COMPARATIVE ANALYSIS OF OLSR AND DSR ROUTING PROTOCOL PERFORMANCE ON VEHICULAR AD HOC NETWORK (VANET)

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ABSTRACT

Communication between vehicles is essential in increasing comfort and safety for drivers and passengers. Technology advancements offer a new concept: the Vehicular Ad Hoc Network (VANET). The VANET network allows vehicles on the road to communicate directly with other vehicles while moving and without using the fixed infrastructure. A routing protocol is needed to facilitate communication in the network. Routing protocols are used to find routes between nodes to send messages to each other and forward packets along the selected route. In this study, a comparative analysis of the performance of the topology-based routing protocols will be carried out: Optimized Link State Routing (OLSR) and Dynamic Source Routing (DSR) on VANET with a case study of urban road scenarios. Both protocols are simulated using Network Simulator 2 (NS-2) with a scenario of changing the number of nodes. The two protocols were compared and analyzed from the parameters of packet delivery ratio, end-to-end delay, routing overhead, throughput, packet loss, and collision rate. Based on the simulation results, the overall DSR routing protocol has a better performance value with an average Packet delivery ratio of 99.92%, End-to-end delay of 0.0894 ms, Routing overhead of 1,000 ms, the throughput of 261.55 kbps, Packet loss of 0.0778% and collision rate 1.8770. While the OLSR routing protocol has an average value of Packet delivery ratio of 99.89%, End-to-end delay of 0.0878 ms, Routing overhead of 1,000 ms, throughput of 230.27 kbps, Packet loss of 0.1007%, and collision rate of 1.6687.

Keywords: *DSR, OLSR, Routing Protocol, QoS, VANET*

1. INTRODUCTION

Vehicular Ad-Hoc Network (VANET) is a wireless technology derived from Mobile Ad Hoc Network (MANET), which is being developed as part of ITS (Intelligent Transportation System). VANET aims to assist in increasing efficiency and safety in driving. VANET technology works so that vehicles can communicate with each other [1].

VANET builds three types of communication, namely vehicle-to-vehicle communication (V2V), vehicle-to-infrastructure (V2I), and infrastructure-to-infrastructure (I2I). The fundamental goal of VANET is to develop vehicle communication systems to enable fast and efficient data exchange for driver safety and comfort. In addition, it can also be used as an intelligent traffic information system [2].

The challenge in VANET technology is the ever-changing network topology and the process of finding and maintaining routes. To facilitate communication in the network, routing protocols are used. The routing protocol is communication between nodes and routers that is useful for sharing network information [3].

Routing protocols in VANET are categorized into five categories, one of which is a topology-based routing protocol. Furthermore, based on the architecture, the topology-based routing protocol in VANET is divided into three: reactive, proactive, and hybrid [4]. In this study, a comparative analysis of the performance of two routing protocols included in the base routing protocol will be carried out: Optimized Link State Routing (OLSR) and Dynamic Source Routing (DSR).

The purpose of this study is to simulate the VANET network for vehicle communication using the OLSR and DSR routing protocols on SUMO and NS-2 software for scenarios of changes in the number of nodes in urban areas right at (JL. Tuanku Tambusai, JL. Jendral Sudirman, J.L. Soekarno Hatta and Jl. JL Arifin Ahmad, Pekanbaru City, Riau). The next step is to produce comparable data on the QoS parameter performance of the OLSR and DSR routing protocols.

Furthermore, data analysis of the performance comparison of the OLSR and DSR Routing Protocols on the Vehicular Ad Hoc Network (VANET) was carried out based on the results of the AWK command. QoS performance parameters in the form of Packet delivery ratio, the routing overhead, end-to-end delay, Throughput, Packet Loss, and Collision rate. This paper is organized into four sections, namely introduction, methodology, results and discussion and conclusion.

1.1. *VANET Architecture*

A VANET architecture consists of different domains and individual components, as shown in Figure 1 [5].

