Performance Analysis of Ad-Hoc Routing Protocol for Vehicular Ad-Hoc Network (VANET)

Dwi Shakti M, Emy Haryatmi

Abstract*: *Vehicular Ad-hoc Network (VANET) are an emerging technology with vehicle. As a subset of Mobile Ad-hoc Network (MANET) application, VANET is considered to be a new phase of technology to the Intelligent Transportation System (ITS). VANET is a technology Using VANET vehicles can become aware of the dynamic behavior of other vehicles regardless of the driver's ability. In addition, infrastructure can obtain situational awareness at various levels of detail to manage traffic and potentially send emergency services. When traffic jam occurred in pick hour, vehicle in that area should be able to give a way to emergency services such as ambulance. Such traffic happened every day in Jakarta especially on weekdays. This research focused on designing the traffic condition and analyzing the routing protocol for VANET for Jakarta smart cities. Before implementing VANET in Jakarta, simulation using NS2 was conducted with two environment scenes. The first environment scene was the vehicle move one by one on each intersection. The second environment scene was the vehicle move in the opposite direction. The number of mobile nodes used in the environment scene as vehicle and infrastructure were 50, 100, 150, 200, 250, 300, and 350. we set 10 nodes as infrastructures for all number of mobile nodes used in the simulation and the remaining nodes as vehicles. We used more nodes as vehicle because the number of vehicles in the Jakarta was higher than the number of infrastructures. The network area used in this simulation was 2000x2000. We used constant bit rate (CBR), two ray ground propagation and omni antenna to simulate the environment scenes. The routing protocols used in this research were Ad-hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Destination Sequenced Distance Vector (DSDV). The result of this research showed that AODV achieved the highest throughput and the best packet delivery ratio. The lowest end-to-end delay was achieved by DSDV. Accordingly, simulation result showed that AODV has the best performance and preferable routing protocol of VANET for Jakarta environments.

Keywords*: *Ad-hoc network, AODV, DSDV, DSR, NS2, VANET

I. INTRODUCTION

Currently the number of vehicles in Jakarta, especially cars, is increasing. Accordingly, traffic jam always occurred in Jakarta especially in weekdays and pick hour. When emergency services were in the way, many cars had difficulty to pull over to give way to the emergency services. To overcome this problem, one feature is being developed and already implemented in the car. Such feature is the network infrastructure for communication channels in the car.

Vehicular Ad-Hoc Network is a subset of Mobile Ad-Hoc Network (MANET) application. VANET is one of most challenging areas for the improvement of Intelligent Transportation System (ITS) in order to mobility and connectivity to exploit the transport systems in an efficiently and safer way. Communication between cars is often referred to Vehicular Ad-Hoc Networks (VANET) and it has many advantages such as reducing cars accidents and minimizing the traffic jam. As shown in Figure 1, VANET can be classified into two types of communication technique such as Vehicle-to-vehicle communication (V2V) and Vehicle-to-Infrastructure communication (V2I) [1][2].

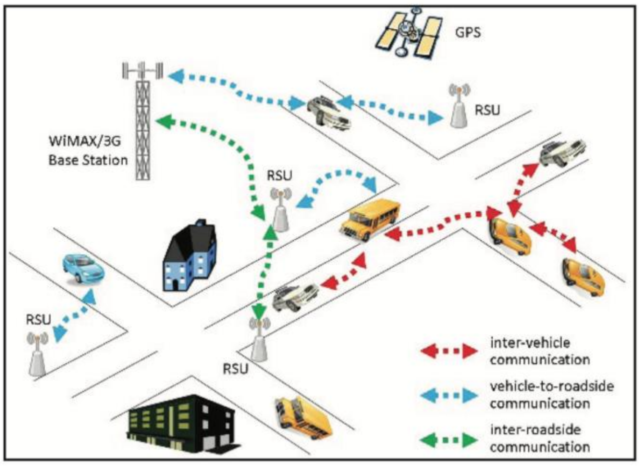

Fig 1 Communication of VANET [1]

V2V communication refers to inter vehicle communication, uses multi-hop multicast/broadcast to transmit information over multiple hops. The advantages of V2V communications are allowing short and medium range communications, supporting short messages delivery and minimizing latency in the communication link [3]. V2I communication configuration represents a single hop broadcast where the roadside unit sends a broadcast message to all equipped vehicles in the vicinity. V2I communication configuration provides a high bandwidth link between vehicles and roadside units. The Infrastructure may be placed every kilometer or less, enabling high data rates to be maintained in heavy traffic [4].

