



Performance Analysis of DSDV, AOMDV, and ZRP Routing Protocols Application Simulation in Pekanbaru Vehicular Ad Hoc Network (VANET)

Ery Safrianti¹, Linna O. Sari², Fitriani Saputri³

^{1,2,3}Department of Electrical Engineering, Universitas Riau

^{1,2,3}Pekanbaru, Indonesia

email: ¹esafrianti@eng.unri.ac.id, ²linnaoasari@lecturer.unri.ac.id, ³fitriani.saputri@student.unri.ac.id

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ABSTRACT

In order to protect drivers and avoid accidents, vehicles need information on traffic conditions. To get information quickly, communication technology between vehicles is needed. One of the methods used to obtain information between vehicles that move dynamically is communication technology such as VANET. VANET has network characteristics that change rapidly due to the highly dynamic node movement. Therefore, it is necessary to choose the right routing protocol for optimal data transmission. In this study, Destination Sequenced Distance Vector (DSDV), Ad-hoc on Demand Multipath Distance Vector (AOMDV), and Zone Routing Protocol (zrp) routing protocols were tested using 3 field scenarios. The first scenario is a variation of the number of nodes 100, 250, 600, and 700 nodes. The second scenario is a variation of the transmission ranges of 250m, 500m, and 1km. The third scenario is the variation of node speeds of 10 km/hour, 20 km/hour, 30 km/hour, 40 km/hour, and 50 km/hour in Pekanbaru city of Riau province. This research was carried out using the simulation method along with the Quality of Service (QoS) performance testing parameters comprising packet delivery ratio, end to end delay, throughput, collision rate, and packet loss. Out of the three scenarios tested, AOMDV is the best routing protocol to be implemented because it outperforms the other two protocol evaluated in all designated scenarios in the paper. Meanwhile, DSDV and ZRP are superior in end to end delay and routing overhead parameters, respectively.

1. Introduction

The 2018 data obtained from the Riau Province Revenue Agency indicated that the total number of 4-wheeled vehicles registered in the Pekanbaru city is 181,748. This high number of vehicles causes several traffic problems, such as increased number of accidents and congestion. Therefore, it is necessary to develop a communication technology capable of providing vehicle traffic information such as the Vehicular Ad Hoc Network (VANET). Over the last few years, various wireless technological devices that provide communication between vehicles have been developed. VANET is one of such technologies developed with Mobile Ad Hoc Network (MANET) for vehicles to communicate with each other (Pradana et al., 2017). This device enables each car to receive information related to traffic conditions and travel conditions, using nodes, which form an Ad hoc network called the Vehicular Ad hoc Network (VANET) (Dimiyati et al., 2016).

The fundamental objective of this research on VANET is to develop a vehicle communication system that allows fast and efficient data exchange that is used as an intelligent traffic information system (Pradana et al., 2017). Although VANET is very helpful for traffic information systems, the construction of VANET systems infrastructure is not easy because it requires high cost in its development and testing. In order that research on VANET can be continued, VANET network modeling is carried out in the form of simulation (Nutrihadi, 2016). The advantage of doing the simulation beforehand is the flexibility to model and evaluate the design without building a physical network. The simulation results are expected to provide the foundations to allow the actual implementation of the technology in Indonesia, especially in Pekanbaru.

VANET has a routing protocol that functions to determine the route according to its characteristics. According to Virgono and Yovita (2016) routing protocols are very influential on network performance and

are used to face challenges related to dynamic network topology. This study is conducted to simulate the maximum performance comparison of proactive, reactive and hybrid types of DSDV, AOMDV, and ZRP routing protocols. Data is collected through direct method by counting the number of vehicles passing several protocol roads. The obtained data are simulated on software with variations in the transmission distance range to improve the reliability of the routing path used and create a more extended connection between vehicles. The scenario is carried out in conditions of network changes and breakneck node speeds.

The VANET network provides driving safety information, so a fast and efficient routing protocol is needed. VANET Network performance is measured by the Quality of Service (QoS) parameter, because QoS describes the measurement of the ability of a network to achieve maximum performance determined by parameters such as end-to-end delay, packet delivery ratio, routing overhead, throughput, collision rate, and packet loss obtained using the AWK script. The data obtained is compared in graphical form.

The contribution of this research is to produce recommendations for a VANET network model in Pekanbaru City that implements DSDV, AOMDV, and ZRP as its routing protocols, using several parameters such as end to end delay, packet delivery ratio, and routing overhead, collision rate and packet loss. The research results are expected to be used as a reference in implementing the VANET network in Pekanbaru.

2. Literature review

2.1. Vehicular Ad-hoc Network (VANET)

Vehicular Ad hoc Network is the development of a wireless and Mobile Ad hoc Network (MANET), which considers all vehicles in the system as nodes capable of communicating with other cars on specific scopes. Furthermore, the moving nodes on MANET and VANET depend on ad hoc routing protocols to determine the technique required to send messages from the source to the destination node (Arditya et al., 2017)

The communication methods on VANETs are categorized into two types, namely those carried out between vehicles equipped with communication equipment known as Vehicle-to-Vehicle (V2V) and communication between vehicles and infrastructure placed at the curb called Vehicle-to-Infrastructure (V2I) as shown in Figure 1. Furthermore, the devices placed by the sides of the road to support communication between vehicles are called Roadside Units (RSU). Meanwhile, the two central systems that support the VANETs besides RSU are called On-Board Unit (OBU) and Application Unit (AU)(Dimiyati et al., 2016).

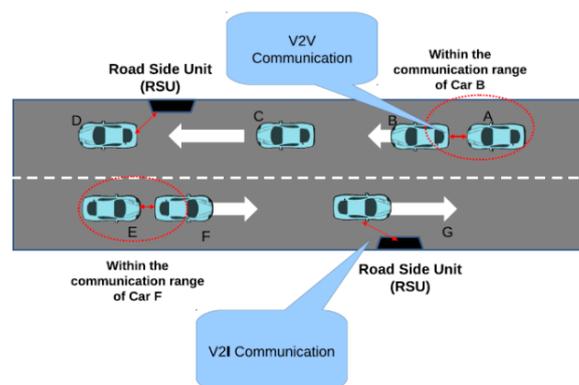


Figure 1. Types of communication on VANET (Rehman et al., 2013)

Due to the unavailability of a static topology by VANET, data is relayed between the source and destination nodes. Therefore, a routing algorithm is required to determine the path needed to send data on a dynamic topology. This led to the development of several routing algorithms on VANET with various advantages. These routing protocols are categorized into five categories, namely position-based, topology-based, broadcast-based, cluster-based, and geocast-based routing protocols as shown in Figure 2.

Topology-based routing protocols use routing tables to store link information as a basis for packet forwarding from the source to the destination node. Based on network architecture, this protocol is categorized into three types, namely Proactive, Reactive, and Hybrid protocols (Pradana et al., 2017).

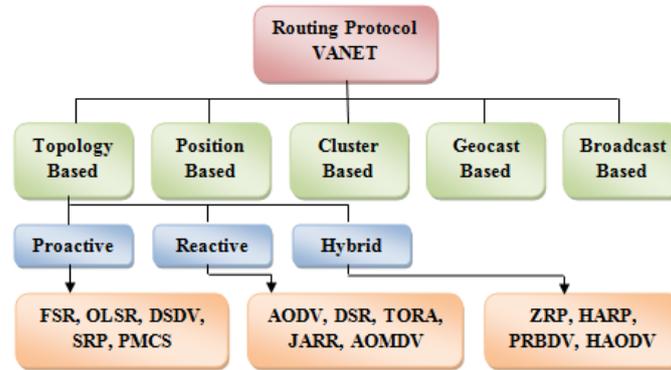


Figure 2. Routing protocols on VANET (Pradana et al., 2017)

a) Proactive Routing Protocol

The advantage of a proactive routing protocol is that it does not require route discovery because the destination route has been previously saved. Example: FSR, OLSR, DSDV.

b) Reactive Routing Protocol

The advantage of the reactive routing protocol is that the route search is performed when communication is needed by the node. It consists of the Route Discovery phase, where the requested packet floods the network to determine the path. Example: AODV, DSR, JARR, TORA, AOMDV

c) Hybrid Routing Protocol

Hybrid Routing Protocol was introduced to reduce overhead control and the initial delay in the route discovery process in the proactive routing protocol. Example: ZRP, HARP, HAODV.

