Evaluation of AODV and DSDV Routing Protocols for V2V Communication in VANET

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***Abstract*— This research mainly concentrates on evaluating reactive (Ad hoc On-demand Distance Vector (AODV)) and proactive (Destination Sequenced Distance Vector (DSDV)) routing protocols for V2V communication in VANET. For simulation experiments, vary the amount of vehicles in the same simulated geographical environment and collect data such as throughput, end-to-end delay and packet delivery ratio. A comparison of performance analysis has been presented to evaluate advantages and disadvantages of AODV routing and DSDV routing for V2V communication.**

***Keywords*— routing protocols; AODV; DSDV; vehicular network; ns2; SUMO**

I. Introduction

In recent decades, with the development of wireless communication technology and sensor technology, Connected Vehicle (CV) has been a promising technology to which academia, industry and government institutions all pay great attention. Basically, connected vehicles switch road conditions, on-board sensor data from Electrical Control Units (ECU) and location information from Global Positioning System (GPS) periodically or occasionally with wireless communication. In fact, as a very important role in Intelligent Transportation Systems (ITS), many researches have been conducted. For example, the U.S. Department of Transportation (USDOT) connected vehicle research program aims to realize communication from Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V), and to provide a variety of applications including safety, mobility and environment. Most of the applications focus on reducing traffic accidents, and some will help release traffic jams in cooperation with smart roadside infrastructure. The USDOT Southeast Michigan 2014 Connected Vehicle Test Bed[1] is developed as a test environment for CV applications. Generally, to implement CV, a set of communication techniques[2] are available such as Bluetooth, Radio Frequency Identification (RFID), WIFI, Wireless Access in the Vehicular Environment (WAVE), Zigbee, Dedicated Short Range Communications (DSRC). DSRC which works on channels divided in a 75 MHZ bandwidth at 5.9 GHZ band is the future standard for Vehicular Communication Systems(VCS).

Although CV has a bright future, some challenges exist due to its intrinsic characteristics. For example, high mobility leads to an instable network topology on inter-vehicle communication which is the most frequent situation for CV. On the other hand, obstacles including buildings and vehicles, affects wireless signal propagation. The Vehicular Ad hoc Network (VANET) models V2V communication into a network which consists of multiple mobile nodes. Since the network topology changes rapidly and the communication distance is limited, how to compute the best route to transmit packets in VANET turns out a question. In other words, identifying an appropriate routing protocol for VANET will significantly improve the network performance.

As the above motivation demonstrates, the objective of this research mainly concentrates on evaluating reactive and proactive routing protocols for V2V communication in connected vehicle environment in VANET. Actually, routing protocols can be sorted into two categories: proactive routing and reactive routing. The authors select AODV as a reactive routing protocol and DSDV as a proactive routing protocol, and deploy it into simulations based on NS2. For simulation experiments, the amount of vehicles in the same simulated geographical environment is varied and collected data such as throughput, delay and loss rate. Finally, compare simulation results and analyze them to see advantages and disadvantages of proactive routing and reactive routing in VANET.

The performance analysis of proposed protocols has been done using simulation tools Network Simulator (NS) and Mobility model generator for Vehicular networks (MOVE) over Simulation of Urban Mobility (SUMO). The rest of the paper is organized as follows: section 2 presents related works of this research, AODV and DSDV routing protocols is explained in detail in section 3. Section 4 presents simulation model used for carrying out the experiment. Section 5 shows the analysis and results and section 6 covers the conclusion and future scope.

II. Related Works

In this section, related works to evaluate routing protocols are discussed in this section.

Saini and Mahapatra simulated AODV routing protocol using SUMO, MOVE and NS2 for VANET. The performance of AODV routing protocol was analyzed based on throughput and packet drops [3]. They found that throughput of sending packets was almost uniform for 100 nodes and throughput of receiving packets became more uniform with higher number of nodes. They also showed that number of packet dropped in initial few seconds is more in a network where numbers of nodes are more.

