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Effect of Load Balancing Bonding and Failover on Speed, Latency, Average, and Packet Loss

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ABSTRACT

This study evaluates the performance of a network with and without load balancing bonding. The tests were conducted in a VMware virtual environment and applied to an Internet Service Provider (ISP) network. The setup involved two routers connected via three virtual cables configured for load balancing bonding, with a computer acting as the test environment. A workload of 1,000 packets was used for the evaluation. The results demonstrated superior performance when load balancing bonding was applied compared to when it was not. In the default condition, the speed in Balance Round Robin mode was higher, achieving 0.157 Mbps (Tx) and 3.4 Mbps (Rx). Latency was lower in Balance Round Robin mode, recorded at 729 ms. The average throughput in Balance Round Robin mode was also higher at 768 bps. Packet loss was consistently 0%, with no lost packets observed. Under failover conditions, Balance Round Robin mode maintained superior performance, with speeds of 0.107 Mbps (Tx) and 2.2 Mbps (Rx). These values were derived using Bandwidth Test and Traceroute tools. In conclusion, the implementation of load balancing bonding significantly improves network performance in terms of speed, latency, average throughput, and packet loss, under both default and failover conditions. These findings highlight the potential of load balancing bonding to enhance the reliability and efficiency of network operations.

I. INTRODUCTION

The rapid development of computer networks and the internet, especially as a medium for information dissemination, has made a reliable connection increasingly essential [1]. Individuals, organizations, and Internet Service Providers (ISPs) must effectively manage their networks to prevent system failures, data loss, or inaccuracies [2]. Diverse computer networks require various resources, including servers, storage, and applications [3].

Load balancing and bonding are two critical techniques in computer networks that complement each other and are highly beneficial for enhancing performance, availability, and scalability in network management. Load balancing distributes traffic across multiple servers connected through bonding, ensuring that each server handles only a portion of the total traffic, thereby improving overall system performance [4]. Bonding, on the other hand, enhances speed, bandwidth, and redundancy in connections between load balancers and the backend servers [5],[6].

To provide a solid foundation for this research, several relevant studies are reviewed. The first study [7] evaluated parameters such as packet loss, delay, jitter, and throughput. The results indicated that bonding interfaces offer greater network stability compared to single-link networks, as evidenced by lower jitter values.

The second study [8] focused on failover testing, using parameters such as packet loss and throughput. The results showed that link aggregation using two bonding interfaces increased average UDP bandwidth from 0 bps/91.6 Mbps to 0 bps/184.9 Mbps, and TCP bandwidth from 0 bps/93.8 Mbps to 0 bps/105.5 Mbps. Utilizing MikroTik Router, link aggregation effectively enhanced bandwidth throughput by combining two physical Ethernet links into a single logical link.

This study aims to evaluate the performance improvement of networks using load balancing bonding compared to those without it. Unlike previous studies, this research employs three load balancing bonding modes: Balance Round Robin, Balance Transmit Load Balancing, and Balance Adaptive Load Balancing. The tests were conducted in a VMware virtual environment and applied to an ISP network. The network configuration involved two routers connected via three virtual cables, serving as load balancing bonding, and a computer used for testing. A workload of 1,000 packets was transmitted in networks both with and without load balancing bonding.

The performance evaluation focuses on parameters such as speed, failover [9], latency [10], average throughput [8], and packet loss [11]. Additionally, a comparison of these parameters is made between networks with and without load balancing bonding to highlight the performance differences.

II. METHOD

This research utilizes three modes of Load Balancing Bonding: Balance Round Robin [12], Balance Transmit Load Balancing [13], and Balance Adaptive Load Balancing [14]. The study involves several stages aimed at addressing the identified problems, as illustrated in Figure 1.

