Bandwidth Management using Per Connection Queue and Queue Tree: A Case Study on a High School Network

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Abstract

This research aims to enhance the efficiency of bandwidth utilization at MTs Muhammadiyah Tawangsari using the PCQ and Queue Tree bandwidth management methods on a MikroTik router. Through this approach, an analysis of bandwidth requirements, network topology design, and implementation were conducted. Post-implementation measurement results show a remarkable improvement in average user download speeds: 17.3 Mbps in administration rooms, 10 Mbps in classrooms, and 18.8 Mbps in faculty rooms. These results indicate a significant improvement in tailored bandwidth distribution that meets the specific needs of each network area and ensures that all users receive equal bandwidth usage. This leads to more evenly distributed and efficient network performance.

Keywords: Bandwidth Management, MikroTik Router, Bandwidth Utilization Efficiency, PCQ, Queue Tree

1. Introduction

In the current age of technology, networks play a vital role in ensuring the long-term success of an organization, regardless of its size. Networks play a crucial role in facilitating communication, sharing information, and managing organizational activities [1]. Nevertheless, a prevalent problem encountered with networks is the constrained availability of bandwidth [2]. These issues can lead to disruptions in the organization's operations, including sluggish internet connectivity and the inability to exchange information. Hence, it is imperative for organizations to possess a proficient bandwidth management system to efficiently oversee their bandwidth [3].

The bandwidth management technology employed encompasses the Per Connection Queue (PCQ) and Queue Tree methodologies. PCQ is a valuable technique for enhancing the Quality of Service (QoS) in extensive internet networks by ensuring that each connection has its own queue, allowing for more granular control and fairness among multiple users [4]. This method helps prevent any single user from monopolizing the bandwidth, thereby improving overall network performance.

Queue Tree, on the other hand, is specifically designed to handle complex queue operations on network traffic. It allows for hierarchical queuing structures, enabling the organization of data transactions and prioritization of data packets based on specific criteria such as source connection, destination, or type of service. This hierarchical approach ensures that critical data is transmitted with higher priority, reducing excessive queuing and latency [5].

When combined, PCQ and Queue Tree methodologies offer a robust solution for bandwidth management. PCQ provides individualized queue management per connection, while Queue Tree offers a flexible and scalable structure for organizing and prioritizing traffic. This collaboration ensures efficient utilization of network resources, improved QoS, and a reduction in network congestion and latency [6][7].
2. Method
The Network Development Life Cycle (NDLC) method is an approach to developing computer network systems that allows for careful monitoring of system performance [8][9]. NDLC involves stages such as strategic business planning, application development lifecycle, and data distribution analysis. In this study, NDLC is utilized to design and implement bandwidth management at MTs Muhammadiyah Tawangsari, focusing on needs analysis, network topology design, prototype simulation, implementation, and network performance monitoring [10][11].

2.1 Analysis
Based on interviews and surveys with the network administrators of MTs Muhammadiyah Tawangsari, it was found that their network utilizes Optical Network Termination (ONT) or modems, which, although supporting large bandwidth capacities, cannot evenly distribute that capacity. Consequently, the first rooms accessing the internet receive larger bandwidth compared to subsequent users, resulting in uneven bandwidth usage and a lack of specific needs such as bandwidth management [12].

2.2 Designed System

Based on the analysis results, a new system design was developed to address the existing weaknesses [13]. Changes to the network topology include adding router devices. In the new topology (see Figure 1), all devices that were previously connected directly to the modem are now connected through routers. The router's function is to regulate more even bandwidth distribution through bandwidth management on MikroTik routers [14]. The design of IP addressing allocation was also planned to optimize the network, with IP addresses divided into four main networks: internet source, computer laboratories, faculty rooms, classrooms, and administrative rooms (see Table 1).
Table 1 IP Address Allocation

<table>
<thead>
<tr>
<th>Device</th>
<th>Blok IP</th>
<th>Usable IP</th>
<th>Gateway</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBD53iG</td>
<td>192.168.1.0/24</td>
<td>192.168.1.1 - 192.168.1.254</td>
<td>192.168.1.1</td>
<td>Modem ISP</td>
</tr>
</tbody>
</table>

The bandwidth management design using the Per Connection Queue (PCQ) method ensures even bandwidth distribution according to the number of users. This method automatically divides bandwidth based on the number of users accessing the internet, with readjustments made when additional users are added [15]. The implementation of this design aims to improve efficiency and security in the network at MTs Muhammadiyah Tawangsari (see Table 2).

