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COMPARATIVE ANALYSIS OF PERFORMANCE BETWEEN ECMP AND NTH METHODS IN IMPLEMENTATION OF MICROTIC-BASED DUAL LINK LOAD BALANCING TECHNIQUES

Dian Novianto[1], Yohanes Setiawan Japriadi[2]
[1,2]Department of Informatics Engineering, ISB Atma Luhur Pangkalpinang
[1,2]Jl. Jenderal Sudirman, Kel. Selindung Baru, Kec. Gabek, Kota Pangkal Pinang, Indonesia
Email : diannovianto@atmaluhur.ac.id[1], ysetiawanj@atmaluhur.ac.id[2]

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Abstract
Load balancing is a technique within the network that functions to divide the network into two or more links with the aim that internet access needed by clients on the network does not experience problems. However, there are various methods that can be used in the load balancing technique, so it is necessary to test the performance of these methods in order to choose which method has better performance. In this study, the methods implemented in the load balancing technique are ECMP and NTH. The research methodology used is qualitative and comparative, and PPDIOO as a network development model. By applying the comparative method, there is a comparison of the results of testing load balancing techniques using the ECMP and NTH methods. Testing is done by downloading files in two different sizes, with criteria less than 100 MB and more than 100 MB. Performance analysis of Quality of Service (QoS) is based on four parameters. There are throughput, delay, jitter and packet loss. The results of the Quality of Service (QoS) load balancing technique are the best after being tested and compared based on predetermined parameters. It concludes that the NTH method is slightly better than ECMP because it has a slightly larger throughput value.

I. INTRODUCTION

Loss of internet connection is a major problem in an organization that relies heavily on internet access in its business processes. This can be avoided if an organization has two or more links to support its network infrastructure. This link is an access point to the internet provided by the internet service provider (ISP) to its customers.

Even though it has two or more links, it is necessary to manage data traffic on the network so that there is no overload at any of the access link points. The management of data traffic on the network for multi-links is referred to as a load balancing technique. This load balancing technique is used to distribute the traffic load on two or more access links in a balanced way. This technique also allows data traffic on the network to run optimally, by maximizing throughput, and minimizing response time at the router, so as to avoid traffic overload on one connection line or link. In implementing load balancing techniques, network administrators can use several methods, including ECMP and NTH.

Equal Cost Multi Path (ECMP) is the alternate path selection at the gateway and is one of the easiest and fastest load balancing methods for load balancing or dividing the traffic load to the internet [1]. Generally, ECMP is applied when dividing traffic going to the internet through several ISPs, and ECMP is simply done by configuring the default route on the router and by using several gateways at once, but the Administrative Distance value of each gateway is the same [2].

The NTH (N-th Connection) method is known as the method of distributing the target connection direction from each user, so that the traffic load of the two ISPs can be maintained in balance and work together. This is because every new connection that enters and passes through the router will be managed via ISP 1 or ISP 2 [3].

There are two main parameters of this NTH, every and Packet. Every is a counter parameter, while packet is a packet indication of how many rules from this NTH will be executed. Thus the use of NTH is done by activating a counter on the mangle, then marked with a route-Mark. This route mark is used as the basis for creating policy routes. NTH is implemented in a series consisting of every and packet which will be realized in an integer series. In this load balancing method, incoming data packets will be marked as a variable n in the data type integer. The integer value for every is the number of groups you want to form, if you want to divide the load into 2 groups. Every will be worth 2 while in packets. The integer value is a queue sequence starting from numbers 1, 2, 3 and so on or incoming packets will be known as packets 1, 2, 3 and so on. With the existing rules, the paths that have

been marked as NTH will be combined, or the total bandwidth at the output is the sum of each bandwidth on the 2 connections [4].

Therefore, to determine the performance of the two methods in the load balancing technique, a test is needed that includes the parameters of throughput, delay, jitter and packet loss. The four parameters in the test can show how well the performance of the ECMP and NTH methods in load balancing techniques when providing services for multi-link internet access, both sending data and receiving data, so that it can be used as a consideration in choosing the method for the load balancing technique to be used.

Based on the background of the problem in the previous section, several formulations of the problem can be formulated, how do we apply the ECMP and NTH methods in load balancing techniques. How is the process of testing the ECMP and NTH methods on load balancing techniques so that the results obtained are accurate and how do we get the value of the four parameters of accurate quality of service testing from the file download process.