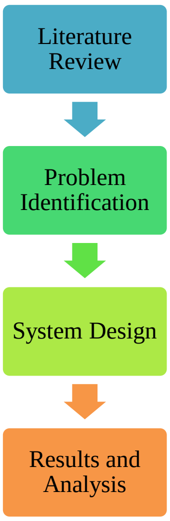

Figure 1. Research Stages

A. Literature Review

A comprehensive literature review was conducted to gather information on the subject matter. References and previous research papers were studied to understand and analyze the performance enhancement of networks using load balancing bonding compared to networks without it.

B. Problem Identification

The system development requirements were identified, including the tools and technical parameters used in the study. These details are outlined in Tables I and II, which serve as a foundation for the experimental setup and performance evaluation.

TABLE I
TOOLS USED

Software	Function
Winbox	Application used for network configuration
Mikrotik	Application used to connect multiple networks
Vmware	Application used for virtual machines
Bandwidth Test	Application used to measure data transfer speed
Traceroute	Application used to measure latency, average, and packet loss

TABLE II
TECHNICAL PARAMETERS

Parameter	Detail
Speed	Time generated from the testing
Failover	Time generated from the testing when a network experiences failure or outage
Latency	Time required for data packets to reach their destination
Average	Time required for data packets to travel from one router to the next
Packet Loss	Percentage of data packets lost

C. System Design

The network configuration involves two routers connected by three virtual cables configured for load balancing bonding. A computer is incorporated into the topology to function as a test client for load balancing bonding.

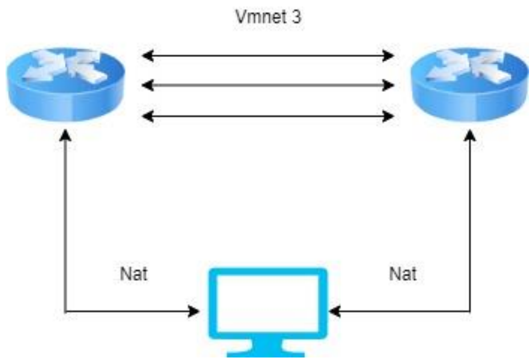

Figure 2. Network Topology

All devices on the Vmnet3, including the client devices connected to the routers via NAT interfaces, are designated as part of the private network, while network segments outside Vmnet3 are considered part of the public network. A network topology diagram was created to visually represent the infrastructure, facilitating better understanding. The topology used in this research is shown in Figure 2.

Each virtual cable in VMware has a bandwidth of 10 Mbps with identical configurations. To connect the routers to the PC, the same type of virtual cable was used, as depicted in Figure 3.

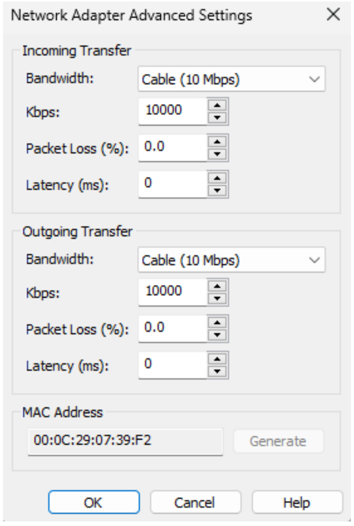

Figure 3. VMware Settings

It shows the configuration for both incoming and outgoing transfer settings, including the bandwidth, packet loss, and latency for network traffic. Here's a description of the key components:

- Incoming Transfer: Configured to a bandwidth of 10 Mbps, with a packet loss of 0% and a latency of 0 ms.
- Outgoing Transfer: Similarly set to 10 Mbps, with 0% packet loss and 0 ms latency.
- MAC Address: A unique MAC address (00:0C:29:07:39:F2) is displayed here, likely generated automatically for the network adapter.

This configuration helps simulate the network performance in a controlled environment, which can be useful for testing various network scenarios or configurations.

D. Result and Analysis

System testing was conducted to evaluate the performance of the developed setup. Primary data collection began with system testing analysis performed using Winbox [15-17], which provides tools such as Bandwidth Test and Traceroute. These tools were employed to gather data for this research. Secondary data were obtained through literature analysis and references used to support the study.

