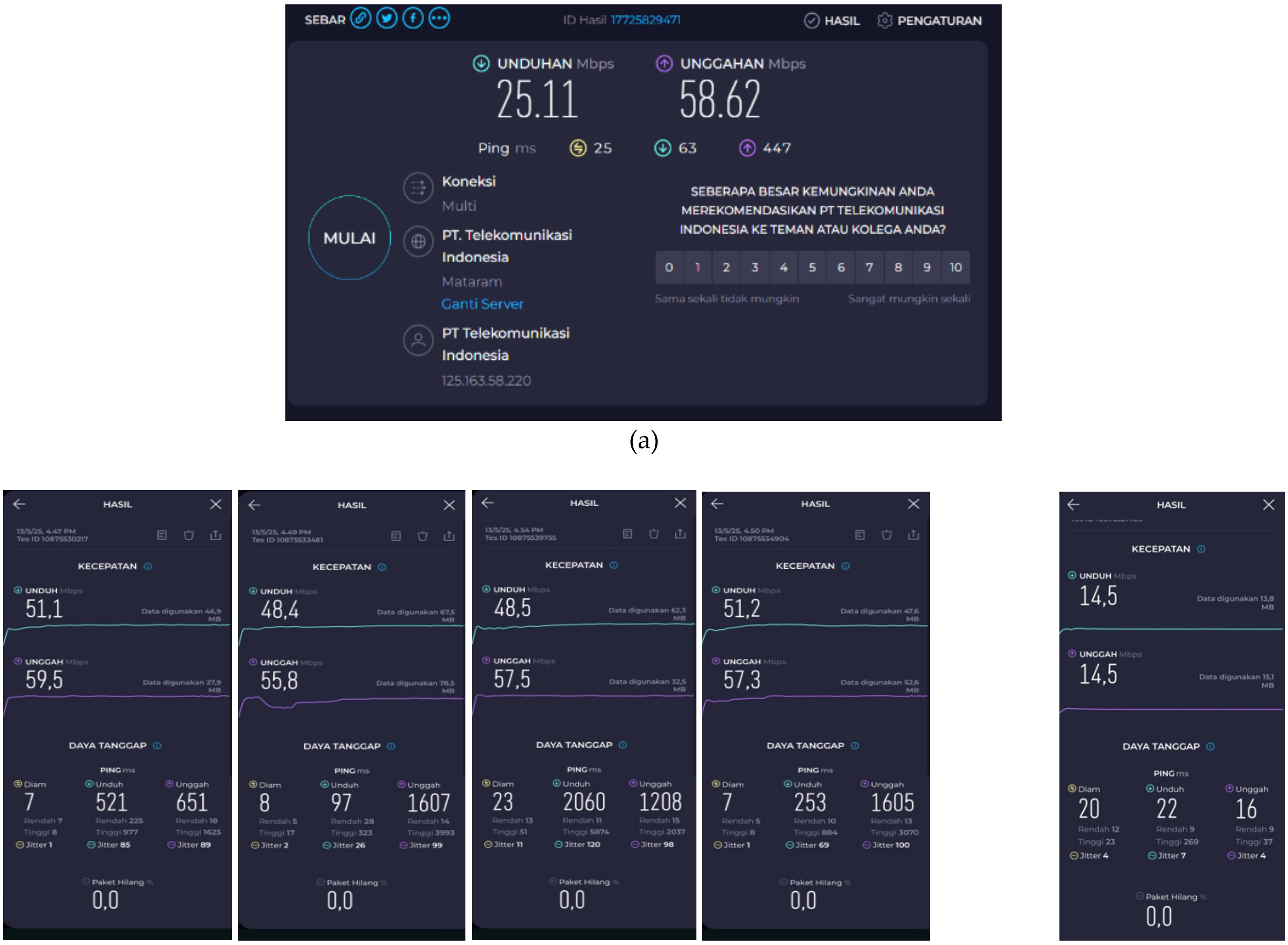
Wireshark, as an open-source packet analyzer, is widely used for network analysis and troubleshooting. It can capture and analyze the contents of data packets transmitted over a network, making it useful not only for monitoring traffic but also for evaluating Quality of Service (QoS) parameters such as throughput, packet loss, delay, and jitter [14].