II. LITERATURE REVIEW

2.1 Network

According to [5], a network is a system consisting of several computer components and other devices designed to be able to share resources and data such as printers and CPU. This network aims to facilitate communication between one device to another. The network is also divided into several types of coverage, including PAN (Personal Area Network), LAN (Local Area Network), MAN (Metropolitan Area Network), WAN (Wide Area Network), and WLAN (Wireless LAN).

2.2 Router

A Router is similar to a bridge. The difference is that the bridge uses the original hardware address (MAC address) to tell which network to send data to, so it can forward the message to the desired segment. However, the bridge cannot see the contents of the message, unlike the router which can see the contents of the message, so the router has a higher level than the bridge. Router is a device that is devoted to handling connections between two or more networks that are connected via packet switching [6].

2.3 Mikrotik

Mikrotik is an independent Linux-based operating system specifically for computers that function as routers [7]. Mikrotik is designed to facilitate computer network administration purposes such as designing and building a computer network system from small to large scale. Mikrotik is divided into two types. There are Mikrotik RouterOS and Mikrotik Routerboard. Mikrotik RouterOS is where the operating system and software can be used to turn the computer into a network router that has various features in network technology. The Mikrotik Routerboard is a piece of hardware that can run RouterOS without the need to install it on a computer, because this Mikrotik router has been designed to run RouterOS so that it can be a reliable router for users.

2.4 Quality Of Service

Quality of Service (QoS) is the ability of a network to provide good service by providing bandwidth, overcoming jitter and delay. From a networking perspective, QoS refers to the ability to provide different services to network traffic. QoS parameters are latency, jitter, packet loss, and throughput. QoS is largely determined by the quality of the network used [8][9].

2.5 Load Balancing

Load Balancing is a technique for dividing network load (Traffic) through several available network links with the aim of increasing throughput, reducing response time and avoiding excessive traffic accumulation. Load balancing technique can be applied if the router has several links to reach a destination network. For example, your MikroTik Router is connected to the internet through 2 (two) ISPs. This means that the router has 2 (two) links to the internet, and traffic coming from the internet is also expected to pass through the two links in a balanced manner [10].

2.6 ECMP

ECMP is a routing technique to route packets through several paths that have the same value. The engine in charge of sending the packet identifies the path based on the next hop [11]. All paths between each node have the same routing value, so data traffic will be divided equally.

2.7 NTH

The known NTH technique is a technique that uses the round-robin method in sharing the load. Existing packages will be grouped into several groups sequentially. The first package is in the first group, the second package is in the second group, and so on. After that, each group will be removed through the available exit interfaces sequentially. The first group will exit through the first interface, the second group will exit through the second interface, and so on [12]. NTH is an integer (Nth number). Basically the incoming connections to the router process will be the same stream, even if they come from different interfaces. When implementing the NTH method, this will provide a limit to the router to process connections from certain sources only. When the router has created a new kind of queue for the constraints we gave above, the NTH process starts [13].

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III. RESEARCH METHOD

3.1 Data collection

The method used in this study uses a qualitative method where the researcher is the main tool in data collection [14]. The data collection that the author does is by looking for reference sources related to the research topic, both from scientific journals and from books. In this way the author can understand the workings of the techniques and methods used, so it is hoped that later in testing the configuration of the implementation of the two methods will run well and smoothly.

In addition, in this study the author also uses a comparative research method, which is to compare the performance of the two load balancing methods by creating a simulation model in the form of a load balancing technique configuration using the ECMP method and a load balancing technique configuration using the NTH method, which is activated alternately on a Mikrotik routerboard tested using a laptop as a client by downloading files of a certain size, so that a recorded data packet can be captured in traffic while downloading the file.

3.2 Design Model

The network life cycle model that we use in this study is the PPDIOO model developed by Cisco. PPDIOO itself consists of several stages that must be passed, namely, Prepare (preparation), Plan (Planning), Design (Design), Implement (Implementation), Operate (Operation) and Optimize (Optimization). In this model, the network design is developed based on the technical and business requirements obtained from the previous conditions. The network design specification is a comprehensive and detailed design that meets today's technical and business requirements. The network must provide availability, reliability, security, scalability and performance [15]. PPDIOO model can be described as in the following figure:

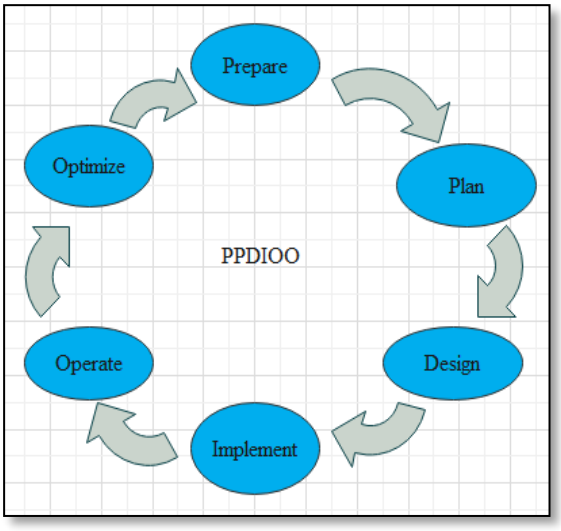


Figure 1. PPDIOO Network Lifecycle [15]

3.3 Data analysis

In making the simulation model, the specifications of the hardware and software requirements that the researchers used in this study can be seen in table 1 below:

Table 1. Devices used

Software	Hardware
Windows 8.1 Pro 64 bit	Laptop dengan Spesifikasi: Processor A8-4500M up to 2.80 GHz, GPU: AMD HD8750 2GB Vram, RAM 4GB, HDD 500GB
Winbox Loader versi 3.2.7	
Cisco Packet Tracer 8.0	Router RB1100AHx4 1U Rackmount engan Spesifikasi: processor Alpine AL21400 1.4GHz Quad Core, 1GB RAM, routerOS level 6.
Wireshark .3.2.6	Kabel UTP Cat 5e, Access point TPLink TLWA901ND

The network topology that the author uses in the configuration simulation and testing of the load balancing system uses the ECMP and NTH methods which can be seen in Figure 2 below.:

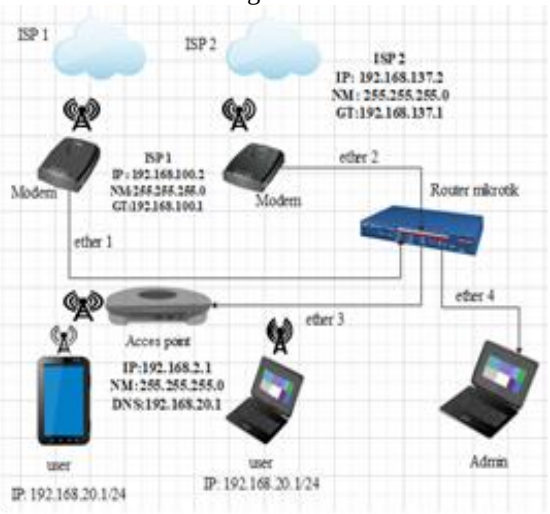


Figure 2. Network topology

From the topology image, the test will be carried out by a laptop, and the router will be connected to 2 ISPs that will forward data packets to the internet. This study will use testing on internet access connectivity when downloading files and the file download activity starts, the Wireshark application will run which is in charge of recording statistics of data traffic that occurs on the router. There are 2 categories of file sizes that will be downloaded in this test. There are files measuring > 100 MB, and files measuring < 100 MB. Testing will be carried out through the client computer against network load balancing. This test will measure the

performance of the load balancing network with several parameters. They are throughput, delay, jitter and packet loss. Later, the wireshark application that has been run to capture data packets will get values for measurements according to the parameters that have been set. The calculation of the value and category of each parameter is as follows:

1. Throughput

Throughput is the effective data transfer rate measured in bps (bits per second). Throughput itself is the total number of successful packet arrivals observed at the destination during a certain time interval, then divided by the duration of that time interval [16]. The following is the throughput value based on [17].

Table 2. Throughput

Throughput Category	Throughput	Indeks
Very good	100%	4
Good	75%	3
Medium	50%	2
Bad	< 25%	1

Throughput calculation equation

$$\text{throughput} : \frac{\text{received data packet}}{\text{length of observation}}$$

2. Delay

Delay is the time it takes for data to travel the distance from origin to destination. Delay can also be affected by distance, physical media congestion or also a long processing time [16]. The following is the delay value based on [17].

Table 3. Delay

Category Delay	The amount of the delay	Indeks
Very good	< 150 ms	4
Good	150 s.d 300 ms	3
Medium	300 s.d 450 ms	2
Bad	> 450 ms	1

Delay calculation equation

$$\text{delay} : \frac{\text{length of observation}}{\text{total packets received}}$$

3. Jitter

Jitter is caused by variations in queue length, in data processing time, and also in packet recombination times. Jitter is usually called delay variation which is closely related to latency [16]. The following is a jitter value based on [17].