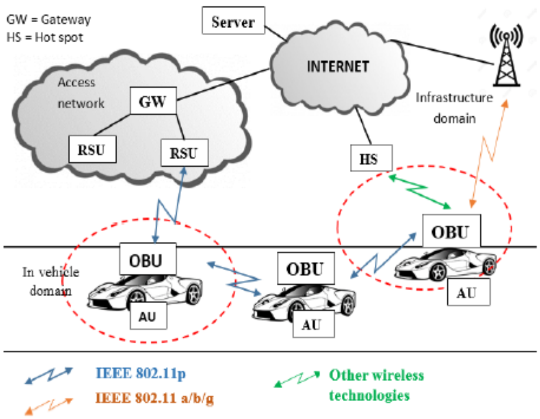

Figure 1. VANET System Architecture [5]

Figure 1 shows three domains, vehicle, ad hoc, and infrastructure, including individual components (application unit, onboard unit, and roadside unit) [6].

a. In-Vehicle Domain. A vehicle consists of an onboard unit (OBU) and one or more application units (A.U.). A.U. executes a set of applications that take advantage of OBU communication capabilities [7].
b. Ad hoc domains. An ad hoc domain consists of vehicles equipped with OBUs and roadside units (RSUs) without central coordination, forming a VANET [7].
c. Infrastructure Domains. The infrastructure consists of RSU and Wireless Hotspots (H.T.), which vehicles can access as security or non-security applications. When an RSU is used to access the internet, it is usually regulated by a road administrator or public authorities [7].

1.2. *Topology-Based Routing Protocol*

The topology-based routing protocol uses a routing table to store link information as the basis for packet forwarding from the source node to the destination node [8]. In general, topology-based routing protocols in VANET are divided into two major groups, proactive and reactive [1].

Proactive

In a proactive routing protocol, each node has a complete routing table. It means a node will know all routes to other nodes in the network. Furthermore, each node will update its routing table periodically so that changes in the network topology can be known at each time interval [3]. An example of a Proactive routing protocol is the OLSR routing protocol.

Optimized Link State Routing (OLSR)

OLSR is an optimization of the link state algorithm. The central concept of OLSR is the MPR (multipoint relay) mechanism, a neighboring node chosen by a node with certain specifications. The node selected for the MPR can be two hops away from the other node. The concept of MPR is to reduce the number of broadcast messages with the same information and reduce routing overhead. The advantage of using OLSR is that it can optimize the use of available bandwidth [9].

Optimized Link State Routing Protocol (OLSR) is a proactive routing protocol that determines its routing table by updating it every time there is a link change. Using a technique called Multipoint Relaying (MPR) to minimize network overhead due to the flooding process for route setting [2]. In OLSR, only nodes selected as MPR nodes can forward received messages to speed up the delivery time of information and reduce the possibility of the same node receiving the same message.

The two messages in OLSR routing are hello and topology control (T.C.). The hello message is tasked with finding information on the condition of the link and neighboring nodes. The hello message will also select the MPR selector set, which is responsible for selecting neighboring nodes that act as MPR nodes. Through this hello message, the sending node can determine its MPR node. Hello messages are only sent as far as one hop, while T.C. messages are broadcast throughout the network. The benefit of T.C. messages is to spread information about neighboring nodes that have been defined as MPR, including the MPR selector. TCS is propagated periodically, and only MPR nodes can forward T.C. messages. The difference between ordinary flooding and MPR flooding in the OLSR routing protocol can be seen in Figure 2.

