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Analysis and optimization of the LAN network Using the Load Balancing Technique (Case Study: University of Muhammadiyah Palembang Campus)

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ABSTRACT

The increasing use of the internet on campus directly affects bandwidth requirements to support academic activities and student services. When internet usage exceeds available bandwidth capacity, network performance degrades, causing delays and disruptions that reduce user comfort and service quality. Therefore, optimizing bandwidth utilization is essential to maintain a stable and reliable campus network. One effective approach is the implementation of load balancing, which distributes network traffic evenly across multiple connection paths. When the main path becomes congested, traffic can be redirected through a backup Internet Service Provider (ISP), ensuring continuity of service. Load balancing also enhances network availability by minimizing the risk of overload and reducing the potential for server failure. With balanced traffic distribution, bottlenecks can be avoided and overall network performance can be improved. The results of this study indicate that load balancing successfully optimizes network resource usage without requiring changes to the existing network infrastructure. The technique allows the network to operate more efficiently, especially during periods of high traffic, by ensuring a fair distribution of data flow. Consequently, load balancing proves to be an effective solution for maintaining optimal, stable, and scalable network performance in a campus environment.

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1. Introduction

The need for human needs for communication and information needs encourages the rapid advancement of communication and information facilities. Rapid progress in the world of information and communication has led to the development of various means of communication and information networks. Computers are one of the communication and information management tools that are growing very rapidly. By using a computer network that can connect between one computer and another, computers are a reliable means of communication and information in the current era of sophistication of communication and information facilities [1].

One form of the development of computer networks is the Internet. The ease of communication and information facilities provided by the Internet makes the implementation of the Internet a superior means in

every institution. The more students, the easier it will be to get the means to connect to Internet services, allowing the use of the Internet among academics to increase.

The development of Internet use on campus will automatically affect the need for bandwidth. To run the Internet smoothly, an adequate bandwidth quota is needed. If the usage exceeds the existing bandwidth service, the smooth Internet network will be stalled or stopped. The cessation or stagnation of Internet network services will certainly interfere with the process of comfort of lectures and student services on campus [2].

For this reason, an anticipation is needed to avoid overloading bandwidth usage capacity. In order for Internet network traffic to continue running, a redundancy scenario is needed where the system will continue to run even if there are components that are not working, such as the availability of overloaded bandwidth. Bandwidth capacity optimization can be done by increasing the bandwidth source by applying the load balancing function.

So that if one ISP experiences problems in providing Internet service or if there is traffic density in Internet use on campus, there will be a backup of the system that can solve the problem. One way to overcome this problem is to implement load balancing where bandwidth is increased by adding different Internet service providers (ISPs). Where currently on campus has not implemented load balancing as a means of anticipating bandwidth needs. Implementing load balancing means increasing bandwidth from different ISP sources but with management management remaining one. With this step, the bandwidth that enters the campus comes from two different ISPs but is managed with one management [3].

Dependence on Internet services with one ISP company has the potential to experience disruptions where if one day the ISP company's services are down, the network that is its customers will automatically also be down, for that the need for bandwidth backup is necessary to maintain the smooth availability of Internet services. It is possible to optimize bandwidth usage in Internet usage. Optimization can be done by utilizing the load balancing setting path to balance when traffic is full where the main path will be backed up with another path from the backup ISP [4].

A case study conducted by Muhammad Dedy Haryanto and Imam Riadi in 2014 with the title "Network Analysis and Optimization Using Load Balancing Techniques (Case Study: Muhammadiyah Palembang Campus)" is in line with this research so that it can be used as a reference. Based on the tests carried out in this study, the optimal application of load balancing is achieved. The implementation of load balancing can run without changing the existing network, and makes the connection run more optimally if there is an increase in network traffic due to the balanced division of connection lanes.

From the experiments carried out, it was concluded that *load balancing* works well when one connection source is off, then the *backup* will automatically run by taking the connection from the second source. Optimization that can be applied to *load balancing* in the Muhammadiyah Palembang campus network can be done by dividing the path that is balanced between the amount of *main bandwidth* and the spare *bandwidth*. So the *backup* speed will be the same as the main connection speed. Choosing the right ISP source provides optimization when network outages occur at the source *provider*. So *backups* don't experience the same problem because they come from *other providers*. The large *backup bandwidth* used to backup the main network provides optimization when the main network experiences problems, the backup connection speed will remain smooth to use because *the bandwidth is* also large[5].

