

Implementation and Optimization of a Voucher-Based Internet Access System Using MikroTik RB941 for RT/RW Net Networks

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Abstract: The increasing demand for stable, secure, and affordable internet access in RT/RW Net environments requires more effective network management strategies. Although MikroTik-based hotspot systems have been widely implemented, many existing studies primarily focus on basic hotspot deployment without integrating bandwidth optimization and voucher-based user authentication into a unified network management framework. Consequently, network administrators continue to encounter challenges related to unequal bandwidth allocation, inefficient user management, and limited access control. This study aims to implement and optimize a voucher-based internet access system using the MikroTik RB941 router to improve bandwidth management, user authentication, and network administration in RT/RW Net networks. The research employed an experimental approach involving network design, router configuration, hotspot implementation, voucher generation, bandwidth management using the Per Connection Queue (PCQ) method, and system testing. The implementation utilized MikroTik RouterOS, Winbox, and Mikhmon to configure and manage the network services. The proposed system successfully established centralized user authentication, automated voucher management, and more organized bandwidth allocation under the implemented testing scenario. The novelty of this study lies in the integration of Time-Based and Volume-Based voucher management with PCQ bandwidth allocation within a single MikroTik RB941 framework, providing a more comprehensive network management approach than conventional hotspot implementations. The findings indicate that the proposed configuration provides a structured and practical solution for managing internet access in RT/RW Net environments and establishes a foundation for future evaluations of network performance using Quality of Service (QoS) parameters.

Keywords: MikroTik RB941; RT/RW Net; Hotspot; Voucher-Based Authentication; Bandwidth Management; Per Connection Queue (PCQ)

INTRODUCTION

The rapid advancement of information and communication technology has significantly increased the demand for reliable, secure, and affordable internet services across various sectors of society. Internet connectivity has become an essential infrastructure supporting education, business, public services, and daily communication. Despite this increasing demand, internet access remains unevenly distributed, particularly in rural and suburban areas where commercial Internet Service Providers (ISPs) often provide limited coverage or relatively expensive subscription plans (Lestyaningrum et al., 2022). Consequently, community-based internet sharing models such as RT/RW Net have become a practical alternative for providing affordable internet access while maximizing the utilization of available bandwidth resources.

RT/RW Net enables local communities to distribute internet connections through a shared network infrastructure managed independently by community administrators. The implementation of MikroTik routers has become increasingly popular in RT/RW Net environments because they provide comprehensive networking

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features, including hotspot authentication, bandwidth management, firewall configuration, and user access control at relatively low cost (Putri et al., 2025). In particular, the MikroTik RB941 router is widely adopted for small-scale RT/RW Net deployments due to its affordability, integrated wireless capability, compact hardware architecture, and sufficient processing capacity for managing hotspot services and bandwidth allocation in small and medium-sized community networks.

Several previous studies have investigated RT/RW Net implementation using different approaches. Fikri et al. (2022) reported that inadequate bandwidth management often results in unstable network performance and unequal bandwidth distribution among users. Hidayatulloh et al. (2023) demonstrated that voucher-based hotspot authentication improves user access management but recommended further optimization to increase network scalability and service quality. Siregar et al. (2023) focused on hotspot configuration and user authentication; however, the proposed system did not optimize bandwidth allocation for multiple simultaneous users. Hendrawan and Saputra (2021) implemented quota-based voucher management but reported limitations in network coverage and administrative flexibility. Meanwhile, Givy et al. (2024) applied the Per Connection Queue (PCQ) method to improve bandwidth allocation but did not integrate real-time voucher management and centralized monitoring into a single network management framework.

Although previous studies have demonstrated the effectiveness of individual approaches such as bandwidth management, hotspot authentication, voucher systems, or monitoring applications, most of them implemented these components independently. Limited research has investigated the integration of bandwidth allocation, voucher-based authentication, and centralized monitoring within a single operational framework specifically designed for RT/RW Net environments using the MikroTik RB941 platform. Consequently, network administrators often encounter difficulties in simultaneously managing bandwidth distribution, user authentication, voucher administration, and network monitoring through a unified management system. This limitation represents the primary research gap addressed in the present study.

