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Bandwidth Management Analysis Using the Peer Connection Queue (PCQ) Method with Radius Authentication (Case Study at A Vocational High School in Bandung)

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ABSTRACT

This study examines the application of bandwidth control through the Per Connection Queue (PCQ) approach within the computer network of a vocational school in Bandung. The project aims to optimize bandwidth management for users, including students, instructors, and school personnel, utilizing Mikrotik routers and the Winbox program. The study confines its focus to the school's Wi-Fi network, which operates from 08:00 to 15:00. By limiting the study to specific aspects, the research aims to enhance its focus and yield accurate results.

The research approach employs a descriptive analysis method to delineate the established bandwidth management system, in conjunction with the Network Development Life Cycle (NDLC) method for system development. Data collection is performed by configuring the PCQ, RADIUS authentication, and firewall and filtering parameters to block irrelevant websites. The system will undergo testing via simulation and installation to assess its effectiveness in improving network performance. The findings demonstrate that the PCQ technique effectively improves bandwidth utilisation, whereas RADIUS authentication provides an additional security layer for users within the vocational school network. The implementation of this system is anticipated to reduce internet disruptions, enhance service quality, and facilitate educational activities within the school. The research advocates for the establishment of a real-time monitoring system and the provision of training for network users to ensure efficiency and security.

Keywords: Bandwidth, PCQ, Mikrotik

INTRODUCTION

In the advanced digital era, internet access has become essential for educational institutions, including vocational schools in Bandung. The internet is essential for facilitating educational activities, including access to online materials, communication between educators and learners, and improved school management. Nonetheless, the increasing number of users and linked devices has rendered bandwidth management a considerable concern. This vocational institution, dedicated to offering optimal facilities for students and educators, encounters challenges in bandwidth management. Unregulated bandwidth consumption can result in sluggish and unreliable internet connections, hence hindering the educational process. Consequently, a proficient bandwidth management solution is essential to guarantee equitable and optimal access for all users.

The Per Connection Queue (PCQ) method is a bandwidth control mechanism that can resolve this issue. PCQ facilitates equitable bandwidth distribution based on the number of connections established by users. (Budi Purnomo Siahaan et al., 2022) This strategy allocates a proportional share of bandwidth to each user, preventing any individual user or device from monopolising bandwidth consumption.

Furthermore, a robust authentication mechanism is crucial for maintaining security and order in network usage. Authentication identifies authorised users and regulates access to the network, permitting only registered individuals to utilise network resources. This study aims to assess the effectiveness of bandwidth control using the Per Connection Queue (PCQ) approach in conjunction with RADIUS authentication at a vocational institution in Bandung. The analysis will encompass an assessment of network performance before and after the implementation of PCQ and authentication, along with the identification of advantages and obstacles encountered during the implementation process.

Bandwidth measures the volume of information that can be transmitted from one location to another within a specified period. (Sari et al., 2022) It can evaluate both analogue and digital data streams, albeit it is now predominantly utilised for assessing digital data flow. The measurement unit for bandwidth is bits per second, commonly abbreviated as bps. A bit, or binary digit, is the fundamental unit of information comprising the digits 0 and 1. This

measure quantifies the number of bits (0s and 1s) that can be transmitted over a medium per second.

Bandwidth

Data communication transpires at a precise instant when bandwidth is employed. The term "bandwidth" is frequently encountered in everyday life. Bandwidth classifications are divided into two primary categories:

1. Digital Bandwidth
   Digital bandwidth denotes the volume of data transmitted in bits per second over a network. This bandwidth conveys information in a digital format, either via cables or wirelessly.
2. Analogue Bandwidth
   Analogue bandwidth denotes the frequency range, measured in Hertz, within which a signal can be precisely captured. Furthermore, analog bandwidth generally possesses a comparatively diminished capacity compared to digital bandwidth (Muhammad, Ibrahim Hasan, 2016).

Bandwidth management is a network administration strategy designed to provide equitable and optimal network performance for linked devices. It is utilized to ensure that adequate bandwidth meets the traffic requirements of data and information, thereby mitigating competition among applications (Subhiyanto, 2021).

