JEECS (Journal of Electrical Engineering and Computer Sciences)
Vol. 10, No. 1, June 2025, pp. 59-68
e-ISSN: 2579-5392 p-ISSN: 2528-0260

Implementation of Internet Network Load Balancing at the Faculty of Computer Science UNUSIDA Using the ECMP Method

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Article Info

Article history:
Received: 15 November 2024
Revised: 31 December 2024
Accepted: 3 January 2025

Keyword:
Bandwidth
ECMP
Internet
Load balancing
Mikrotik

Abstract

A stable internet speed is essential in supporting worker and student task completion. Slow internet connectivity can become a persistent hindrance if it occurs continuously. Previous research indicates that conventional load balancing methods still have limitations in handling uneven traffic loads. This study, therefore, explores methods to optimize internet link utilization by distributing traffic load evenly, known as load balancing, using the Equal Cost Multi-Path (ECMP) method. This approach aims to maintain maximum data/packet flow, thereby preventing overload on a single link or connection failure. Testing was conducted by comparing network performance before and after ECMP implementation on two different ISPs. The test results showed that before implementing the ECMP method load balancing, the internet speed of ISP 1 was 29 Mbps, and the speed of ISP 2 was 16 Mbps. While after implementing load balancing using the ECMP method, the internet speed was 63 Mbps. Therefore, it is proven that implementing load balancing using the ECMP method can maintain and increase connection speed and share the load on both gateways so that overload does not occur.

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DOI: https://doi.org/10.54732/jeecs.v10i1.7

1. Introduction

In the advancing digital era, the Internet has become an essential infrastructure within educational institutions, particularly at the Faculty of Computer Science at Nahdlatul Ulama University of Sidoarjo (UNUSIDA). The Internet serves as a means of communication and a channel for disseminating information or educational developments to all levels of society. The internet has many uses, particularly in education, functioning as an information repository, a news distribution platform, and a source for both free and paid downloads [1]. The growing demand for internet usage across various fields has led administrators to utilize and integrate multiple Internet Service Providers (ISP) to ensure sufficient internet availability [2].

One of the most effective approaches to handling heavy traffic loads is through load balancing techniques. Network load balancers are important components in data centers that provide scalable services. Workload distribution algorithms are based on heuristics, e.g., Equal-Cost Multi-Path (ECMP) [3]. Load balancing distributes workloads evenly across multiple paths or servers to prevent congestion at a single point. In UNUSIDA's internet network, this helps optimize resources and enhance connectivity performance. One way to improve network quality is by using more than one ISP, ensuring that the other can serve as a backup if one ISP encounters issues. With load balancing, traffic runs optimally, maximizing throughput, reducing response time, and preventing overload on a single connection path [4]. Internet access is a crucial element in academic processes, so when an ISP experiences disruptions, campus connectivity can be lost. As a result, all academic activities, research, and administrative tasks may be hindered as lecturers, students, and staff cannot access internet-based data or services. By utilizing two ISPs, this issue can be effectively addressed [5].

Internet Service Providers (ISP) offer both local and international connections, with bandwidth serving as an indicator of data transmission capacity. As demand increases, campuses can utilize multiple ISPs and implement Equal Cost Multi-Path (ECMP) to efficiently distribute network traffic. The Faculty of Computer Science at UNUSIDA is expected to benefit from improved speed, stability, and efficient network management, supporting digital learning, collaborative research, and integrated online administration [6]. In the use of a single line, if there is a sudden increase in data traffic, it will cause the server to become burdened which causes a decrease in performance. However, in the ECMP method network performance can be increased by utilizing the available paths by dividing data traffic evenly so that the server is not overloaded and if one path fails or is interrupted, the data packet will be diverted to another available path. The ECMP method is an effective load-balancing method for optimizing network performance, where in complex networks ECMP can help increase network availability and speed up data transmission [7].

