PERFORMANCE ANALYSIS ON GPSR PROTOCOL IN VANETS ENVIRONMENT OF OVERLAY NETWORK AND FORWARDING NODE SELECTION METHODS

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ABSTRACT

VANETs are technology in Intelligent Transport Systems (ITS) in driving safety and convenient network services for vehicle users. However, the high mobility of VANETs makes the topology change frequently, resulting in the unavailability of routes and causing communication failures between nodes. Greedy Perimeter Stateless Routing (GPSR) is a routing protocol that solves communication problems in the VANETs environment. GPSR is a geographic routing protocol that uses information on the location of neighbouring nodes and the transmission range to the nearest destination node. But, GPSR does not always find the optimal route because not all nearby nodes can forward packets to their destination during heavy traffic and many intersections.

In this research, the overlay network and forwarding node selection methods will be used to solve problems in the GPSR routing protocol related to communication instability because of changing node positions. Based on the results of testing and analysis that has been carried out on a grid scenario with 50 nodes, the Packet Delivery Ratio results are 32.60. In contrast, the results for the real scenario with the same nodes produce a value of 64. The analysis of End to End Delay in the 50-node grid scenario produces 5.64, while the real scenario results with 50 nodes yield the value of 24.11. The analysis Routing Overhead in the grid scenario with 50 nodes produces a value of 39,978, while the results of the real scenario with 50 nodes get a value of 10,239. With the result of these two analysis methods, it is expected to increase the average value of package delivery.

***Keywords**: GPSR, greedy forwarding, forwarding node, overlay network.*

I. INTRODUCTION

Technological developments have penetrated various aspects of life, including transportation. One of the issues currently being developed in the Intelligent Transport System (ITS) is how ITS is designed as sophisticated as possible to support accurate and on-time information sending traffic to drivers and transportation authorities. Its purpose is to improve mobility, quality, comfort and safety in the city. The purpose is to improve mobility, quality, comfort, and safety in the city where it applies the concept of smart cities. The ITS is expected to be able to provide information in real-time to users related to the situation of the road to be traversed. For example, if the road to be passed is jammed, alternative roads that do not experience congestion will be provided. In addition to providing alternative roads and solutions to avoiding traffic jams, ITS also provides information about the condition of the vehicles around to reduce the possibility of accidents[1]. One of the sophistication of ITS that is still being developed is the Vehicular Ad Hoc Network (VANET). VANET allows vehicles to communicate with each other from one vehicle to another, which this communication makes between drivers can remind each other about an accident or other information needed.

VANETs are built for communication between vehicles, Vehicle-to-Vehicle (V2V) communication, and Vehicle-to-Infrastructure (V2I) communication for several significant applications[2]. VANETs have several unique characteristics: high vehicle mobility, limited transmission distance, traffic density, no energy limit, and predictable vehicle position. In VANETs, the network topology often changes because of the speed factor of the nodes, which causes the communication between nodes unstable. Node next hop selected in greedy forwarding mode may have gone out of transmission range before receiving the packet. Perimeter forwarding mode will be carried out if the greedy forwarding method fails. In this case, redundancy can occur in route formation[3].

The routing category in VANETs in development is based on the position of each node or what is often referred to as a position-based hybrid routing protocol. The position-based hybrid routing protocol is the best. It's because the source can know and predict the position, speed, and path information of other nodes before sending the node, so it can be ascertained that the destination node and vice versa can receive the packet sent by the source node. Behind the advantages, position-based routing protocols have a disadvantage when a node experiences a maximum local problem, where the node cannot send packets to the next node. It is because there are no nearby nodes with the closest position to the destination node or all surrounding nodes that have already received the packet[4].

Research[5] presents GPSR-L, an improved version of GPSR, by considering the link lifetime to select the next hop node. However, the research assumes that the speed of the vehicle is constant. The speed of the vehicle can change, not be constant.

Research[6] presents a reliability-based GPSR protocol that ensures only links with a reliability factor more significant than a certain threshold are selected when establishing routes from source to destination. In this study, the authors only assume that the vehicles are moving in the same direction when calculating link reliability. They do not consider other factors such as distance, the direction of movement of the next hop candidate, and destination in selecting the next hop.

Greedy Perimeter Stateless Routing Protocol(GPSR) is a routing protocol based on the position of each node which is intended for VANETs environment. GPSR uses the greedy forwarding method in sending and forwarding packets. This method works with the rule that the next-hop node will be selected based on the closest distance to the destination node, but this can cause a condition of the maximum local state. In addition, to the maximum local problem in greedy forwarding, selecting the next-hop node based on the closest distance to the destination node can cause packet delivery failure because of limited transmission.

The GPSR protocol has a recovery method, which is perimeter forwarding for delivery based clockwise; it makes no packets lost in the topology. This method is considered less effective because it can increase the delay in sending packets, the number of routing packets in delivery, and the routes that be formed are ineffective[7]. The top local condition in the greedy forwarding method cannot be avoided, so using perimeter forwarding is indispensable.