VANET is mainly aimed at providing safety related information and traffic management. Safety and traffic management entails real time information and directly affect lives of people travelling on the road [3]. The objectives of this research were to design and to analyze the performance of VANET routing protocol which

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can be implemented in a Jakarta environment. This research used NS2 to simulate the design. The simulation was conducted in 2 different environment scenes based on Jakarta traffic condition. This environment was elaborated with V2V and V2I communication technique.

II. LITERATURE REVIEW

A. Related Work

Several studies have been carried out to enhance the routing on VANET. Junya [5] proposed contents oriented communications (COC) systems for VANET through inter vehicle communication (IVC) systems. The benefit of this systems was vehicular accident and congestion sent to the driver therefore driver could avoid such traffic. Manjot Kaur [6] proposed a secure and design framework for potential VANET. Anas Abu Taleb [7] already studied VANET routing protocols and application suggest to studying the performance at different routing protocol. In [1] have studied that reactive routing protocol i.e. AODV with better performance on V2V applications. Also Saed Tarapiah [8] studied that not a one routing protocols is better and more efficient in all conditions and in all different environments. Divya Rathi [9] present and proposed AODV routing protocol can achieves better performance in city and only use 30-50 vehicles and 8-10 roadside units. According to these researches, the total nodes used in the experiment was up to 350 nodes of vehicle and infrastructure.

B. Routing Protocol

Various protocols have been developed for VANET technology that can be classified according to different criteria such as protocol characteristics, information routing techniques, service quality and network architecture. In this research, we used Topology Based Protocol. We used Destination Sequence Distance Vector (DSDV) for proactive routing protocol. For reactive routing protocol, we used Ad-Hoc on Demand Distance Vector (AODV) and Dynamic Source Routing (DSR).

a. Destination Sequence Distance Vector (DSDV) is based on the shortest path algorithm where a routing table is maintained by each node that is used to store routing information to every other node in the network. In order to reduce the size of the routing table, information related to the best or the shortest path are only maintained rather than storing information about multiple paths [7].

b. Ad-Hoc on Demand Distance Vector (AODV) is a reactive routing protocol based on DSDV and DSR algorithm. It has the ability of both unicast and multicast routing. This routing protocol is greedy of energy as it aims to reduce the number of broadcast messages sent across the network by discovering routes on demand instead of keeping all information on the updated route [10].

c. Dynamic Source Routing (DSR) is based on two processes; route discovery and route maintenance. When a non-existing route to destination is required. The source node initiate route discovery process. Thus, a route request message is to the neighbors of the source node. Then, these nodes broadcast the route request message until a node with a direct link to the destination is found. When a route reply message is received by the source node, the new route will be stored in its routing table [11].

III. METHODOLOGY

The methodology of this research was conducted in three steps.

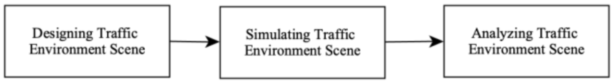

Fig. 2 Methodology of VANET Routing Protocol

The first step was designing the traffic environment. We designed the traffic environment according to the situation happened in Jakarta. Traffic environment was used as a benchmark to represent congestion in the city. There are two traffic environments scene used in this research. The first traffic environment scene was the vehicle move one by one on the intersection as shown in figure 2. We used 50, 100, 150, 200, 250, 300, and 350 mobile nodes in the experience. There are 10 nodes used as infrastructure and the remaining mobile nodes was used as vehicle. In figure 2, the number of nodes used for this traffic environment scene was 50 nodes. Node 41 until 50 was used as infrastructures. For the rest of mobile nodes used in the experience was the same number of mobile nodes for infrastructure. The remaining mobile nodes was used as vehicles.