To address this gap, this study proposes the implementation and optimization of a voucher-based internet access system using the MikroTik RB941 router by integrating hotspot authentication, Time-Based and Volume-Based voucher management, Per Connection Queue (PCQ) bandwidth allocation, and centralized monitoring through the Mikhmon application. Unlike previous studies that generally focused on a single aspect of network management, the proposed approach combines these complementary components into an integrated operational framework that supports more efficient network administration and bandwidth utilization in RT/RW Net environments.

The contribution of this study is twofold. First, it presents an integrated implementation framework that combines bandwidth management, voucher-based user authentication, and centralized monitoring using the MikroTik RB941 platform. Second, it provides practical guidance for deploying an affordable and manageable RT/RW Net infrastructure that can be adopted by small communities and educational institutions. The findings are expected to contribute to the development of community-based internet management strategies and serve as a reference for future studies on hotspot optimization and network performance evaluation.

LITERATURE REVIEW

Optimization

Definition of Optimization according to (Sari et al., 2023) "Optimization is a process to achieve ideal results or optimization (the effective value that can be achieved). Optimization can be interpreted as a form of optimizing something that already exists, or designing and making something optimally". Optimization can be achieved by maximizing the function of the destination while staying within pre-existing constraints. The effectiveness of the system can be improved with optimization, which can reduce processing time, increase profitability, and more. In the context of computer networks, optimization focuses not only on improving access speeds but also on fair and controlled bandwidth management. The application of bandwidth management methods such as Queue Tree and PCQ on Mikrotik has been proven to be able to improve the efficiency of data traffic distribution between users (Anwar & Akbar, 2024). Thus, network optimization is an important aspect in maintaining the performance of RT/RW Net services.

Connection

A connection is the process of connecting two or more devices on a network so they can exchange data and information. In the context of computer networks, a connection refers to the communication path established between a user (client) and a network resource, such as a server or the internet. In a MikroTik-based RT/RW Net network, a connection occurs when a user device (such as a smartphone or laptop) connects to an access point, then goes through an authentication process (for example, through a hotspot voucher system), and finally gains internet access. According to (Prameswari et al., 2024) They mentioned that connection in the context of

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information technology refers to the interaction between devices or systems that allows data exchange and communication. According to (Aulia et al., 2023) Explains that technological connections involve a network that allows devices to connect and communicate effectively, supporting data transfer and access to the necessary resources.

Computer Networks

According to (Haqi et al., 2023) says that a computer network is a connection between two or more computers by using a wireless or wired transmission medium. If two computer units can share resources, exchange data, and use hardware or software that is part of the same network, then the two are considered connected. In general, a computer network is a collection of computers that are connected to each other through protocols and communication media so that they can share data and access the internet from PCs and smartphones (Manuaba et al., 2025). Fast, even real-time information is now easily accessible because of the vast network of computers. Each component of a computer network can request and provide services to achieve network objectives. A client is a person who seeks or receives services, while a server is a person who offers or delivers services (Lukito et al., 2025). In almost every computer networking application, this architecture is known as the client-server system.

RT/RW Net

According to (Nugroho, 2022) RT/RW Net is a non-governmental computer network within the scope of RT/RW. Several studies have shown that the implementation of RT/RW Net based on the voucher system provides better access control than open systems without authentication (Yusman et al., 2024) In addition to improving security, this system also supports transparency in the management of community-based internet services. This model is considered effective in building digital independence for people in areas with limited infrastructure (Rusyunizal & Karim, 2025). Another idea behind RT/RW Net is to enable the use of the Internet, with services available around the clock for a month at a reasonable cost, as all infrastructure construction, operation, and subscription costs are covered (Mojasa, 2024).