II. LITERATURE REVIEW

A. Related Research

VANETs follow the same communication principles and architecture as MANETs regarding self-management, self-origination, and shared radio. Communication in VANETs can be classified into two main classes, which Vehicle-to-Vehicle (V2V) communication and Vehicle-to-Infrastructure (V2I) communication[8]. In V2V communication, vehicles can communicate directly with each other, while in V2I communication, vehicles can communicate with stationary infrastructure on the side of the road.

The first group includes various vehicles and mobile communication devices, including navigation devices and mobile phones. The infrastructure group consists of various infrastructures involved in VANET, such as access points, gateways, etc. Figure 1 shows an example of the VANET architecture with various constituent components based on references from the C2C CC (Car2Car Communication Contortium). Vehicles that are members of VANET must be equipped with an On-Board Unit (OBU) and an Application Unit (AU). OBU acts as a terminal as well as a wireless router. The VANET infrastructure access point is the Road Side Unit (RSU). RSUs are placed strategically along roads, such as at crossroads or traffic lights. OBU can be considered a moving node in this network, and RSU is a stationary (static) node.

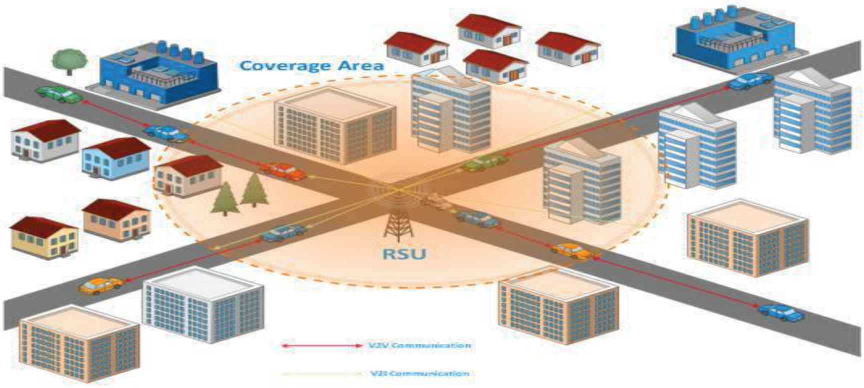


Figure 1. Communication architecture at VANETs[9]

The main components of VANETs are the Application Unit (AU), On Board Unit (OBU) and Road Side Unit (RSU)[10]. Figure 1 shows the components laid out on the VANETs architecture. RSU is located in a static position. OBU is a communication device that uses application services and is located on every vehicle. The AU is the network application and can be located on every vehicle or in the RSU.

VANETs have several beneficial characteristics to assist routing protocol performance, including:

1. Number of Nodes

The number and density of nodes in VANETs vary; the number of nodes can be enormous in urban areas during peak hours. Still, the number of VANETs nodes can be very few in rural areas where the number of cars equipped with communication capabilities is limited.

2. High node mobility

Vehicles as nodes of VANETs can move at high speeds is more than 100 km/h; this can cause a disconnection between nodes. For example, if a speeding vehicle communicates with a slow-moving vehicle, the communication does not hold long.

3. Changeable network topology

Because the VANETs nodes have high mobility, the VANETst network topology that is formed also experiences changes.

4. Predictable network topology

Although the VANETs nodes move a lot, their movement is limited by the topology of the road they travel through.

5. Unlimited energy sources

Compared to finite MANET nodes, VANETs nodes have unlimited power sources. Batteries generated from moving vehicles can provide continuous power to communicate.

6. Available information location

Location information of nodes given by GPS can reduce data transmission time and network throughput. In addition, information on the position and speed of moving nodes can also help estimate the mobility pattern of these nodes.

III. METHOD

In this research, the traditional GPSR will be modified with the concept of the overlay network and Forwarding node selection. This study uses two types of maps: grid maps and real maps. Grid mobility scenarios will be initiated with GPSR forwarding node selection, while real mobility scenarios will be with the GPSR overlay network method. After getting the results from the grid and real mobility, it will be analyzed to get the best results from both scenarios.

The design of the grid mobility scenario begins with determining the required simulation area, in which of the areas the length and width are determined. Next, from the length and width of the area, we can determine how many intersections or shortcuts are needed so that we can know the number of plots. After knowing the number of plots, we can determine the length and width of each tile. For example, the area of the simulation area is 1000m2. From that area, the length and width of the area are 1000m x 1000m. The critical intersection is 11 points, and it can produce ten plots. Thus, to get an area of 1000m x 1000m with ten plots, the length and width of each plot are 100m x 100m.

The design of real mobility scenarios begins with selecting the area to be simulated. This research uses a map from OpenStreetMap to retrieve the area created for the simulation model. The area taken is the western part of Surabaya City. After selecting the area, we can download it using the export feature of OpenStreetMap. This map exported from OpenStreetMap has a .osm extension.

