Infortech, Vol. 8, No. 1, June 2026, E-ISSN: 2715-8160, Page. 57-62
Published: LPPM Universitas Bina Sarana Informatika
JURNAL INFORTECH
website: http://jurnal.bsi.ac.id/index.php/infortech/

Analysis and Implementation of the PCQ Method in MikroTik-Based Bandwidth Management

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ARTICLE INFORMATION

Artikel History:
Received: 20-05-2026
Revised: 03-06-2026
Accepted: 15-06-2026
Available Online: 22-06-2026

Keyword:
Bandwidth Management
Per Connection Queue
MikroTik Router
Simple Queue
Quality of Service

ABSTRACT

This study aims to implement bandwidth management using the Per Connection Queue (PCQ) method on a MikroTik router to overcome uneven bandwidth distribution. The main problem frequently encountered is the lack of optimal network traffic management, which impacts network performance and work productivity. The research method used is the Network Development Life Cycle (NDLC) with data collection techniques through observation, interviews, and literature studies. The analysis results indicate that the network does not yet have a bandwidth management system and priority allocation among departments. The proposed solution is the implementation of Simple Queue combined with the PCQ method to distribute bandwidth fairly according to the needs of each floor or department. The testing results show that the PCQ method can distribute bandwidth more systematically and stably, with achieved bandwidth values close to the predetermined targets, such as the 17th floor achieving 68.97/69.53 Mbps from a target of 70 Mbps. The study concludes that the combination of Simple Queue and PCQ on a MikroTik router is effective in creating fair, measurable, and efficient bandwidth management that supports business activities.

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INTRODUCTION

Computer networks have become the foundation of global communication and information exchange in today's interconnected digital world. This technology plays a vital role in supporting information exchange, resource sharing, and digital business operations (Gudhka, 2024). The development of information technology has made computer networks the primary infrastructure supporting operational activities and the growth of modern businesses (Afofalu & Tsoeu, 2025). Good and reliable internet communication quality has a significant positive effect on work productivity (Al-Aloosy et al., 2024).

However, in network environments with many users, problems related to uncontrolled bandwidth distribution are often found. Uncontrolled bandwidth distribution can cause certain data flows to experience insufficient resources or degraded service quality (Chapanduka et al., 2025). One of the main causes of these problems is the absence of effective bandwidth

DOI: https://doi.org/10.31294/infortech.v8i1.

management mechanisms (Daru et al., 2021). Without proper bandwidth regulation, certain users or data flows may consume most network resources, reducing service quality for other users. This issue can be solved through bandwidth allocation strategies that improve fairness among users (Liu et al., 2022). When bandwidth is not properly managed, Quality of Service (QoS) parameter analysis indicates a decline in network performance (Kuncoro, 2025). Other issues arising from improper bandwidth management include increased packet loss due to full buffer queues, transmission delays, and reduced network efficiency (Said, 2023).

This condition also occurs in the internal network of PT Serasi Tunggal Mandiri, where no bandwidth management system or priority allocation among departments has been implemented, resulting in suboptimal bandwidth distribution. Adaptive bandwidth management is required to dynamically regulate resource distribution and overcome ineffective bandwidth control problems (Mangkey, 2025).

MikroTik routers are widely used in network environments because features such as Simple Queue, Queue Tree, and Layer7 Protocol can proportionally distribute bandwidth based on user categories, block irrelevant access, and significantly improve internet connection stability (Prasetyo et al., 2024). MikroTik devices can be effectively utilized in network management to support data traffic needs and maintain connection stability (Prasetyo et al., 2025). One of the methods provided by MikroTik is Per Connection Queue (PCQ). PCQ offers queue control per connection, preventing a single user from monopolizing bandwidth and enabling fairer bandwidth allocation while improving overall network performance, especially when implemented together with Queue Tree (Daru et al., 2021).

The use of queue mechanisms such as Queue Tree on MikroTik routers enables more efficient hierarchical bandwidth management, helping maintain connection stability and fair bandwidth distribution among users to improve Quality of Service in community networks (Mangkey, 2025). The combination of PCQ with queue mechanisms such as Queue Tree on MikroTik routers has proven capable of distributing bandwidth fairly and automatically, preventing resource domination by a single client, and improving overall network service quality (Prasetyo et al., 2024).