Table 4. Jitter

Category Jitter	Jitter	Indeks
Very good	0	4
Good	0-75 ms	3
Medium	75-125 ms	2
Bad	125-255 ms	1

Jitter calculation equation

$$\text{Jitter} : \frac{\text{total delay variation}}{\text{total packets received}}$$

4. Packet Loss

Packet Loss is a parameter that describes a condition that shows the total number of lost packets that can occur due to collision and congestion on the network [16]. The following is the packet loss value based on [17] .

Table 5. Packet Loss

Packet Loss Category	Packet Loss	Indeks
Very good	0 %	4
Good	3 %	3
Medium	15 %	2
Bad	25 %	1

Packet Loss calculation equation

$$\text{Packet loss: } \frac{(\text{Packets sent} - \text{Packets received}) \times 100\%}{\text{Packets sent}}$$

IV. DISCUSSION

4.1 Design

In this study the author uses the PPDIOO Network Lifecycle network development method where this method consists of: Prepare (preparation), Plan (planning), design (design), Implement (implementation), operate (operation) and optimize (optimization) [15]. As for what the author will do at each stage is as follows:

1. Prepare (preparation)

In this stage what the author will do is to collect the data. The process of collecting data, such as literature studies from scientific journals and books, is used to add information needed in the analysis of problems and needs so that when the load balancing system is built and tested it can run well.

2. Plan (Planning)

In this stage, what the author will do is to analyze hardware and software requirements, make a schedule for configuration work and load balancing system trials, as well as draft the required budget.

3. Design (Design)

In this stage, what the author will do is to design a network topology for a load balancing system to apply the ECMP method and the NTH (N-th Connection) method on the mikrotik routerboard, both in the form of a physical and logical network

topology using the Cisco Packet Tracer 8.0 simulation application.

4. Implement

In this fourth stage, what the author will do is to configure the mikrotik routerboard so that it can run a load balancing system with the ECMP method and the NTH method, where this configuration is done alternately on the same routerboard.

5. Operate (Operation)

In this stage what the author will do is to test the performance of the ECMP method and the NTH method in the load balancing network system configuration. This test aims to determine the performance of the two methods in handling data traffic on the network when entering or leaving the routerboard, and also to find out whether the configuration has gone well as planned or not.

6. Optimize (Optimization)

In this stage what the author will do is to improve the quality of the network system, such as upgrading the hardware and software needed in the test scenario at a later time.

4.2. Implementation

This section will discuss the implementation of ECMP method configuration and NTH method in load balancing technique. After that, there is a test that is simulated by capturing data traffic on the network while downloading files with sizes less than 100 MB and more than 100 MB. To get a capture of data packets that pass across the network, the author uses the Wireshark application and takes advantage of the summary feature of the application.

For the first implementation stage, the author configures the ECMP method on the Mikrotik routerboard. The two interfaces leading to the internet can be passed. Then two NAT masquerade rules are made on the interface.

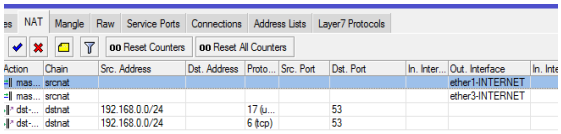


Figure 3. NAT Masquerade

Then do the configuration on the route menu to determine the default gateway. This serves so that data packets can go to any destination with a predetermined gateway.

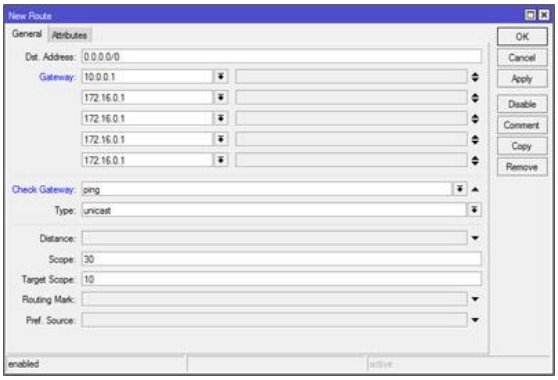


Figure 4. Routing

If one of the gateways is detected as unreachable or unreachable, check gateway will kill the connection from that gateway and redirect the connection to another gateway that is still active.