DSDV

DSDV is an ad hoc proactive routing protocol algorithm, which uses a distance vector routing method equipped with a sequence number. This method allows each node in the network to exchange routing tables through neighboring nodes (Febrian et al., 2018).

AOMDV

AOMDV is a reactive routing protocol that develops from the AODV uni-path routing protocol to minimize frequent connection failures and interrupted routes. Similar to other routing protocols, it also provides two primary services, namely route discovery and maintenance. AOMDV is vector based and uses a hop-by-hop approach. Furthermore, it only searches for needed routes using the route discovery procedure (Anisia et al., 2016).

ZRP

The ZRP concept on the network is the building zone of each node that allows for several zone construction. According to (Adiwicaksono, 2017), the nodes within a predetermined geographic area is also known as the radius.

2.2. Network Simulator

NS-2 is a network simulation software with a simple script language developed using two programming languages, namely C++ and TCL (Shiddi Qi et al., 2017).

2.3. Simulation of Urban Mobility (SUMO)

SUMO is one of the tools for mobility generators used for VANET simulations. It is an open-source microscopic traffic simulation package designed to handle networks with broad channels (Pradana et al., 2017).

2.4. Open Street Map (OSM)

OpenStreetMap (OSM) is a web-based project used to create a free and open map of the world, built entirely by volunteers by conducting surveys using GPS devices, digitizing satellite imagery, and collecting and freeing geographical data that is publicly available.

2.5. AWK

AWK is a programming language used to manipulate data and make reports. It can also be used in the command line and script by sequentially scanning the line standard input, file, or output processe(AM et al., 2019).

2.6. Network Performance Parameters

Network performance is measured by the quality of service (QoS) parameter. It can show consistency, the success rate of sending data, etc. Several parameters can be used to measure network performance, namely, packet delivery ratio (PDR), end to end delay (E2E), overhead routing (RO), throughput, collision rate, and packet loss (AM et al., 2019)

1. Packet delivery ratio (PDR)

Packet delivery ratio is the ratio between the number of packets received by the destination and the number of packets sent by the source. Packet Delivery Ratio is calculated with equation 1, where received is the number of data packets received and sent is the number of data packets sent.

$$PDR = \frac{received}{sent} \times 100\% \dots\dots\dots (1)$$

Packet Delivery Ratio may indicate the success of the package sent. The higher the Packet Delivery Ratio, the more successful the package delivery is (Ovari, 2017). ITU-T G.114 recommends that the value for the quality of service (QoS) in the packet delivery ratio (PDR) is 100% in VANET (vehicular ad hoc network) communications with this value, the routing protocol can work properly.

2. End to End Delay (E2E)

E2E is calculated from the average delay between the time the packet was received and when it was sent as shown in equation (2), where $t_{received}[i]$ is the time of receiving the packet with the order / id ith, $t_{sent}[i]$ is the time when the packet is sent with the order / id-i, and sent is the number of data packets sent.

$$E2E = \frac{\sum_{i=0}^{sent} t_{received} - t_{sent}[i]}{sent} \dots\dots\dots (2)$$

Based on ITU-T G.114 recommendations, a delay of not greater than 100 ms for VANET communications is recommended, with a limit of 400 ms for communications that can still be received in a VANET.

3. Overhead Routing (RO)

Overhead Routing is the number of routing control packets transmitted during the simulation. The calculated control packages are Route Request (RREQ), Route Reply (RREP) and Route Error (RRER), routing overhead formula, as shown in Equation 3.

$$RO = RREQ_{sent} + RREP_{sent} + RRER_{sent} \dots\dots\dots (3)$$

4. Throughput

Throughput is the effective data transfer rate, which is measured in bps or kbps obtained by the total number of packet arrivals that have been successfully received by the destination during a certain time interval divided by the duration of the time interval. The formula for calculating throughput can be seen in equation 4.

$$Throughput = \frac{the\ number\ of\ data\ packets\ received}{data\ packet\ delivery\ time} \dots\dots\dots (4)$$

5. Collision Rate

The collision rate is the total number of packets accumulated in one period. The formula for calculating the collision rate can be seen in equation 5 (AM et al., 2019).

$$Collision\ Rate = \frac{the\ number\ of\ collision}{packet\ data\ sent} \dots\dots\dots (5)$$

6. Packet Loss

Packet loss is the percentage of the number of packets that the destination failed to receive. The formula for calculating packet loss can be seen in equation 6 (AM et al., 2019)endations for QoS packet loss ratio value categories is in accordance with ITU-T G.114.

$$Packet\ Loss = \frac{data\ packet\ sent - data\ packet\ received}{data\ packet\ sent} \dots\dots\dots (6)$$

3. Method

3.1. Simulation Flowchart

Figure 3 is a flowchart of the simulation process with an actual map obtained from the OpenStreetMap (OSM). The SUMO simulation results are used to complete the script on the protocol using the NS-2 software. Furthermore, the simulation is performed to obtain products and performance analysis of the DSDV, AOMDV, and ZRP routing protocols used in VANET communication.

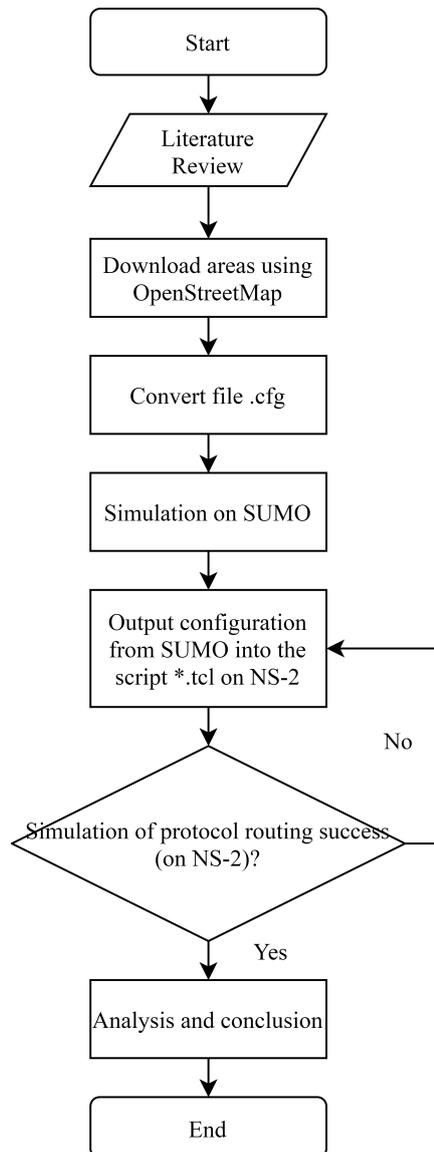


Figure 3. Research Flow Diagram

3.2. Simulation Parameters and Specifications

The simulation scenario of the study is carried out on Jendral Sudirman street in the urban area of Pekanbaru city. The simulation is carried out for 300 seconds using a real scenario before it is tested to determine the factor change in the number of nodes that can affect the VANET service's performance of the compared routing protocol. Some of the parameters set in the scenario script are shown in Table 1.

Table 1. Simulation design parameters

Parameters	Specifications
Network Simulator	NS-2.35
Routing Protocol	DSDV, AOMDV, ZRP
Simulation Time	0-300 seconds
Packet size	512 bytes
Number of Nodes	20,50,100,150
Simulation Area	4362 m x 6962 m
Antenna type	Omni Antenna
Propagation model	Two-ray Ground
Data type	TCP
Channel type	Wireless Chanel

3.3. Designing on OSM and SUMO

On the OpenStreetMap, a selected area can be downloaded by clicking on export. The downloaded maps are later converted into a file with the extension *.net.xml using SUMO tools, namely netconvert. The detailed mechanism for creating a scenario map is shown in Figure 4.

