Simulation and Performance Analysis of Network Backup Systems Using Hot Standby Router Protocol (HSRP) Method on Real-Time Networks

Imelda Uli Vistalina Simanjuntak, Junas Haidi, Heryanto, and Lukman Medriavin Silalahi

Abstract—**The phenomenon that occurs today is an increase in the use of electrical energy consumption every year and especially in Public Street Lighting (PSL) lamps. It can be noticed that almost every road is public, and the expressway has PSL lights. PSL lamps are installed on each median, left or right of the road with a distance between ± lights of 30meters. The object of research on this foreign cooperation is located in the PIK2 project located in the Dadap area, Indonesia. The PSL lamp installation location has a road length of ±1.8Km. PSL lamps used have a power of 250watts. While the specific purpose of this study is to design and analyze measurements of power, voltage and current in PSL lamps and also to control and monitor the condition of PSL lamps through the Wireless Sensor Network (WSN) by applying a star topology for the efficiency of electrical energy consumption in PSL lamps, using microcontrollers, sensors, and LoRa. This research is expected to produce a best practice model for the application of WSN in the PSL system in Indonesia and become a recommendation for companies in improving WSN technology and global competitiveness. The proposed research methods are quantitative and objective, so this study is applied to acquire and distribute data at PSL light points. The data on the sensor will be sent through the end node which is then sent to the coordinator node or gateway. The sensor data on this tool can be displayed by accessing the ubidots.**

Keywords—**WSN; control and monitoring; earthquake early warning**

I. INTRODUCTION

IN the era of digitalization of society 5.0, all needs have been carried out with electronic money transactions, digital data, and so on. This makes the real-time network standard must have excellent performance to avoid high transaction spikes at any time. Therefore, improving performance through a backup system when the network is down must be optimized continuously in both short and broad scopes.

All companies in the banking sector must continuously improve their network performance, especially when it is down, by shortening the repair time while the network is backed up.

Availability and redundancy of network device connections that are always connected without limits must be fulfilled by many companies, especially banks, to protect business and transactions in case of a system failure or loss or damage to customer data. Impact on company losses. Redundancy can be achieved by installing multiple devices or channels in the required locations.

So far, the WAN network has experienced downtime due to problems with Cisco router devices that fail to work or downtime. The HSRP (Hot Standby Router Protocol) method is applied as a Cisco proprietary protocol as a failover mechanism consisting of a router cluster with an active router and a standby router. If there is a failure on the network, using the HSRP method can minimize the cause and duration of the link down.

Research using the HSRP method as network redundancy to minimize network downtime has also been applied in several fields, such as telecommunication companies, taxes, Indonesian ports, and so on [1]–[4]. HSRP method integration research [5]–[10] and a comparison of other HSRP backup method designs are also used as a reference in this study [11]–[14].

Based on journals and conference papers that examine the HSRP method, it brings newness to better performance parameters in banking networks. It measures network performance based on throughput, delay, jitter, and packet loss parameters[15]–[18]. The hypothesis will provide better performance than before using the HSRP backup system.

The scope of this research consists of simulation and analysis of the HSRP backup system to minimizing downtime duration [19]–[22], So, the formulation of problems at the core of this research includes calculating and analysing the duration of downtime, measuring throughput, delay, jitter, packet loss obtained before and after using the HSRP backup system and comparing it with similar research to show the research contribution given to the HSRP method in this research.

Against the background of the problems described above, this research aims to design the availability of router redundancy that can reduce the outage duration using the Hot Standby

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Router Protocol (HSRP) method and packet tracking software to minimize company losses.

II. RESEARCH METHOD

A. HSRP and Non-HSRP Research Block Diagram

In this study, the HSRP method will be configured on a multilayer switch device in the core block. What distinguishes between HSRP and non-HSRP is that when a device failure occurs in the core, it will impact network users; one way to minimize downtime when such a failure occurs is the HSRP method.