After getting a map of the area used as a simulation, the map is converted into a file with the extension .net.xml using the SUMO tool that is netconvert. The next stage has the same stages as when designing a grid mobility scenario: making node movements using RandomTrips and two routers. Then merge the converted real map file into a file with the .net.xml extension and the node movement file created earlier. The result of the merger is a scenario file with a .xml extension. The resulting file is converted into a .tcl file to be applied to NS-2.35. The real scenario creation flow is similar to the grid scenario creation flow. However, the map.net.xml map is generated from the converted OSM map.

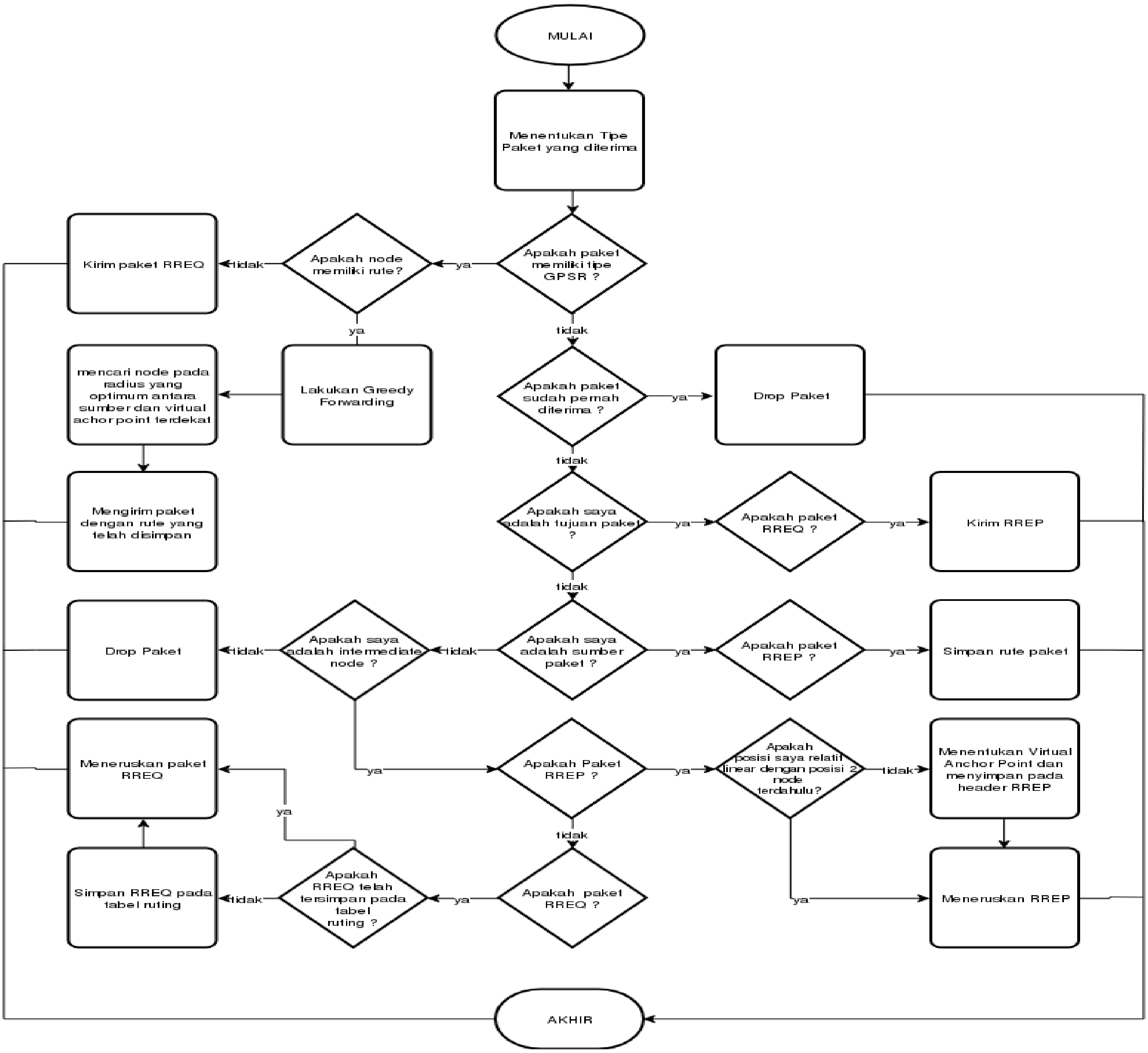


Figure 2. Flowchart of GPSR Overlay Network.

GPSR Overlay Network was made before the package delivery process. After all nodes in the VANETs environment perform beacon messages, all nodes will have their respective neighbour tables, and beacon messages are used to determine the position of each node. GPSR uses beacon messages in predetermined time intervals. The source node will send a Route Request (RREQ) packet to the destination node. The method of sending RREQ packets uses the Dynamics Source Routing (DSR) method, where the packet will be sent to a one-next-hop node and then broadcast to all existing neighbour nodes.