Load balancing is responsible for distributing and balancing traffic loads across two or more ISPs evenly, ensuring optimal throughput, minimizing response time, and preventing overload on any single ISP path [8]. The mechanism involves MikroTik evenly distributing the load between the two ISPs and selecting the appropriate ISP route [9]. Load balancing is widely used by institutions and companies both in Indonesia and globally. The computing distribution technique with load balancing works by dividing the load across multiple network links. Load balancing techniques are categorized into several methods, including static route using Nth, address list, Equal Cost Multi-Path (ECMP), failover, and Per Connection Classifier (PCC) [10]. Therefore, many universities utilize multiple ISPs to prevent internet access disruptions. Network infrastructure with more than one ISP is designed to maintain connection quality by providing a reliable backup route if the primary route experiences issues, ensuring that academic and administrative activities continue smoothly without interruptions [11]. Despite its widespread use, the Equal-Cost Multi-Path (ECMP) method has limitations, such as hash collisions that can degrade the performance of throughput-dependent applications and increase latency for delay-sensitive applications [12].

Furthermore, the ongoing development in information and communication technology has intensified the need for fast, stable, and secure internet connectivity within academic environments. At UNUSIDA's Faculty of Computer Science, the internet functions as the backbone supporting various activities, from digital-based learning and collaborative research to integrated administrative management. The rising demand for internet connectivity is not only driven by an increase in the number of users but also by the growing use of connected devices like laptops, smartphones, and IoT (Internet of Things) devices, which add complexity and volume to network traffic. Relying on a single internet line without appropriate traffic management can lead to bottlenecks, where one part of the network becomes overly congested, disrupting overall network performance. Therefore, implementing ECMP in load balancing becomes crucial in ensuring each available internet path is optimally utilized, avoiding potential bottlenecks and guaranteeing consistent network performance to support various academic and administrative activities.

2. Research Methodology

2.1 Load Balancing

Load balancing is a technique for distributing network load across multiple available paths to increase throughput and reduce response time. If a MikroTik router is connected to two ISPs, data traffic can be evenly distributed across both paths [13].This research employs an experimental approach utilizing Winbox software to explore the capabilities of the MikroTik Routerboard RB750 in implementing load balancing techniques. The focus of this experiment is to test the performance of Equal-Cost Multi-Path (ECMP) routing. By setting up a controlled environment, this experiment aims to evaluate how effectively ECMP distributes traffic across multiple paths, thereby enhancing overall network performance and reliability. The experimental setup will include various scenarios to assess the router's performance under different load conditions, providing a comprehensive understanding of the benefits associated with ECMP.

The effectiveness of load balancing is crucial in optimizing resource utilization, preventing server overload, and managing unexpected traffic surges. Amid the dynamics of modern business and information technology, load balancing serves as a foundation for maintaining system performance, ensuring service availability, and delivering an optimal user experience. As technology advances, challenges in load balancing continue to evolve, driving research and innovation to address the growing complexity of dynamic computing environments [14].

2.2 ISP (Internet Service Provider)

ISP (Internet Service Provider) is a company or business entity that sells internet connections or the like to customers. ISPs were originally very synonymous with telephone networks, because in the past ISPs sold internet connections or access through telephone networks.

The definition of ISP (internet service provider) is a company engaged in internet services. The company invests its funds to build internet network infrastructure. If we want to connect to the internet network, we must first connect our computer to a certain ISP by complying with the conditions given by the ISP starting from the amount of fees charged, data transfer speed, and also the time limit to access the internet. ISP-ISO in Indonesia is a member of the Indonesian Internet Service Providers Association (APJII).

2.3 ECMP Methods

The results of this experiment will be meticulously documented and analyzed to identify potential solutions for the challenges encountered in network management. Through a detailed examination of the collected data, this study aims to provide insights into the advantages and functionalities of the ECMP method, elucidating its role in optimizing load balancing. With the analysis of the experimental results, it is hoped that the benefits and functions of this method can be concluded in detail, offering relevant recommendations for the issues faced in network management.

Implementing load balancing with Equal Cost Multi-Path (ECMP) to address issues in the Faculty of Computer Science at UNUSIDA involves distributing traffic load across two regulated gateway paths, each carrying an equal share of the load (equal cost). This approach is expected to enhance throughput, improve response time, and prevent excessive traffic congestion [15]. By optimizing network performance, ECMP ensures a more stable and efficient internet connection, supporting academic and administrative activities seamlessly.