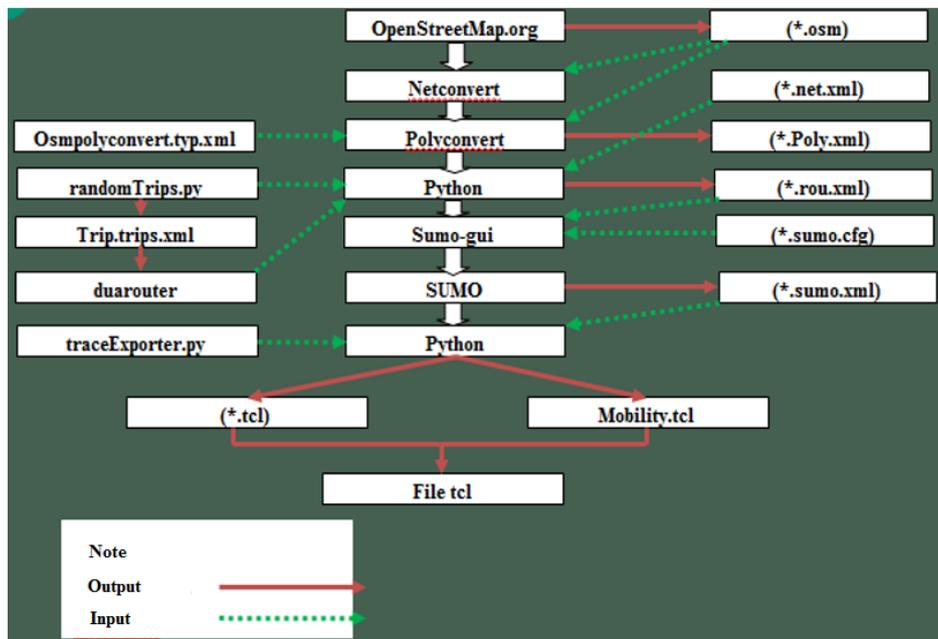


Figure 4. Mechanisms for creating map scenarios from Openstreetmap

Figure 5 shows a map that has been configured with the SUMO simulator which is used to simulate vehicle movements. Combining SUMO with openstreetmap.org allows simulation of traffic on various

locations in the world. SUMO is used to configure the map to ensure that the simulation approaches the actual situation within an area of 4,362 m x 6,962 m.

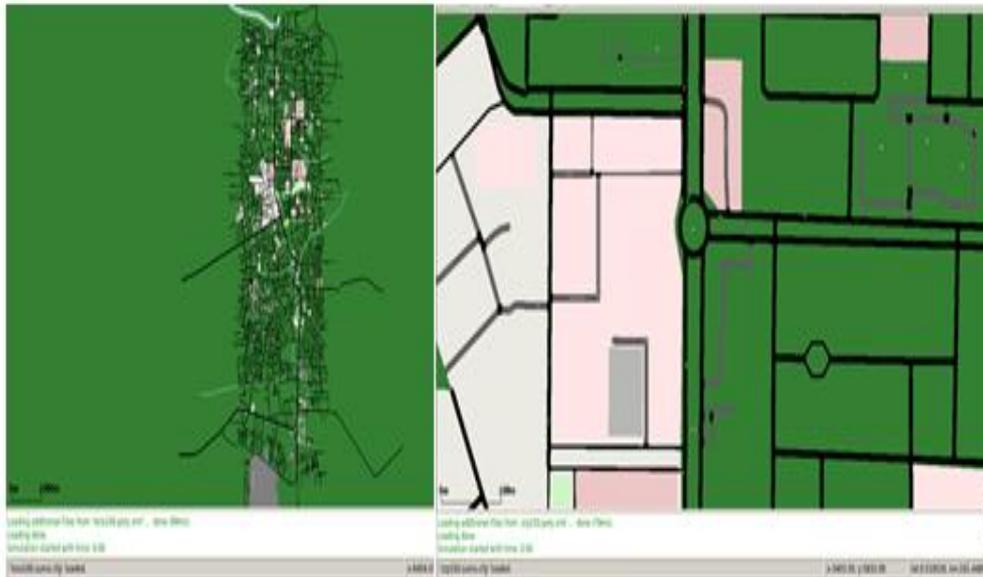


Figure 5. VANET simulation on Sumo

3.4. Simulation on NS-2

The scenarios from the map produced by SUMO are used to simulate the VANET communication network using NS-2. Furthermore, SUMO's simulated results combine with *.tcl extension script, which contains the environment configuration. This research also modified the *.tcl file, thereby making it possible to be run on the terminal to produce *.nam file output before being analyzed with various required performance metrics.

4. Result and Discussion

This study simulates data sampling at the flyover on the intersection of Jalan Jendral Sudirman and Jalan Tuanku Tambusai (Jalan Nangka). The real data scenario for the change in the number of nodes uses four variations, namely 100, 250, 600, and 700 (vehicles), while the transmission distance uses three variations, namely 250m, 500m, and 1km. The scenario of node speed changes uses a standard vehicle acceleration limit set by the government for urban roads of 50 km/hr. The speed change scenario uses five variations of speed, namely 10 km/hour, 20 km/hour, 30 km/hour, 40 km/hour, and 50 km/hour. A total of three scenarios are used to determine the changes in the QoS parameter performance value. The parameters used are Packet delivery ratio, routing overhead, End to end delay, Throughput, Collision Rate, and Packet Loss.

4.1. Comparison of QoS Performance Results Based on Changes in Number of Nodes Scenarios

Routing protocol performance results show changes of numbers on several QoS parameters, namely packet delivery ratio, end to end delay, routing overhead, throughput, and packet loss. Furthermore, by running the AWK command on the parameters tested, the following results are obtained:

4.1.1 Packet Delivery Ratio (PDR) Based on Changes in Number of Nodes Scenarios

Figure 6 shows the PDR performance of the DSDV, AOMDV, and ZRP protocols. From the three routing protocols, it can be seen that when the density of nodes is 100 and 250, the PDR values of the three routes increase by almost similar values, but when the number of nodes is 600 and 700 the performance of the DSDV and ZRP routing protocols decreases, due to dense network conditions and excessive number of tables routing maintained by the DSDV protocol. This condition causes the failure to form the routing table.

AOMDV, DSDV, and ZRP have an average PDR of 99.8814%, 99.2094%, and 99.1393%, therefore, it can be concluded that based on an average PDR value, routing protocol AOMDV has a better PDR than DSDV and ZRP because each increase in the number of nodes, led to a rise in the resulting PDR value.