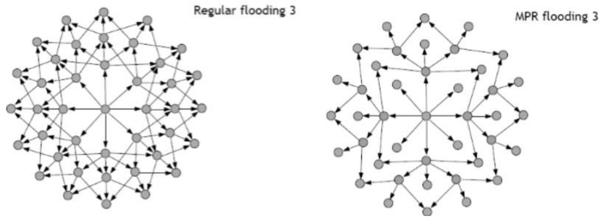

Figure 2. Normal Flooding vs. MPR Flooding

Figure 2. depicts the fundamental differences between ordinary flooding and MPR flooding. In regular flooding, all nodes will broadcast throughout the network so that the same

node can receive the same message more than once. Flooding MPR will select an MPR node whose job is to forward messages to other nodes. Nodes that are not MPR nodes will not forward messages to other networks. It will minimize the chances of the same node getting the same message repeatedly. Based on this, OLSR is referred to as a link state update [10].

Reactive

Reactive routing protocols work when needed. For example, if a node wants to send a data packet to another node, the reactive routing protocol will work to find and establish the right path with a stable connection. First, the origin node performs a broadcast request to the destination node, then the destination node replies by sending a reply. From this process, it is determined which path will be used to transmit data [3]. An example of a Reactive routing protocol is DSR.

Dynamic Source Routing (DSR)

Dynamic Source Routing Protocol (DSR) is one of the routing protocols found in VANET. DSR is classified as a reactive routing protocol because it works based on the routing of the previous node. Therefore, each node must have a routing table. The entries in the routing table will be updated based on topology changes that occur [11].

DSR has two working mechanisms, namely, route discovery and route maintenance. Route discovery occurs when a source node wants to send a packet to the destination node, and the source node will see its route cache. Route maintenance occurs if there is a broken link, and the routing table will be updated according to the wishes of the source node [8]. The route search process in the DSR can be seen clearly in Figure 3.

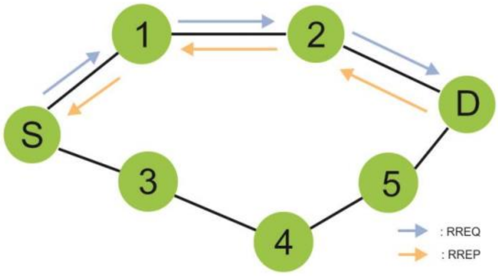

Figure 3. DSR Route Search Process [12]

Figure 3 is the route search process in the DSR routing protocol. Route search by spreading the request message to all nodes. After the request message reaches the destination node, it will send a replay message by choosing the closest route to the source node.

The advantage of this routing protocol is that there is no periodic packet delivery such as hello messages which aims to check whether there is a broken connection between nodes in the network. It will minimize routing overhead and save energy per node. In addition, routes are built on demand or only when needed, so the energy used and routing overhead are smaller. Nodes in the network also have a route cache that will be very useful when there is damage or loss of connection to the destination node.

2. METHODOLOGY

2.1. *Research Stages*

The research process is based on the routing protocol used to obtain the results of comparing QoS parameter values . The stages that are carried out are as follows:

1. Determine the simulation parameters to see which protocol has better performance.
2. The map selection on openstreetmap.org is then exported to download the selected area. The downloaded map is then converted into a file with the extension *.net.XML using tools from SUMO, namely netconvert.

3. Determining the number of nodes using the polyconvert configuration to poly.XML, the results from netconvert will be used by randomTrips.py to create a .rou.XML file containing the number of nodes.
4. Simulation of SUMO by copying the file sumo.cfg then changing the input according to the simulation made.
5. After the successful simulation, convert the resulting file to sumo.XML and then command python to generate the simulated node movement into the NS-2 application. Finally, configure the results into a script.tcl routing protocols (OLSR) and (DSR). Th tcl script runs on NS-2 and outputs file.tr and nam.
6. Performance test data retrieval is done after all scripts run without errors. Performance test data is viewed using the *.awk script.
7. Analysis of Simulation Results. It is a series of processes to determine the performance results of the VANET communication network using the OLSR and DSR routing protocols, which have been designed as expected. To determine the performance, it is necessary to analyze the parameters of Packet Delivery Ratio, routing overhead, end-to-end delay, throughput, packet loss, and collision rate.