2.4 Research Flowchart

The block diagram in Figure 1 explains the flowchart. In the network configuration process, the first stage starts from the Start point, which is the initial step to ensure all hardware is properly connected and perform physical connection checks between devices. After ensuring the physical connection is running well, the next step is to perform IP Address Configuration. At this stage, IP address settings are configured on each device interface, determining the IP address range to be used (for example 192.168.1.0/24), setting static IPs for routers and servers, and configuring subnet masks according to network requirements. Most importantly, ensuring there are no IP conflicts in the network.

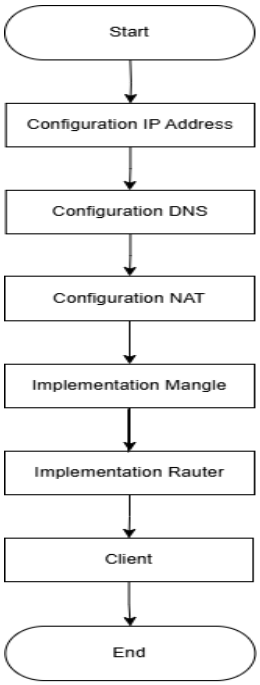

Figure 1. Stages of Research Flowchart

After the IP Address is properly configured, the next step is DNS (Domain Name System) Configuration. In this stage, administrators need to set up DNS servers for domain name resolution, configure Primary and Secondary DNS servers, determine DNS forwarders if needed, and set up various DNS records such as A records, MX records, and CNAMEs. Then proceed with NAT (Network Address Translation) Configuration which includes setting up translation between private and public IPs, configuring Source NAT for internet access, setting up Destination NAT for services that need to be accessed from outside, creating NAT rules and policies, and configuring Port Forwarding as needed.

The Mangle Implementation stage is an important step in configuring packet marking for QoS, creating rules for traffic marking, setting up connection marking, implementing routing marks if needed, and configuring packet prioritization. Next is Router Implementation which includes routing protocol configuration (both static and dynamic), setting up routing tables, configuring routing interfaces, setting up firewall rules, implementing routing policies, managing bandwidth, and configuring QoS (Quality of Service).

After all router configurations are complete, the focus shifts to the Client side. At this stage, configuration settings are made on the client side, ensuring clients receive IP addresses (either static or DHCP), setting default gateways, ensuring DNS settings, and performing connection testing. The network configuration process ends at the End stage, where comprehensive testing is conducted, verification of all configurations, documentation of completed configurations, configuration backup, and system monitoring to ensure stability. Each stage in this process is interconnected and must be carried out sequentially to ensure the network system can run optimally.

2.5 Requirements Analysis

Table 1 describes the components required before conducting the trial. The Mikrotik RB750gr3 is a router used to design and implement load balancing using the ECMP (Equal Cost Multi-Path) method. This router is capable of evenly distributing network traffic across multiple paths with equal cost, ensuring optimal efficiency and network speed. In this context, the Mikrotik RB750gr3 is ideal for environments that require reliable and stable bandwidth management.

Winbox version 3.41 is a tool used to configure the Mikrotik router. This application provides an intuitive graphical interface, making it easy for users to manage various router settings without relying on a text-based interface. Meanwhile, the Windows 11 operating system used on the user's laptop offers compatibility and optimal performance for running applications like Winbox, ensuring the entire configuration process runs smoothly.

2.6 Network Topologi Design

Figure 2 illustrates the topology design to be created, A computer network with load balancing features aims to efficiently distribute internet traffic load. This study tests a network configuration based on Mikrotik for load balancing, with Unusida hotspot as the access provider and smartphones for testing. The Figure 2 is the network topology design.