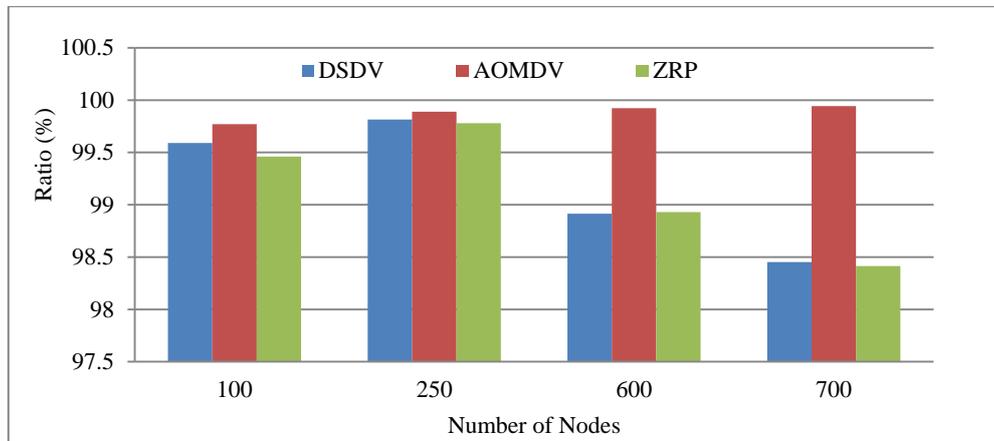


Figure 6. Packet Delivery Ratio changes in the number of nodes

4.1.2 End to End Delay (E2ED) Based on Changes in Number of Nodes Scenarios

Figure 7 shows that the end to end delay value of the three routing protocols increases with a rise in the number of nodes or vehicles. The lowest average end to end delay obtained by the DSDV routing protocol has an average value of 0.08394 ms, while AOMDV and ZRP are 0.09437 ms and 0.104926 ms, respectively. The low end to end delay value of DSDV is due to the proactive nature, with routing table used to send packets at each node. Furthermore, direct delivery is carried out to shorten the delivery time of packets. The AOMDV and ZRP delivery processes tend to be longer because the two protocols carry out the route discovery process. Proactive ZRP routing cannot be used when the receiver node is not yet in the sending radius zone, therefore, it tends to make a route discovery when sending packets that cause an extra delay. When the number of nodes in the simulation was escalated to 600 and 700, it can be seen in Figure 7, delay in the ZRP protocol could not be detected due to the excessive nodes in the system. Therefore, the ZRP protocol is suitable for handling routing transactions in the environment where the number of nodes is small.

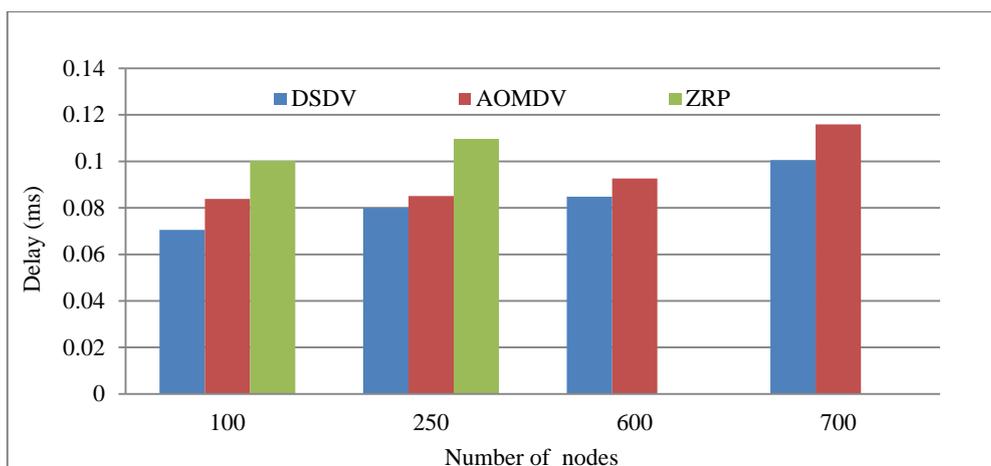


Figure 7. End-to-End delay changes in the number of nodes

4.1.3 Routing Overhead (RO) Based on Changes in Number of Nodes Scenarios

Figure 8 is a percentage comparison of the three overhead protocol routing values. The results obtained show that the ZRP routing protocol has a small overhead value compared to DSDV and AOMDV

with average overhead value of 0.503, and 1. RO values of 1.003 and 1.00025, respectively. DSDV has a higher RO value because it is a proactive routing protocol that updates the routing table continuously in such a way that it floods the network with a large amount of bandwidth.

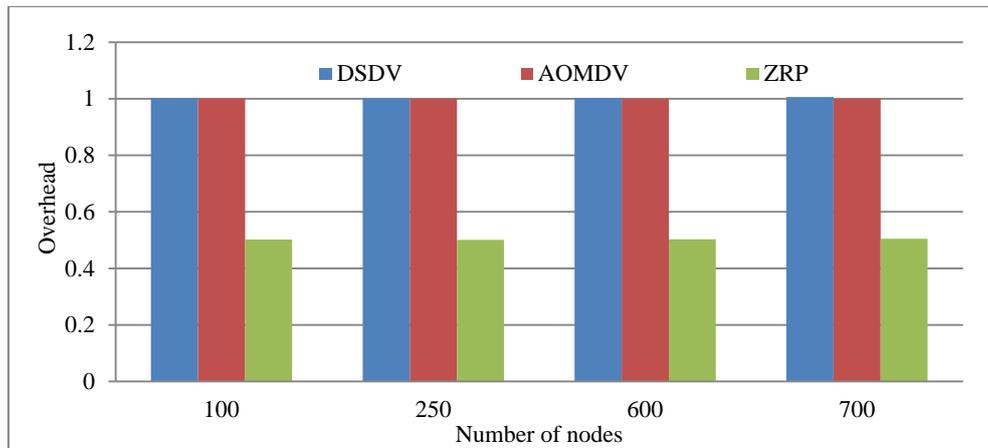


Figure 8. Routing overhead changes in the number of nodes

4.1.4 Throughput Based on Changes in Number of Nodes Scenarios

Throughput describes the condition of data rate in a network, the higher the value owned by the routing protocol, the better the data transmission in the network. Figure 9 is a comparison of the results of DSDV, AOMDV, and ZRP routing protocol throughput performance.

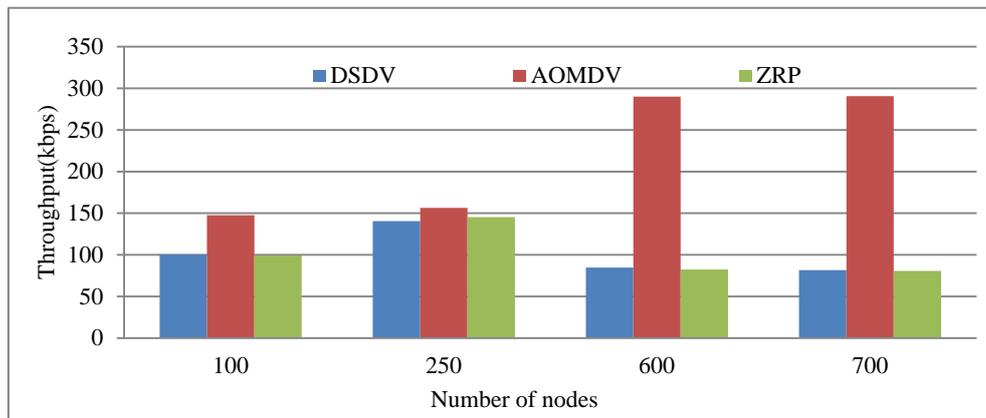


Figure 9. Throughput changes in the number of nodes

The above chart shows that throughput value of the AOMDV protocol increases with a rise in the number of nodes. Furthermore, an increase in the amount of packet delivery ratio, or the received packet presentation also leads to a rise in the rate of data reception. From this study, the highest average throughput with packet delivery is obtained by the AOMDV routing protocol with results for 100, 250, 600 and 700 nodes of 143.52 kbps, 156.36 kbps, 289.94 kbps, and 290, 67 kbps.

4.1.5 Collision Rate Based on Changes in Number of Nodes Scenarios

Figure 10 shows a comparison graph of the DSDV, AOMDV, and ZRP protocol collision rate values. Out of the three routing protocols tested, the highest value of the collision rate occurs in the DSDV protocol, with an average of 1.49315. This is in contrast with the AOMDV and ZRP protocols, with average values of 1.0166, and 1.4158, respectively. Based on the comparison of the average values obtained

for the three routing protocols, the AOMDV collision rate is better than DSDV and ZRP, due to its ability to build the route when there is a request.