Park et al. developed a simulation environment for evaluating IntelliDriveSM to evaluate the integration of a microscopic traffic simulator and a wireless communications network simulator that incorporates IntelliDriveSM messages defined in SAE J2735 [4]. A lane changing advisory algorithm was evaluated to demonstrate a more realistic evaluation using a freeway network in Northern Virginia. This study shows that there is no significant impact on communication delays in the performance of applications. They found that maximum delays were only 55milliseconds for a Basic Safety Message (39bytes) and 1.3milliseconds for an A la Carte Message (20bytes, designed for advisories).

Ma et al. demonstrate that the simulation platform allows for implementing traffic surveillance and management methods in the traffic simulator PARAMICS and for evaluating different communication protocols and network parameters in the communication network simulator, Network Simulator version 2 (ns-2) [5]. They used PARAMICS realistically model the traffic flow of the selected test network. PARAMICS API was also used to continuously collect traffic measurements and to synchronize command control and data exchange with ns-2. On the other hand, the real-time vehicle-to-vehicle and vehicle-to infrastructure communications, including addressing, routing, and scheduling solutions, were modeled in the ns-2 environment. In this paper, they have discussed several VANET protocols.

In [6], they found that the position based routing has better performance because there is no creation and maintenance of global route from source node to destination node in VANET. In the position based routing protocol, all the packets are received with small average delay, better throughput, and effective utilization and also help to prevent the accidents on the road effectively. In this paper, the traffic simulator VISSIM and the network simulator ns-2 will be used to evaluate some representatives of communication protocol family between V2I and V2V at roadway intersections.

The objective of this research mainly concentrates on evaluating throughput and delays for DSDV and AODV routing protocols.

III. Routing Protocols in VANET

A routing protocol can be defined how desired information exchanges between different entities in expected amount of time. An ad hoc network is the cooperative engagement of a collection of mobile nodes without the required intervention of any centralized access point or existing infrastructure. VANET is a subclass of MANET (Mobile Ad hoc NETwork). VANETs are classified based on the specialty of their mobility pattern and topology that changes rapidly. Ad hoc network protocols are first enforced and tested for MANETs and after that evaluated for VANET environment. VANET routing protocols can be classified as follows:

1. Position(geographic) Based Routing Protocol
2. Topology Based Routing Protocol
3. Broadcast Based Routing Protocol
4. Cluster Based Routing Protocol
5. Geocast Based Routing Protocol

In this paper, the authors mainly focused on topology based routing protocol that is AODV (reactive routing protocol) and DSVD (pro-active routing protocol).

A. AODV

AODV is defined as reactive routing protocol. A route is created between nodes depending on a packet needs to be send to a node or not. AODV gives loop-free routes in case of repairing a broken link and does not need global periodic routing advertisement because of their ability to create symmetric links among neighboring nodes. AODV neither follow a path if it does not hear from any nodes nor exchange routing information or any periodic routing table if nodes do not on the way of active paths. Moreover, if a node acts as an intermediate node, then it needs to communicate with other nodes [7]. The primary objectives of this algorithm are as follows: 1) broadcast discovery packets if it is required needed, 2) differentiate between detection of local connectivity management neighborhood and general maintenance of topology and, 3) distribute information if there is any changes in local connectivity to those neighboring mobile nodes those are likely to need the information.

B. DSDV

DSDV is a proactive protocol that maintains a routing table with entries for all the nodes in the network (i.e., not just the neighbors of a node) . According to DSDV protocol, paths are calculated using the Bellman-Ford algorithm [8]. The path cost is determined based on the hop count, which the total number of hops between source and destination. DSDV propagated through periodic and trigger update mechanism changes. A sequence number for each node is used to eliminate the chance of having routing loops within the network. The sequence number for each node is independent and the number should be increased each periodic update of a node. The normal update sequence number must be even and updated by 2 for the next routing message. This node can only change of its sequence number and cannot affect other node's sequence number. The sequence number of a node for an expired route to its neighbors should be increased by 1 (odd number). After receiving updated sequence number, the node will check the sequence number. The entry in routing table will be removed if the sequence number is odd.