Furthermore, when the RREQ packet arrives at the destination node, the destination node will send a Route Reply (RREP) packet. The RREP will be sent to the source node by the same route as the RREQ. After the RREP arrives at the source node, the source node will store the route traversed by the RREP.

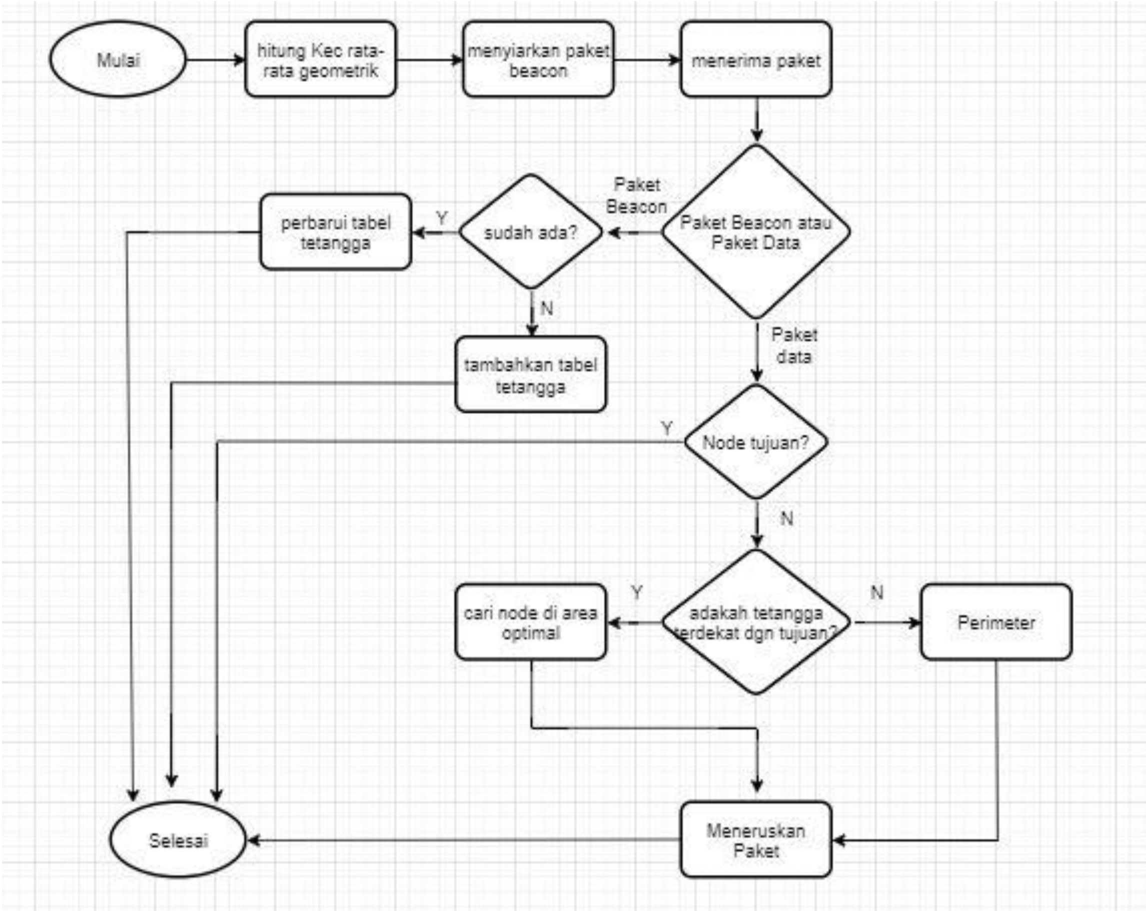


Figure 3. Flowchart of GPSR Average speed

This section will describe the proposed algorithm for modifying the GPSR routing protocol. In the first stage, each node calculates the geometric mean of speed. The geometric mean of this speed is calculated periodically before broadcasting the beacon message. In the beacon message, a new column is added that is useful for storing information on the geometric average speed of the node. Then the beacon message is broadcast to the neighbouring nodes. Broadcasting the beacon message is useful for recognizing neighbouring nodes that can be reached. A node receiving a beacon message accepts and updates the neighbour table.

TABLE I
SIMULATION PARAMETERS.

No.	Parameter	Specification
1	CPU	Core i7-8550U
2	RAM	8 GB
3	Number of Vehicles	50
4	Maximum speed	25 Km/hour
5	Sending node and destination node	Static Position

IV. RESULT AND DISCUSSION

The results of this research are divided into two: simulation results using grid mobility scenarios and simulation results using real mobility scenarios. Each simulation result includes a discussion of overlay network implementation analysis and forwarding node selection by comparing routing metrics, including PDR (Packet Delivery ratio), RO (Routing Overhead), and E2D (end-to-end delay).

A. *Packet Delivery Ratio* (PDR) Grid scenario.

PDR is the percentage of packets sent to their destination. PDR analysis is carried out in the scenario with 50 nodes at each maximum speed limit of 25 m/s. The results of the Packet Delivery Ratio (PDR) analysis in the 50-node scenario can be seen in table 2.