Along with the development of information technology, the need for a reliable and efficient computer network is increasing. A good network must be able to provide optimal performance despite significant load spikes. However, one of the main challenges in network management is the uneven distribution of workloads, which can lead to bottlenecks, decreased performance, and even system failures. Load balancing techniques are an important solution in overcoming this problem. Load balancing allows for an even distribution of network traffic across multiple servers or resources, thereby improving efficiency[6], reducing response times, and optimizing resource usage. In this context, research on network analysis and optimization using load balancing techniques is very relevant to ensure stable and reliable network performance.

2. Research Methods

The method used in this study to analyze and optimize the network uses the load balancing technique. The methodology applied includes research design, network system design, selection of load balancing techniques, procedures carried out, and methods of processing data obtained from system testing[7].

2.1 Research Design

This study uses an experimental approach with the aim of testing the performance of the network system after the application of the load balancing technique. The experimental method was chosen because it allows direct measurement of network performance under controlled conditions. In this study, the author will

apply the load balancing technique to the network system that has been designed and measure the difference compared to the network condition without the load balancing technique. This approach makes it possible to identify the direct impact of load balancing techniques on network performance, such as increased throughput, reduced latency, and increased availability. The experiment was carried out using network simulations that allowed full control over the relevant variables [8].

2.2 Network System Design

Network system design is the process of planning and designing a computer network infrastructure to meet the specific needs of an organization or individual. This design covers various aspects, from hardware and software selection, network topology, protocols used, to security and scalability [9].

The network systems analyzed in this study are designed using a client-server server-based network topology. This topology was chosen because of its flexibility in managing data traffic between various network nodes. In this design, a central server acts as the primary distribution point to manage requests from multiple connected clients. The system tested includes multiple network devices such as routers, switches, and servers that will be configured to implement load balancing techniques. The use of appropriate hardware and software is essential to ensure that the experiment can be run effectively. Routers and switches are used to regulate the flow of data between devices, while servers will be responsible for load sharing using a load balancing algorithm [10].

2.3 Load Balancing Techniques Used

In this study, the load balancing technique applied is a software-based technique, using round-robin and least connection algorithms. The round-robin algorithm was chosen for its simplicity in distributing the load evenly among multiple servers or resources, while the least connection algorithm was chosen for its ability to optimize load distribution based on the number of active connections.

A round-robin algorithm will simply divide the load alternately to each server or node in the network, while the least connection algorithm will focus more on the server with the smallest number of connections, allowing for more efficient balancing when multiple servers experience load spikes. These two techniques will be tested to see which one is more optimal in improving network performance in different scenarios [11].

2.4 Research Procedure

This research is carried out through several main steps which include system design, implementation, and evaluation. The first step is to design a network system with a server-client topology and configure the necessary hardware and software. After that, a load balancing algorithm is applied to the central server to divide the load of incoming data traffic.

The testing process is carried out by simulating a large enough data traffic and observing the network's response to various types of loads. The test was carried out under two conditions: with active load balancing and without load balancing. Measurements are made against network performance parameters such as response time, throughput, and connection failure rate [12].

Tests were conducted in a variety of scenarios to evaluate how load balancing techniques can optimize load distribution on more complex networks. Each experiment records data related to network performance, which will be used for further analysis.

2.5 Research Variables

In this study, some of the variables measured and analyzed include:

a) Response Time: The time it takes for the server to respond to requests from clients.
b) Throughput: The amount of data that can be transmitted in units of time, which measures the efficiency of the network.
c) Network Availability: The percentage of time that the network can operate without interruption or failure.
d) The success of load balancing can be seen from the increase in network throughput and availability values as well as reduced response times, especially in high-load network conditions.

2.6 Data Processing Methods

The data obtained from the test will be analyzed using descriptive statistical techniques to see the trend of network performance under both conditions (with and without load balancing). In addition, a comparative analysis between the two load balancing techniques tested (round-robin and least connection) will be carried out to see which algorithm gives the best results in terms of efficiency and effectiveness.

The analysis method also includes the use of graphs to visualize comparisons between measured parameters, such as response time and throughput, across different load conditions. This evaluation will provide a clear picture of how load balancing can affect overall network performance.

3. Results and Discussion

The results of the test and analysis were carried out to assess the effectiveness of the application of load balancing techniques in the network system being tested. The test was conducted using two load balancing algorithms, namely round-robin and least connection, to compare network performance before and after the technique was applied.