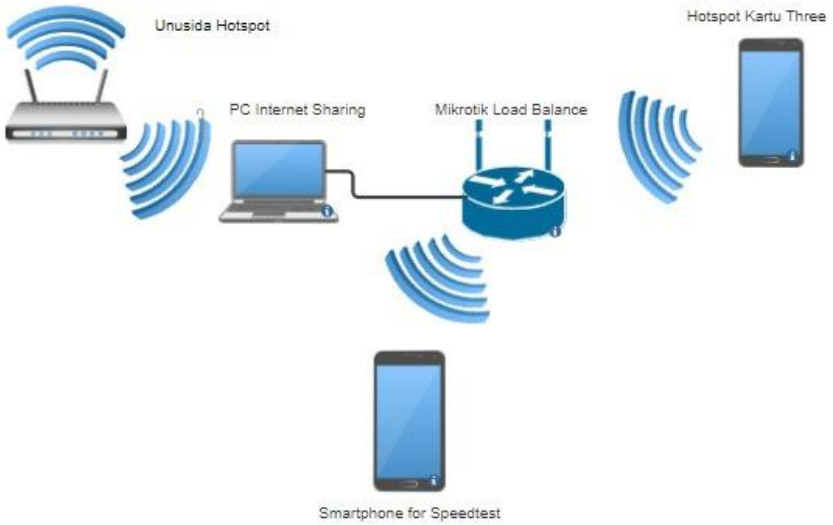

Figure 2. Designing a Network Topology

Table 1. Device Specifications.

No	Specifications	Description
1	Mikrotik RB750gr3	Router used to design and implement load balance with ECMP method
2	Winbox versi v3.41	Tools used to configure the proxy
3	Windows 11	User laptop operating system

The Mikrotik-based network configuration with load balancing has proven effective in distributing internet connectivity stably. This system provides an efficient solution to enhance network performance in educational environments or areas with high connectivity needs.

3. Results and Discussions

3.1 Results

In the design and implementation of load balance using the ECMP method, there are several stages of settings carried out using Winbox tools, including inputting IP addresses, Domain Name System (DNS), Network Address Translation (NAT), Mangle, and Route/Routing. The first step is to configure the basics of MikroTik, starting with setting the IP address. The following is the configuration for setting the IP Address address:

a. IP Address List

Figure 3 explains the IP address configuration, in the context of network administration. In the context of network administration, managing IP addresses and network interface configurations is crucial to ensuring smooth communication between devices within a network. One of the tools commonly used for this purpose is the Address List, which allows network administrators to monitor and configure various connected network interfaces. This tool not only simplifies the management of IP addresses and subnets but also aids in troubleshooting network issues by providing clear information about each interface, such as IP addresses and associated network addresses. This article will further explore the function and importance of this tool in network management.

The first row displays an interface labeled "ISP-WiFi-Hotspot1" with an IP address of 192.168.10.2 and a network address of 192.168.10.0. The next two rows show additional interfaces labeled "ISP-WiFi-Hotspot2" and "ISP-WiFi-Hotspot3," each with different IP addresses and network addresses. This tool is used for managing and configuring network interfaces in the context of network administration or troubleshooting. The information displayed in the table, including IP addresses and network addresses, indicates that this device plays a crucial role in network management, especially in setting up and monitoring various network interfaces associated with WiFi-based ISP connections.

b. Domain Name System (DNS)

DNS input is an important step in accessing a site or web. In addition, DNS functions as a storage system for information about host names or domain names, and as a web service that translates websites into internet addresses.