Figure 1 shows a non-HSRP network block diagram where the way it works itself only has active devices without any backup devices. If there is a failure, such as an interface or a dead device, the entire network will experience downtime, and data exchange or communication made by the client will be disrupted. the active and backup states. Because forwarding devices use the same IP address and MAC address (virtual), users connected to the corporate network will continue to run without communication interruptions. Furthermore, if the path or device that previously failed has returned to life, then the device will return to being an active device because of the configuration that has been given to that device. The device that replaced the position of the previously active device will return to being a standby device.
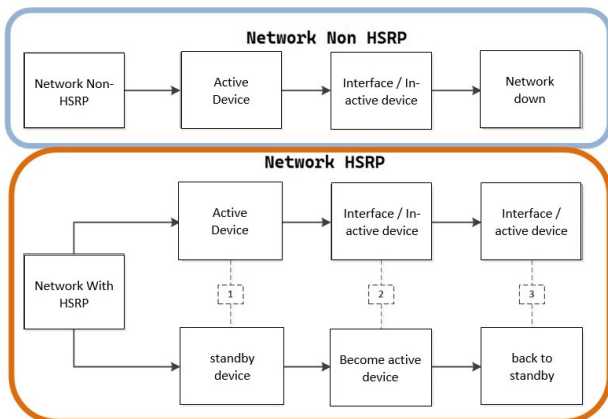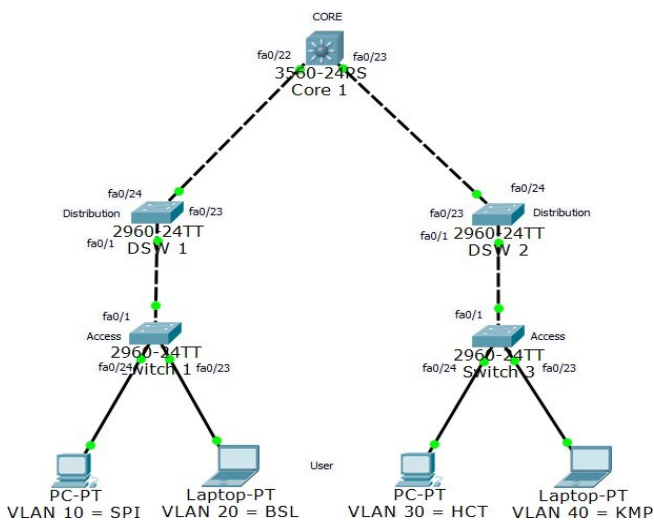