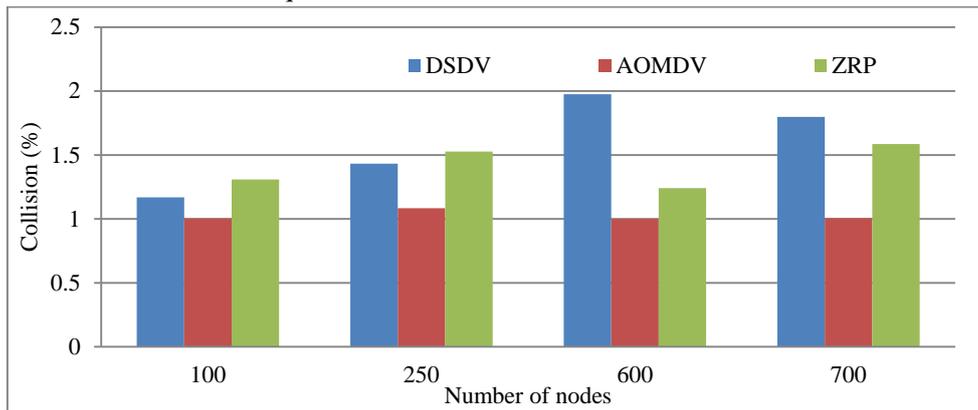


Figure 10. Collision rate real scenarios

4.1.6 Packet Loss Based on Changes in Number of Nodes Scenarios

Packet loss is the amount of data lost during the data transmission process, therefore the data received is not the same as the amount sent. Furthermore, the smaller the packet loss value, the better the network performance with the result of each node calculation shown in Figure 11.

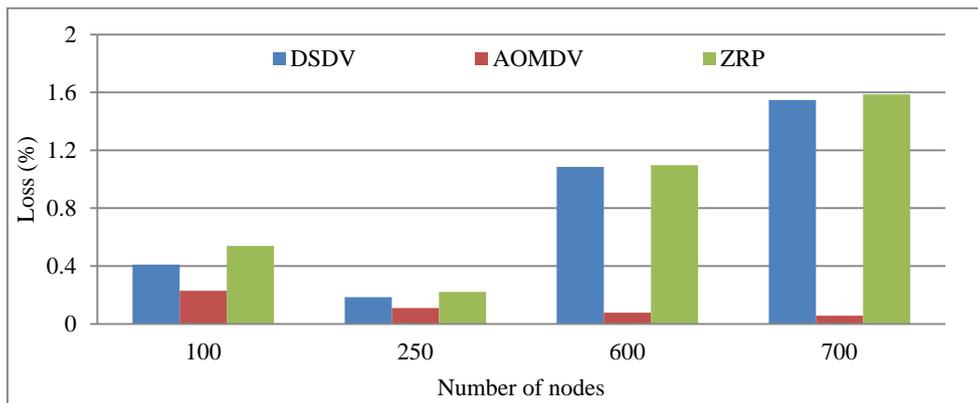


Figure 11. Real packet loss scenarios

Figure 11 shows that the AOMDV protocol has a better packet loss performance than DSDV and ZRP with values of 0.036475%, 0.7148%, and 0.8607%, respectively. The low packet-loss value of AOMDV is due to the nature that can adapt to the VANET network environment. Alternative routes have the ability to overcome the high node mobility that tends to occur frequently and quickly. Therefore, packet delivery tends to occur when the intermediate node is suddenly passed from the sender to the receiver. According to Muhtadi, Perdana, & Munadi (2015), the AOMDV packet loss routing protocol is better than DSDV and ZRP. This is in accordance with the research carried out by Anjum, Bondre, & Khan (2015), which stated that the AOMDV has a packet loss value better than AODV.

Overall, based on the ITU-T G.114 standard, the packet loss generated from these three routing protocols has a good loss value for each additional number of nodes. The best percentage packet loss value is obtained by the AOMDV routing protocol.

4.2. Comparison of QoS Performance Results Based on Transmission Distance and Transmit Power

Scenarios testing based on transmission distance and transmit power are carried out using three variations, namely 250 m, 500 m, and 1 km. The difference in transmission distance and transmit power in this test is shown in Table 3.

Table 3. Scenarios based on transmission distance and transmit power

Transmission Distance (m)	Transmit Power (dBm)
250	0.281838
500	4.509408
1000	72.15052

4.2.1 Packet Delivery Ratio (PDR) for Transmission Distance Variation Scenarios

Figure 12 shows the PDR performance of the DSDV, AOMDV, and ZRP protocols based on the variation of transmission distance. The graph shows that the change in transmission range affects the performance of all three routing protocols on the VANET network. Meanwhile, the simulation results indicate that the performance of the three protocols shows better PDR results at the 500-meter transmission range. Conversely, the PDR starts to decrease when the transmission range exceeds 500 meters, which indicates that the AOMDV protocol has an average PDR of 99.8409%. In comparison, DSDV and ZRP have average PDR values of 99.6951% and 99.632%, respectively. Therefore, it can be concluded that AOMDV routing protocol have better PDR values than DSDV and ZRP.

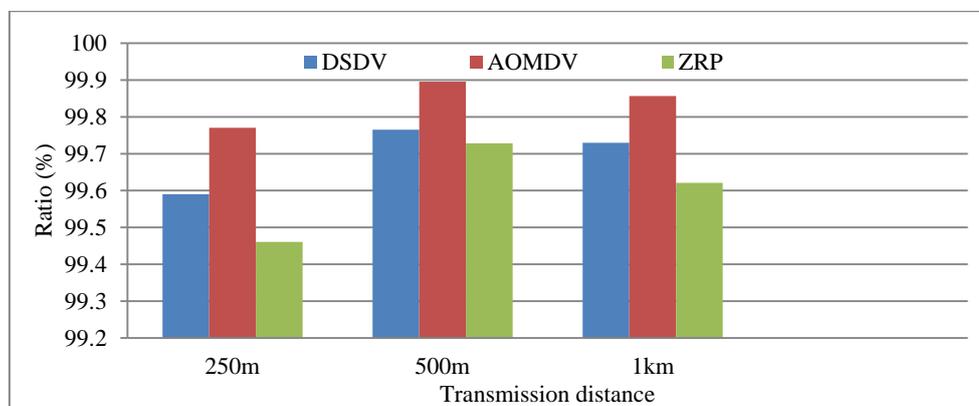


Figure 12. Packet delivery ratio transmission distance variations

4.2.2 End to End Delay (E2ED) for Transmission Distance Variation Scenarios

Figure 13 shows that an increase in transmission range leads to a rise in three protocols. From this study, the lowest average end to end delay obtained by the DSDV routing protocol with an average value of 0.08002 ms, while AOMDV and ZRP were 0.08489 ms and 0.107837 ms, respectively.

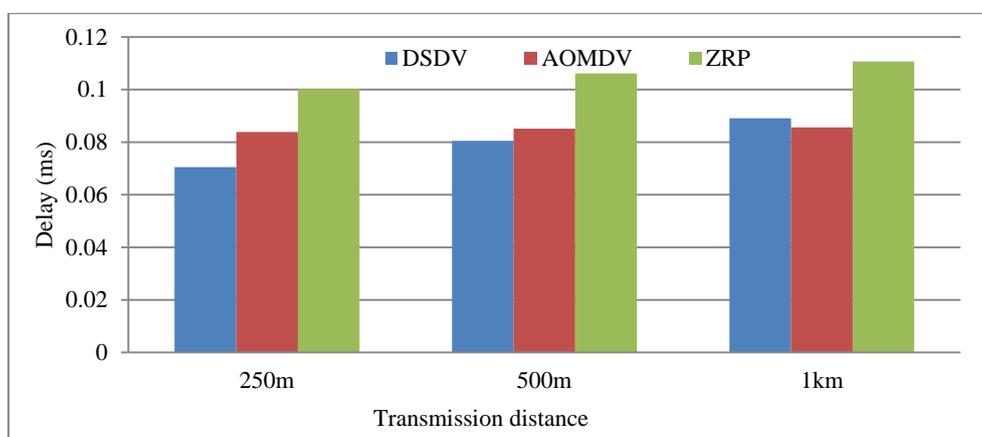


Figure 13. End to End delay of transmission distance variations

4.2.3 Routing Overhead (RO) for Transmission Distance Variation Scenarios

Figure 14 shows that the ZRP routing protocol has a small overhead value compared to DSDV and AOMDV. This is because the excess of the hybrid routing protocol reduces control overhead, while the AOMDV, which is a multipath routing protocol, finds alternative routes with minimal additional overhead. This is conducted by utilizing the majority of the alternative routing information that already exists. ZRP has an average overhead of 0.501, while DSDV and AOMDV have average RO of 1.002, and 1,003, respectively.