a. Nomada Regular (30 Mbps)
The regular Nomada bandwidth allocation (30 Mbps) was tested by capturing data traffic as users connected to the internet. The captured packets were then analyzed to obtain QoS parameters.

b. Nomada VIP Guest (50 Mbps)
The VIP guest allocation (50 Mbps) was also measured by recording and analyzing traffic using Wireshark. The QoS results were extracted from the captured data for further comparison.

c. Nomada Office (10 Mbps)
Finally, the Nomada Office allocation (10 Mbps) was tested in the same way. Data packets were captured and processed to determine throughput, packet loss, delay, and jitter performance.

The summary of QoS results for the three bandwidth categories—Regular, VIP Guest, and Office—is illustrated in Figure 7, which presents a comparative visualization of throughput, packet loss, delay, and jitter measurements.



(a)

(b) (c)

Figure 6. (a) Nomada Regular Speed Test, (b) Villa Nomada Speed Test 1, 2, 3 and 4, and (c) Nomada Office Speed Test

4.4. Total QoS Measurement Results

By improving Quality of Service (QoS), it is hoped that the problem of over-capacity bandwidth usage can be resolved [22], [23], [24]. QoS helps users to be more capable of getting faster performance from network-based applications, according to the network quality standards from TIPHON (Telecommunications and Internet Protocol Harmonization Over Network) [12], [25], [26].

a. Delay parameters
   The time it takes for data to travel from its origin to its destination. Delay can be influenced by distance, physical media, congestion, or long processing times [27].
b. Jitter Parameters
   Variation or change in packet arrival time delay. Jitter is also defined as interference in digital or analog communications caused by signal changes.

Table 1. Delay.

Catagory	Large Delay	Indexs
Very Good	<150 m/s	4
Good	150 m/s – 300 m/s	3
Currently	300 m/s – 450 m/s	2
Bad	>450 m/s	1

Table 2. Jitter.

Catagory	Large Jitter	Indexs
Very Good	0 m/s	4
Good	0 m/s - 75 m/s	3
Currently	75 m/s – 125 m/s	2
Bad	125 m/s – 225 m/s	1

Table 3. Packet Loss.

Catagory	Large Packet Loss	Indexs
Very Good	0 – 2 %	4
Good	3 -14 %	3
Currently	12 – 24 %	2
Bad	>25 %	1

Table 4. Throughput.

Catagory	Large Througput	Indexs
Very Good	100 %	4
Good	75 %	3
Currently	50 %	2
Bad	25 %	1

