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].
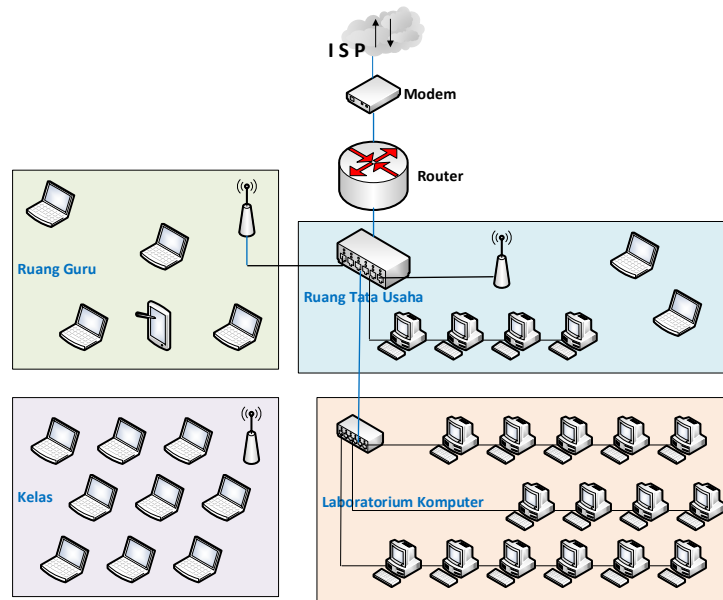
2.2 Designed System

Figure 1 Planned network topology.

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

Device	Blok IP	Usable IP	Gateway	Description
	192.168.1.0/24	192.168.1.1 - 192.168.1.254	192.168.1.1	Modem ISP
	192.168.8.0/26	192.168.8.1 - 1923.168.8.62	192.168.8.1	Lab-Kom
RBD53iG	192.168.8.64/26	192.168.8.65 - 192.168.8.126	192.168.8.65	Ruang-Guru
	192.168.8.128/26	192.168.8.129 - 192.168.8.190	192.168.8.129	Ruang-Kelas
	192.168.8.192/27	192.168.8.193 - 192.168.8.222	192.168.8.193	Ruang-TU

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

| Network	Bandwidth	Keterangan
192.168.8.0/26	15/50Mbps	Lab-Kom
192.168.8.64/26	10/20Mbps	Ruang-Guru
192.168.8.128/26	10/20Mbps	Ruang-TU
192.168.8.192/27	8/10Mbps	Ruang-Kelas
192.168.8.0/26	15/50Mbps	Lab-Kom

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).
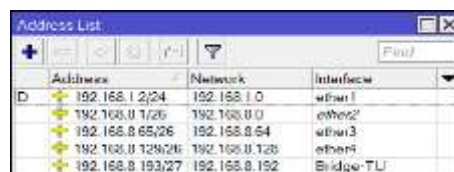
Figure 2 IP Address Configuration Result

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.
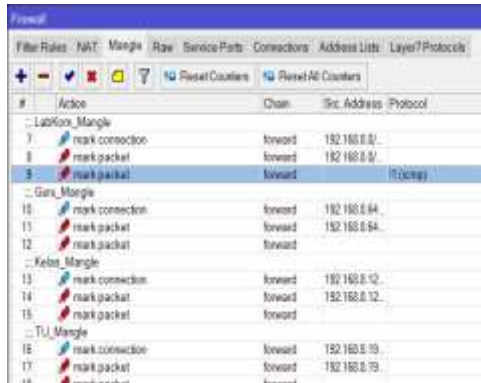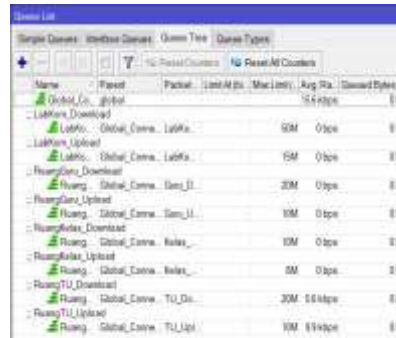