Based on these problems, this study focuses on implementing bandwidth management using the PCQ method combined with Simple Queue on MikroTik routers. The objective of this study is to analyze the effectiveness of the PCQ method in distributing bandwidth fairly and measurably according to the needs of each floor or department. By implementing this method, it is expected that network service quality can improve and optimally support business activities in a sustainable manner.

RESEARCH METHOD

A. Research Design and Chronology

The research model used is the Network Development Life Cycle (NDLC). NDLC is a method used in computer network development because it provides a systematic and structured framework through stages of analysis, design, implementation, monitoring, and network management, thereby helping achieve effective and efficient network implementation in various complex organizational network case studies (Prayitno & Yasir, 2025). NDLC provides systematic stages ranging from needs analysis to network performance testing, ensuring that the research results can be scientifically justified.

B. Research Procedure

The stages of the research are as follows:

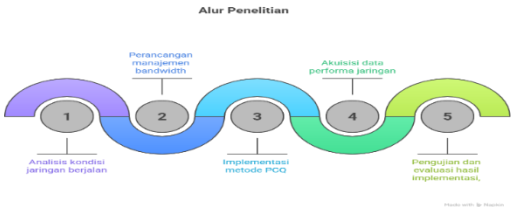

Figure 1. Alur Research Step

1. Analysis Stage

At this stage, an analysis of the existing network was conducted to identify the main problems. The analysis included network topology, internet bandwidth capacity, number of active users, and bandwidth usage patterns on each floor or department. The analysis results showed that there was no structured mechanism for bandwidth distribution and prioritization, resulting in unequal bandwidth usage.

2. Design Stage

Based on the analysis results, a bandwidth management system using Simple Queue combined with Per Connection Queue (PCQ) was designed. Simple Queue was used to limit bandwidth allocation per floor or department, while PCQ was used to distribute bandwidth automatically and fairly to each active connection. This approach aligns with the Quality of Service (QoS) principles in network traffic management.

3. Implementation Stage

The implementation was carried out on a MikroTik router by creating a PCQ queue type and integrating it into Simple Queue. The implementation procedure can be represented in the following algorithm:

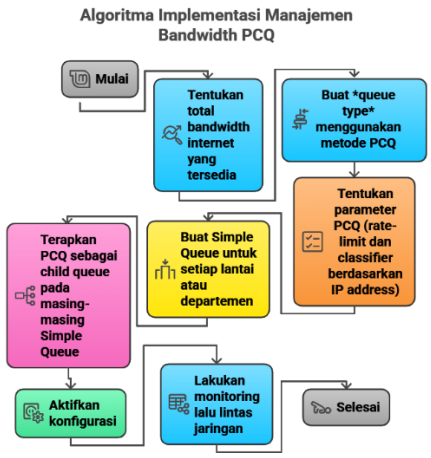

Figure 2. Algorithm Implementation Management of Bandwidth PCQ

The pseudocode of the bandwidth management algorithm is presented as follows:

```
START
SET total_bandwidth
FOR each department DO
   CREATE simple_queue(department)
   SET max_limit(simple_queue)
   CREATE pcq_type
   ATTACH pcq_type TO simple_queue
END FOR
ENABLE queue_configuration
MONITOR network_traffic
END
```

4. Data Acquisition

Data acquisition was conducted to obtain information regarding network performance before and after the implementation of the PCQ method. Data were collected through:

- Observation, by monitoring network traffic and connection responses during operational and peak hours.
- Interviews, with network administrators to gather information about network needs and constraints.
- System monitoring, using queue statistics and interface traffic features on the MikroTik router.

The collected data included actual bandwidth values, connection stability, and bandwidth usage suitability according to predetermined targets.