Simple Queue

An uncomplicated approach for restricting bandwidth based on data velocity. Simple Queue is a bandwidth management technique utilised in small to medium-scale networks to control each user's download and upload bandwidth consumption. (Mariyanto & Maslan, 2023)

The Per-Connection Queue is an enhancement of the Stochastic Fairness Queuing (SFQ) technique. Both models function similarly, as they endeavor to equilibrate internet network traffic by generating a substream (or subqueue) (Nafa Nandi, 2024).

Quality of Service is a metric for assessing the condition of a network and aims to delineate the qualities and nature of a service. Quality of Service is generally employed to assess a certain array of performance characteristics.

Packet loss is a metric that signifies the total number of lost data packets resulting from collisions and congestion across all applications, as transmission diminishes overall network efficiency despite sufficient bandwidth. (Prasetyo, E., Santoso, T., & Riyadi, 2024)

Index	Quality	Packet Loss
4	Very Good	0%
3	Good	3%
2	Average	15%
1	Poor	25%

It is based on Linux and designed for use in network routers. Mikrotik routers are equipped with several features, including bandwidth management, a firewall, a plug-and-play hotspot, and remote Winbox GUI management and routing capabilities.

Winbox

A tool employed for Mikrotik connecting and configuration via MAC addresses or IP protocols. Winbox enables the rapid and straightforward configuration of Mikrotik RouterOS and Routerboard through a graphical user interface. Winbox is constructed with the Win32 binary but is operable on Linux and Mac OSX via Wine. All Winbox functions are meticulously crafted to resemble console functions closely, ensuring the use of identical terminology (Dennis, 2023).

Computer network

A telecommunications network enabling data exchange between computers for communicative purposes. The objective of a computer network is to fulfil its goals, wherein each component can solicit and deliver services. The entity seeking or receiving services is referred to as a client, whereas the entity providing or dispatching services is termed a server. This architecture is referred to as a client-server system and is utilised in nearly all computer network applications (Haryadi, J. H. J., Ubaidi, U., Hari, N. H. H. N. H., & Rachman, 2024).

Topology is a technique for interlinking computers to establish a network. The topology employed will dictate the network's functionalities, hence influencing its future performance. Consequently, a Network Engineer must be proficient in understanding various network topologies and adeptly implement them in the network under construction (Sofyar, S., Risdayati, S., & Andini, 2024).

This project aims to develop effective bandwidth management solutions for implementation at a vocational school in Bandung and to provide valuable insights for other institutions facing similar challenges. Ultimately, in light of the aforementioned academic background, I plan to execute bandwidth control utilising Mikrotik routers at a vocational school in Bandung.

METHOD

Bandwidth management is a network administration strategy designed to ensure equitable and optimal network performance for devices linked to the network. This method facilitates the efficient allocation of resources, guaranteeing a fair experience for all users.

Moreover, bandwidth management is employed to ensure that sufficient bandwidth meets the traffic requirements of data and information. This approach mitigates competition among apps, facilitating smoother operation and enhancing overall performance (Faisal & Fauzi, 2018).

DISCUSSION

Analysis of the Running System

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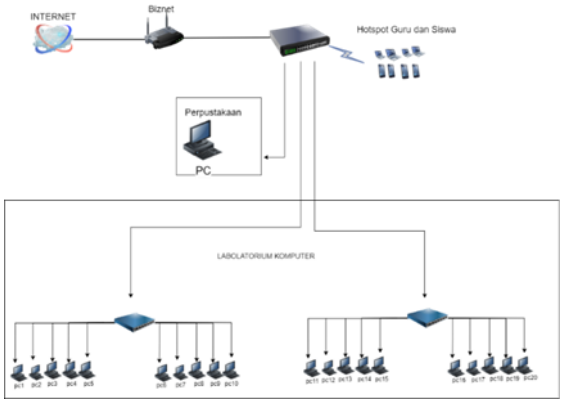

Figure 1. Analysis of the Running System

The vocational school in Bandung utilises a Local Area Network (LAN) configured in a star topology. The network comprises an Indihome modem, which also serves as an access point. This access point facilitates the distribution of internet connectivity to wireless-enabled devices. Internet connectivity is available in many locations, including the principal's office, faculty rooms, and the computer lab. The modem is connected via a UTP cable to various hubs, which subsequently provide an internet connection to the server PC and multiple computers in the lab. The following illustrates the network topology that was formerly implemented at the vocational school in Bandung.