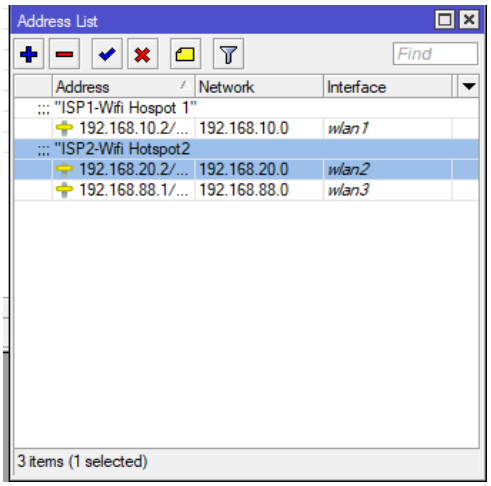

Figure 3. IP Address List

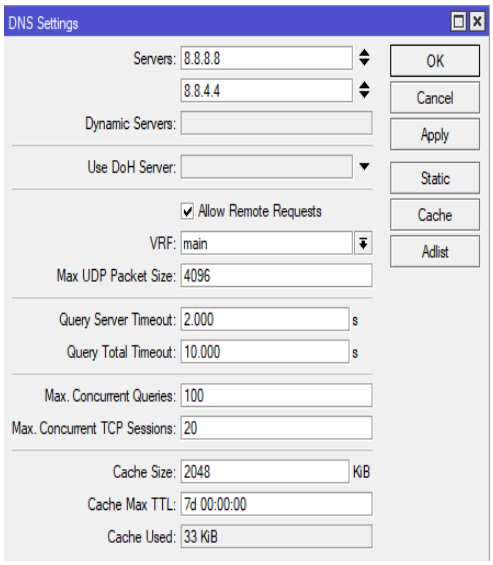

Figure 4. DNS

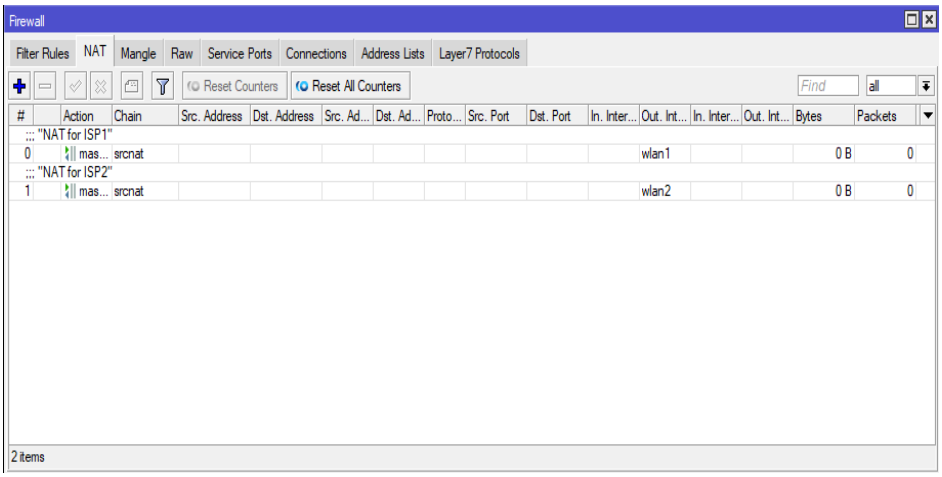

Figure 5. NAT

Figure 4 explains about DNS The Server section allows users to input the IP addresses of the DNS servers to be used, such as 8.8.8.8 and 8.4.4.4. The Dynamic Servers field is likely used to configure dynamic DNS servers that may be applied in more complex networks. The Use DDNS Server option enables users to specify a DDNS (Dynamic DNS) server to be used in the configuration. The VRF field is related to the Virtual Routing and Forwarding feature, commonly found in enterprise-level networking devices, used to manage multiple virtual networks. The Max UDP Packet Size setting controls the maximum size of UDP packets used for DNS queries, while the Query Server Timeout and Query Total Timeout settings define the acceptable timeout durations for DNS queries.

c. Network Address Translation (NAT)

The next stage is to set up a firewall-NAT Figure 5 explains about NAT Configuration so that the local network can be translated so that it is connected to the internet, where wlan1 is ISP 1 and wlan2 is ISP 2. In the Firewall window, there is a tab called NAT (Network Address Translation), which is used to configure the IP address settings involved in network traffic. NAT allows the translation or modification of source or destination IP addresses in data packets as they traverse the network. In this configuration, users can set rules to control how internal IP addresses are translated to external IP addresses or vice versa, depending on the applied policy.

The NAT tab is essential in network management, particularly in networks where many devices share a single public IP address. By using NAT, a local network with multiple devices can access external resources using one public IP address, while the internal IP addresses of the devices remain

hidden. This NAT configuration is also used to manage traffic flowing in and out of the network, ensuring that external connections are only accepted by devices with valid rules. Therefore, the NAT tab in the Firewall window plays a critical role in ensuring both security and efficient IP address management within the network.

d. Route

The last stage is to configure load balance. The application of routes / routing aims to choose the best path for a packet to reach the destination computer. The Route List window is a key tool in network management for configuring and managing routing tables. It displays a list of routes, including destination addresses, gateways, distance metrics, routing tables, and the prioritized source for each route. This information helps administrators select the most efficient paths for directing network traffic.