TABLE 2
AVERAGE CALCULATION RESULTS for PACKET DELIVERY RATIO in GRID Scenario

Number of Nodes	Traditional GPSR	GPSR Average Speed	Difference
50	23,64	32,60	8,96

In table 2 and figure 4, we can see the results of the PDR evaluation on 50 nodes, Packet Delivery Ratio with a maximum speed of 25, GPSR average speed gets 32.60 compared to 23.64 results from Traditional GPSR. With a difference of about 8.96.

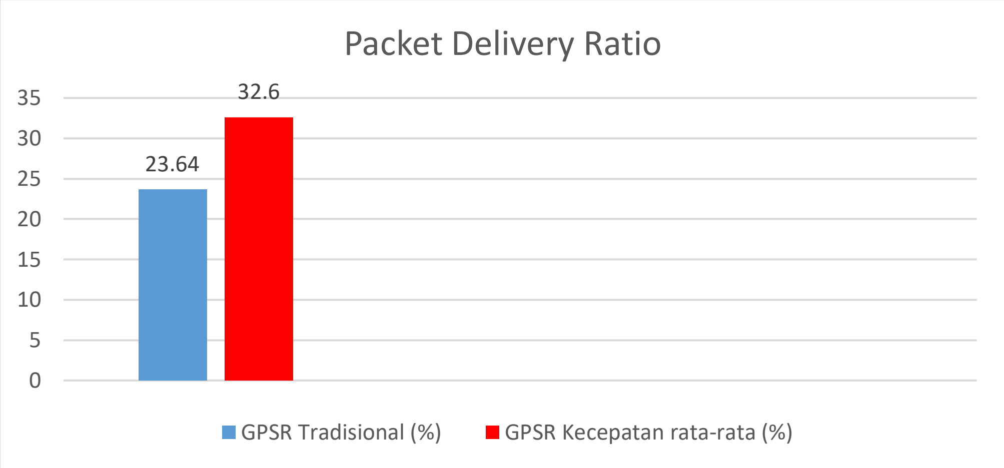


Figure 4. Packet Delivery Ratio Chart

B. *End to End Delay grid* scenario.

E2D is the average time for each packet transmission. Each scenario is made ten times in this trial, and the E2D value is evaluated and averaged. End-to-end Delay analysis is carried out in the scenario with 50 nodes at each maximum speed limit of 25 m/s. The results of the E2D analysis in the 50-node scenario can be seen in Table 3 and Figure 5.

TABLE 3
AVERAGE CALCULATION RESULTS for *END-TO-END DELAY in GRID* SCENARIO

Number Of Nodes	Traditional GPSR	GPSR Average Speed	Difference
50	7,42	5,64	1,78

The average value of end-to-end delay in the 50-node scenario shows that the scenario with the lowest delay value is from the GPSR average speed with a value of 5.64. The delay value of the GPSR with the average speed is lower than that of the traditional GPSR. GPSR with average speed is better than traditional GPSR in terms of delay.