IV. Simulation Model

In this section, we will discuss various tools used for simulation which can produce realistic mobility model, Performance metric and simulation parameters.

A. *Simulation tools*

AODV and DSDV routing protocol performance is analyzed using the following simulation tools in VANET.

1) Network Simulator 2: Network Simulation 2 (widely known as NS2) is used to simulate wired and wireless network functions and protocols (i.e., TCP, UDP, routing algorithms) [9]. This is an event driven network simulation tool. It is also useful to study dynamic communication networks. In NS2, user can specify different network protocols and simulate their behaviors very easily. The authors used NS2 to simulate routing protocols because of its flexibility and modulator nature. C++ and OTCL interpreter is used to write NS2 code that generates NAM (Network ANimator) output file [10]. The network simulator (NS) contains all commonly used IP protocols. NAM is use to visualize the simulations.

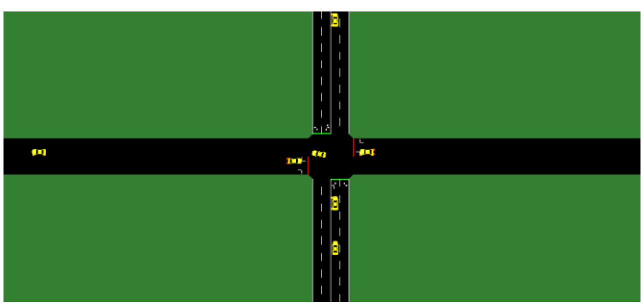

Fig. 1: SUMO-GUI visualization

2) Simulation of Urban Mobility (SUMO): SUMO is microscopic multimodal road traffic simulator. SUMO is developed by Institute of Transportation Systems of German Aerospace Center. It is an open source software and licencesed under GPL (General Public License). User can build their road topology from scratch or they can use different map formats [11].

3) Mobility model generator for vehicular networks (MOVE): MOVE is a tool that used to generate realistic mobility models for VANET simulations. Fig. 2 presents visualization of MOVE. MOVE is very useful to quickly generate real world mobility model in VANET without writing simulation script. Recently MOVE is implemented in Java and is built on top of SUMO. It provides a set of Graphical User Interface (GUI) that automatically generate simulation script. MOVE provides a mobility trace file that contains real world vehicle movements informatin. NS2 immediately can use this information.

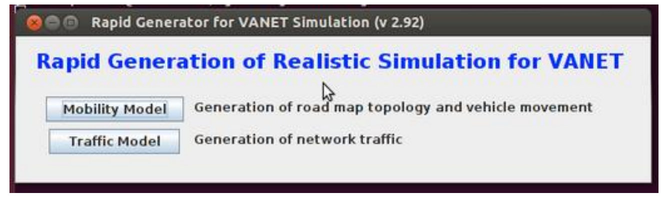

Fig. 2: Visualization of MOVE

B. *Performance parameters for evaluation*

The authors selected following parameters to evaluate performance of AODV and DSDV as follows:

1) Receiving Throughput: Receiving throughput defines how many packets have been received from source node to sink node through a communication link per second. In our experiments, we used transportation layer packet to compute thoughput. The unit of throughput is bps. Higher throughput value indicates better performance of network.

2) Sending Rate: Sending rate defines how many packets have been sent from source node through a link per second.

3) Average Throughput: Average throughput measures the average amount of packets sent from source node to destination. It's a very signification criterion to evaluate network performance.

4) Packet Delivery Ratio: Packet delievery ratio is an important measurement to see how many packets have been successfully delivered from source node to destination node. Generally, network congestion, queue overflow and communication error affect packet delivery ratio.

5) Average End-to-end Delay: Average end-to-end delay is the average number of latency for a packet from source node to destination. We measured the delay at transportation layer.