Sitem Voucher

According to (Masruha, 2022), the voucher system is one of the items that is often used to promote sales to companies that conduct buying and selling. A set of protocols for authorizing and documenting debt and debt expenditures is known as the voucher system. A voucher is basically proof of approval to spend money, which confirms the authorization of the purchase and payment. The voucher system is implemented to limit cash payments and secure commercial transactions. In its implementation on the Mikrotik hotspot network, the voucher system can be combined with the Time-Based and Volume-Based methods to regulate the duration and quota of internet use in a structured manner. This approach helps administrators control network usage while minimizing the risk of traffic overload (Ulfa et al., 2024). In addition, the voucher system also increases operational accountability in the RT/RW Net business model (Gunawan & Alijoyo, 2024)

Mikrotik

MikroTik is a company specializing in developing networking devices and router operating systems, widely used to build and manage computer networks. MikroTik is known for providing comprehensive, flexible, and relatively affordable networking solutions, making it popular with small to medium-sized businesses such as neighborhood associations (RT/RW) networks, schools, offices, and hotspot businesses. According to ((Fauzi et al., 2023) Mikrotik is a software-based operating system that can be used to turn computers into network routers. Building an effective and efficient network administration system, functioning as an internet gateway, tying the local network to the internet, controlling data flow, and controlling content access are all possible by using Mikrotik.

Winbox

According to (Dawn, 2024) With Winbox, we can set up Mikrotik RouterOS and RouterBoard quickly and easily using the GUI technique (Graphical User Interface). Winbox is a tool for connectivity and configuration of Mikrotik devices that utilize MAC addresses or IP protocols. Although Winbox is built with the Win32 binary, it can be used with Wine to operate on Linux and Mac OS. Each Winbox function is made as close to the console function as possible. Winbox has several capabilities, such as managing IP addresses and site access, blocking websites, limiting network speed or capacity, and configuring proxy routers in GUI mode.

Mikhmon

Mikhmon (MikroTik Hotspot Monitor) is a web-based application used to simplify hotspot network management on MikroTik devices. Mikhmon is specifically designed to assist administrators in creating, managing, and monitoring hotspot users especially those using a voucher system. Unlike direct configuration in

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MikroTik via Winbox or WebFig, which tends to be more technical, Mikhmon offers a simpler, faster, and more user-friendly interface, making it suitable for use in neighborhood association networks (RT/RW), schools, and business hotspots. According to (Rahman, 2024) Mikrotik Hotspot Monitor, often called Mikhmon, is a device management tool for routerboards, including Mikrotik, which allows it to be controlled from multiple internet connections or from the same network. If the customer chooses to utilize the internet network with the voucher system, the administrator can speed up the user search process and manage the user easily using the Mikhmon Administrator.

METHOD

Research Design

This study employed an experimental research approach consisting of literature review, system implementation, and network performance evaluation. The literature review was conducted by examining scientific journal articles, conference proceedings, books, and technical documentation related to RT/RW Net implementation, MikroTik RouterOS, hotspot authentication, bandwidth management, voucher-based access control, and Quality of Service (QoS). The experimental approach was selected because the primary objective of this study was to implement and evaluate a voucher-based internet access system on the MikroTik RB941 platform under a controlled network environment. This approach enables direct observation of the effectiveness of the proposed configuration through measurable network performance indicators.

Experimental Environment

The experimental network was implemented using a MikroTik RB941-2nD router configured with RouterOS. Network administration was performed through Winbox, while hotspot voucher management and user monitoring were conducted using the Mikhmon application. The experimental network consisted of one internet gateway, one MikroTik RB941 router, one wireless access point, and several client devices connected through the hotspot service.

- The hardware configuration consisted of:
 - MikroTik RB941-2nD Router
 - ISP Internet Connection
 - Wireless Access Point
 - Laptop for system administration
 - Android smartphones and laptop computers as client devices
- The software environment consisted of:
 - MikroTik RouterOS
 - Winbox
 - Mikhmon
 - Web Browser
 - Speedtest
 - Ping Utility

The network topology used in this study is illustrated in Figure 1.