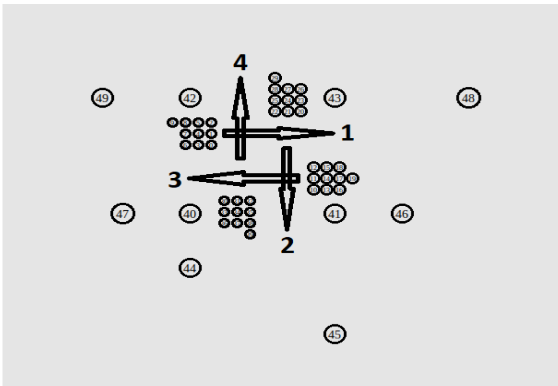

Fig 3. First Environment Scene

The second traffic environment scene was the vehicle move in the opposite direction as shown in figure 3. The number of mobile nodes used in the traffic environment scene was the same as the previous traffic environment scene. Mobile nodes numbered with 41 until 50 still used as infrastructures. The vehicle was the remaining mobile nodes.

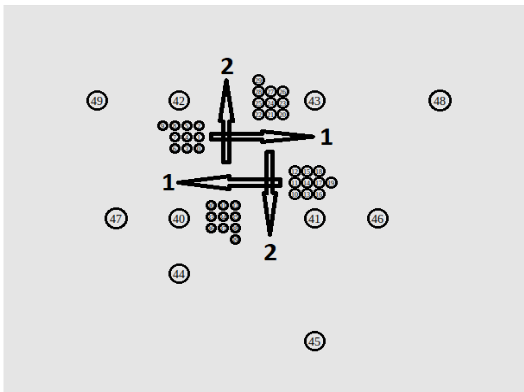

Fig 4. Second Environment Scene

The second step was to simulate those traffic environment scenes in Network Simulator 2 (NS2). There were two groups of parameters used in the simulation. The first group of parameters used in the simulation such as network area, radio range, traffic type, visualization tool, duration, MAC layer, routing protocol and number of nodes. The value of each parameter was shown in table 1.

Table 1. Simulation Parameters

Parameters	Value
Network Area	2000 x 2000
Radio Range	200
Traffic Type	CBR
Visualization Tool	Nam, Trace
Duration	100 seconds
Mac Layer	802.11p,802.11
Routing Protocol	AODV, DSDV, DSR
Number of Nodes	50,100,150,200,250,300,350

The second group parameters were the wireless channel type, radio propagation type, MAC Type, interface queue type, link layer type, antenna model, maximum packet in ifq and time when the simulation stop. The value of those parameters was shown in table 2. Those parameters should be chosen before running the simulation.

Table 2. NS2 Parameters

set opt(chan)	Channel/WirelessChannel	Channel type
set val(prop)	Propagation/TwoRayGround	Radio propagation
set val(netif)	Phy/WirelessPhy	MAC type
set val(mac)	Mac/802_11	Interface queue type
set val(ifq)	Queue/DropTail/PriQueue	Link layer type
set val(ll)	LL	Link layer type
set val(ant)	Antenna/OmniAntenna	Antenna model
set val(ifqlen)	50	Max packet in ifq
set val(nn)	50 – 350	Number of mobile nodes
set val(rp)	AODV, DSDV, DSR	Routing protocol
set val(stop)	100.0	simulation stop

The simulation would start after choosing the number of mobile nodes and parameters. The simulation would stop when the time reach 100.

The third step was to analyze the result of simulation. The output of simulation was saved in two files such as nam and trace file. Nam file was used to visualize the simulation. In nam file, we could see the mobile nodes going from one place to another and the propagation of mobile nodes signal. In trace file, all the data was recorded during simulation. Those data such as nodes sending packet to other nodes, time nodes received packet from other nodes, and others. All those data could be process into throughput, packet delivery ratio and end-to-end delay.