Administrators can optimize data flow, ensuring it reaches the correct destination through the best path. Figure 6 illustrates the Router Configuration, which is essential for managing complex networks effectively. Proper routing setup helps to avoid congestion and improve overall network performance. Additionally, route configurations play a crucial role in enforcing network security and traffic management policies, ensuring reliable and secure network operations.

3.2 Load Balance Network Testing with ECMP Method

Bandwidth Speed Testing (https://fast.com/id/#). Below are the results from ISP 1 and ISP 2 before using ECMP and load balancing. This display presents the results of an internet speed measurement from the Internet Service Provider (ISP) named FAST. Figure 7 explains the trial before using this load balancing ISP 1. The information includes a download speed of 29 Mbps, an upload speed of 17 Mbps, and a latency of 26 ms. The measurement was conducted at a location identified as the Indosat area.

These results indicate that ISP FAST provides relatively stable internet speeds for general usage, with latency within acceptable limits for online activities. However, it is important to note that the measurement results may vary depending on network conditions at the measurement location and other factors, such as the number of users connected during the test.

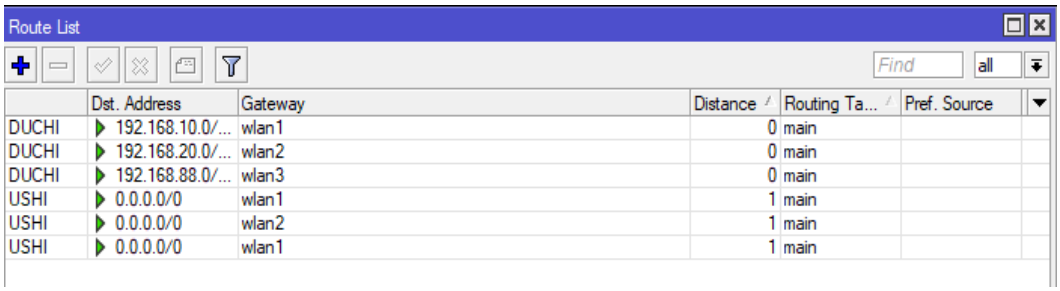

Figure 6. Route

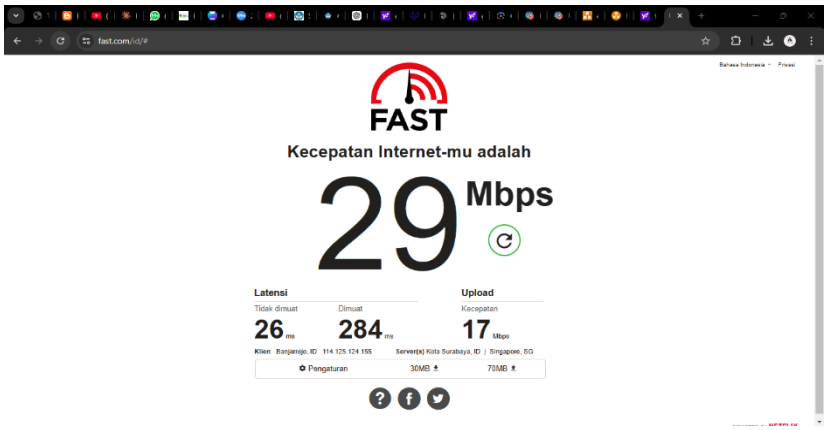

Figure 7. ISP 1

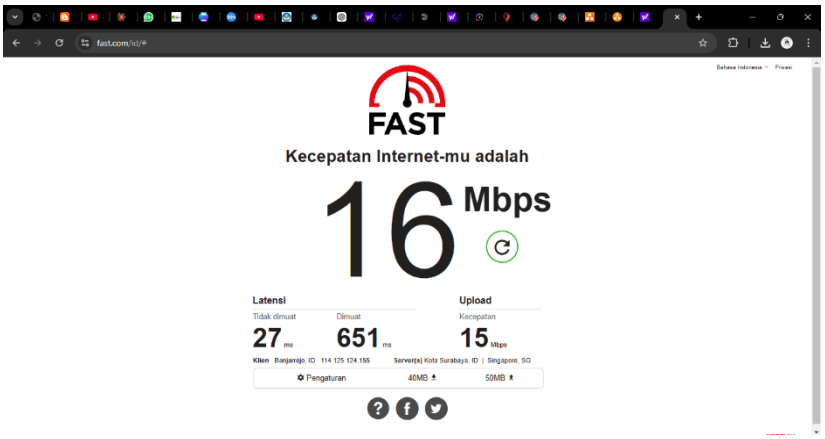

Figure 8. ISP 2

Figure 9. Load Balance Network Testing with ECMP Method

The internet speed measurement results from the Internet Service Provider (ISP) FAST indicate a download speed of 16 Mbps and an upload speed of 15 Mbps, with a latency of 27 ms. The measurement was conducted in a specific area, namely the Telkomsel region. The recorded download speed reflects the connection's ability to receive data from the internet, while the upload speed represents the capacity to send data to servers or other devices. A latency of 27 ms indicates a relatively responsive connection, suitable for everyday internet activities such as streaming, browsing, and online communication. Figure 8 illustrates the trial conducted before using load balancing with ISP 2.

Network performance variations are often influenced by geographical factors, the number of users connected, and the infrastructure conditions in the area. Although these measurement results provide a general overview of the quality of FAST ISP services in the Telkomsel area, actual performance may vary in other locations or at different times. This highlights the importance of regular internet speed evaluations to ensure consistent service quality that aligns with user needs and the standards promised by the service provider.