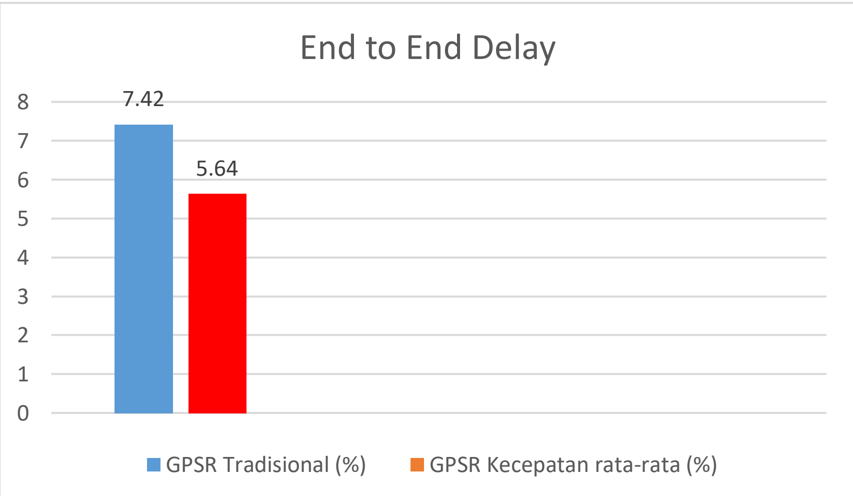


Figure 5. End-to-End Delay Chart

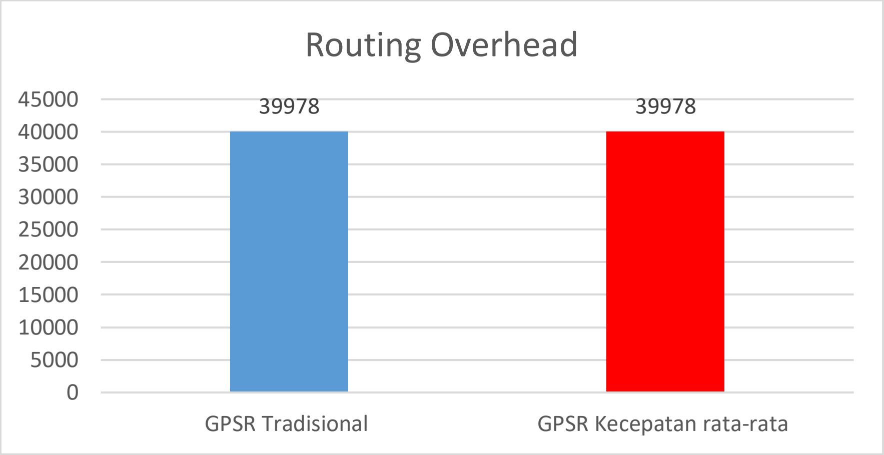
C. *Routing Overhead grid* scenario.

The Routing Overhead performance evaluation results on all variations of the maximum speed value show the same value. The average value of Routing Overhead in this test can be seen in table 4; Routing Overhead is the number of routing packets during the simulation using that scenario.

TABLE 4
AVERAGE CALCULATION RESULTS for ROUTING OVERHEAD in *GRID* SCENARIO

Number of Nodes	Traditional GPSR	GPSR Average Speed	Difference
50	39978	39978	0

Evaluating the Routing Overhead performance of all variations shows no different values. The average value of routing overhead in this analysis can be seen in table 4. Routing Overhead is the number of routing packets during the simulation using the Grid scenario.



Gambar 6. *Routing Overhead* Chart

D. *Packet Delivery Ratio real* scenario.

Figure 7 shows a PDR comparison chart between the traditional GPSR and the GPSR Overlay Network protocol. The results of the average calculation and the difference in PDR values from the real scenario can be seen in table 5.

TABLE 5
AVERAGE CALCULATION RESULTS for *PACKET DELIVERY RATIO* in *REAL* SCENARIO.

Number of Nodes	Traditional GPSR	GPSR Overlay Network	Difference
50	24,5	64,0	39,5

Figure 7 shows that the Packet Delivery Ratio of the GPSR Overlay Network protocol has better performance than the traditional GPSR protocol with increased performance. That is because of the void area where there are no nodes. Although the transmission distance of each node is 200 meters, the traditional GPSR method, which applies to the destination position as a reference in the selection of the next node, causes frequent packets to fail to be sent. The failure of packets sent in traditional GPSRs is caused by the node in charge of forwarding packets experiencing maximum local conditions. GPSR Overlay Network can avoid nodes with maximum local conditions that have a position near the void area in the next node selection.

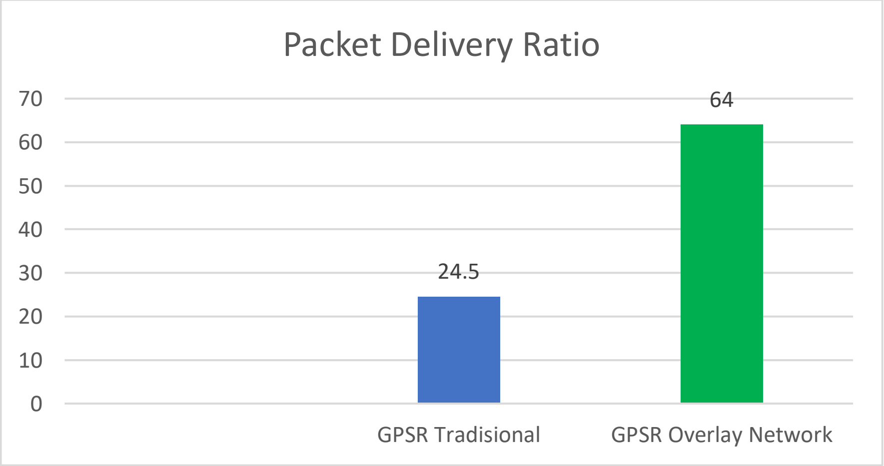


Figure 7. *Packet Delivery Ratio* Chart

Table 5 shows that the traditional GPSR and GPSR Overlay Networks have a high difference in PDR. In the environment of 50 nodes, GPSR Overlay Network gets a difference in the average value of the Packet Delivery Ratio of up to 39.5. From this analysis, it can be concluded that the GPSR Overlay Network has a higher PDR value than the traditional GPSR.