Table 2 Bandwidth allocation using the PCQ method

<table>
<thead>
<tr>
<th>Network</th>
<th>Bandwidth</th>
<th>Keterangan</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.8.0/26</td>
<td>15/50Mbps</td>
<td>Lab-Kom</td>
</tr>
<tr>
<td>192.168.8.64/26</td>
<td>10/20Mbps</td>
<td>Ruang-Guru</td>
</tr>
<tr>
<td>192.168.8.128/26</td>
<td>10/20Mbps</td>
<td>Ruang-TU</td>
</tr>
<tr>
<td>192.168.8.192/27</td>
<td>8/10Mbps</td>
<td>Ruang-Kelas</td>
</tr>
<tr>
<td>192.168.8.0/26</td>
<td>15/50Mbps</td>
<td>Lab-Kom</td>
</tr>
</tbody>
</table>

3. Results and Discussion

3.1 Bandwidth Management System Implementation

At this stage, the primary focus is on implementing and configuring the bandwidth management system using PCQ (Per Connection Queue) and Queue Tree to ensure even and optimal internet distribution at MTs Muhammadiyah Tawangsari. This process includes hardware installation and software configuration using the Winbox application [16].

3.2 Bandwidth Management Configuration Implementation

3.2.1 IP Configuration

Basic configuration on the MikroTik router is done to ensure the network runs optimally so that bandwidth can be evenly distributed later [17]. The first step is interface configuration, where interfaces are checked, and unused ports are disabled. Next, each port is assigned an IP address according to its path, with ether 2 to ether 5 for users and the internet ether connected to the internet path (see Figure 2).

Figure 2 IP Address Configuration Result

3.2.2 Configuration with PCQ and Queue Tree

Bandwidth management is set up by creating firewall mangle and queue list settings using PCQ features to evenly distribute bandwidth [18].

1. Firewall Mangle

Firewall mangle is used to create packet marking, which functions to label or mark packets entering the router. Figure 3 shows the firewall mangle configuration result.
2. Queue List

After creating packet marking, bandwidth management configuration is done using Queue Tree and PCQ to evenly distribute bandwidth. Figure 4 shows the bandwidth management configuration result.

![Queue List](image1)

Figure 3 Firewall Mangle Configuration Result

![Queue List](image2)

Figure 4 Bandwidth Management Configuration Result

3.2.3 Implementation Results and Discussion

After implementing bandwidth management using PCQ and Queue Tree, the network at MTs Muhammadiyah Tawangsari experienced significant improvement compared to the previous conditions [19].

Previously, bandwidth distribution was uneven, causing some users to have slower internet access. However, after implementation, bandwidth usage became more controlled and evenly distributed in each room, as seen in the test results in Figure 5.

![Queue List](image3)

Figure 5 Queue Tree Inspection Result

With this improvement, internet connectivity in each room becomes more stable and reliable. Each room receives bandwidth allocation according to its needs, enhancing the user experience in accessing the internet.

The results demonstrate the effective performance of the Queue Tree and PCQ methodologies for bandwidth management. Through the implementation of these techniques, all users in the network receive equitable bandwidth utilization, ensuring a fair distribution of network resources.

4. Conclusion

Based on the results and discussions presented, it can be concluded that the combined use of PCQ and Queue Tree methods for bandwidth management has been successfully implemented at MTs Muhammadiyah Tawangsari. This algorithm effectively allocates bandwidth evenly to each client, ensuring that no single user monopolizes the network, thus maintaining a balanced and efficient network performance. This is evidenced by speed test results, which show download speeds of 17.3 Mbps in administrative rooms, 10
Mbps in classrooms, and 18.8 Mbps in faculty rooms. These results indicate a significant improvement in the distribution of bandwidth, tailored to meet the specific needs of each network area, all users in the network receive equitable bandwidth utilization, resulting in a more evenly distributed and efficient network performance.

References

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