V. Simulation Steps

The following are the requirements to run SUMO and MOVE using the Ubuntu 12.04 (64bit) operating system.

a. MOVE.jar (This software will work only with sumo version 0.12.3) [11].
b. SUMO (0.12.3)
c. JDK (To run MOVE)

The command to run MOVE.jar is $] java -jar MOVE.jar. Fig. 4 presents the MOVE architecture. The following two steps are followed to create simulation using MOVE.

1. Mobility Model (as shown in Fig. 5)

2. Traffic Model (as shown in Fig. 6)

In Mobility Model of MOVE, the network can be generated manually, automatically or imported from a real world map. Two types of input are required to generate manual: 1) nodes and 2) edges (as shown in Fig. 5). A “node’ could be either a junction or the dead end of the roads. Moreover, the junction nodes could be either signalized intersection or un-signalized intersection. The edge is road network that connects two nodes (intersection). Speed limit, number of lanes, the road priority and the road length are the attributes for an edge. Fig.7 and Fig.8 shows snapshots of nodes editor and edge editor. One can also generate a real world road map by importing real world maps from publicly available database. The following steps need to follow for map editor.

1. Node (file.nod.xml)
2. Edge (file.edge.xml)
3. Configuration (file.netc.cfg)
4. Create Map (file.net.xml)

Vehicle Movement Editor was used to generate vehicle movements manually (as shown in Fig. 5). Number of vehicles in a particular route, vehicle departure time, origin and destination of the vehicle, duration of the trip, vehicle speed was used to specify several properties of vehicle routes. We can define the probability of turning to different directions at each junction in the editor.

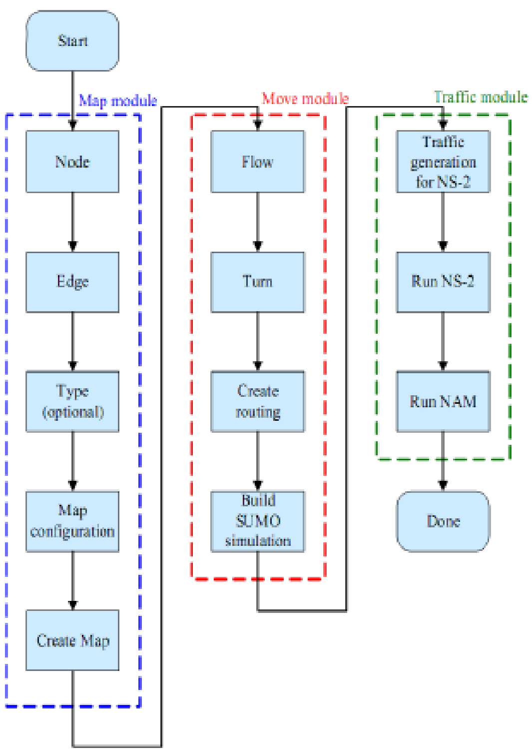

Fig. 4: MOVE architecture flowchart (Adopted from [12]).