IV. SIMULATION AND RESULT

After designing and simulating the traffic environment scene, we gathered all data and process it thus we could see the result nicely. We simulated three routing protocol in all number of mobile nodes because we would like to see the performance of nodes such as throughput, packet delivery ratio and end-to-end delay. The example of the output of simulation in trace file was shown in figure 4.

```
r 1.969740559 _5_ AGT  --- 31 cbr 1000 [13a 5 0 800] ------- [0:0 5:0 32 5] [12] 1 0
r 1.970029745 _0_ MAC  --- 0 ACK 38 [0 0 0 0]
s 1.970140148 _21_ MAC  --- 0 RTS 44 [242e 12 15 0]
r 1.970492682 _18_ MAC  --- 0 RTS 44 [242e 12 15 0]
s 1.970502682 _18_ MAC  --- 0 CTS 38 [22f4 15 0 0]
r 1.970807215 _21_ MAC  --- 0 CTS 38 [22f4 15 0 0]
s 1.970817215 _21_ MAC  --- 30 cbr 1078 [13a 12 15 800] ------- [21:0 18:0 32 18] [12] 0 0
r 1.979441749 _18_ MAC  --- 30 cbr 1020 [13a 12 15 800] ------- [21:0 18:0 32 18] [12] 1 0
s 1.979451749 _18_ MAC  --- 0 ACK 38 [0 15 0 0]
r 1.979466749 _18_ RTR  --- 30 cbr 1020 [13a 12 15 800] ------- [21:0 18:0 32 18] [12] 1 0
r 1.979466749 _18_ AGT  --- 30 cbr 1000 [13a 12 15 800] ------- [21:0 18:0 32 18] [12] 1 0
r 1.979756283 _21_ MAC  --- 0 ACK 38 [0 15 0 0]
s 2.040000000 _21_ AGT  --- 32 cbr 1000 [0 0 0 0] ------- [21:0 18:0 32 0] [13] 0 0
r 2.040000000 _21_ RTR  --- 32 cbr 1000 [0 0 0 0] ------- [21:0 18:0 32 0] [13] 0 0
SFs 2.040000000 _21_ 32 [21 -> 18] 1(0) to 18
s 2.040000000 _0_ AGT  --- 33 cbr 1000 [0 0 0 0] ------- [0:0 5:0 32 0] [13] 0 0
r 2.040000000 _0_ RTR  --- 33 cbr 1000 [0 0 0 0] ------- [0:0 5:0 32 0] [13] 0 0
SFs 2.040000000 _0_ 33 [0 -> 5] 1(0) to 5
s 2.040000000 _21_ RTR  --- 32 cbr 1020 [0 0 0 0] ------- [21:0 18:0 32 18] [13] 0 0
s 2.040000000 _0_ RTR  --- 33 cbr 1020 [0 0 0 0] ------- [0:0 5:0 32 5] [13] 0 0
s 2.040255000 _0_ MAC  --- 0 RTS 44 [242e 5 0 0]
r 2.040607186 _5_ MAC  --- 0 RTS 44 [242e 5 0 0]
s 2.040617186 _5_ MAC  --- 0 CTS 38 [22f4 0 0 0]
r 2.040921373 _0_ MAC  --- 0 CTS 38 [22f4 0 0 0]
s 2.040931373 _0_ MAC  --- 33 cbr 1078 [13a 5 0 800] ------- [0:0 5:0 32 5] [13] 0 0
r 2.049555559 _5_ MAC  --- 33 cbr 1020 [13a 5 0 800] ------- [0:0 5:0 32 5] [13] 1 0
s 2.049565559 _5_ MAC  --- 0 ACK 38 [0 0 0 0]
r 2.049580559 _5_ RTR  --- 33 cbr 1020 [13a 5 0 800] ------- [0:0 5:0 32 5] [13] 1 0
r 2.049580559 _5_ AGT  --- 33 cbr 1000 [13a 5 0 800] ------- [0:0 5:0 32 5] [13] 1 0
```

Fig 5. Example of Experiment Result of DSR Using 50 Mobile Nodes

The experiment result was processed using awk script therefore three parameters could be obtained. Those parameters were throughput, packet delivery ratio and end-to-end delay. The result was summarized in following subsection.