Analysis of Problems Found in Existing Network

1. Internet Connection Often Down:

   The internet connection often suffers from disturbances, resulting in unstable access. These disruptions may result from the restricted capacity of the Indihome modem or complications with the internet service provider. Moreover, the devices' shortcomings in managing excessive traffic may also be a contributing cause.
2. Ineffective Bandwidth Management:

   The absence of efficient bandwidth management results in an uneven distribution of bandwidth among users. Certain users may encounter sluggish connections, particularly during periods of high demand. The existing Indihome modem lacks sufficient bandwidth management capabilities, which hinders the ability to regulate and distribute bandwidth according to the requirements of individual users or applications.
3. Inconsistent Network Performance:

User experiences differ, as speeds may significantly decrease during periods of heavy user activity or when bandwidth-intensive programmes are in use. The erratic network performance may result from the constraints of network devices in managing significant traffic concurrently, along with the absence of traffic prioritization configurations.

4. Lack of User Authentication

   The lack of an authentication method permits unrestricted access to the network for anyone within the Wi-Fi range, potentially resulting in misuse and diminished network performance. The absence of sufficient authentication permits unrestricted access, potentially overloading the network with unauthorised users.

5. Network Security:

   The lack of a comprehensive security mechanism renders the network susceptible to unauthorised access and cyberattacks. The existing network hardware (modem/router) may lack sufficient security measures, and insufficient monitoring of network access might intensify security vulnerabilities.

6. Bandwidth Settings Based on Needs:

   In the absence of consistent bandwidth control, high-bandwidth apps or services may impair the operation of other applications, including access to online educational resources. The absence of policies or controls for allocating bandwidth according to application priority or user requirements may result in performance issues.

Proposed Use Case

Weighted Average Method Analysis

The proposed Use Case delineates the operations undertaken in bandwidth management. This diagram delineates the processes represented within a collection of Use Cases, the participating actors, and their interrelations as illustrated in the Use Case diagram. The Use Case diagram offers a visual depiction of all actors and their interactions within a system. It provides a succinct summary of the interactions among Use Cases, actors, and the system, without detailing the utilisation of a Use Case. This Use Case will elucidate the functionalities inherent in the developed system. The suggested Use Case for a vocational high school in Bandung is outlined as follows:

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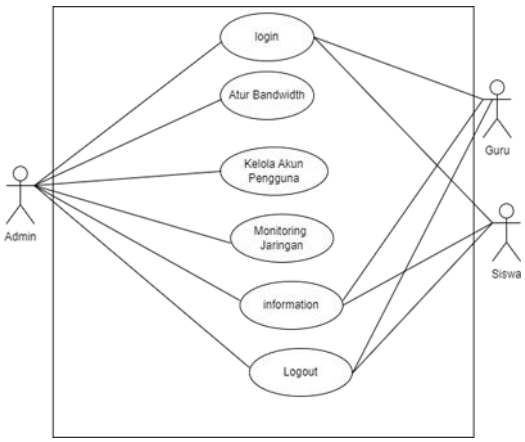

Figrue 2. Proposed Use Case

Proposed Topology Design

The suggested network configuration for bandwidth management analysis employs the Per Connection Queue (PCQ) method with authentication at a vocational high school in Bandung, aimed at optimising bandwidth allocation and improving network access security.