2.2. *Simulation Parameters*

The test was carried out in an urban environment using an actual map of the Pekanbaru city area, obtained through the opensstreetMap.org application. Simulation time was carried out for 300 seconds. Then, several factors that can affect the performance of VANET will be tested by comparing the OLSR and DSR routing protocols. Factors that can affect VANET performance are changes in the number of nodes. The parameters used in this study can be seen in Table 1.

Table 1 . Simulation Parameters

Parameter	Specification
Network Simulator	NS-2.35
Routing Protocol	OLSR and DSR
Simulation Time	0-300 and 0-900 seconds
Package Size	512 Bytes
Multiple Nodes	100,150,200,250,550 and 700
Node Speed	50 km/h and 30 km/h
Simulation Area	7971 m x 7894 m
Antenna Type	Omni Antenna
Propagation Model	Two-ray Ground
Data Type	TCP
Channel Type	Wireless Channel

3. RESULT AND DISCUSSION

Penulisan persamaan matematika harus diberi nomor secara berurutan dan dimulai dengan (1) sampai akhir makalah. P The test is carried out based on the previous test scenario to test the performance of the two routing protocols, OLSR and DSR, with changes in the number of nodes on the VANET network. Simulations were performed using Network Simulator version 2.35.

3.1. *Packet Delivery Ratio* (PDR*)*

PDR is the ratio of packets successfully received by the destination node to the total packets sent by the source node. The higher the PDR value, the better the routing protocol performance.

The results of packet delivery ratio performance on the OLSR and DSR routing protocols using the scenario of changing the number of nodes is shown in Figure 4. The data shows that the increase in the number of nodes will affect the value of the quality of the packet delivery ratio (PDR). In the OLSR and DSR routing protocols, the PDR value increases with every increase in the number of nodes. As a result, the DSR routing protocol has the highest PDR, with a value of 99,9322%.

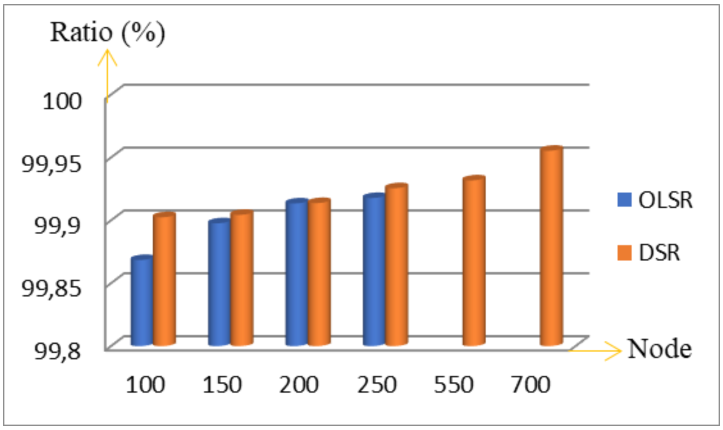

Figure 4. Graph of PDR performance

3.2. *End-to-end delay*

End to End Delay is the average time of each packet when it reaches its destination. The results of end-to-end Delay performance using the scenario of changing the number of nodes can be seen in Table 2.

Table 2. End-To-End Delay Performance Results

***End-to-End delay* (second)**		
Number of Nodes	**OLDER**	**DSR**
20	0.1161	0.1314
50	0.1178	0.1329
100	0.1257	0.1292
120	0.1319	0.1289

Table III shows that the end-to-end delay in the OLSR routing protocol increases with every increase in the number of nodes, with an average value of 0.1228 seconds. Meanwhile, the highest average end-to-end delay is the DSR routing protocol, with a value of 0.1306 seconds. The number of nodes affecting communication on the VANET can be seen in Figure 5.