A. Throughput

The first result of simulation was throughput. The throughput of scene 1, vehicle move one by one on each intersection, was shown in table 3.

Table.3 Experiment Result of Throughput for Scene 1

Node	AODV	DSDV	DSR
50	202.97	135.86	178.08
100	197.12	137.6	181.94
150	192.75	140.65	173.27
200	179.05	149.96	193.69
250	185.74	152.68	188.87
300	179.89	161.34	182.47
350	187.97	138.16	191.35
Average	189.36	145.18	184.24

The mobile nodes used in the simulation from 50 to 150 nodes shown that AODV has the highest throughput (202.97, 197.12, 192.75). DSR has the highest throughput (193.69, 188.87, 182.47, 191.35) for 200 to 350 mobile nodes. However, the highest average of throughput was AODV while the lowest average of throughput was DSDV. The lowest throughput was DSDV for all mobile nodes used in the simulation.

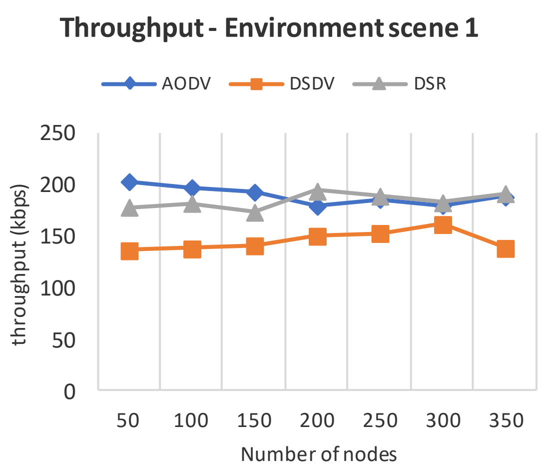

Fig. 6 Throughput for Scene 1

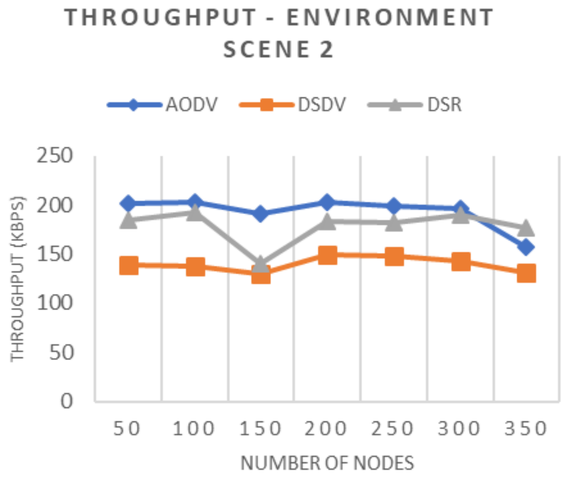

Fig. 7 Throughput for Scene 2

From figure 4, we can see that throughput of AODV from scene 1 was decreasing as the mobile node was increasing from 50 to 200 nodes. However, throughput stay steady when the mobile nodes used in the simulation was from 200 to 350 nodes. Throughput of DSR remained steady for 50 to 150 nodes and increased for 200 nodes. Afterwards, throughput stay steady for 250 to 350 nodes. Both AODV and DSR almost have the same value of throughput for 250 to 350 nodes. The lowest throughput was given by DSDV for all mobile nodes.

Table 4. Experiment Result of Throughput for Scene 2

Node	AODV	DSDV	DSR
50	201.98	138.32	183.92
100	202.72	137.68	192.45
150	190.6	129.43	140.28
200	202.39	149.96	182.77
250	198.27	147.41	182.48
300	196.79	143.19	190.08
350	157.3	131.53	176.47
Average	192.86	139.65	178.35

The result of simulation for throughput of scene 2 was shown in table 4. AODV had the highest throughput for almost all mobile nodes used in the simulation compared to DSDV and DSR. When 350 nodes were implemented in the simulation, the throughput of AODV was decreasing (157.3) but the highest average throughput was still AODV. The lowest throughput for scene 2 was DSDV while DSR remained steady.