Fig. 1. HSRP and non-HSRP block diagram
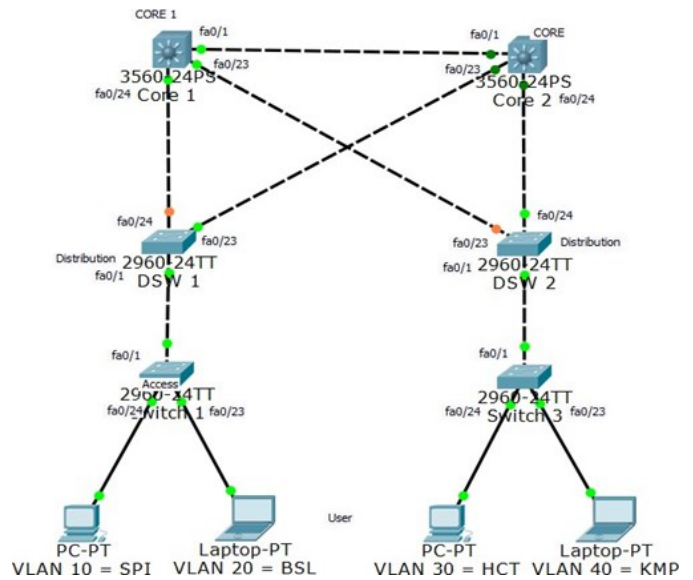

Fig. 2. Existing network topology

Fig. 3. HSRP method network design

B. Existing Network Topology

The network topology ran on companies in the banking sector before using HSRP, as shown in Figure 2. The network topology running in this banking company follows the network hierarchy, which consists of core, distribution, and access. The core layer uses a Cisco Catalyst 3560 24-port type layer of three switches with 24 fast ethernet ports and 2-gigabit ethernet ports. The distribution layer uses a 24-port Cisco Catalyst 2960 device with a managed switch type, which can be configured and equipped with VLAN features to connect to LAN segments simultaneously. The access layer uses the same device as the distribution layer, the Cisco Catalyst 2960 24-port.

The network topology in this figure only displays the core of the network that will be focused on with the HSRP method because it cannot display the original topology of the company.

It can be seen in Figure 2 that there is only one multilayer switch device. That will cause the user to experience communication problems when a failure occurs on one of the devices or links on the core. Downtime that occurs when changing devices or broken links certainly requires much time, during this downtime, it will undoubtedly harm the company.

C. New Network Topology Design

The design of a computer network failover system topology using the HSRP feature on a Cisco multilayer switch is shown in Figure 3. The design of a new network topology still uses the existing network and only adds links and configurations. The addition of a cable connection is provided between the two multilayer switches, and also the addition of HSRP configuration on the multilayer switch device. That aims to establish a failover system to tolerate errors, minimize downtime, and avoid communication failures within the company. With the addition of the link, the connection between the two multilayer switch devices becomes redundant, and when one link is down, the connection can still work with the other link.

The computer network design in Figure 3 uses two multilayer switches, namely the main and backup. Both are connected by link and each other through two distribution switches. Both switches have LAN IP addresses on the same network to know

the active status of the other multilayer switch. When data is sent through an active multilayer switch, only one active multilayer switch works to transmit data, and the other continues to send hello messages to find out the status of the active multilayer switches around it, this is intended for the following backup process if the previous active multilayer switch was interrupted.

D. Trial Scenario

The trial scenarios used are the backup link, failover link, and QoS (Quality of Service) trials. Table I and table II are a backup and failover link trials will be carried out on network simulator software, namely cisco packet tracer, by displaying show running and standby from the simulation device.

TABLE I
BACKUP LINK TESTING SCENARIOS

No.	Name Test	Function to be tested	Scenario	Expected results
1	Link Test Backup	Link backup interface	On each multilayer switch, a point to point IP interface ping test is carried out	Backup links works

TABLE II
FAILOVER LINK TESTING SCENARIOS

No.	Name Test	Function to be tested	Scenario	Expected results
1	Link Test Failover	The process of moving the main link to the path backups	Simulation by turning off the multilayer switch as active links	Transfer of data lines move from the main link to backups

While table III is a testing the QoS will use Wireshark. The data obtained will be calculated according to the existing formula. This trial is a black box testing method. This method is used to determine whether the system is running correctly.

TABLE III
QUALITY OF SERVICE PARAMETER TESTING SCENARIO

No.	Name Test	Function to be tested	Scenario	Expected results
1	Test Quality of Service	Network quality parameters (packet loss, delay, throughput, and jitter)	Network quality parameters (packet loss, delay, throughput, and jitter)	Parameters of network quality are in the category with good conditions

Black box testing observes execution results using test data and examines device functions. This test evaluates the fundamental aspects of the system without regard to the internal logical structure of the software. The test data generated by the software is then checked to see whether it is following the expected results.