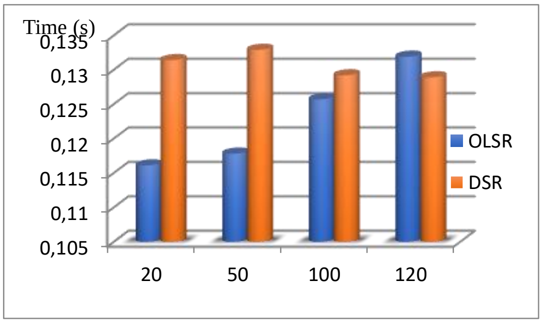

Figure 5. Performance graph of end-to-end delay

From graph 5, the OLSR routing protocol experiences an increase in the value of end-to-end delay every time the number of nodes increases. On the contrary, for the DSR routing protocol, the value decreases every time the number of nodes increases, and the highest delay occurs when the number of nodes is 50.

3.3. *Routing Overhead*

This routing overhead is used to calculate the work efficiency of a routing protocol. The smaller the value of routing overhead generated by the routing protocol, the more efficient the performance of the routing protocol. Testing is done by running the AWK command on the Ubuntu program. The maximum number of vehicles used is 250 and 700. The following is a comparison of the performance of routing overhead routing protocols OLSR and DSR can be seen in Figure 6.

In the DSR routing protocol, the number of packets sent and received data has increased as the number of nodes increases, while in the OLSR protocol, there is an increase from node 100 to node 200 and decreases in node 250. Therefore, the number of routing packets and data in DSR is more significant than in the OLSR protocol. Based on the number of packets sent and data received on the two routing protocols, a comparison of the overhead routing value of the OLSR and DSR protocols is obtained. The results of the comparison of routing overhead values can be seen in Figure 6 below.

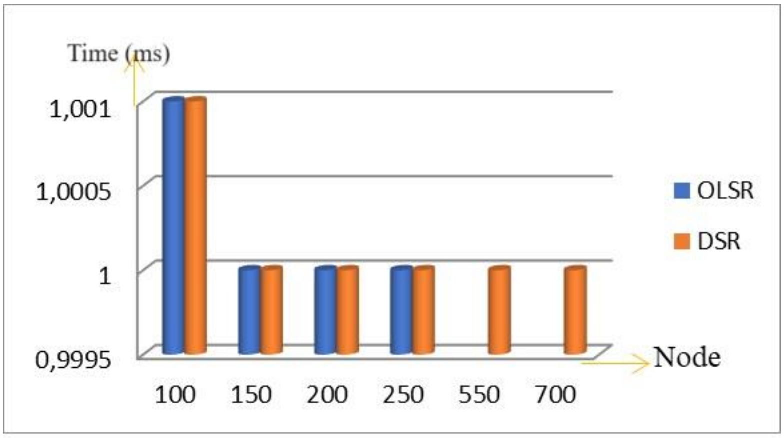

Figure 6. Graph of Routing Overhead Value on Changes in Number of Nodes

Figure 6 is the percentage comparison of the overhead values of the two routing protocols used. The results indicate that the OLSR and DSR protocols have the same average overhead. It is because OLSR uses the MPR system to update its routing table. So only nodes marked as MPR will send broadcast messages. It will reduce routing overhead and avoid excessive bandwidth usage. While in DSR, there is no periodic packet delivery such as hello messages, which aims to check for connections between damaged nodes in the network. It can minimize routing overhead and save energy per node.

3.4. *Throughput*

Throughput describes the condition of the data rate in a network. The greater the throughput value of the routing protocol, the better the data transmission in the network. The results of the throughput performance of the OLSR and DSR routing protocols can be seen in Figure 7.

The OLSR routing protocol with more than 250 nodes cannot be simulated because OLSR has a drawback: it can only perform simulations with the highest number of nodes at 250. The throughput results of the scenario of changing the number of nodes can be seen in Figure 7.