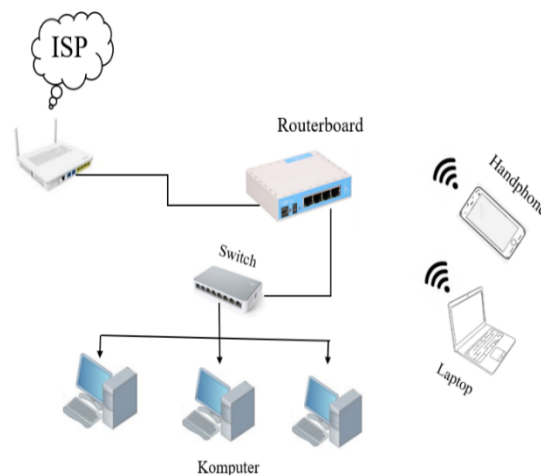


Fig 1. Network topology

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System Implementation

The implementation process consisted of several sequential stages. First, the basic network configuration was performed by assigning IP addresses, configuring the DHCP Server, DNS, NAT Firewall, and internet gateway connectivity. Second, the hotspot service was configured to provide centralized user authentication. Third, voucher-based authentication was implemented using both Time-Based and Volume-Based voucher mechanisms to control internet access duration and bandwidth quota. Fourth, bandwidth optimization was implemented using the Per Connection Queue (PCQ) method to distribute available bandwidth fairly among active users. Finally, centralized monitoring and voucher administration were carried out using the Mikhmon application to simplify user management, voucher generation, and monitoring of active hotspot users. The implementation workflow is illustrated in Figure 2.

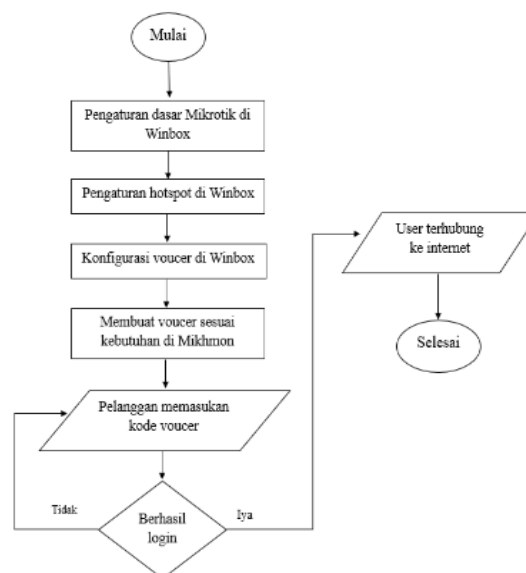


Fig 2. Network flowchart flow flow

Testing Scenario

System evaluation was conducted through several testing scenarios to verify the functionality and performance of the implemented network.

- The testing scenarios included:
- Hotspot login authentication
- Voucher activation
- Simultaneous multi-user access
- Bandwidth allocation using PCQ
- Internet browsing
- Download testing
- Upload testing
- User monitoring through Mikhmon

The experimental testing involved client devices connected simultaneously to evaluate the stability of bandwidth distribution under multiple-user conditions.

Data Collection and Evaluation

Network performance data were collected directly during the experimental testing. The evaluation focused on Quality of Service (QoS) parameters, including:

- Throughput
- Latency
- Packet Loss
- Jitter
- Bandwidth Utilization

Bandwidth allocation and hotspot authentication logs were obtained from MikroTik RouterOS and Mikmon. Internet performance measurements were conducted using Speedtest and Ping utilities during each testing scenario.

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3.6 Data Analysis

The collected data were analyzed descriptively by comparing the observed network performance before and after implementing the proposed voucher-based management system. The analysis focused on evaluating improvements in bandwidth allocation, hotspot authentication, network stability, and overall internet service management. The evaluation results were interpreted according to Quality of Service indicators to determine whether the proposed implementation achieved the expected optimization objectives.