5. Testing

Testing was conducted using a comparative method before and after implementation. The testing parameters focused on:

- Suitability of actual bandwidth with the target allocation
- Fairness of bandwidth distribution among users
- Network connection stability

The testing results were analyzed descriptively to assess the effectiveness of the PCQ method in improving network service quality. This method aligns with the QoS evaluation approaches commonly used in computer network research.

C. Research Instruments and Measurement Indicators

The research instruments used in this study consisted of a MikroTik router configured through Winbox, queue statistics available in RouterOS, interface traffic monitoring, and an observation sheet for recording bandwidth allocation targets and actual throughput. Measurements were conducted by comparing network conditions before and after the PCQ implementation during normal operational periods and peak usage periods. This procedure was intended to ensure that the obtained results reflected practical network conditions rather than only configuration assumptions.

The evaluation indicators used in this study included bandwidth target suitability, distribution fairness, connection stability, user domination, and administrative feasibility. Target suitability was observed from the closeness between the planned bandwidth allocation and the actual bandwidth achieved after configuration. Distribution fairness was evaluated based on whether active users within the same floor or department could share available bandwidth proportionally. Connection stability was assessed from the consistency of throughput during monitoring, while user domination was identified from traffic patterns before and after PCQ activation.

The measurement interpretation was conducted descriptively by comparing the target bandwidth allocation with the observed bandwidth after implementation. A configuration was considered effective when the actual bandwidth value approached the predetermined target, traffic fluctuation decreased, and no single user or department dominated network resources. This evaluation approach was selected because the main objective of the study was to solve a practical bandwidth management problem in a real office network environment.

RESULTS AND DISCUSSION

A. Results of Bandwidth Management Implementation

The research results were obtained from network testing before and after implementing bandwidth management using the PCQ method combined with Simple Queue on a MikroTik router. The testing focused on bandwidth distribution across several floors/departments with predetermined bandwidth allocation targets.

Before implementing the PCQ method, observations showed that bandwidth distribution was uneven. Some users or departments excessively consumed bandwidth, causing reduced internet access speed and unstable connections for other users. This condition was indicated by significant bandwidth

fluctuations and the failure to achieve bandwidth allocation targets on each floor.

After implementing the Simple Queue and PCQ configuration, the testing results showed significant improvements in bandwidth fairness and stability. Each floor obtained bandwidth close to the predetermined target. For example, on the 17th floor, the achieved bandwidth ranged from 68.97–69.53 Mbps out of the 70 Mbps target, indicating that the PCQ method effectively and systematically distributed bandwidth.

Table 1. Comparison of Bandwidth Distribution Before and After PCQ Implementation

Location / Floor	Target Bandwidth **(Mbps)**	Before PCQ **(Mbps)**	After PCQ **(Mbps)**	Description
17 Floor	70	Unstable (≤55)	68,97 – 69,53	Close to target
Mezzanine	50	Fluctuating	±48 – 50	More stable
Basement 1	30	Uneven	±28 – 30	Stable
Basement 2	30	Uneven	±28 – 30	Stable

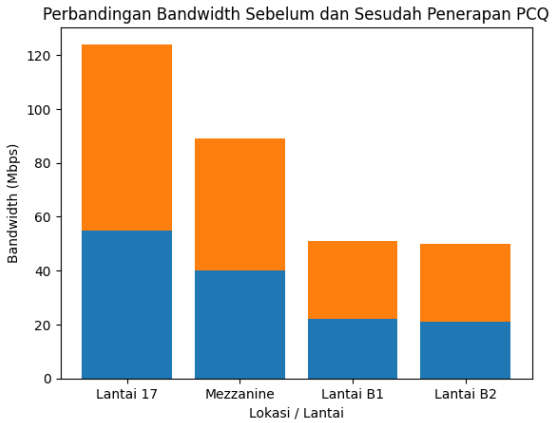

Figure 3. Comparison of Bandwidth Distribution Before and After PCQ Implementation

Figure 3 shows the comparison of bandwidth distribution before and after implementing the PCQ method. Before PCQ implementation, bandwidth usage on each floor tended to fluctuate and did not achieve the target allocation. After PCQ implementation, bandwidth on each floor became more stable and closer to the target value. This indicates that the PCQ method can improve bandwidth distribution fairness and reduce usage domination by certain users.