Figure 3 Firewall Mangle Configuration Result

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.
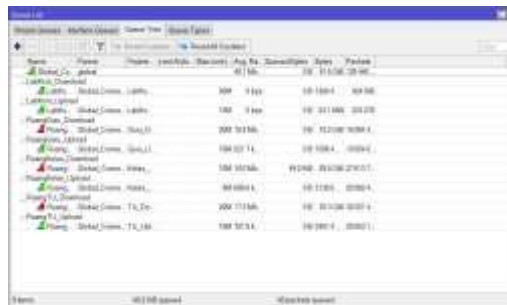

Figure 5 Queue Tree Inspection Result

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

[1] F. W. Christanto, A. F. Daru, and A. Kurniawan, "Metode PCQ dan Queue Tree untuk Implementasi Manajemen Bandwidth Berbasis Mikrotik," *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, vol. 5, no. 2, pp. 407–412, Apr. 2021, doi: 10.29207/RESTI.V5I2.3026.

[2] R. Sopandi, . S., H. Priyandaru, A. Taufik, and U. Saputra, "Implementasi Manajemen Bandwidth Pada Smk Darul Mu'in Pakuhaji Dengan Metode Simple Queue Dan Filtering Content," *Technologia : Jurnal Ilmiah*, vol. 14, no. 2, pp. 117–123, Apr. 2023, doi: 10.31602/TJI.V14I2.9546.

[3] E. Mufida, D. Aryo Krisnadi, and T. Informatika STMIK Nusa Mandiri Jakarta, "Implementasi Manajemen Bandwidth Menggunakan Metode Queue Tree (Studi Kasus Pada Universitas Pancasila)," *Jurnal Teknologi Informatika dan Komputer*, vol. 5, no. 1, pp. 19–23, Mar. 2019, doi: 10.37012/JTIK.V5I1.242.

[4] M. S. Anwar, "Analisis QoS (Quality of Service) Manajemen Bandwidth menggunakan Metode Kombinasi Simple Queue dan PCQ (Per Connection Queue) pada Fakultas Teknik Universitas Islam Sumatera Utara," *sudo Jurnal Teknik Informatika*, vol. 1, no. 2, pp. 82–97, Jun. 2022, doi: 10.56211/SUDO.V1I2.24.

[5] S. Luthfi, S. Kapita, H. K. Sirajuddin, Y. Muin, "Development of Adaptive Bandwidth Allocation Model Using PCQ for Network Performance Optimization," *Technium: Romanian Journal of Applied Science and Technology*, vol. 17, pp. 234–237, Nov. 2023, ISSN: 2668-778X.

[6] C. Smansub, B. Purahong, P. Sithiyopasakul, C. Benjangkaprasert, "A Study of Network Bandwidth Management by Using Queue Tree with Per Connection Queue," *11th International Conference on Computer and Electrical Engineering*, 2019, doi: :10.1088/1742-6596/1195/1/012019.

[7] M. M. Hamdi. H. F. Mahdi, M. S. Abood, R. Q. Mohammed, A. D. Abbas, A. H. Mohammed, "A review on Queue Management Algorithms in Large Networks," *IOP Conference Series: Materials Science and Engineering, 2nd International Scientific Conference of Engineering Sciences (ISCES 2020)*, vol. 1076, doi: 10.1088/1757-899X/1076/1/012034.

[8] F. M. Naufal, M. R. Vahlevi, A. Widayana, M. L. Zulfa, and D. Juardi, "Implementasi Keamanan Hotspot Menggunakan Proxy Dan Firewall Dalam Mengatasi Resiko Ancaman Serangan," *Jurnal Ilmiah Rekayasa dan Manajemen Sistem Informasi*, vol. 8, no. 2, p. 148, Aug. 2022, doi: 10.24014/RMSI.V8I2.17691.