The graphic of throughput for scene 2 was shown in figure 5. The throughput of AODV was increasing when the mobile nodes used in the simulation was increasing. However, when 350 nodes were used in the simulation, the throughput drop below the DSR throughput. The DSR throughput was increasing for 50 to 100 nodes but it was decreasing when the nodes used in the simulation was 150 nodes. Subsequently, it was increasing as the number of nodes was increasing. The DSDV throughput was the lowest throughput and almost steady for all mobile nodes used in the simulation.

B. Packet Delivery Ratio

Packet Delivery Ratio (PDR) was obtained from the percentage of total packet received in the nodes to all packet sent to the nodes. The data of packet delivery ratio was shown in table 5 and table 6. Accordingly, the graph of packet delivery ratio was plotted in figure 6 and figure 7. The packet delivery in table 5 and figure 6 was for the scene 1. The packet delivery in table 6 and figure 7 was for the scene 2.

Table.5 Experiment Result of Packet Delivery Ratio for Scene 1

Node	AODV	DSDV	DSR
50	99.27%	66.45%	88.83%
100	96.41%	67.30%	90.69%
150	94.27%	68.79%	86.33%
200	87.58%	73.35%	96.61%
250	90.85%	74.68%	94.19%
300	87.98%	78.91%	91.01%
350	91.94%	67.58%	95.44%
Average	92.61%	71.01%	91.87%

Based on Table 5, it can be seen that AODV and DSR have a very large ratio compared to DSDV, although AODV is slightly different from being the highest for scene 1 PDR. The highest PDR was 99,27% for AODV routing protocol for 50 nodes used in the simulation while the lowest PDR was 66,45% for DSDV with the same mobile nodes used in the simulation.

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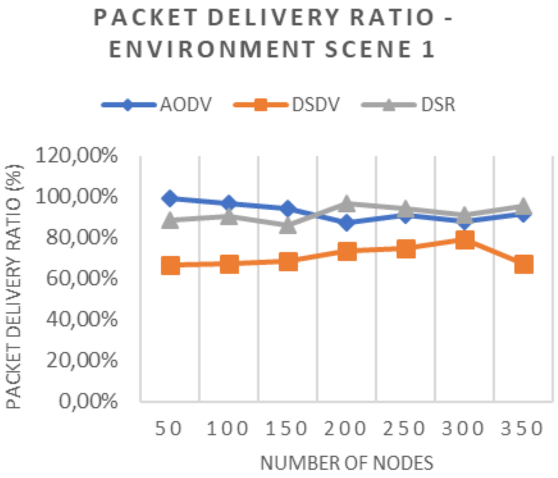

Fig.8 Packet Delivery Ratio for Scene 1

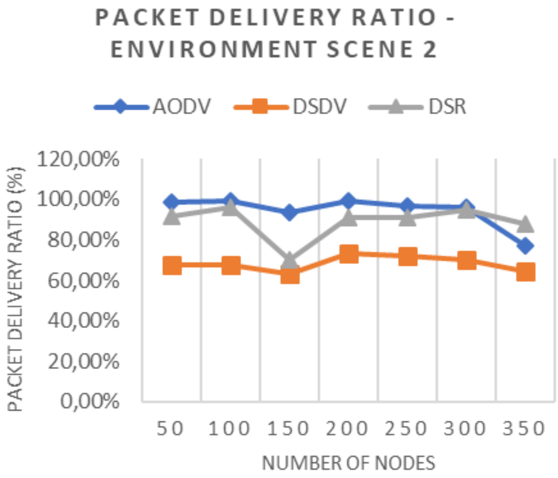

Fig.9 Packet Delivery Ratio for Scene 2

The graphic of PDR for scene 1 was shown in Figure 6. It can be analyzed that AODV still has good results at low nodes. It was decreasing when the number of nodes was increasing. DSR was slightly increasing when the number of nodes was increasing. It can be concluded that DSR has a good PDR when it was on a very crowded road.