Table 2. Comparison of Network Conditions

Parameter	Before PCQ	**After PCQ**
Bandwidth Distribution	Uneven	Even
Connection Stability	Fluctuating	Stable
User Domination	Present	None
Target Suitability	Not achieved	Close to target

B. Discussion of Bandwidth Distribution Performance

The implementation of the PCQ method proved capable of overcoming bandwidth domination problems by certain users. This occurs because PCQ distributes bandwidth based on the number of active connections, ensuring that each user receives a relatively fair share of bandwidth. With this mechanism, traffic spikes from one user no longer significantly affect other users.

The combination of Simple Queue and PCQ also provides flexibility in bandwidth regulation among floors or departments. Simple Queue acts as the main bandwidth allocation limiter, while PCQ ensures internal distribution runs evenly. This approach produces a bandwidth management system that is not only fair but also easy to configure and manage by network administrators.

In terms of network stability, testing results showed that connections became more stable after PCQ implementation. Bandwidth fluctuations decreased, and network service quality improved, especially during peak hours. This directly impacted user convenience in accessing network-based services.

C. Novelty and Research Innovation

The novelty of this study lies in the practical implementation of the combination of Simple Queue and PCQ as an effective bandwidth management solution in multi-floor office network environments. Unlike approaches that only use static bandwidth limitation, this method enables adaptive bandwidth sharing based on the number of active connections, making it more suitable for multi-user network characteristics.

Furthermore, this study demonstrates that the PCQ method is not only effective in academic or small-scale environments but can also be practically implemented in corporate networks with varying bandwidth requirements across departments.

D. Research Implications

The implication of this study is the availability of a fair, measurable, and easy-to-implement bandwidth management solution using MikroTik routers. The results of this study can serve as a reference for network administrators in designing more efficient bandwidth management systems, particularly in network environments with many users.

Practically, implementing the PCQ method can improve network service quality and optimally support corporate business activities. This study also opens

opportunities for further development by integrating other Quality of Service (QoS) methods to comprehensively enhance network performance.

E. Research Limitations and Future Work

This study was limited to the implementation and evaluation of bandwidth distribution using Simple Queue and PCQ in a MikroTik-based office network environment. The evaluation focused on actual bandwidth achievement, fairness of distribution, connection stability, and the reduction of user domination. More detailed Quality of Service parameters such as latency, jitter, packet loss, and long-term throughput variation were not measured comprehensively. Therefore, the results should be interpreted as practical implementation evidence for bandwidth management rather than as a complete QoS benchmarking study.

Future research may expand the evaluation by comparing PCQ with Queue Tree, Hierarchical Token Bucket (HTB), and other queueing mechanisms in different network traffic conditions. Longer observation periods are also recommended to identify bandwidth behavior during daily, weekly, or monthly usage patterns. In addition, the integration of automated monitoring dashboards can be developed to record queue performance periodically, enabling network administrators to make data-driven decisions when adjusting bandwidth allocation policies.

CONCLUSION

Based on the research results and discussion, it can be concluded that implementing bandwidth management using the Per Connection Queue (PCQ) method combined with Simple Queue on a MikroTik router is effective in overcoming uneven bandwidth distribution problems. The implementation of this method improves bandwidth fairness and stability on each floor or department while preventing bandwidth usage domination by certain users. The testing results show that the actual bandwidth obtained after PCQ implementation is close to the predetermined allocation targets, thereby optimizing network service quality and supporting the company's operational activities. Therefore, the PCQ method can serve as a practical and efficient solution for network bandwidth management in office environments with many users.

ACKNOWLEDGEMENT

The author would like to express sincere gratitude to all parties who have contributed to the implementation, preparation, and writing of this research. Special thanks are extended to the PT Serasi Tunggal Mandiri dan network administrator for providing access to data and information that greatly supported this study.

In addition, the author would like to thank colleagues and all parties who have provided guidance, suggestions, and support throughout the research process. Finally, the author expresses heartfelt appreciation to family members for their prayers, support, and motivation, which made the completion of this research possible.

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