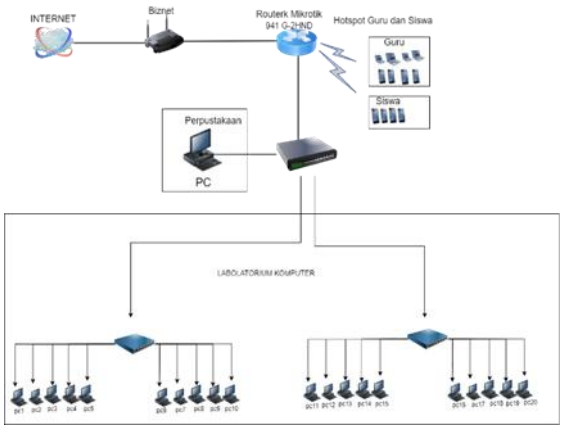

Figure 3. Proposed Topology Design

The Internet Service Provider (Biznet) supplies a bandwidth of 50 Mbps to SMK Mekarrahayu, which is administered via the Per Connection Queue (PCQ) technique on the MikroTik router. The bandwidth is allocated as follows: 5 Mbps for the library, 20 Mbps for the computer lab, 15 Mbps for students, and 10 Mbps for teachers. The MikroTik router presently connects to devices situated 20 to 40 metres from the internet source, enabling users or clients to access the internet. Nonetheless, a significant issue arises: clients frequently encounter buffering and network outages when utilised concurrently due to the absence of

bandwidth restrictions for each client. The resolution is to do bandwidth management. This will enhance service for users or clients by avert bandwidth conflicts that result in network downtime.

User Analysis

The objective of user analysis is to collect the information required to devise and execute essential enhancements or modifications.

1. User and student information

No	Description	Teacher	Learners
1	Man	8	23
2	Woman	6	16
TOTAL		14	39

2. Room data

   In a vocational high school in Bandung, there exists a room with the following specifications:

No	Description	Amount
1	Classroom	3
2	Lab Room	1
3	Library Room	1
4	Teacher's room	1
TOTAL		6

   Simulation Prototype

   Executing a prototype system trial by emulating the deployment of a system utilising Virtualbox and Mikrotik OS. This will offer a comprehensive summary of the network connection procedure for all connected devices.

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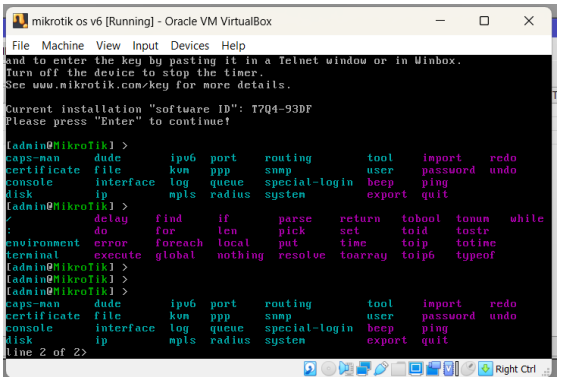

Figure 4. Simulation Prototype

Design Implementation

The Per Connection Queue method is a bandwidth management strategy that facilitates equitable distribution by prioritising traffic according to individual connections. Each user connection is individually managed using a dedicated bandwidth queue, ensuring that no one connection monopolises bandwidth and compromises the performance of others.

The Bandwidth Setting Implementation phase consists of a succession of configurations established in prior stages. This phase will elucidate the configuration of basic queue bandwidth control. Biznet allocates the 50 Mbps bandwidth through the Per Connection Queue (PCQ) technique on the MikroTik router, distributing it into four segments: 5 Mbps for the library, 20 Mbps for the computer lab, 15 Mbps for students, and 10 Mbps for teachers.

Monitoring

The subsequent phase following deployment in the six stages of the NDLC approach is network monitoring.

Throghput

Throughput refers to the volume of data effectively transmitted across a network within a specified timeframe. Throughput may be quantified in bits per second (bps), bytes per second (Bps), kilobits per second (kbps), or kilobytes per second (KBps).

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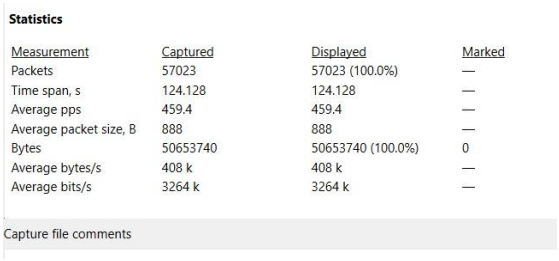

Statistics

Measurement	Captured	Displayed	Marked
Packets	57023	57023 (100.0%)	—
Time span, s	124.128	124.128	—
Average pps	459.4	459.4	—
Average packet size, B	888	888	—
Bytes	50653740	50653740 (100.0%)	0
Average bytes/s	408 k	408 k	—
Average bits/s	3264 k	3264 k	—

Capture file comments

Figure 5. Throghput

From the data above there is:

Total *Bytes*: 50,653,740 bytes

Total *Time*: 124.128 detik

So Throughput:

$$Throughput = \frac{50{,}653{,}740\ bytes}{124.128\ detik}$$

Throughput = 408,000 *bytes/s* = 3,264,000 *bits/s* =3.264 *Mbps*

Packet Loss

Packet loss transpires when one or several data packets transmitted over a network do not arrive at their intended destination. Packet loss can be quantified as a proportion of the total packets transmitted.