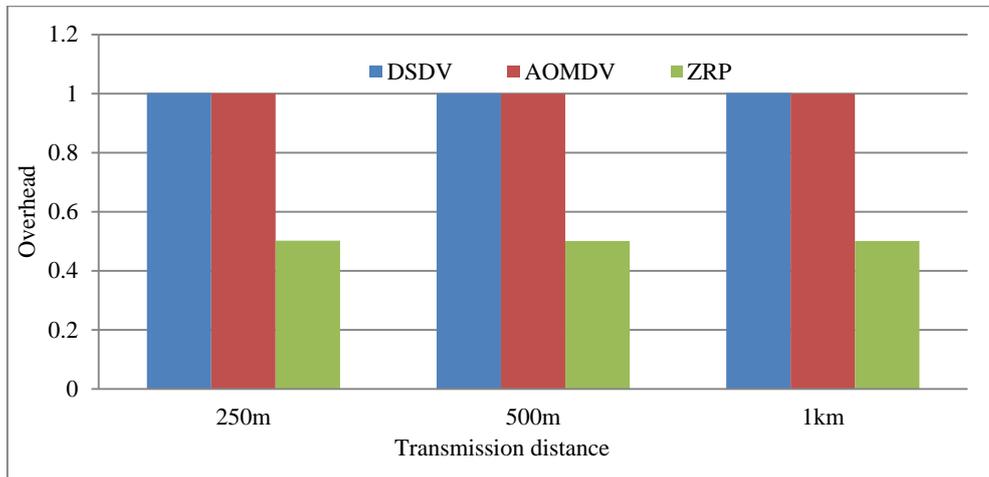


Figure 14. Overhead routing variations in transmission distance

4.2.4 Throughput for Transmission Distance Variation Scenarios

Figure 15 shows that there are changes in transmission range which affect the performance of the three routing protocols on the VANET network. The simulation results show that the performance of the three protocols has better throughput results at the transmission range of 500 meters. Conversely, throughput starts to decrease when the transmission range exceeds 500 meters. The results show that the AOMDV, DSDV and ZRP protocols have an average throughput of 169.67 kbps, 144.08 kbps, and 130.71 kbps respectively. Therefore, it can be concluded that AOMDV routing protocol has a better throughput value than DSDV and ZRP.

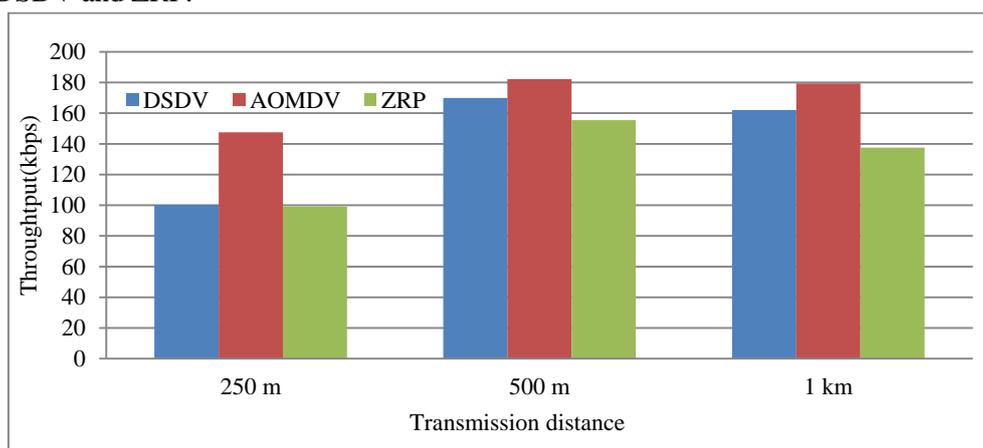


Figure 15. Throughput transmission distance variations

4.2.5 Collision Rate for Transmission Distance Variations Scenarios

Figure 16 shows that the transmission range affects the collision rate, with the best protocol obtained by AOMDV due to its ability to build routing when there is a request. Whereas in ZRP, there is an increase in collision rate because its routing makes many alternative paths and needs a significant bandwidth. This

leads to the inability of channels to accommodate data and collide with each other. Out of the three routing protocols tested, the highest collision rate occurred in the ZRP, with an average value of 1.5353%. In contrast, the AOMDV and DSDV protocols had average values of 1.3098 and 1.3686%, respectively. Based on the comparison of the average values obtained from the three routing protocols, the AOMDV collision rate is better than DSDV and ZRP due to its ability to build routes upon request.

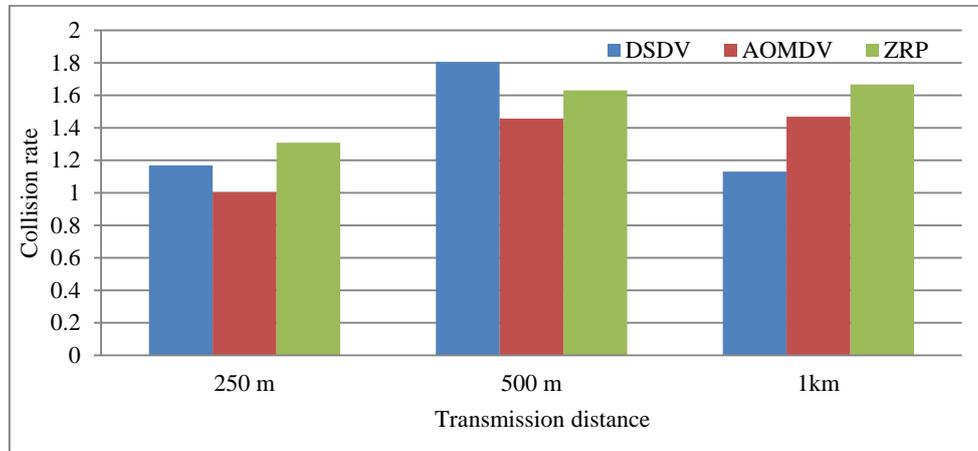


Figure 16. Collision rate for transmission distance variations

4.2.6 Packet Loss for Transmission Distance Variation Scenarios

Figure 17 shows that the change in transmission affects the performance of the three routing protocols on the VANET network. The performance of the three protocols shows better packet loss results at the transmission range of 500 meters. However, the packet loss starts to decrease when the transmission range exceeds 500 meters, with AOMDV, DSDV and ZRP values of 0.1591%, 0.2148%, and 0.3968%, respectively. It can be concluded that based on the average PDR value, AOMDV routing protocol has a better packet loss value than DSDV and ZRP.