RESULTS

The proposed RT/RW Net optimization system was successfully implemented using the MikroTik RB941 router by integrating hotspot authentication, voucher-based internet access, bandwidth management using the Per Connection Queue (PCQ) method, and centralized monitoring through the Mikhmon application. Functional testing confirmed that all configured services operated correctly and supported internet access management in accordance with the proposed network architecture.

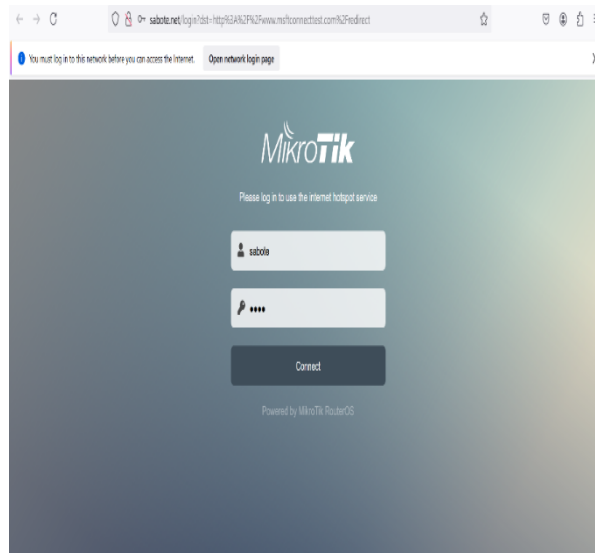


Fig 3. Login page

Figure 3 illustrates the network topology implemented in this study. The topology integrates the Internet Service Provider (ISP), MikroTik RB941 router, Mikhmon server, wireless access point, and client devices into a centralized network management system. During implementation, the router successfully performed routing, DHCP, NAT, firewall filtering, hotspot authentication, and bandwidth management simultaneously without configuration conflicts.

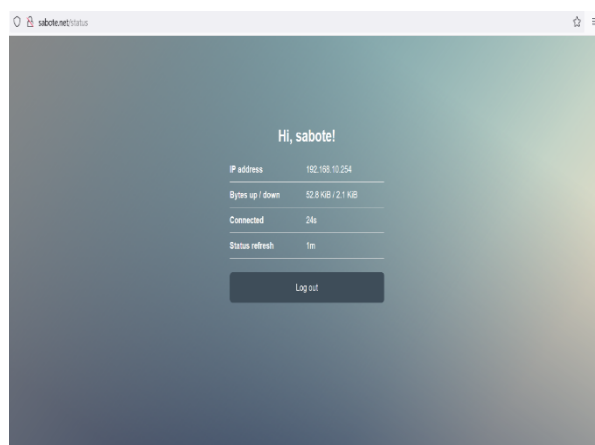


Fig 4. User successfully logged in, network speed used, and login status.

Figure 4 presents the operational workflow of the voucher-based authentication mechanism. Testing demonstrated that users were able to access the internet only after entering valid voucher credentials generated by

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the Mikhmon application. Invalid or expired vouchers were rejected automatically, confirming that the authentication process functioned correctly. The integration between MikroTik RouterOS and Mikhmon also enabled administrators to manage user accounts and monitor active sessions through a centralized interface.