From the existing data:

Captured packets = 57,023

Displayed packets = 57,023

Lost packets = Total Sent Packets - Captured packets (tidak ada packet loss yang tercatat di sini, sehingga Packet Loss = 0%).

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Management

The subsequent phase is management or administration. This phase encompasses the maintenance and preservation of the entire constructed system.

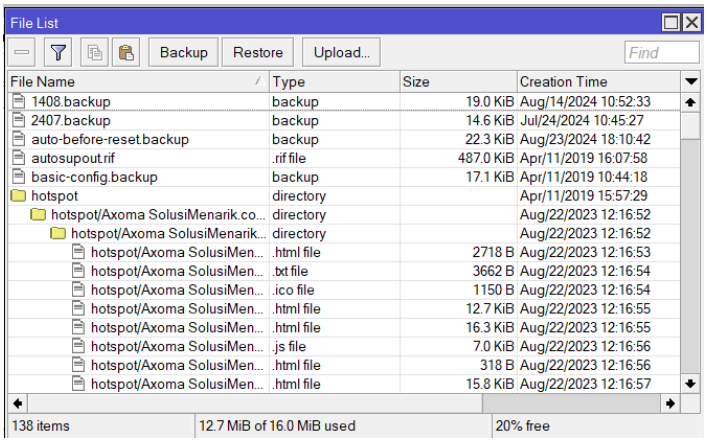
During this phase, various management measures will be implemented to guarantee the system functions as anticipated. The actions undertaken comprise:

1. Authenticate with hotspot login

Figure 6. Authenticate with hotspot login

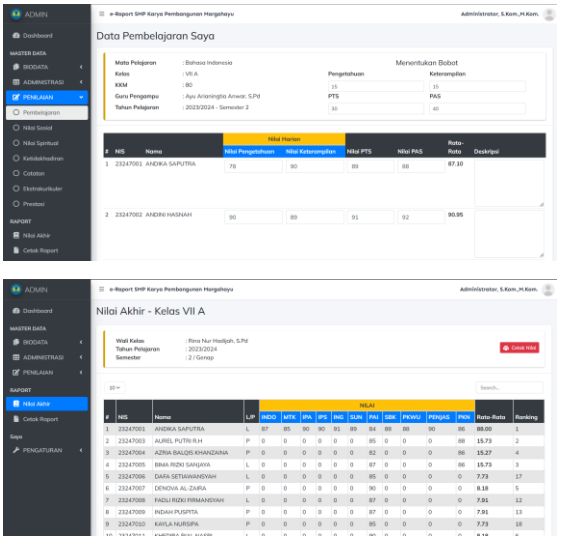
In the image above, the network at one of the vocational high schools in Bandung for wireless already has a login page, so if a user from outside randomly enters, they must go through authentication first.

2. Mikrotik backup configuration



Figrue 7. Mikrotik backup configuration

The backup configuration for MikroTik is essential. If the router configuration encounters an issue, the system can be reset and restored.



CONCLUSION

This study effectively illustrates that the application of bandwidth management through the Per Connection Queue (PCQ) approach in a vocational high school network in Bandung may improve bandwidth utilisation efficiency. The system, utilizing a MikroTik router and the Winbox program, efficiently manages bandwidth for students, teachers, and staff while enhancing security through RADIUS authentication.

The research findings demonstrate that the use of this technology can reduce internet connection interruptions and enhance service quality, significantly benefiting the educational activities at the school. The report advocates for the establishment of a real-time monitoring system and the provision of training for network users to maintain continuous efficiency and security.

This research presents a targeted and practical approach to bandwidth management in an educational setting.

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