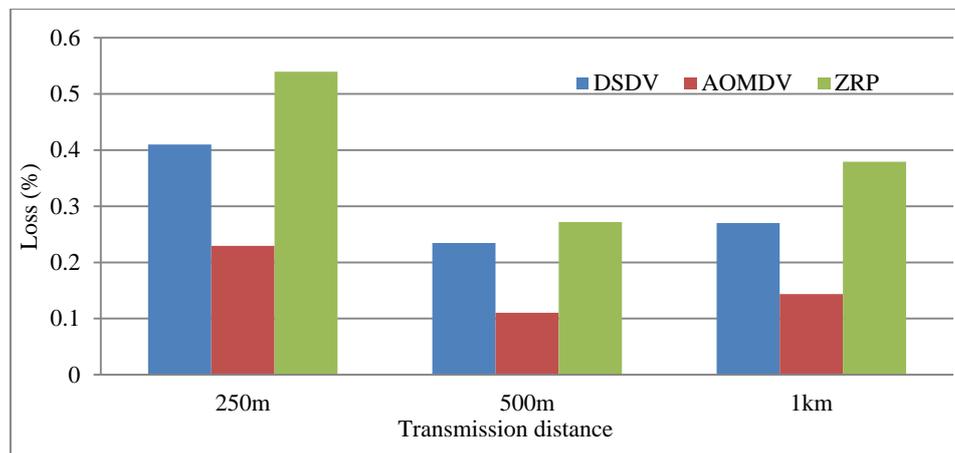


Figure 17. Packet loss transmission distance variations

4.3. Comparison of QoS Performance Results Based in Node Speed Change Scenarios

This scenario is carried out to test the ability of the three routing protocols to deal with network topology that occurs due to changes in node speed in Pekanbaru city. The number of vehicles used is 100 nodes, and the speed used is based on Law Number 111 of 2005, Article 3 paragraph 2, which stated that the maximum speed limit in the city is 50 km/hour. Therefore, this research simulates changes in the speed of 10 km/h, 20 km/h, 30 km/h, 40 km/h and 50 km/h as shown in Table 4.

Table 4: Scenarios for node speed changes

Number of nodes	Nodes speed changes	
	Km/h	m/s
100 Nodes	10	2,77
	20	5,56
	30	8,33
	40	11
	50	13,98

4.3.1 Packet Delivery Ratio (PDR) in Node Speed Change Scenarios

Figure 18 shows that the PDR of the three protocols tends to decrease with increase in node speeds. Furthermore, an increase in speed, leads to a rise in the distance between nodes, thereby causing a line break that results in a repeat of the search for a new route. In this scenario, the change in node speed of AOMDV is obtained by the highest average Packet Delivery Ratio of 99.4923%. These results are due to the nature of AOMDV, which can adapt to the VANET network environment due to its multipath features and multiple alternative paths. When one of the main lines is cut off, it is immediately replaced by another alternative route. The Average Packet Delivery Ratio of the scenario of changes in node speed on DSDV and ZRP are 99.1006%, and 98.6129%.

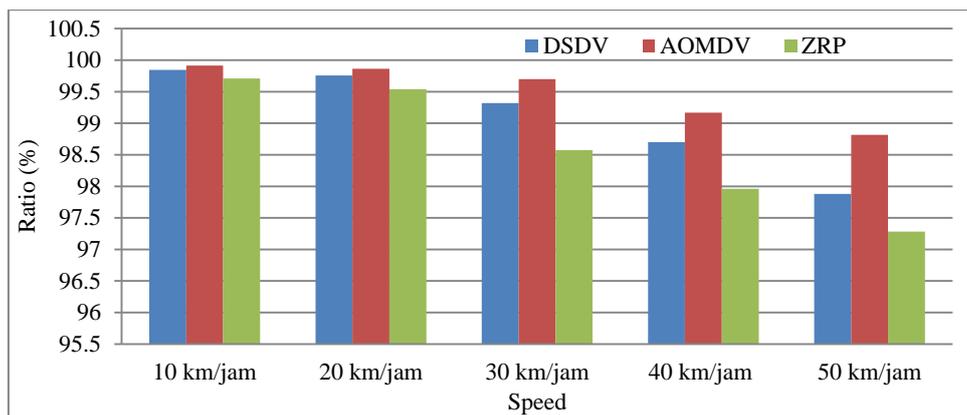


Figure 18. Packet delivery ratio in node speed change scenarios

4.3.2 End to End Delay (E2ED) in Node speed Change Scenarios

Figure 19 shows that the lowest average end to end delay of DSDV, is obtained by the proactive routing protocol, with an average value of 0.081512 ms due to the proactive nature. The process of sending packets on DSDV uses a routing table that has been formed at the sender, intermediate, and receiver nodes. Therefore, direct delivery is carried out to shorten the delivery time of packets from the sending process to the destination. Overall based on the ITU-T G.114 standard in Table 2.2, the value of end to end delay resulting from these three routing protocols is sharp. The average end to end delay on AOMDV is 0.09024ms, and ZRP is 0.115741ms.

4.3.3 Overhead in Node Speed Change Scenario

Figure 20 shows that the ZRP routing protocol has a small overhead value compared to DSDV, and AOMDV. It also has a small overhead value, because the excess of the hybrid routing protocol reduces control overhead. Meanwhile AOMDV, which has multipath features, does not have high coordination overhead between nodes because communication is only carried out when needed. Furthermore, ZRP has an average overhead of 0.5044, while DSDV and RO has an average RO of 1.0054, and 1.002, respectively.

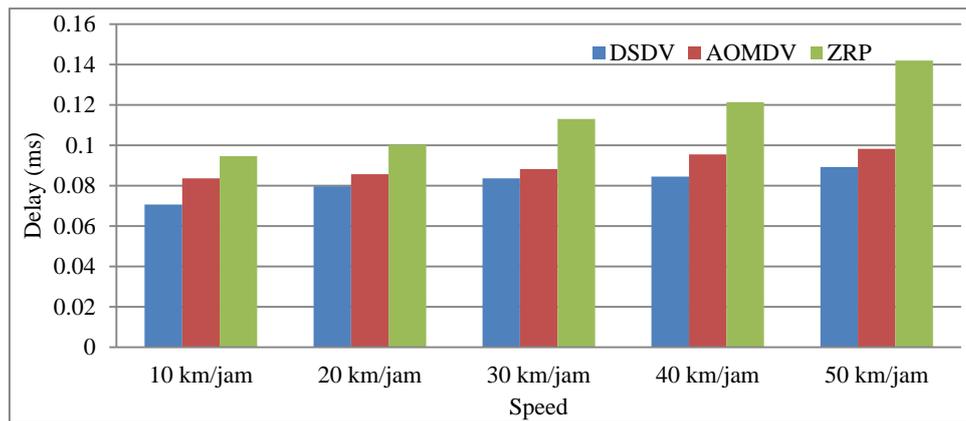


Figure 19. End to end delay in node speed change scenarios

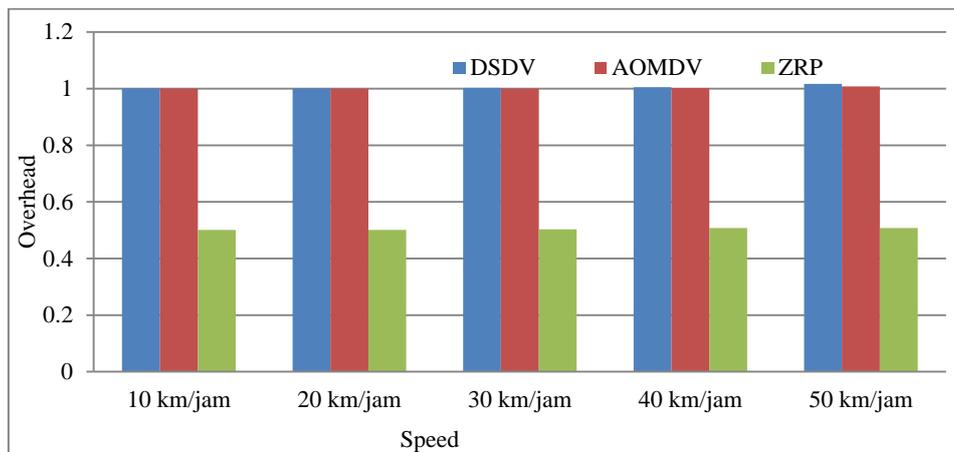


Figure 20. Overhead routing in node speed change scenarios

4.3.4 Throughput in Node Speed Changes Scenario

Figure 21 shows that the three protocols tend to decrease with an increase in node speeds. This is because an increase in speed leads to a rise in the distance between nodes, thereby causing a line break that results in a repeat of the search for a new route. In this scenario, the change in node speed is obtained by the highest average packet delivery ratio of the reactive routing protocol, AOMDV, at 171.74 kbps. The average throughput scenario of changes in node speed on DSDV and ZRP are 142,064 kbps, and 124,278 kbps.