The test results obtained in the virtual environment are relevant and can potentially be applied to real-world physical networks. This relevance is ensured by carefully designing the experiment with variables such as network topology, workload conditions, simulation configurations, consistent use of load balancing bonding modes, and selecting appropriate metrics to measure network performance improvements, including speed, latency, average throughput, packet loss, and failover.

Although the simulation provides valuable insights into the mechanisms of load balancing bonding, it should be noted that the results may not entirely reflect the performance of physical networks, which are inherently more complex. Factors such as network hardware variations, interference, and dynamic workload fluctuations can significantly impact performance outcomes.

Further research is needed to validate the simulation results by employing physical hardware and more realistic workloads. This would enable a more accurate assessment of the performance improvements achieved by load balancing bonding under conditions closer to real-world environments.

III. Result And Analysis

Testing to compare speed was conducted using the Bandwidth Test tool with predefined bonding modes. The first test was performed on networks using load balancing bonding and networks without load balancing bonding. The second test included failover mechanisms applied to both network configurations.

Testing to compare latency, average throughput, and packet loss was conducted using the Traceroute tool. The workload consisted of 1000 packets transmitted in each predefined bonding mode without applying the failover mechanism.

- Latency Comparison. The first test compared latency in networks with and without load balancing bonding.
- Average Throughput Comparison. The second test evaluated average throughput under the same conditions.
- Packet Loss Comparison. The third test compared packet loss between networks with and without load balancing bonding.

These tests aim to evaluate the performance improvements achieved with load balancing bonding compared to networks without load balancing bonding.

A. Configuration of Balance Round Robin

Initially, bonding interfaces were added to each router, followed by configuring slave parameters based on the router interfaces used in MikroTik. After adding the slave parameters, the bonding mode was set to Balance Round Robin as per the test requirements. The detailed configuration is shown in Figure 4.

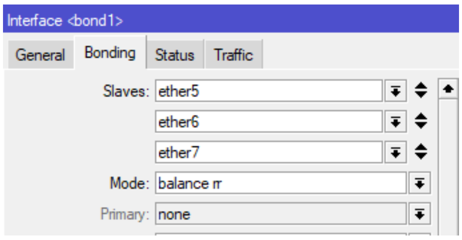

Figure 4. Balance Round Robin Configuration

Figure 4 shows the Balance Round Robin configuration on Mikrotik, where three network interfaces (ether5, ether6, and ether7) are combined into a bonding interface with the Balance Round Robin mode. This mode distributes the network load evenly across the slave interfaces, ensuring balanced packet data distribution and improving overall data transfer speeds. This configuration is useful for optimizing bandwidth usage and providing network redundancy, enhancing performance and stability in congested network conditions or when a network interface fails.

B. *Configuration of Balance Transmit Load Balancing*

Similarly, bonding interfaces were added, and slave parameters were configured for each router. The bonding mode was then set to Balance Transmit Load Balancing for the respective tests, as shown in Figure 5.

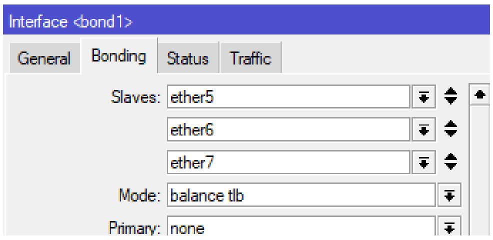

Figure 5. Balance Transmit Load Balancing Configuration

Figure 5 shows the Balance Transmit Load Balancing (TLB) configuration in Mikrotik, where three network interfaces (ether5, ether6, and ether7) are configured in a bonding interface. In this mode, the network traffic is distributed based on the outgoing traffic load across the slave interfaces. Unlike Balance Round Robin, which evenly distributes traffic in both directions (incoming and outgoing), Balance TLB optimizes the outbound traffic load balancing while utilizing the best available network interface for incoming traffic. This helps in improving the overall performance, reducing congestion on any single interface, and ensuring better load distribution in a network environment.