3.1 Overview of the running system

The need for the internet at this time is increasing, because more and more internet users are looking for information, news, and being used as a communication medium. The internet has become a communication medium that is increasingly popular with users and has become a daily necessity, the development of communication technology makes communication more effective and efficient. In addition, the internet can also facilitate the work of its users to communicate remotely and from close ranges.

Along with the development of the internet and its increasing users, it causes internet users in a network to want an optimal and maximum network of internet networks provided for its users. The internet at this time has been widely used by government agencies, institutions and schools to improve the services provided by these institutions or institutions, the use of the internet in the school environment is used to improve the teaching and learning process carried out in the school and improve the services of the school, but because of the large number of students, teachers, and employees who use the internet freely or irregularly it causes traffic load The internet network in the school has become larger and uncontrollable.

Therefore, the Quality of Service (QOS) network at the school needs to be improved in order to get maximum network and bandwidth, one of which is by using the Load Balancing method and user bandwidth management, where this Load Balancing combines 2 networks from different internet service providers into one, with the aim of distributing the traffic load to each ISP in a balanced manner. The implementation of Quality Of Service (QOS) is a solution to manage the bandwidth used on the network so that users who use the network do not consume bandwidth freely (Mair & Ariska, 2018). Network topology is a structured design or design connecting between nodes in a network where network topology is related to the mechanism used in managing these nodes in accessing the network (Wardi et al., 2020).

The Load Balancing technique does not increase the amount of network bandwidth due to the accumulation of the 2 ISPs, but the Load Balancing is a technique used to divide the traffic load from the two bandwidths so that it can be used in a balanced manner (Mustofa & Ramayanti, 2020), the Load Balancing technique has several methods used to divide the load of network traffic on microtic routers, In the application of Load Balancing there is an algorithm used for the distribution of the load to match the server behind it, one of which is by using Nth, Nth is one of the methods used in Load Balancing, Nth is an integer (N number) of the division of network connections that will be mangled to the route that is used as Load Balancing, in this nth method uses a round robin algorithm, where the distribution of the burden is divided fairly or equally.

In addition to the Load Balancing technique, user bandwidth management is also needed to regulate the distribution of connections or traffic load on a network, this bandwidth management aims to regulate the size or small path of each data packet that passes through the network, this bandwidth management reduces or prevents the occurrence of free internet use on a network. By using the Load Balancing method and network bandwidth management in a school, it can be used optimally and optimally and the distribution of bandwidth can be used fairly and equitably. The design of the network topology of load alanccing and bandwidth management can be seen in Figure 1 below.

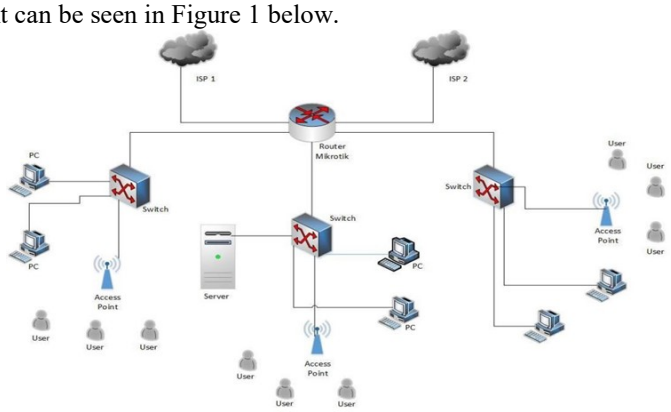

Figure 1. System Overview

Figure 1. is an overview of the system depicted with a network topology that describes *Load Balancing* and *Bandwidth* management techniques. The topology design uses 2 different ISPs that are combined into one on

the microtik router, on the microtik router there is also a configuration that regulates the amount *of bandwidth* given to students, employees, and teachers with different bandwidth sizes . Networks that have been combined into one using *the Load Balancing* method can be deployed through switches or *access points* that connect *clients* with *servers*. A *server computer* that is connected through *a switch* that provides a variety of information and client data security, *the switch* is used to connect *the router* with several different devices, *the access point* on the topology is used to connect devices that use *wireless technology* such as, *mobile phones*, laptops, tablets, etc.

3.2 Diagram Fishbone

Supporting to clarify the research carried out from the problems obtained so that the results are in accordance with what is expected in this study, the research is described using a fishbone diagram to analyze the cause of a problem or condition as shown in figure 2 below.