III. RESULT AND DISCUSSION

A. Backup Link Test Results

This test is conducted to prove that the backup link interface is running correctly. Backup link testing is carried out by conducting a Ping test from Host 2 to VLAN IP interfaces on Core 1 (192.168.10.2 and 192.168.20.2) and Core 2 (192.168.30.3 and 192.168.40.3). The Ping test results show a reply, and Core 2 as a backup link has worked well, as seen in Figure 4.
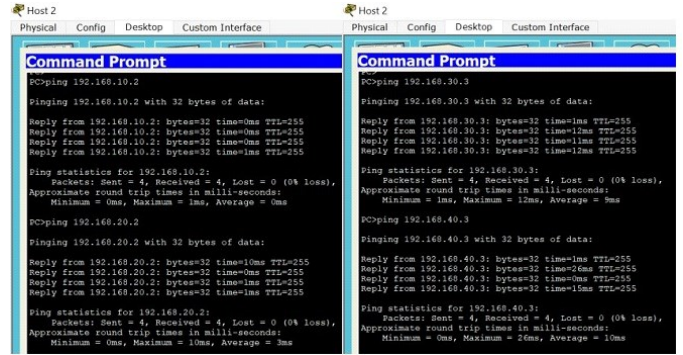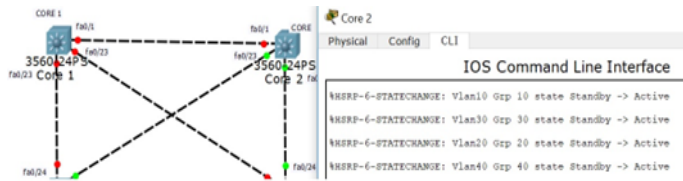

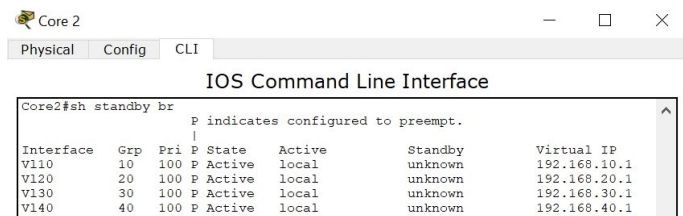Fig.4. Backup link test results

Fig. 5. Core 2 status during failover

Fig. 6. Show core 2 active state

B. Failover Link Results

This test is carried out to show the displacement of the path through the active device. When it is down, it will pass through the standby device. Testing is done by turning off the interface on the Core 1 device. Figure 5 shows that the Core 2 device changes from standby to active because Core 1 is considered dead after the hold time runs out.

In Figure 13, using the show standby brief command, it will be seen that the VLAN interface on the Core 2 device is in an active state with the same virtual IP. The information on the standby list shows unknown, which means that because the Core 1 device is down, it cannot send or receive hello packets, so Core 1 needs to learn about the status of the new Core 2 as an active device.

In Figure 7, and a trace route test is carried out with the tracer command. It can be seen that the communication from Host 2 to Host 3 and vice versa has changed through the VLAN interface on the Core 2 device until it finally arrives at the IP address of the intended host, which means that the data packet has passed correctly through the Core 2 device which replaces the Core 1 device as the active device.
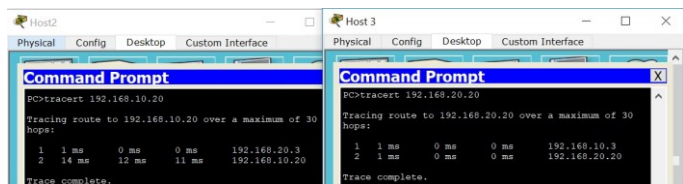

Fig. 7. Trace route after failover
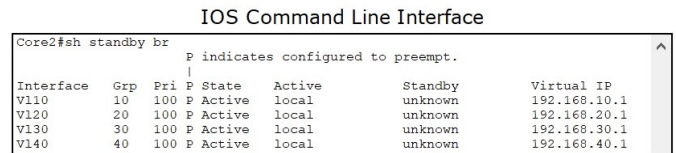
Fig. 8. Core 1 status

Fig. 9. Core 2 status

When the Core 1 interface comes back to life, it will immediately continue its duties as an active device, but when it gets a Hello Packet from Core 2 containing its status, Core 1 will lose and become a Standby Router. However, in this simulation, Core 1 is given a preemptive command. This privilege can be given to a Router or MLS so that when Core 1 comes back to connection, it will become an Active Router, not a Standby Router.