C. *Configuration of Balance Adaptive Load Balancing*

The bonding interfaces and slave parameters were configured similarly, followed by selecting the Balance Adaptive Load Balancing mode. Details are depicted in Figure 6.

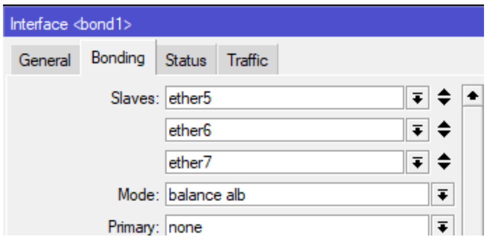

Figure 6. Balance Adaptive Load Balancing Configuration

D. *Configuration Without Load Balancing*

In this configuration, bonding interfaces were added and slave parameters were set, but the bonding interface was disabled as per the test requirements. This configuration is detailed in Figure 7.

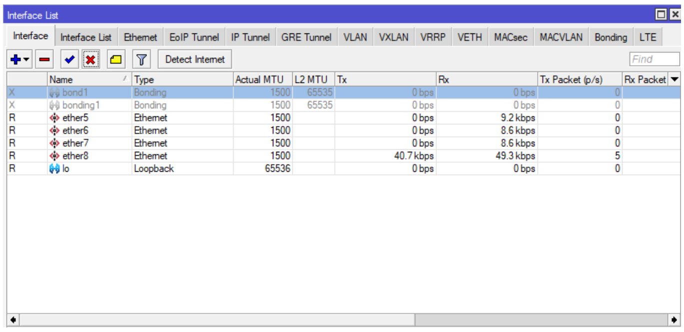

Figure 7. Configuration Without Load Balancing

E. *Speed Analysis*

The speed tests revealed significant improvements when using load balancing bonding. Before implementing load balancing bonding, the recorded speeds were 0.052 Mbps (Tx) and 1.1 Mbps (Rx). After applying load balancing bonding, the speeds increased to 0.157 Mbps (Tx) and 3.4 Mbps (Rx), as shown in Figure 8. This demonstrates the advantages of load balancing bonding in enhancing network performance.

TABLE III
SPEED CALCULATION RESULTS

No	Mode Bonding	Tx	Rx
1	Balance Round Robin	0.157 Mbps	3.4 Mbps
2	Balance Transmit Load Balancing	0.045 Mbps	3.2 Mbps
3	Balance Adaptive Load Balancing	0.12 Mbps	3.3 Mbps
4	Without Load Balancing	0.052 Mbps	1.1 Mbps

Table III presents the speed calculation results from the tests conducted before and after using load balancing bonding with the modes: Balance Round Robin, Balance Adaptive Load Balancing, and Balance Transmit Load Balancing. For a clearer comparison, please refer to the comparison chart shown in Figure 8.

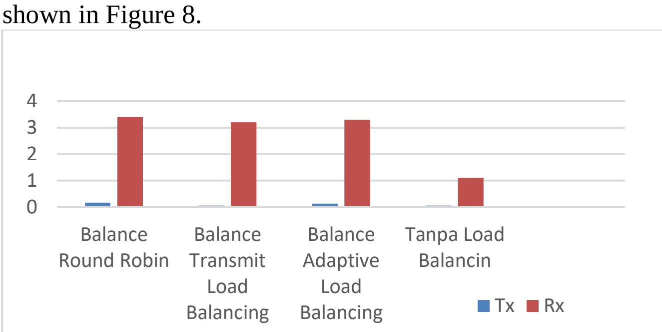

Figure 8. Speed Comparison Chart

F. *Failover Analysis*

During failover conditions, speed tests were conducted, and the results indicated that speeds before using load balancing bonding were lower compared to speeds after implementing load balancing bonding. This comparison is illustrated in Figure 9. The speeds recorded before using load balancing bonding were 0.05 Mbps (Tx) and 1.1 Mbps (Rx), while speeds after using load balancing bonding were 0.107 Mbps (Tx) and 2.2 Mbps (Rx). The implementation of load balancing bonding continued to demonstrate superior performance.