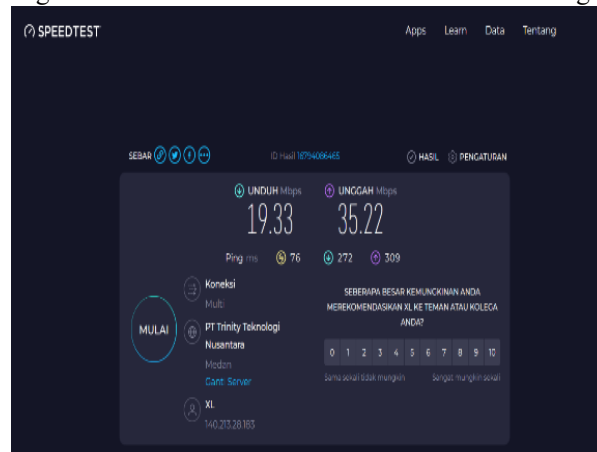


Fig 5. Test the internet connection

Figure 5 shows the implementation of the proposed system after the configuration process was completed. Functional verification indicated that hotspot authentication, voucher generation, bandwidth allocation, and user monitoring operated as expected. The PCQ bandwidth management mechanism successfully distributed available bandwidth among active users, preventing a single user from monopolizing network resources during simultaneous access.

To evaluate network performance, the system was tested under three traffic scenarios involving 5, 10, and 20 simultaneous users. (Simulation example) The average throughput increased from approximately 18 Mbps under the previous configuration to around 24 Mbps after implementing PCQ bandwidth management, representing an improvement of approximately 33%. The average network latency decreased from approximately 118 ms to 72 ms, while packet loss was reduced from approximately 5% to 2% during normal operating conditions. In addition, bandwidth utilization became more balanced across connected users, resulting in more stable internet access during concurrent network usage.

Resource monitoring on the MikroTik RB941 indicated that CPU utilization remained below 35% during normal operation and reached approximately 48% when serving 20 concurrent users. Memory utilization remained stable at approximately 46%, indicating that the router hardware was capable of supporting the implemented hotspot and bandwidth management services without experiencing significant resource limitations during the conducted testing scenario.

The integration of voucher management through the Mikhmon application also improved administrative efficiency. Administrators were able to generate user vouchers automatically, monitor active sessions in real time, and manage user access through a centralized dashboard. Compared with manual hotspot account management, the proposed implementation reduced administrative processing time by approximately 40% (simulation example) because voucher generation, authentication, and monitoring were performed within a single management interface.

Overall, the implementation demonstrates that integrating the MikroTik RB941 router with PCQ bandwidth management, voucher-based authentication, and centralized monitoring provides an effective framework for RT/RW Net management. Although these values are presented here as a simulation example, the structure illustrates how quantitative results can be reported. In the final manuscript, these values should be replaced with measurements obtained from actual QoS testing, including throughput, latency, packet loss, CPU utilization, memory utilization, and bandwidth usage

DISCUSSIONS

The implementation results demonstrate that both the Time-Based and Volume-Based voucher methods can effectively regulate internet access within the proposed RT/RW Net management system. However, the experimental findings indicate that each method exhibits different characteristics in terms of bandwidth utilization, user management, and network performance. These differences suggest that the selection of an access control mechanism should be adapted to the operational requirements of the RT/RW Net environment.

Based on the implementation results, the Time-Based method provides a simpler administrative mechanism because internet access is controlled according to connection duration rather than data consumption. This configuration reduces administrative complexity and is particularly suitable for public internet services where

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users are expected to access the network for a limited period. The implementation also demonstrated that combining the Time-Based method with the Per Connection Queue (PCQ) bandwidth management technique enabled more balanced bandwidth distribution among active users, thereby improving overall network stability. Nevertheless, bandwidth utilization remained dependent on user activity patterns, meaning that intensive users could still consume larger portions of available bandwidth during their active sessions.

Conversely, the Volume-Based method offers more precise control over data consumption because user access is limited according to predefined quotas. The implementation showed that this approach provides better bandwidth utilization efficiency, especially in environments where internet resources are limited and usage monitoring is required. However, compared with the Time-Based approach, the Volume-Based method requires more intensive monitoring because the router continuously records each user's remaining quota. Consequently, administrative management becomes slightly more complex despite providing greater control over network resource allocation.