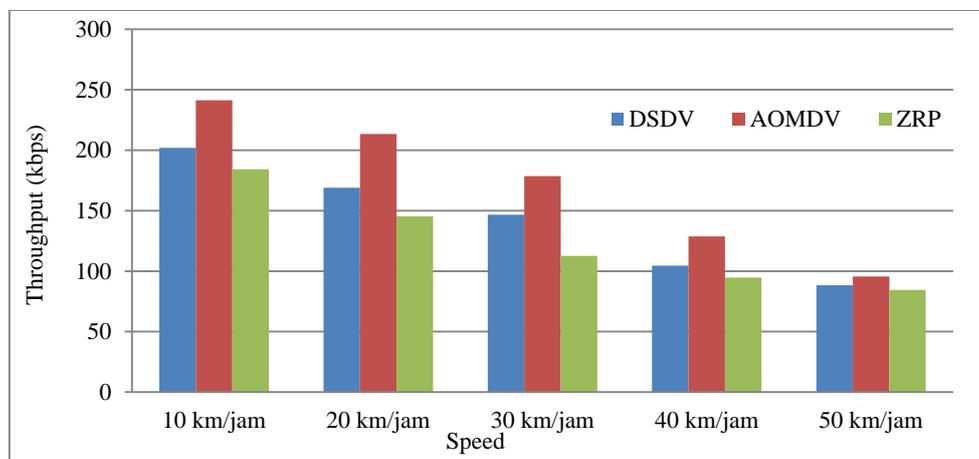


Figure 21. Throughput change in node speed scenarios

4.3.5 Collision Rate in Node Speed Changes Scenarios

Figure 22 shows that the collision rate at AOMDV is the best due to its ability to build routes when there is a request. Whereas in ZRP, an increase in collision rate can occur due to its ability to route and make numerous alternative paths that are large enough with bandwidth, thereby leading to the inability of the channels to hold data and collide with each other.

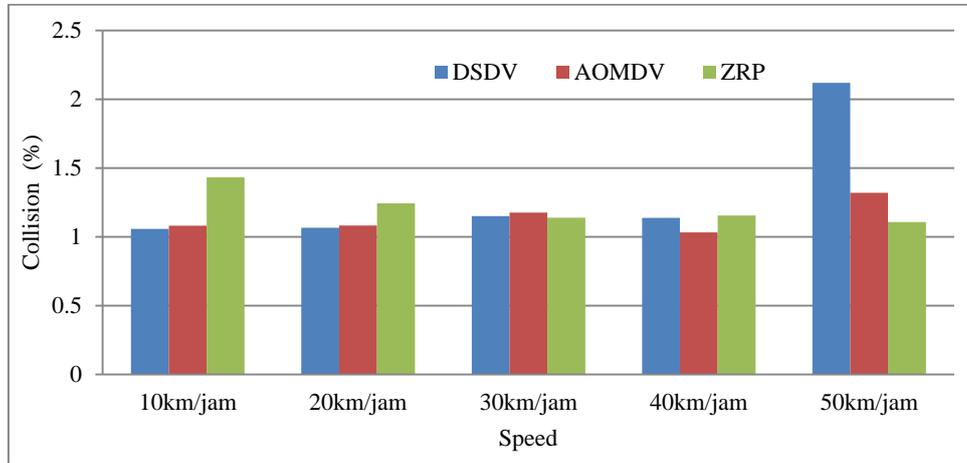


Figure 22. Collision rate change in node speed scenarios

4.3.6 Packet Loss in Node Speed Changes Scenarios

Figure 23 shows that packet values indicate that the three protocols tend to increase with rise in node speeds. AOMDV protocol has a better packet loss performance than DSDV with average packet loss of 0.4991%, while DSDV and ZRP are 0.8653%, and 1.3596%, respectively.

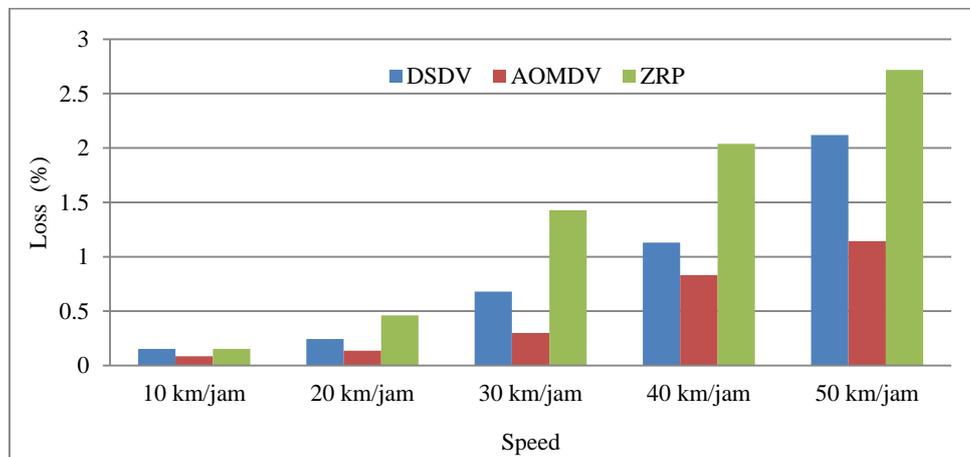


Figure 23. Packet loss in node speed change scenarios

5. Conclusion

Based on the testing process of DSDV, AOMDV, and ZRP routing protocol performance using test parameters of packet delivery ratio, end-to-end delay, routing overhead, throughput, collision rate, and packet loss, the study comes to the following conclusions.

Vehicular Ad Hoc Network (VANET) communication with AOMDV, DSDV, and ZRP routing protocols are based on the scenario of changes in the number of nodes, variations in transmission distance, and differences in node speed that affect the QoS performance value. The result shows that the packet delivery ratio, end-to-end delay, routing overhead, throughput, collision rate, and packet loss have varying values.

The result on the node number changes scenario showed AOMDV is superior to almost all performance metrics with an average values of Packet Delivery Ratio at 99.8814%, Overhead Routing at 1.00025, Throughput at 221.1225 kbps, Collision Rate at 1.49315% and Packet loss at 0.036475%. The better performance of AOMDV routing protocol resulted from the implementation of multipath concept which can minimize route failure or disconnection. Whereas the end to end delay value of the three routing protocols increases with a rise in the number of nodes (vehicles), which leads to network congestion.

The results on the transmission distance variation scenario showed that the QoS of the three routing protocols have better performance results on the transmission range of 500 meters and start to decrease when the transmission range exceeds this number, taking into account that VANET is an ad hoc network for short-distance vehicle communication. Tests on the AOMDV transmission range are superior with an average values of Packet Delivery Ratio at 99.8409%, Routing Overhead at 1.002, Throughput at 169.67 kbps, Collision Rate at 1.3098%, and Packet Loss at 0.1591%. The best end to end delay value is obtained by DSDV routing protocol with an average delay value of 0.08002 ms, considering that packet delivery on DSDV uses a routing table that has been formed at each node, thus direct delivery is carried out to shorten the time of packets from the process delivery to the destination.

The results on the node speed scenario show that the QoS performance of the three tested routing protocols tends to decrease when node speeds increase because of the increased distance between nodes. Furthermore, it leads to a break in the path that result in a repeat of the search for a new route. Tests on the AOMDV transmission range are better in almost all performance parameters with an average value of Packet Delivery Ratio 99.4923%, End to End Delay 0.09024 ms, Routing Overhead 1.0054, Throughput 171.74 kbps, Collision Rate 1.1368%, and Packet Loss 0.4991%.

According to this study AOMDV as a reactive routing protocol is the best routing protocol that can be applied in Pekanbaru VANET network, because it is superior to almost all performance parameters tested in each of the scenarios. This research is based on observations on field data according to road conditions and the number of vehicles in the city of Pekanbaru, so the simulation results may apply in other cities with similar field conditions.

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