TABLE IV
RESULTS OF SPEED CALCULATION DURING FAILOVER

No	Mode Bonding	Tx	Rx
1	Balance Round Robin	0,107Mbps	2.2 Mbps
2	Balance Transmit Load Balancing	0.01Mbps	0.1 Mbps
3	Balance Adaptive Load Balancing	0,078Mbps	2.1 Mbps
4	Without Load Balancing	0,05Mbps	1.1 Mbps

Table IV provides details of the speed calculations under failover conditions, comparing results before and after implementing load balancing bonding in Balance Round Robin, Balance Adaptive Load Balancing, and Balance Transmit Load Balancing modes. The graphical comparison can be observed in Figure 9.

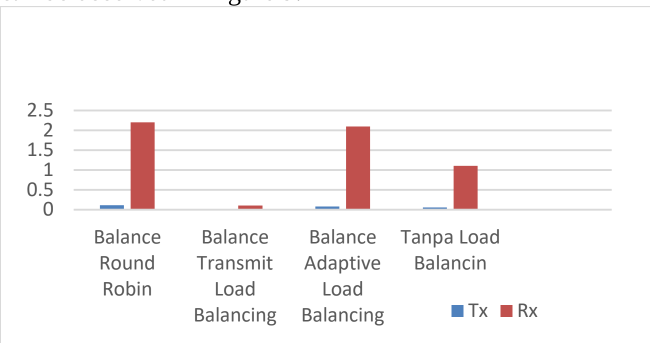

Figure 9. Speed Comparison Chart During Failover

G. *Latency Analysis*

The latency test results revealed that latency before using load balancing bonding was higher than after its implementation.

TABLE V
LATENCY CALCULATION RESULTS

No	Mode Bonding	Latensi
1	Balance Round Robin	729ms
2	Balance Transmit Load Balancing	749ms
3	Balance Adaptive Load Balancing	759ms
4	Without Load Balancing	779ms

This comparison is depicted in Figure 10, where the latency value before using load balancing bonding was 779 ms, and after implementation, it was reduced to 729 ms. Load balancing bonding consistently showed better performance.

Table V contains detailed latency calculations from tests conducted before and after implementing load balancing bonding using Balance Round Robin, Balance Adaptive Load Balancing, and Balance Transmit Load Balancing modes. The graphical representation of these comparisons is shown in Figure 10.

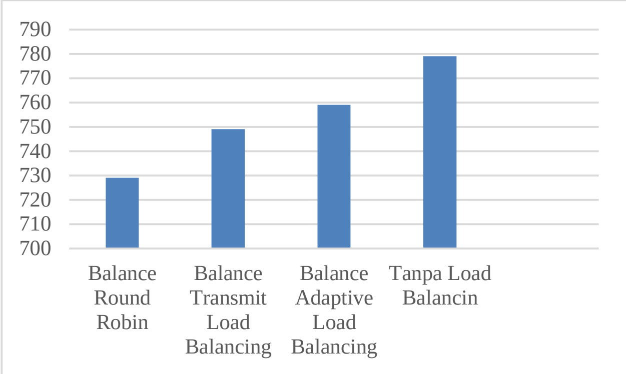

Figure 10. Latency Comparison Chart

H. *Average Throughput Analysis*

The test results for average throughput indicated that values before implementing load balancing bonding were lower compared to after its use. As shown in Figure 11, the average throughput before using load balancing bonding was 734 bps, while it increased to 768 bps after the implementation. Load balancing bonding consistently demonstrated an advantage over configurations without it.