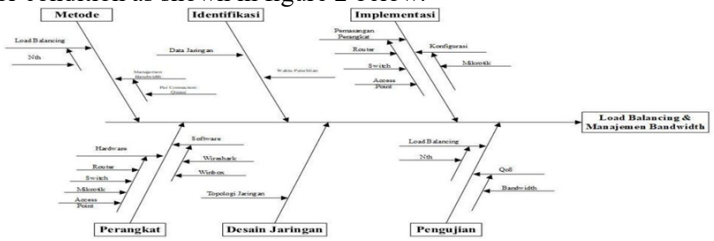

Figure 2. Diagram Fishbone

Figure 2. is a fishbone diagram that describes the flow or stages carried out in the Load Balancing and Bandwidth Management study. The first stage of this study is located in the fin in the section above, which describes the stage of the research method, at the stage of the research method is the stage that determines the research method that will be used to solve the problem in the research, the stage of the research method uses two methods, namely Load Balancing and Bandwidth Management, Load Balancing in the study using the Nth method, and in Bandwidth Management using the Per Connection Queue (PCQ) method

The second stage is located in the lower fin which describes the device used in the research, in the device part there are two parts of the device used, namely hardware and software, in the hardware device used, namely Router, Switch, Access Point, and Mikrotik, in the software device used are Wireshark and Winbox. The third stage is located in the upper fin section which describes identification, in the identification section describes the activities carried out to collect data from libraries and reliable sources or from the library of related research that has been carried out previously, in the identification section there are two parts, namely network data and research time.

The fourth stage is network design, in the network design section it is an activity to design a research flow that is carried out in accordance with the problems and literature studies obtained previously, the design stage of this research aims to achieve the research objectives that have been set or as a guideline for researchers in the research process, in the design section there is a design design of the network topology that will be implemented at the research case study site. The fifth stage is the provision of means to conduct research that has been described at the research design stage, the implementation stage is the stage to realize the research design stage to get a product resulting from the research conducted, in the implementation section there are two parts, namely device installation and configuration, in the device installation there are several necessary devices such as Routers, Switch, and Access Point, in the configuration section there are microtic devices used to run the Load Balancing and Bandwidth Management methods. The sixth or last stage is located on the fin at the bottom which describes the testing stage, the testing stage is the stage that is carried out at the end of the stages carried out in the research, the system that has been previously created will be tried and tested to assess the results obtained from the implementation of the system that has been created, this testing stage is also carried out documentation of the results obtained to ensure that the research carried out gets the results that have been carried out expected.

3.3 Description of Implemented Systems

The network system applied in this study consists of several main devices, namely servers, routers, switches, and clients connected in a server-client topology. A central server serves to manage requests received from clients, while routers and switches are used to distribute data traffic across the network.

In this experiment, two load balancing techniques were tested: round-robin and least connection. The round-robin algorithm divides the load alternately between servers, while the least connection prefers the server with the smallest number of connections to optimize load distribution. Each server used has the capacity to handle multiple client connections simultaneously.

Configuration health check How does Load Balancer monitor server health? For example, by pinging, checking ports, or sending HTTP requests. Persistence configuration (if needed) How Load Balancer ensures the same client is always routed to the same server (also known as session affinity or sticky sessions). Failover configuration How does Load Balancer handle server failures? For example, by redirecting traffic to another server that is still functioning.

3.4 Test Results

The test results showed a significant difference in network performance between the conditions before and after the application of the load balancing technique. The following are the main results obtained from the test:

a) Response Time: With the implementation of load balancing, the response time received by the client is significantly reduced. In a system without load balancing, the response time tends to increase as the number of clients connected increases, whereas with the load balancing technique, the response time remains stable even though the number of clients increases.
b) Throughput: Implementing load balancing also increases network throughput. The round-robin and least connection algorithms both showed increased throughput compared to the no-load balancing condition. However, the least connection algorithm shows a greater increase in throughput in high-load network conditions, as it is more efficient in regulating the distribution of connections.
c) Network Availability: In terms of network availability, both load balancing algorithms help reduce the likelihood of connection failure. With load balancing, the system can avoid overloading a single server, which directly increases network availability. In a condition without load balancing, one server that is overloaded can cause a decrease in network availability.

3.5 Analysis of Test Results

Based on the results obtained, it can be concluded that the application of load balancing techniques has a significant impact on improving network performance. In terms of response time, load balancing helps keep response times low despite the increase in the number of clients. The least connection algorithm, which takes into account the number of active connections on each server, has been shown to be more efficient in addressing uneven load distribution on servers.