Further testing is done by downloading files with two categories, less than 100MB in size and more than 100MB in size. After testing, the author reconfigures the routerboard using the NTH method.

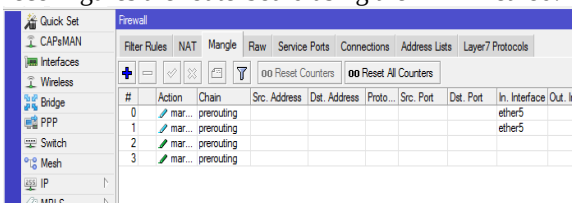


Figure 5. Mangle

In the application of the NTH method, it is necessary to mark the data packets that pass through the network through a predetermined interface. This marking serves to find out where the packets that pass through come from, to then be directed according to the available gateways.

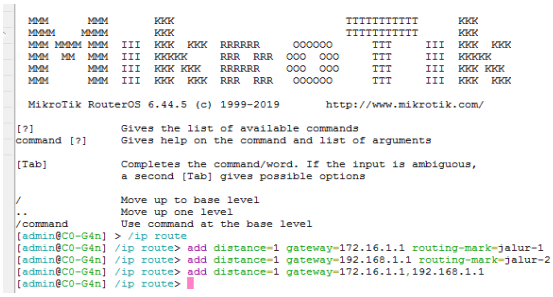
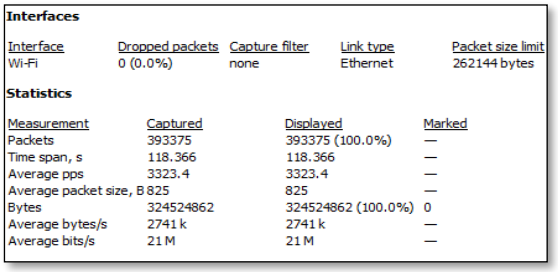


Figure 6. Routes

Next, it is necessary to determine the gateway according to the path that has been made, line 1 and line 2. Line 1 is for packets marked as connection 1, and line 2 is for packets marked as connection 2 in the mangle. After the configuration is done, the next step is testing. Just like in the ECMP method, the NTH method is also tested by downloading files that are less than 100MB in size and files that are more than 100MB in size.

When the data traffic capture results from each method have been obtained, this next step will be calculated according to the provisions of each parameter. In Figure 7 you can see an example of the capture of the Wireshark application that is being used. The following is an example of a wireshark summary that can be used for measuring QoS methods in load balancing techniques.



Interfaces

Interface	Dropped packets	Capture filter	Link type	Packet size limit
Wi-Fi	0 (0.0%)	none	Ethernet	262144 bytes

Statistics

Measurement	Captured	Displayed	Marked
Packets	393375	393375 (100.0%)	—
Time span, s	118.366	118.366	—
Average pps	3323.4	3323.4	—
Average packet size, B	825	825	—
Bytes	324524862	324524862 (100.0%)	0
Average bytes/s	2741 k	2741 k	—
Average bits/s	21 M	21 M	—

Figure 7. Wireshark Summary

After the summary data is obtained, then the calculation of the value for each QoS parameter that has been previously determined is carried out. The testing is carried out in the following way:

1. Performance testing of load balancing techniques uses the ECMP method based on QoS.

a. Throughput Calculation

Throughput data obtained through observations uses wireshark tools. The data obtained are as follows:

Table 4. ECMP Data Throughput

Size	Received data packets (Bytes)	Duration of Observation (Second)
≥ 100 MB	9568571	103,612
< 100 MB	13577190	139,366

The data obtained is then calculated using the throughput equation:

Trial > 100 MB :

$$= \frac{\text{received data packet}}{\text{length of observation}}$$

= (9568571/279,612)
= (92350,027 Bps * 8) / 1024
= 721,484 Kbps

Throughput(%)= (721,484/1024)*100%
= **70,45 %**

Trial < 100 MB :

$$= \frac{\text{received data packet}}{\text{length of observation}}$$

= (13577190/139,366)
= (97421,107 Bps * 8) / 1024
= 761,102/ Kbps

Throughput(%)= (761,102/1024)*100%
= **74,32 %**

a. Delay Calculation

Delay data is obtained through observation using wireshark tools. The data are as follows:

Table 5. ECMP Delay Data

Size	Duration of Observation (Second)	Total Packets
≥ 100 MB	103,612 s	104165
< 100 MB	139,366 s	199216