[9] M. Husnaini, W. Bagye, and M. Ashari, "Implementasi Fitur Layer 7 Protocols Mikrotik Rb750 Di Smkn 1 Narmada," *Jurnal Informatika dan Rekayasa Elektronik*, vol. 2, no. 1, p. 78, Apr. 2019, doi: 10.36595/JIRE.V2I1.94.

[10] Y. Mulyanto, M. Julkarnain, and A. J. Afahar, "Implementasi Port Knocking Untuk Keamanan Jaringan Smkn 1 Sumbawa Besar," *JINTEKS*, vol. 3, no. 2, 2021.

[11] A. I. Fajrin, S. Sidik, and R. I. Riyana, "Implementasi Manajemen Bandwidth Menggunakan Simple Queue Dan Filtering Content Pada Pusat Pelatihan Kerja Pengembangan Industri jakarta Timur," *Reputasi: Jurnal Rekayasa Perangkat Lunak*, vol. 2, no. 1, pp. 26–30, Jun. 2021, doi: 10.31294/REPUTASI.V2I1.134.

[12] P. D. Oktaviansyah, P. Korespondensi, : Paradika, and D. Oktaviansyah, "Penerapan Sistem Pengamanan Port pada Mikrotik Menggunakan Metode Port Knocking," *Journal of Network and Computer Applications (ISSN: 2964-6669)*, vol. 1, no. 2, pp. 78–90, Jul. 2022, Accessed: May 16, 2024. [Online]. Available: https://jurnal.netplg.com/index.php/jnca/article/view/10

[13] D. Desmira and R. Wiryadinata, "Rancang Bangun Keamanan Port Secure Shell (SSH) Menggunakan Metode Port Knocking," *Jurnal Ilmu Komputer dan Sistem Informasi (JIKOMSI)*, vol. 5, no. 1, pp. 28–33, Mar. 2022, doi: 10.55338/JIKOMSI.V5I1.242.

[14] B. Ali and M. W. Komala, "Perbandingan Fitur Layer 7 Protocol dan Web Proxy untuk Sistem Keamanan Filtering Rule SMPN 5 Palopo," *Jurnal Literasi Digital*, vol. 1, no. 1, pp. 18–23, Mar. 2021, doi: 10.54065/JLD.1.1.2021.3.

[15] M. Ilham, I. Gunawan, and A. Siregar, "Keamanan Jaringan Wlan Dengan Metode Firewall Filtering Menggunakan Mikrotik Pada Smp Negeri 1 Dolok Merawan," *Jurnal ilmiah Sistem Informasi dan Ilmu Komputer*, vol. 2, no. 3, pp. 01–16, Nov. 2022, doi: 10.55606/JUISIK.V2I3.309.

[16] D. Desmira and R. Wiryadinata, "Rancang Bangun Keamanan Port Secure Shell (SSH) Menggunakan Metode Port Knocking," *Jurnal Ilmu Komputer dan Sistem Informasi (JIKOMSI)*, vol. 5, no. 1, pp. 28–33, Mar. 2022, doi: 10.55338/JIKOMSI.V5I1.242.

[17] C. Prihantoro, A. K. Hidayah, and S. Fernandez, "Analisis Manajemen Bandwidth Menggunakan Metode Queue Tree pada Jaringan Internet Universitas Muhammadiyah Bengkulu," *Just TI (Jurnal Sains Terapan Teknologi Informasi)*, vol. 13, no. 2, p. 81, Jul. 2021, doi: 10.46964/JUSTTI.V13I2.750.

[18] B. Rifai Teknik Informatika, S. Nusa Mandiri Jl Damai No, and W. Jati Barat Jakarta Selatan, "Management Bandwidth Pada Dynamic Queue Menggunakan Metode Per Connection Queuing".

[19] I. Purnamasari and M. A. Mustofa, "Optimasi Pemanfaatan Local Area Network dengan 7 Layer Protocol," 2019.