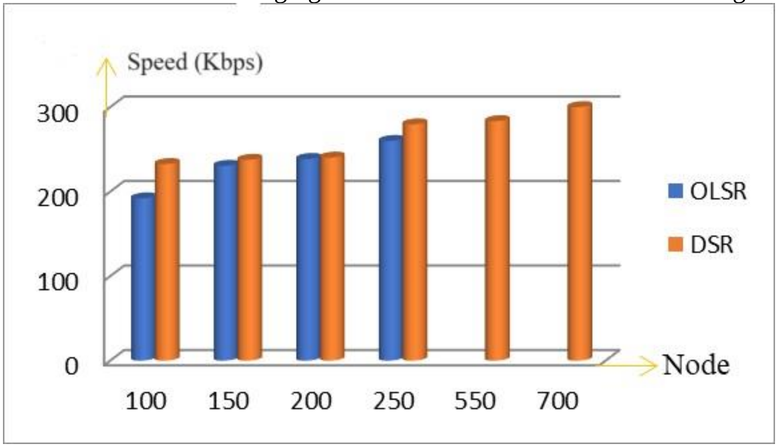

Figure 7. Graph of Throughput Value on Changes in Number of Nodes

Figure 7 is a comparison graph of the throughput value of the OLSR and DSR routing protocols at each increase in the number of nodes. The graphic value on the DSR protocol shows that by using the DSR protocol, the throughput increases as the number of nodes increases. It occurs because the DSR establishes routes on demand and depends on source routing in the routing table for all reachable destination nodes on the network. OLSR also experienced an increase in throughput value as the number of nodes increased because OLSR used the MPR system to update its routing table. So only nodes marked as MPR will send broadcast messages. It will avoid excessive bandwidth usage. The highest throughput value occurs in the DSR routing protocol, with an average throughput of 261.55 kbps. Meanwhile, OLSR has an average throughput value of 230.27 kbps. Based on the TIPHON standard, the throughput generated from these two routing protocols already has a good value for each different number of nodes.

The results obtained from this study indicate that the DSR routing protocol has an average throughput value that is superior to the OLSR protocol.

3.5. *Packet Loss*

Packet loss is the amount of data lost during the transmission process so that the data received is not the same as the amount sent. The smaller the packet loss value, the better the network performance. Based on the tests carried out by running the AWK command on the Ubuntu program, the maximum number of vehicles used is 250 and 700 nodes. The following is a comparison of the performance of packet loss routing protocols OLSR and DSR can be seen in Figure 8.

The OLSR routing protocol with several nodes more than 250 cannot be simulated because OLSR has a drawback which is only able to perform simulations with the highest number of nodes, 250.

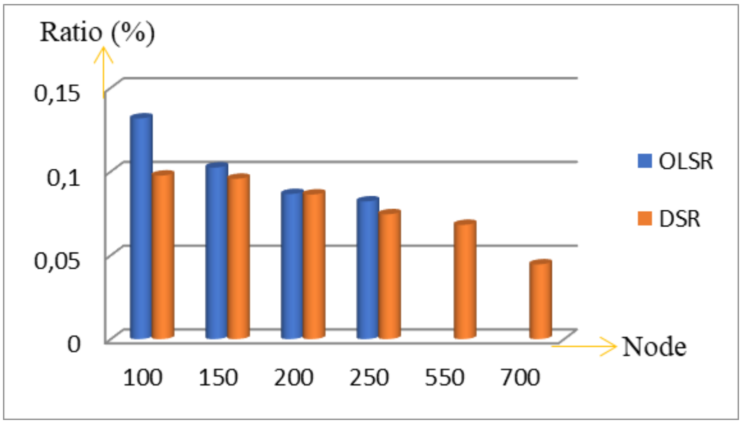

Figure 8 Graph of Packet Loss Value on Changes in Number of Nodes

Figure 8 shows that as the number of nodes increases, the packet loss routing DSR decreases with an average loss value of 0.0778%. Because DSR can adapt to the VANET network environment, the route maintenance on the DSR can overcome network topology changes that tend to occur frequently. It is done quickly, so that packet delivery is still carried out if suddenly the intermediate node that has been determined has an obstacle or the path is interrupted when packet delivery occurs. Meanwhile, OLSR routing decreased with an average loss value of 0.1007%. The decrease in packet loss was caused by OLSR's ability to choose MPR optimally in reducing packet topology control. Packet loss can be affected by the number of hops passed on both routes. A sizeable average packet loss can also be affected by data collisions due to excessive bandwidth usage on a network.