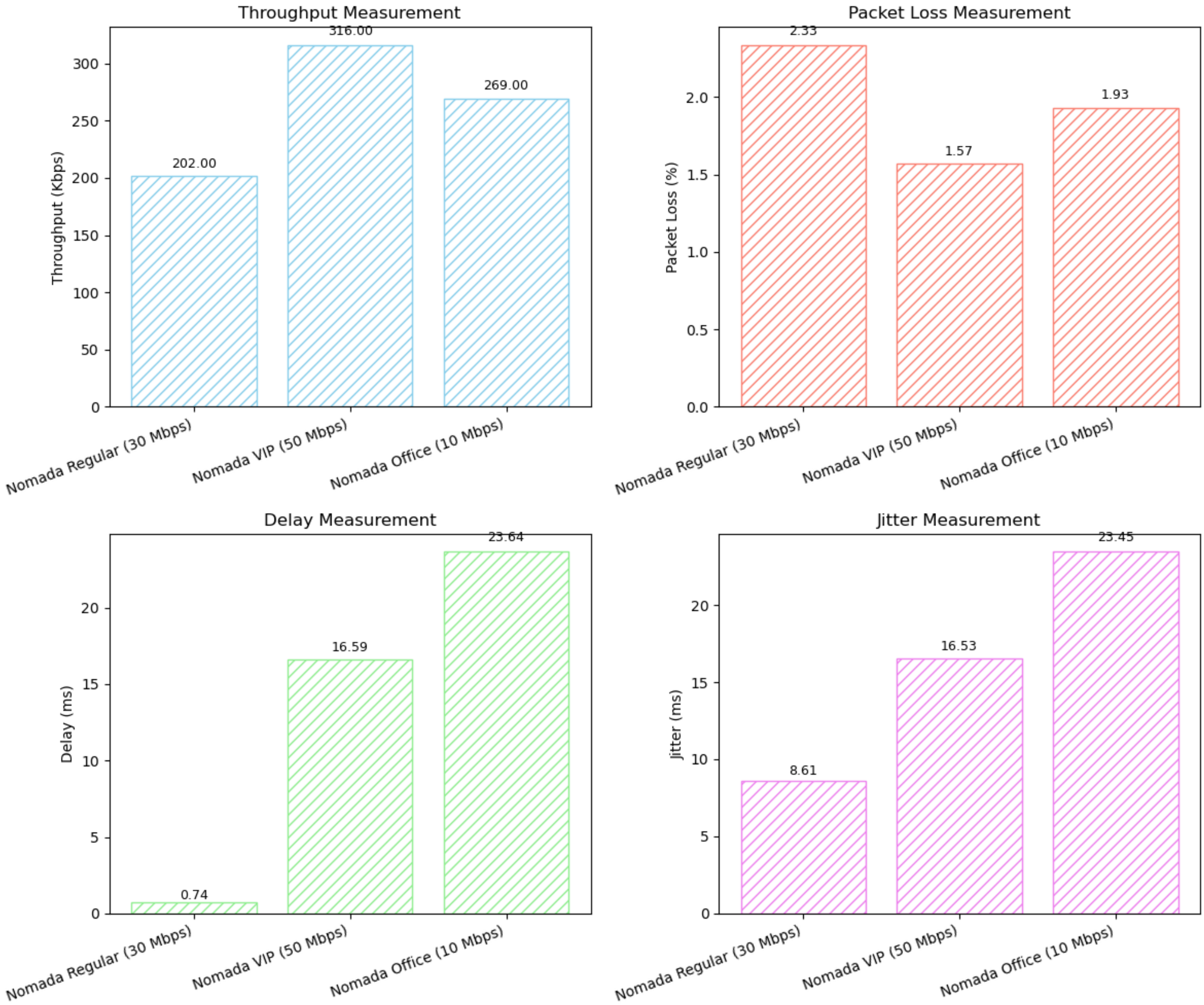


Figure 7. QoS Parameters (Throughput, Packet Loss, Delay, and Jitter) of Nomada Network.

Table 5. QoS Assessment Category and HTB Index Results.

Class	Throughput	Packet loss	Delay	Jitter	Average Index	Final Category
Reguler	Bad	Good	Very good	Good	2.75	**~Good**
VIP guests	Bad	Very good	Very good	Good	3.00	**Good**
Office	Bad	Very good	Very good	Good	Very good	**Good**

c. Packet Loss Parameters
A parameter that describes a condition that shows the total number of packets that cannot reach their destination, where this can be caused by collisions and congestion on the network.

d. Throughput
The actual bandwidth measured at a specific time of day using a specific internet route while downloading a file.

Based on the assessment barometer, we can draw conclusions about the QoS assessment results according to the results obtained in Figure 7. QoS assessment category level is shown in Table 5. From the table, it can be seen that Regular users achieved an average index of 2.75, which falls into the "Good" category, while both VIP and Office users reached an average index of 3.0 (Good). Although throughput performance in all profiles was consistently categorized as Bad, the strong results in packet loss, delay, and jitter improved the overall QoS level, placing all profiles in the "Good" category. This indicates that the HTB implementation was successful in optimizing bandwidth distribution and maintaining stable service quality across user categories.

5. Conclusion

Based on the results of bandwidth optimization using the HTB method, configuration and trial scenarios as well as analysis of the results of the trials that have been carried out, it can be concluded that bandwidth optimization using the HTB (Hierarchical Token Bucket) method has provided bandwidth allocation that can be categorized (Good) for Users based on the results of the QoS analysis and the application of the HTB (Hierarchical Token Bucket) method on Broadband ISPs is considered good on a small scale. So, this can be a reference in implementing bandwidth optimization in other places.

6. Conflicts of Interest

The authors declare no conflicts of interest.

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