Figure 9 explains the results of load balancing using the ECMP method. The internet speed measurement results from the Internet Service Provider (ISP) FAST demonstrate the impact of implementing load balancing using ECMP (Equal-Cost Multi-Path). After applying this method, the download speed increased significantly to 63 Mbps, while the upload speed remained stable at 17 Mbps. Latency, which represents the time delay between a request and the server's response, decreased to 23 ms. The increase in download speed and reduction in latency confirm the effectiveness of ECMP in optimizing network efficiency.

ECMP load balancing distributes internet traffic across multiple equal-cost paths, ensuring better utilization of network resources and enhancing connection reliability. By employing this technique, FAST ISP successfully improved overall internet speed and responsiveness. This improvement is particularly beneficial for users requiring a stable and high-speed connection for activities like streaming or remote work. It highlights the importance of advanced network management in addressing the growing demand for reliable and high-performance internet connectivity.

3.2 Discussions

The test results show that before implementing the Equal-Cost Multi-Path (ECMP) load balancing method, the internet speed from ISP 1 was recorded at 29 Mbps, while ISP 2 only reached 16 Mbps. This highlights a significant disparity in the performance of the two ISPs, which could lead to load imbalances and potential obstacles in ensuring stable internet access across the network. Such imbalances often present a major challenge in networks relying on multiple ISPs, especially in the absence of an effective load distribution mechanism.

After the implementation of load balancing using the ECMP method, the overall internet speed experienced a significant increase, reaching 63 Mbps. This improvement reflects the effectiveness of ECMP in evenly distributing traffic between the two ISPs, thereby optimizing bandwidth utilization from each service provider. With this method, the network can reduce bottlenecks caused by differences in ISP capacities, while ensuring a faster and more stable user experience.

4. Conclusion

The research findings suggest that implementing load balancing through the Equal-Cost Multi-Path (ECMP) method effectively distributes traffic load, contributing to improved internet connection bandwidth. Additionally, configuring load balancing with ECMP and utilizing connection tagging within Mangle enables automatic management of both inbound and outbound packet connections, optimizing traffic flow. It is recommended that adequate hardware be selected to support load balancing, ensuring that the Central Processing Unit (CPU) load on the MikroTik device remains within efficient operational limits. Furthermore, choosing Internet Service Providers (ISPs) with similar quality and connection speeds is advisable to maintain network stability.

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