Table. 6 Experiment Result of Packet Delivery Ratio for Scene 2

Node	AODV	DSDV	DSR
50	98.79%	67.66%	91.69%
100	99.15%	67.30%	95.97%
150	93.23%	63.31%	69.88%
200	98.99%	73.35%	91.01%
250	96.98%	72.10%	90.97%
300	96.25%	70.00%	94.76%
350	76.94%	64.31%	87.86%
Average	94.33%	68.29%	88.88%

For scene 2, based on the data shown in Table 6, PDR tends to be decreasing for DSDV and DSR as the number of nodes used in the simulation was increasing. However, for AODV the PDR was decreasing as the number of nodes was increasing. Even though the PDR of AODV was decreasing as the number of nodes was increasing, the highest PDR was given by AODV. For example, for 200 nodes the value of AODV was 98.99% while for DSDV was 73.35% and DSR was 91.01%. AODV has the highest average PDR.

Based on Figure 7, PDR of DSDV is the most constant compared to reactive routing protocols, AODV and DSR. PDR of AODV and DSR was fluctuate in several nodes. In scene 2, there was decreasing PDR in DSR at 150 nodes and at 350 nodes for AODV. The PDR of AODV still had the best result for those two nodes compared to DSR and DSDV.

C. End-to-end Delay

End-to-end delay was time traveled of a packet from source to destination nodes. It was shown in figure 8 and table 7 for environment scene 1 and figure 9 and table 8 for environment scene 2.

Table.7 End-to-end delay on scene 1

Node	AODV (ms)	DSDV (ms)	DSR (ms)
50	41.59	15.49	36.11
100	93.49	19.26	572.17
150	91.98	26.51	1063.54
200	281.5	48.86	502.96
250	106.19	85.17	220.53
300	358.5	474.38	343.22
350	221.02	180.1	369.24
Average	170.61	121.40	443.97

For the first scenario shown in table 7, DSDV has the smallest end-to-end delay with an average value of 121.40 milliseconds, while DSR has the greatest average value of 443.97 milliseconds. The lowest end-to-end delay value the better performance.

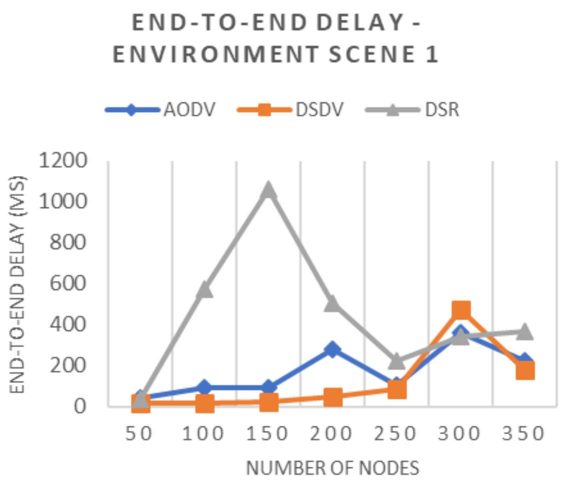

Fig.10 End-to-end delay on scene 1

Based on the graphic in figure 8, end-to-end delay of DSR was increasing significantly from 50 to 150 nodes and was decreasing significantly from 150 to 250 nodes. As the number of nodes was increasing from 250 to 350 nodes, the end-to-end delay of DSR was still increasing. The end-to-end delay of DSDV was increasing for 300 nodes and it was decreasing for 350 nodes. The lowest end-to-end delay for scene 1 was DSDV.