When core 1 up figure 8 shows the state conditions on the core 1 device when the interface is back on, core 1 will start sending hello packets again, indicated by the speak state, then the standby state, and the active state because it uses the preempt command.

When core 1 up figure 9 shows the state condition of the core 2 device after the interface on core 1 is back on, core 2 will receive a hello packet from core 1, which also gives the status that core 1 is alive and takes over the active state. Core 1 is in the speak state, where the status determines whether the device is active and standby after it becomes a standby state.

C.　Quality of Service Test Results

1)　Packet Loss

Based on figure 10, the packets not received are calculated and searched as a percentage (%). To measure the packet loss by counting packets sent with Wireshark. It can be analyzed from 5 trials with different time intervals. It shows that there is no packet loss, or if it is calculated, the value is 0%, which means no lost packets are sent. So, based on the ideal packet loss value category, packet loss in the HSRP network is in an excellent category.
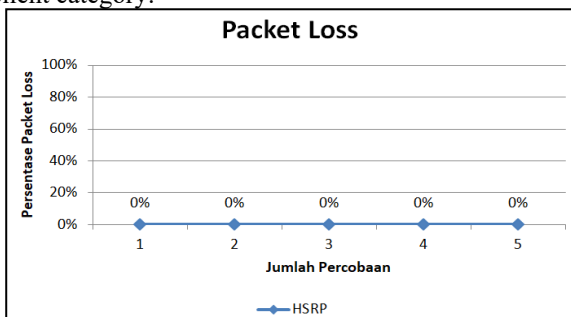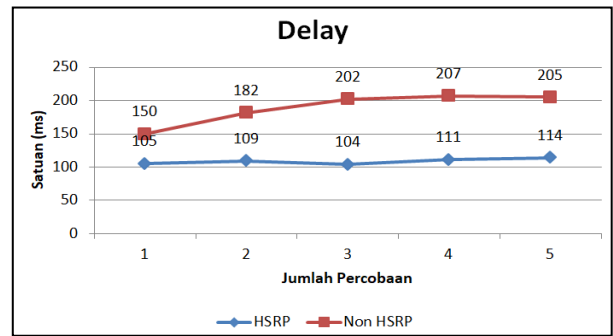

Fig. 10. HSRP packet loss

Fig. 11. HSRP delay

The results of packet loss measurements that have been carried out using the HSRP network are compared with the results from the network before using MPLS. It can be concluded that network simulations using the HSRP method and without HSRP both get a packet loss value of 0%. However, this packet loss condition is obtained when the device is in average condition. The results will certainly differ when the device or interface is down. A network without HSRP will get an enormous packet loss value because it does not have a failover link as a backup device from an active device which may experience a downturn.

2)　Delay

Measurement of the delay parameter with the HSRP method and without HSRP using the Wireshark is shown in figure 11. The measurement results are based on comparing the network simulation before and after using the HSRP method and carried out five times with different time intervals, shown in figure 11.

Figure 11, the red graph shows the delay parameters from network simulations that have not used HSRP. The non-HSRP delay parameter is slightly higher, where the lowest value is 150 ms and the highest value is 207 ms. The average delay is 189.2 ms, where based on the ideal value category, the delay is included in a suitable category, but on the real network, it will be different and can be less stable. Next, the blue graph shows the delay parameter from the network simulation using the HSRP method. After using the HSRP method, an increase in delay is obtained where the lowest delay value is 104 ms and the highest value is 114 ms with an average delay of 108.6 ms; based on the ideal value category, the delay is included in the excellent index category and of course it will be more stable. The smaller the delay index value of a data transmission, the better the data transmission process.

3)　Jitter

Jitter measurement is carried out using the Wireshark, where the jitter itself is usually called the delay variation. The measurement analysis results based on the comparison of the network simulation before and after using the HSRP method were performed 5 times with different time intervals. In Figure 12, the red graph shows the jitter parameters from network simulations that have not used HSRP.