The increased throughput also indicates that load balancing successfully optimizes the use of network resources. In this experiment, the least connection showed better results than round-robin, especially in high-load networks. This is because least connections are more selective in selecting servers with the smallest connections, which helps avoid overloading a particular server.

Network availability also increased significantly after the implementation of load balancing. Without load balancing, servers that experience connection spikes can experience decreased availability or even connection failure. With load balancing, more even load distribution helps reduce the risk of this failure

3.6 Comparison with Related Research

The results of this study are in line with several previous studies that show that the application of load balancing techniques can significantly improve network performance. Previous studies have also shown that the least connection algorithm is more efficient in optimizing network loads, especially in congested network conditions. However, there are also studies that show that round-robins can work better in less congested network conditions or with a limited number of servers. Therefore, the selection of the right load balancing algorithm must take into account the specific characteristics of the network being used, such as the number of clients, server capacity, and data traffic patterns.

For example, a study proposed a new load balancing algorithm for data centers called "Adaptive Load Balancing based on Server Load Prediction". This research can be compared with related research as follows:

a) Research Focus: Load balancing in data centers with a focus on server load prediction.
b) Algorithms Compared: Compared to Least Connection, Weighted Round Robin, and other published load prediction algorithms.
c) Performance Metrics: Response time, server CPU usage, and number of SLA (Service Level Agreement) violations.
d) Test Environment: Simulate using CloudSim with different types of workloads.

e) Results and Contributions: Shows that the proposed algorithm provides a lower response time and reduces the number of SLA violations than other algorithms under various workload conditions. The contribution of this research is to provide a new approach to load balancing in data centers by utilizing server load prediction.

4. Conclusion

Based on the results of the tests and analyses that have been carried out in this study, it can be concluded that several important things regarding the application of load balancing techniques in network systems can be concluded, namely: The application of load balancing techniques, both with round-robin and least connection algorithms, has been proven to significantly improve network performance. The load balancing technique helps maintain a stable response time, even as the number of connected clients increases. The resulting reduction in response time indicates that load balancing successfully distributes the load evenly among existing servers. In the test, the least connection algorithm showed better results compared to the round-robin algorithm, especially in high-load network conditions. This algorithm is more efficient in optimizing the distribution of connections by selecting the server that has the smallest number of connections, thus being able to increase throughput and reduce the possibility of overload on a particular server. The load balancing technique also has a positive effect on network availability. With more even load sharing, the risk of server failure can be reduced, leading to an increase in overall network availability. This shows that load balancing is essential in maintaining stable and reliable network performance, especially on systems involving multiple clients. Better Network Optimization with Load Balancing. Overall, this study shows that the application of load balancing can optimize the use of network resources. Through this technique, the network can operate more efficiently, reduce bottlenecks, and ensure a fair distribution of load between servers, leading to improved network performance.

This research makes an important contribution to the understanding and application of load balancing techniques in optimizing network performance. Through the experiments conducted, it was proven that load balancing can improve overall network performance, with increased throughput, decreased response time, and increased network availability. Thus, the implementation of load balancing is expected to provide significant benefits in managing and optimizing network infrastructure in various fields. With the suggestions given, it is hoped that this research can further contribute to the development of load balancing techniques and their implementation in the real world, as well as open up opportunities for further research in this field.

Acknowledgments

Although this study provides a clear picture of the effectiveness of the application of load balancing techniques, there are several suggestions that can be considered for further research or more optimal implementation: This study only tested two load balancing algorithms, namely round-robin and least connection. The suggestion for further research is to explore other algorithms such as weighted round-robin, random, or dynamic load balancing, which may be better suited for more complex or variable network conditions. This study uses a relatively simple server-client topology. For further research, it is recommended to test load balancing techniques on more complex network topologies, such as cloud-based networks or large data centers involving many servers and nodes, to see how these techniques perform under more dynamic conditions and on larger scales. Although the experiment is conducted under simulated conditions, testing in a real-world environment will provide a better understanding of the effectiveness of load balancing techniques in more complex and unexpected situations. Hands-on testing on real network infrastructure can help evaluate the performance and feasibility of this technique. Further research can explore the integration of load balancing techniques with other network technologies, such as SDN (Software-Defined Networking) and NFV (Network Functions Virtualization), to see how load balancing can work in a more modern and distributed environment.

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