The data obtained is then calculated using the delay equation:

Trial > 100 MB:

$$= \frac{\text{length of observation}}{\text{total packets received}}$$

= 103,612 / 104165
= 9,9469 s * 1000 = **0,99 ms**

Trial < 100 MB:

$$= \frac{\text{length of observation}}{\text{total packets received}}$$

= 139,366 / 199216
= 6,9957 s * 1000 = **0,69 ms**

a. Jitter Calculation

Jitter data is obtained through observation using wireshark tools. The data are as follows:

Table 6. ECMP Jitter Data

Size	Variation Delay	Total Packets
≥ 100 MB	104,012 s	104165
< 100 MB	138,985 s	199216

Trial > 100 MB:

$$= \frac{\text{total delay variation}}{\text{total packets received}}$$

= 104,012 / 104165
= 9,9853 s * 1000 = **0,99 ms**

Trial < 100 MB:

$$= \frac{\text{total delay variation}}{\text{total packets received}}$$

= 138,985 / 199216
= 6,9765 s * 1000 = **0,69 ms**

d. Packet Loss Calculation

Packet Loss data obtained through observations using wireshark tools. The data are as follows:

Table 7. Data Packet Loss ECMP

Size	Data Package Sent	Data Package Received
≥ 100 MB	104165	104165
< 100 MB	199216	199216

The data obtained is then calculated using the packet loss equation:

Trial > 100 MB:

$$= \frac{\text{(Data packets sent–Data packets received)X 100\%}}{\text{Data packets sent}}$$

$$= \frac{(104165 - 104165)\ X\ 100\ \%}{104165} = \mathbf{0\ \%}$$

Trial < 100 MB:

$$= \frac{\text{(Data packets sent–Data packets received)X 100\%}}{\text{Data packets sent}}$$

$$= \frac{(199216 - 199216)\ X\ 100\ \%}{199216} = \mathbf{0\ \%}$$

1. Testing QoS Load balancing using the NTH method.

a. Throughput Calculation

Throughput data obtained through observations using wireshark tools. The data obtained are as follows:

Table 8. Data Throughput NTH

Size	Received data packets (Bytes)	Duration of Observation (Second)
≥ 100 MB	8516580	89,631
< 100 MB	18192788	185,885

The data obtained is then calculated using the throughput equation:

Trial > 100 MB:

$$= \frac{\text{received data packet}}{\text{length of observation}}$$

$$= (8516580/89,631)$$

$$= (95018,241 \text{ Bps} * 8) / 1024$$

$$= 742,330 \text{ Kbps}$$

Throughput(%)= (744,620 /1024)*100%
= **72,49 %**

Trial < 100 MB:

$$= \frac{\text{received data packet}}{\text{length of observation}}$$

$$= (18192788/185,885)$$

$$= (97871,199 \text{ Bps} * 8) / 1024$$

$$= 764,618 \text{ Kbps}$$

Throughput(%)= (501,379/1024)*100%
= **74,66 %**

a. Delay Calculation

Delay data is obtained through observation using wireshark tools. The data are as follows:

Table 9. Data Delay NTH

Size	Duration of Observation (Second)	Total Packets
≥ 100 MB	89,631 s	90591
< 100 MB	185,885 s	187191

The data obtained is then calculated using the delay equation:

Trial > 100 MB:

$$= \frac{\text{length of observation}}{\text{total packets received}}$$

= 89,631 / 90591
= 9,8940 s * 1000 = **0,98 ms**

Trial < 100 MB:

$$= \frac{\text{length of observation}}{\text{total packets received}}$$

= 185,885 / 187191
= 9,9302 s * 1000 = **0,99 ms**

a. Jitter Calculation

Jitter data is obtained through observation using wireshark tools. The data are as follows:

Table 10. Data Jitter NTH

Size	Variation Delay	Total Packets
≥ 100 MB	89,919 s	90591
< 100 MB	186,018 s	187191

Trial > 100 MB:

$$= \frac{\text{total delay variation}}{\text{total packets received}}$$

= 89,919 / 90591
= 9,9258 s * 1000 = **0,99 ms**

Trial < 100 MB:

$$= \frac{\text{total delay variation}}{\text{total packets received}}$$

= 186,018 / 187191
= 9,9373 s * 1000 = **0,99 ms**

d. Packet Loss Calculation

Packet Loss data obtained through observations using wireshark tools. The data are as follows:

Table 11. Data Packet Loss NTH

Size	Data Packets Sent	Data Packets Received
≥ 100 MB	90591	90591
< 100 MB	187191	187191

The data obtained is then calculated using the packet loss equation:

Trial > 100 MB:

$$= \frac{(\text{Data packets sent} - \text{Data packets received}) \times 100\%}{\text{Data packets sent}}$$

$$= \frac{(90591 - 90591) \times 100\ \%}{90591} = \mathbf{0\ \%}$$

Trial < 100 MB:

$$= \frac{(\text{Data packets sent} - \text{Data packets received}) \times 100\%}{\text{Data packets sent}}$$

$$= \frac{(187191 - 187191) \times 100\ \%}{187191} = \mathbf{0\ \%}$$

Based on the results of calculations on each method in the load balancing technique using predetermined parameters, the results of performance comparisons based on categories and QoS values of throughput, delay, jitter, and packet loss parameters are as follows:

Table 12. Comparison of QoS . Parameter Values

No	**Parameter QoS**	**ECMP**	
		Download file size > 100 MB	Download file size < 100 MB
1	Throughtput	70,45 %	74,32 %
2	Delay	0,99 ms	0,69 ms
3	Jitter	0,99 ms	0,69 ms
4	Packet Loss	0%	0%
No	Parameter QoS	NTH	
		Download file size > 100 MB	Download file size < 100 MB
1	Throughtput	72,49 %	74,66 %
2	Delay	0,98 ms	0,99 ms
3	Jitter	0,99 ms	0,99 ms
4	Packet Loss	0%	0%

Explanation of Table 12:

- The throughput value of the NTH method in the trial of downloading files measuring less than 100 MB or more than 100 MB is greater value than the ECMP method, which means the data transfer speed of the NTH method is faster than the ECMP method, although not significantly.
- The delay value of the ECMP method in trying to download files with a size of more than 100 MB is lower than the NTH method. This means that the lag time of the ECMP method is shorter when downloading large files compared to the NTH method.
- The jitter value in the ECMP method is the same as the delay value so that packets will be received faster by the user when downloading large files using the ECMP method in load balancing techniques.
- The value of packet loss in the ECMP and NTH methods does not indicate that there are no lost packets during the observation.

Table 13. Comparison of QoS . Parameter Categories

No	**Parameter QoS**	**NTH**	
		Download file size > 100 MB	Download file size < 100 MB
1	Throughtput	Medium	Medium
2	Delay	Very good	Very good
3	Jitter	Good	Good
4	Packet Loss	Very good	Very good
No	Parameter QoS	PCC	
		Download file size > 100 MB	Download file size < 100 MB
1	Throughtput	Medium	Medium
2	Delay	Very good	Very good
3	Jitter	Good	Good
4	Packet Loss	Very good	Very good

Explanation of Table 13:

a. The throughput value of both the ECMP and NTH methods in the trial of downloading files measuring less than 100 MB and more than 100 MB, both methods fall into the medium category.
b. The delay value of the ECMP and NTH methods in the trial of downloading files measuring less than 100 MB and more than 100 MB is in the very good category, which means that the delay for these two protocols is low.
c. The jitter value of the ECMP and NTH methods for downloading files that are less than 100 MB and more than 100 MB is in good category.
d. The packet loss values in both ECMP and NTH methods fall into the very good category, which during the test did not show any lost data packets on the way.

V. CONCLUSION

Each test result on the specified parameters shows the same performance. Although there are differences in values between methods, they are still in the same category in the QoS parameters. In the throughput parameter, the NTH method has a greater value than the ECMP method in every file download attempt. The delay parameter shows the result that the ECMP method has a shorter delay time than the NTH method, especially in downloading files with a size of more than 100MB. Jitter shows that the ECMP method is also slightly better than the NTH method for trying to download files of more than 100 MB. In packet loss, both ECMP and NTH methods have no lost packets, which means that both methods work very well. The performance of the NTH

method in the application of load balancing on the network is better than the ECMP method, from the results of the Quality of Service (QoS) side testing that is carried out because it has a greater throughput value.

As for some suggestions that the author can give from this research, using a source link from an ISP that has good quality, so that it can provide good service as well. Combining load balancing and failover techniques on managed networks, because these two techniques are closely related and complementary. Always update the amount of bandwidth needed so that network performance can run well and provide satisfaction for clients on the network.

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