TABLE VI
AVERAGE CALCULATION RESULTS

No	Mode Bonding	Average
1	Balance Round Robin	768 bps
2	Balance Transmit Load Balancing	746 bps
3	Balance Adaptive Load Balancing	758 bps
4	Without Load Balancing	734 bps

Table VI provides information about average throughput calculations before and after using load balancing bonding in Balance Round Robin, Balance Adaptive Load Balancing, and Balance Transmit Load Balancing modes. Further details can be observed in the graphical comparison in Figure 11.

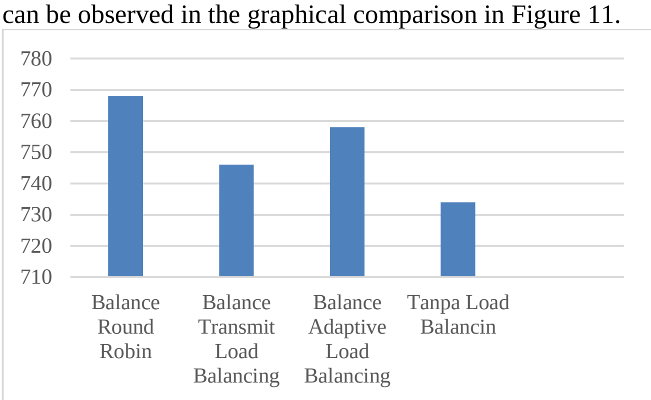

Figure 11. Average Comparison Chart

I. *Packet Loss Analysis*

The packet loss calculations showed no differences, with a consistent value of 0% for both configurations—whether using load balancing bonding or not. A detailed comparison is provided in the graphical representation in Figure 12.

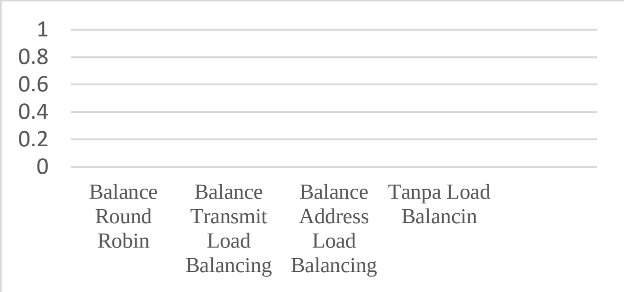

Figure 12. Packet Loss Comparison Chart

IV. Conclusion

Based on the tests conducted by the researcher, it can be concluded that the use of load balancing bonding with the balance mode applied in this study results in better network performance compared to not using it. The speed calculation results show that when using load balancing bonding in the default condition with the Balance Round Robin mode, the achieved speed is 0.157 Mbps (Tx) and 3.4 Mbps (Rx), which is higher than when load balancing bonding is not used, where the speed is only 0.052 Mbps (Tx) and 1.1 Mbps (Rx).

Additionally, the speed calculations under failover conditions show that the speed obtained with load balancing bonding in the Balance Round Robin mode is 0.107 Mbps (Tx) and 2.2 Mbps (Rx), which is still higher than the speed obtained without load balancing bonding, which only reaches 0.05 Mbps (Tx) and 1.1 Mbps (Rx).

The latency calculation results show that when using load balancing bonding with the Balance Round Robin mode, the latency value is 729 ms, which is lower compared to the latency without load balancing bonding, which is 779 ms. The average throughput when using load balancing bonding with Balance Round Robin mode is 768 bps, which is higher than the throughput without load balancing bonding, which is only 734 bps. Meanwhile, the packet loss test results were the same, showing 0% packet loss, meaning no packets were lost in both configurations—whether using load balancing bonding or not.

In conclusion, the use of load balancing bonding with the Balance Round Robin mode is selected because it significantly improves network performance, both in default and failover conditions, compared to other Balance modes and without load balancing bonding, based on speed, failover, latency, average throughput, and packet loss parameters.

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