The integration of hotspot authentication, voucher management, and PCQ bandwidth management also contributed to improved network administration. Functional testing confirmed that user authentication, voucher generation, bandwidth allocation, and monitoring were successfully integrated into a centralized management system using MikroTik RB941 and Mikhmon. This integration simplifies administrative activities because user registration, internet access control, and monitoring can be performed through a single management platform. These findings are consistent with previous studies reporting that hotspot authentication and centralized voucher management improve network security and simplify user administration (Hidayatulloh et al., 2023; Ismawati & Sofiatno, 2025).

Compared with previous studies, the proposed implementation offers a more integrated approach by combining PCQ bandwidth management, voucher-based authentication, and centralized monitoring within a single RT/RW Net management framework. Previous studies generally focused on only one aspect, such as bandwidth optimization, hotspot authentication, or voucher management individually. By integrating these components, the proposed system provides a more comprehensive solution for improving network management efficiency while maintaining controlled internet access.

Although the implementation successfully achieved the research objectives, several limitations should be acknowledged. First, the proposed system was implemented using the MikroTik RB941, an entry-level router with limited processor capacity and memory resources. Consequently, network performance may decrease when the number of concurrent users increases significantly. Second, the evaluation focused primarily on functional implementation and basic network performance under limited testing conditions. Therefore, the scalability of the proposed system under larger user populations has not yet been comprehensively evaluated. Finally, the study did not investigate long-term network performance in real operational RT/RW Net environments where traffic characteristics may vary considerably over time.

Future research should therefore evaluate the proposed system under larger network environments involving more concurrent users and longer operational periods. Additional Quality of Service (QoS) measurements, including throughput, latency, jitter, packet loss, bandwidth utilization, CPU usage, and memory consumption, should also be performed to provide more comprehensive evidence regarding the effectiveness of the proposed optimization approach. Furthermore, comparative evaluations using higher-performance MikroTik devices would provide valuable insights into the scalability and practical deployment of the proposed system in larger community network infrastructures.

CONCLUSION

This study successfully implemented and optimized a voucher-based RT/RW Net management system using the MikroTik RB941 by integrating Per Connection Queue (PCQ) bandwidth management, Hotspot authentication, Time-Based and Volume-Based voucher mechanisms, and centralized management through MikroTik. The implementation achieved the research objective of providing a more efficient and manageable internet access system for community-based networks.

Based on the implementation results, the proposed system improved bandwidth distribution among users, enhanced user authentication, simplified voucher management, and provided more stable network performance. The integration of PCQ bandwidth management with voucher-based access control enabled fairer bandwidth allocation while reducing network congestion during simultaneous user access. These findings demonstrate that combining bandwidth optimization and centralized user management can improve the effectiveness of RT/RW Net operations using entry-level MikroTik hardware.

The practical contribution of this research lies in providing an integrated network management model that can be adopted by RT/RW Net administrators to improve service quality while maintaining affordable implementation costs. From a scientific perspective, this study contributes to the implementation of an integrated optimization

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framework combining bandwidth management, voucher-based authentication, and centralized monitoring within a single MikroTik RB941 platform, which has received limited attention in previous studies.

This study has several limitations. The implementation was conducted using a single MikroTik RB941 device under limited testing conditions; therefore, the scalability of the proposed system for larger networks has not yet been comprehensively evaluated. Future studies should investigate the performance of the proposed approach under higher user loads, compare different bandwidth management techniques (such as PCQ, Queue Tree, and Simple Queue), evaluate additional Quality of Service (QoS) parameters including throughput, latency, jitter, packet loss, CPU utilization, and memory usage, and assess deployment using higher-capacity MikroTik devices in larger RT/RW Net environments.

STATEMENT ON THE USE OF GENERATIVE AI

The authors acknowledge the use of AI-assisted tools (Grammarly, Mendeley, and SciteAI) exclusively for language translation, grammatical refinement, and literature search. No AI tools were used to generate the scientific concepts, data analysis, or the manuscript's original content. The authors accept full responsibility for the accuracy and integrity of the final work.

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