Table.8 End-to-end delay on scene 2

Node	AODV (ms)	DSDV (ms)	DSR (ms)
50	39.67	24.28	537.54
100	64.79	17.9	432.07
150	219.9	49.82	1648.17
200	146.45	27.97	1592.23
250	54.86	320.1	1548.29
300	152.43	681.38	531.81
350	256.51	1005.09	1547.49
Average	133.52	303.79	1119.66

Table 8 showed that DSR has a very highest end-to-end delay, 1119.66 milliseconds, in the second scenario. In this second scenario, it can be seen that AODV has the lowest average value, 133.52 milliseconds, compared to others.

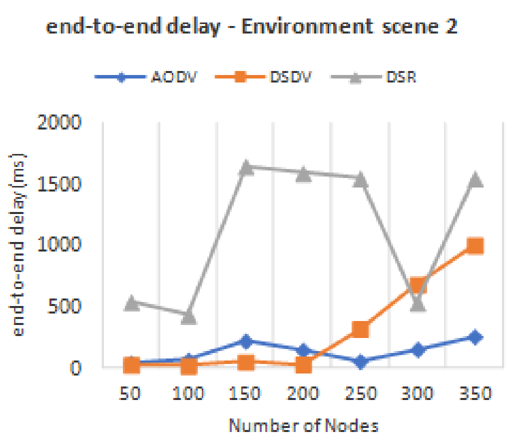

Fig.11 End-to-end delay on scene 2

In this second scenario of end-to-end delay, figure 9 showed the unstable end to end delay that occurs in DSR and DSDV. These conditions were significantly different from the first scenario. In this scenario, AODV has a fairly constant end-to-end delay.

V. CONCLUSION

We managed to design two traffic environment scenes and simulated it using the parameters stated before. The highest throughput was AODV for all traffic environment scenes. AODV was also the highest the Packet Delivery Ratio for all traffic environment scenes. The lowest end-to-end delay was DSDV for traffic environment scene 1 and AODV was the lowest end-to-end delay for traffic environment scene 2. It can be concluded that AODV could work better in a traffic jam and filled with vehicles and infrastructure around it. For further research, it is recommended to use different simulation tools that can be used to simulate dan analyze mobility models. Another performance metric including network statistics and energy consumption can be measured for QoS issues.

REFERENCES

1. Ameer Ali, Dr. Latcha C.A. “Performance analysis of ad-hoc routing protocol VANET using NS2 simulation.”, IJCST, Vol 6, issue 2, pp 127-132, 2015
2. Divya Chadha, Reena. “Vehicular ad hoc network (VANETs): A review. IJIRCCE, Vol 3, Issue 3, 2015
3. Ram Shringar Raw , M. K., Nanhay Singh ."Security challenge, issues and their solutions for VANET.",2013.
4. Divya Chadha, Reena. “Vehicular ad hoc network (VANETs): A review. IJIRCCE, Vol 3, Issue 3, 2015.
5. Junya Fukumoto. “Analytic method for real-time traffic problems by using content oriented communications in VANET”. 7th International Conference on ITS, pp. 1-6, 2007
6. Manjot Kaur, Sukhman Kaur, and Gurpett Singh. “Vehicular ad hoc networks”. JGRES, Vol 3, No 3, 2012.
7. Anas Abu Taleb. “VANET routing protocols and architectures: An overview”. Journal of Computer Science, vol 14, pp 423-434, 2018.
8. Saed Tarapiah, Kahtan Aziz, Shadi Atalla. “Analysis the performance of vehicular ad hoc network”. Procedia Computer Science 124, pp. 682-690. 2017
9. Divya Rathi, R.R. Welekar. “Performance evaluation of AODV rouitng protocol in VANET with NS2”. International Journal of Interactive Multimedia and Artificial Intelligence, Vol. 4, pp. 23-27. 2017.
10. Zineb Squalli, Zaimi, Mohammad Oumnis, and Said El Alaoui Ouatik, “Comparative study of routing protocols performance for vehicular ad-hoc networks”. IJAER, Vol 12, pp 3867-3878. 2017
11. S. Dhankhar and S. Agrawal. “VANETs: A survey on routing protocols and issues”. International Journal Innovative Res. Sci. Eng. Technol., vol 3, pp 13427-13435. 2014.

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