E. *End to End Delay real* scenario.

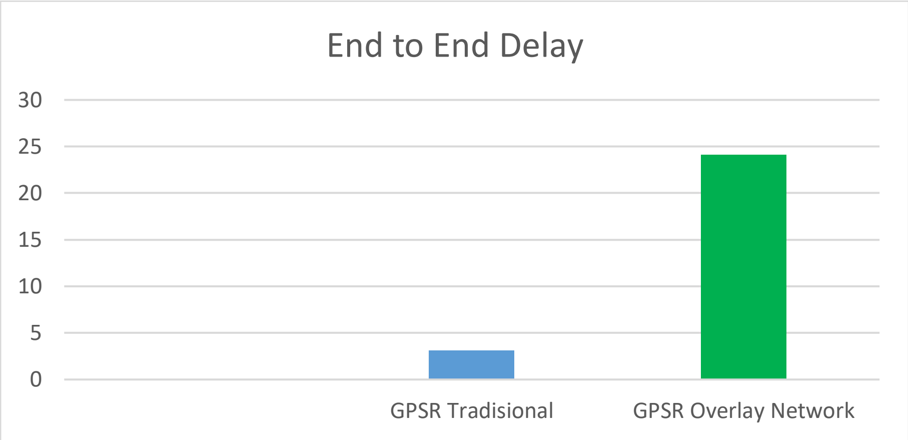


Figure 8 average end to end delay comparison chart

On the traditional GPSR protocol and GPSR Overlay Network from the real scenario, where the GPSR Overlay Network protocol has a higher delay. The results of the average calculation and the difference in the value of end-to-end delay from the real scenario with the addition of the number of nodes can be seen in Table 6.

TABLE 6
AVERAGE CALCULATION RESULTS for *END-TO-END DELAY in REAL* SCENARIO.

Number of Nodes	Traditional GPSR	GPSR Overlay Network	Difference
50	3,13	24,11	20,98

Table 6 shows that the traditional GPSR and GPSR Overlay Networks have a high end-to-end delay difference. In an environment with a density of 50 nodes, GPSR Overlay Network gets a difference in the average end-to-end delay value of up to 20.98 compared to the average end-to-end delay value of traditional GPSR. In this analysis, it can be concluded that the GPSR Overlay Network has a higher end-to-end delay value than the Traditional GPSR.

This significant difference is caused because the traditional GPSR has a low number of packets sent, in which the higher the number of nodes, the lower the PDR value and the higher the end-to-end delay value. While in the GPSR Overlay Network, the protocol managed to send relatively high packets compared to traditional GPSR, the higher the number of nodes, the higher the PDR value and the higher the average end-to-end delay.

F. *Routing Overhead real* scenario.

The result in table 7 is the calculation of the average routing overhead in a real scenario, where the linear Routing Overhead value increases following the increase in the number of nodes in the simulation both on traditional GPSR and GPSR Overlay Networks. That is because of the traditional GPSR and GPSR Overlay Network, there is no failed route repair method, so it does not have an impact on increasing the number of Routing Overheads.

TABLE 7
AVERAGE CALCULATION RESULTS *ROUTING OVERHEAD REAL* SCENARIO.

Jumlah Node	GPSR traditional	GPSR Overlay Network	selisih
50	10,161	10,239	78

Table 7 shows that the traditional GPSR and GPSR Overlay Networks have a small difference in Routing Overhead. In an environment with a density of 50 nodes, the GPSR Overlay Network gets a difference in the average Routing Overhead value of up to 78 compared to the traditional GPSR Routing Overhead average value. That is because the GPSR Overlay Network has a Virtual Anchor Point (VAP) search method before sending the first packet. This method requires Route Request (RREQ) and Route Reply (RREP) packets. Both types of packages are included in the calculation of Routing Overhead.

G. Analysis of Packet Delivery Ratio Result

Based on the test results of the grid scenario with 50 nodes, the Packet Delivery Ratio with 50 nodes yields a value of 32.03. In comparison, the results from the real scenario with 50 nodes, for the Packet Delivery Ratio results, produce a value of 64.0 following the analysis graph of the Packet Delivery Ratio results.

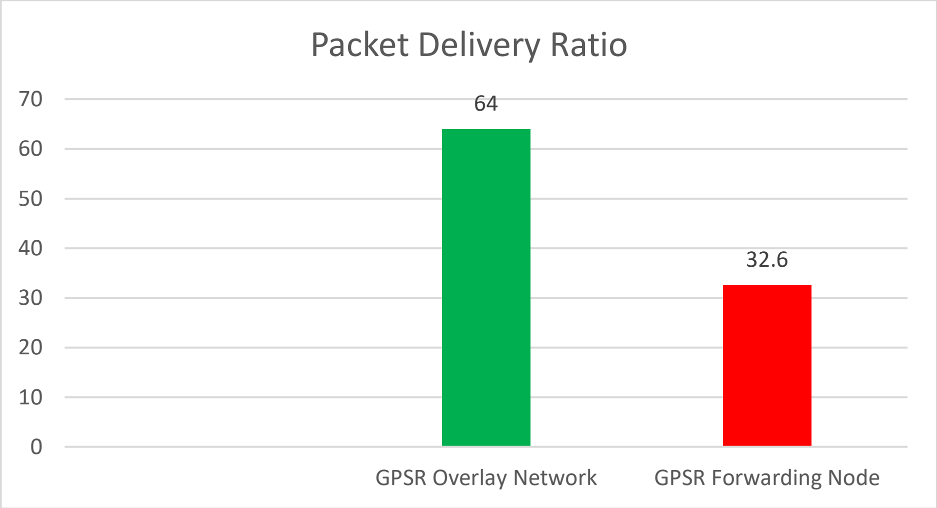


Figure 9. *Packet Delivery Ratio* Chart

Figure 9 above shows that the Packet Delivery Ratio results from the real GPSR Overlay Network scenario are higher, with a difference of 31.40.