It can be seen that non-HSRP jitter parameters get results that are not much different from those of HSRPNon- higher, where the lowest value is 0.15 ms, and the highest value is 0.21 ms. The average jitter is 0.19 ms, based on the ideal jitter values category, including in an excellent category.
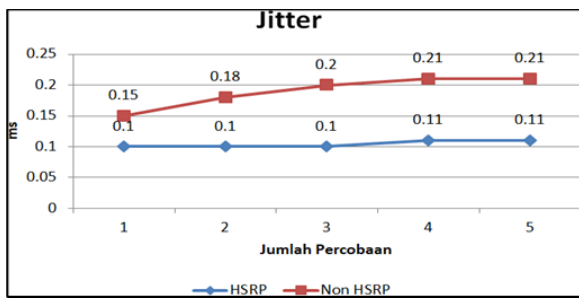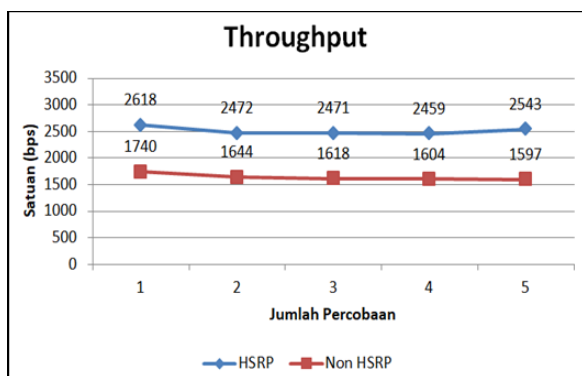
Fig. 12. HSRP jitter

Fig. 13. Throughput delay

4) Throughput

Throughput is the effective data transfer rate (rate), measured in bps (bits per second). Throughput is the total number of successful packet arrivals observed at a destination during a specified time interval divided by the duration of that time interval. The results are in bytes, so they need to be converted into bits. In Figure 13, the red graph shows the throughput parameters of network simulations that have not used HSRP. It can be seen that non-HSRP throughput parameters get lower results where the lowest value is 1.5 kbps, and the highest value is 1.7 kbps. The average throughput is 1.6 kbps based on the ideal throughput values included in the excellent category.

In Figure 13, the blue graph shows throughput data from network simulations that have used the HSRP method. The HSRP throughput parameter obtained better results; the lowest throughput parameter value was 2.4 kbps, and the highest was 2.6 kbps, with an average throughput value of 2 kbps. Where based on the category of ideal throughput value is included in the excellent category. The results obtained before and after using the HSRP method are both in a suitable category. However, using the HSRP method shows better results because the throughput value gets better the higher the value. However, this result will be different from the actual network because it uses a larger bandwidth and may get results in an excellent.

CONCLUSION

After going through the design and testing stages in terms of mechanical, electrical and programming. The system is optimally able to provide information on the value of PSL lamp power on sensor node 1 and sensor node 2 through the website interface application in real-time. Finally, with some review of the results of observations and tests, the following conclusions are the results of the PZEM-004T sensor readings on this tool have an average error value of sensor node 1 readings of

±.002751912%, and an average error value of sensor node 2 readings of ± 0.002751912%. In the measurement of network Quality of Service (QoS) on sensor node 1 with a distance of 50 metres, the troughput result is 34.44 kbps, packet lost is 0.001057082 = 0.11% and delay for 76.50474 ms. In the measurement of network Quality of Service (QoS) on sensor node 1 with a distance of 100 metres, the troughput result is 32.76 kbps, packet lost is 0.001886792 = 0.19% and delay for 86.50910668 ms. Remote monitoring using the web and smartphones can run as long as the device is connected to an internet network connection. From the overall test, an average of 3 seconds is obtained for the response of information on the ubidots web and ubidots android app. The response delay for information will change depending on the connection used.

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