Overall, based on the ITU-T G.114 standard, the packet loss resulting from these two routing protocols already has a good loss value for each different number of nodes.

The results obtained from this study indicate that the DSR routing protocol has a better average packet loss value than the OLSR protocol.

3.6. *Collision Rate*

Collision rate indicates data collisions that occur on the network. The smaller the value generated by the collision rate, the more successfully received data. Based on the tests carried out by running the AWK command on the Ubuntu program, the maximum number of vehicles used is 250 and 700 nodes. The following is a comparison of the Collision rate performance of the OLSR and DSR routing protocols can be seen in Figure 9.

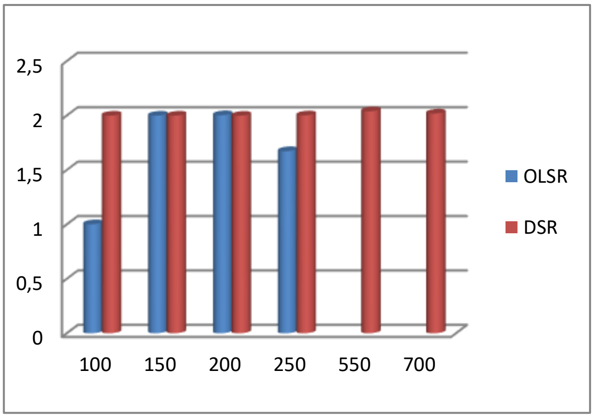

Figure 9 Graph of Collision Rate Value Changes in Number of Nodes

In the DSR routing protocol, there is a constant change in value every time the number of nodes increases, while the OLSR protocol increases with every increase. As a result, the highest collision rate value occurs in the DSR protocol, with an average value of 1.8770, while the OLSR protocol has an average value of 1.6687. Based on the comparison of the average values obtained for the two routing protocols, the OLSR collision rate value is better than DSR even though there is an increase in the OLSR protocol.

Constant changes in DSR values occur because DSR routing is beaconless, which means it builds routes according to the request of the source node. Thus, avoiding the occurrence of bandwidth overhead that can cause data collisions (collision) due to data accumulation on the network even though the average collision DSR is higher. The increasing value of collisions in OLSR occurs because OLSR is proactive and determines its routing table by updating it every time there is a link change, updates made every time on OLSR can cause a data collision or collision. However, there is an increase in the value of collisions in OLSR. Therefore, the average collision value of OLSR is lower than DSR.

The data from the comparison of the OLSR and DSR routing protocols shows that the OLSR routing protocol is superior to DSR based on the performance of the resulting QoS parameters. OLSR has a lower average Collision rate than DSR. The number of nodes that can be simulated shows that the DSR routing protocol is suitable to be applied to areas with high vehicle density, such as Pekanbaru city. Compared to OLSR, which is suitable to be applied to areas with low vehicle density. The application of the VANET communication system in actual conditions aims to provide information about the latest traffic conditions that can be used to avoid vehicle congestion and traffic jams. VANET can also automate the use of brakes on vehicles and help find other routes in the event of a sudden road closure. It is due to road repairs and natural disasters such as floods.

4. CONCLUSION

The results of this research show that changing the number of nodes scenario shows that the DSR protocol produces better performance in terms of the number of nodes and the average value of QoS parameters. DSR has a better value performance with a PDR value of 99.92%, routing overhead of 1 ms, a throughput of 261.55 kbps, and packet loss of 0.0778%, while OLSR has a better performance in the end-to-end delay, with a value of 0.0874 ms and a collision rate of 1.6687.

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