H. Analysis of End-to-End Delay Result

Based on the test results of the grid scenario with 50 nodes, the End to End Delay result with 50 nodes produces a value of 5.64, while the results of the real scenario with 50 nodes, for the End to End Delay result, produce a value of 24.11. With a difference of 18.36. The following graph analyzes the results of End to End Delay.

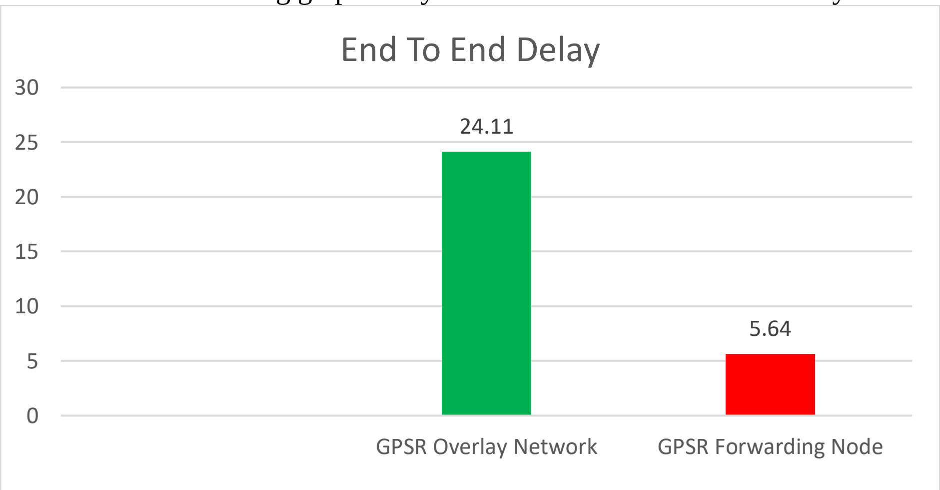


Figure 10. *End To End Delay Chart*

I. Routing Overhead Analysis Results

Based on the test results of the grid scenario with 50 nodes, the Routing Overhead result with 50 nodes produces a value of 39,978. In comparison, the results for the real scenario with 50 nodes, for the Routing Overhead result produces a value of 10,239 along with a graph of the analysis of the Routing Overhead results.

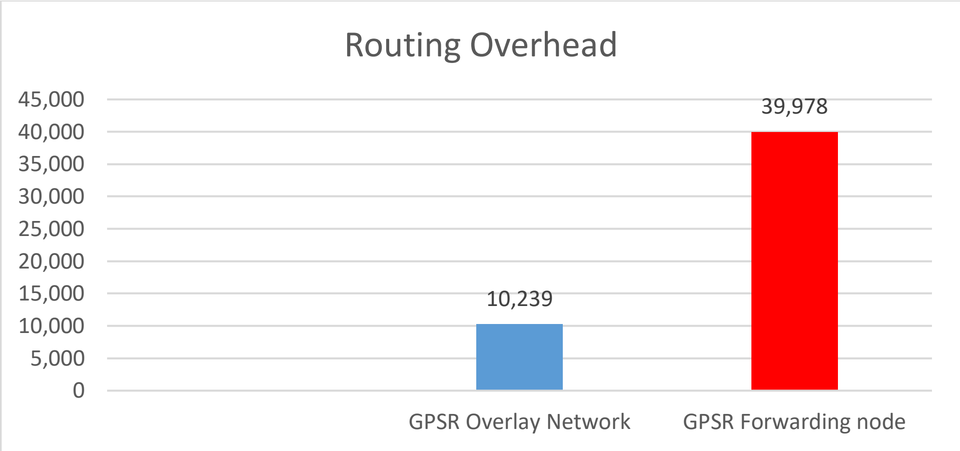


Figure 11. *Routing Overhead* Chart

Figure 11 above shows that the Routing Overhead results from the Realtime Speed GPSR grid scenario are higher, with a difference of 29,739.

V. CONCLUSION

Based on the analysis carried out during the grid scenario from the performance of the GPSR Forwarding node compared to the GPSR Overlay network. The performance of the packet delivery ratio (PDR) has a difference of 31.97. The results of the GPSR Forwarding Node are 32.03, while the GPSR Overlay Network results are 64. The analysis of the results from the End to End Delay GPSR forwarding nodes gets a value of 5.64, while the End to End delay from the GPSR Overlay Network is 23.11. Then the results from the Routing Overhead from the GPSR Forwarding Node are 39,978, while the results from the GPSR Overlay Network are 10,239.

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