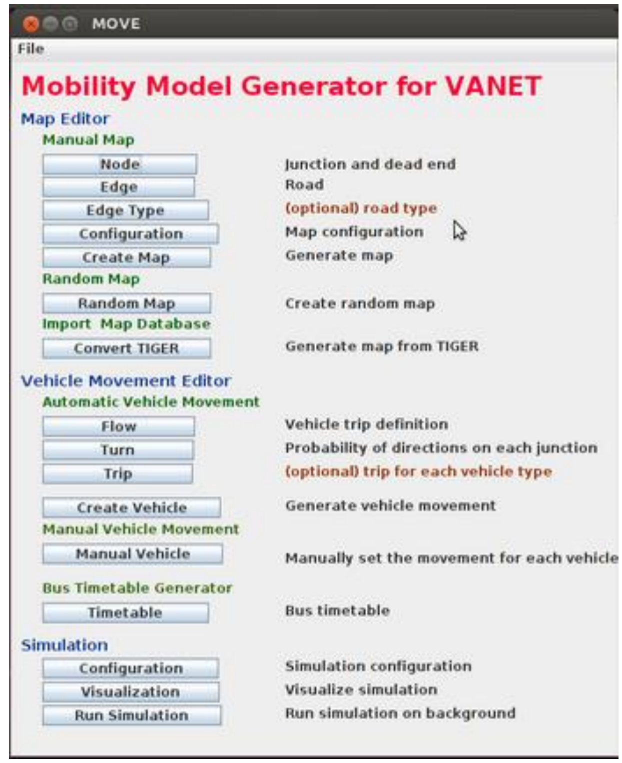

Fig. 5: Mobility model.

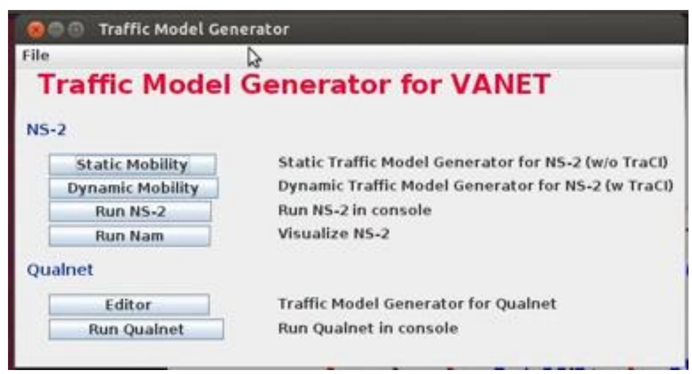

Fig. 6: MOVE visualization of Traffic Model

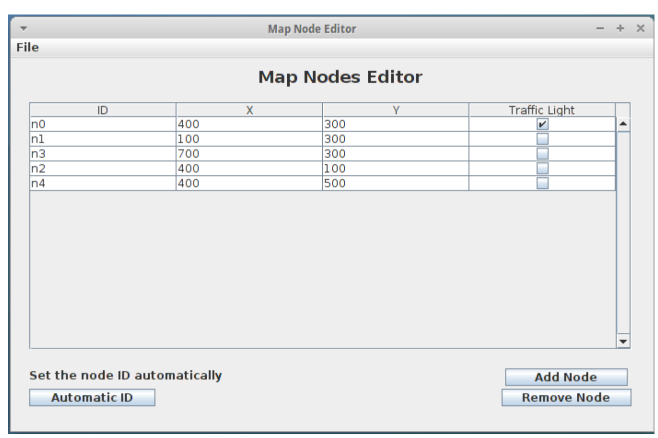

Fig. 7: Node editor.

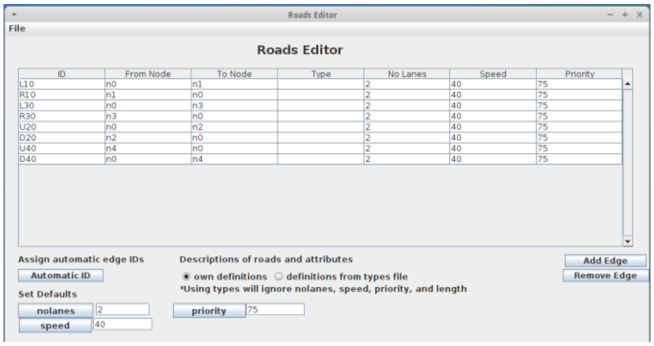

Fig. 8: Edge editor.

The following steps need to follow to generate vehicle movement:

1. Flow (file.flow.xml)
2. Turn (file.turn.xml)
3. Create Vehicle (file.rou.xml)
4. Configuration (file.sumo.cfg) - This file is the one running in sumo-gui
5. Visualization (file.sumo.tr) - This file will be helpful in creating the tcl file for ns2.
6. Run Simulation (no of vehicles emitted and running with simulation time will be shown)

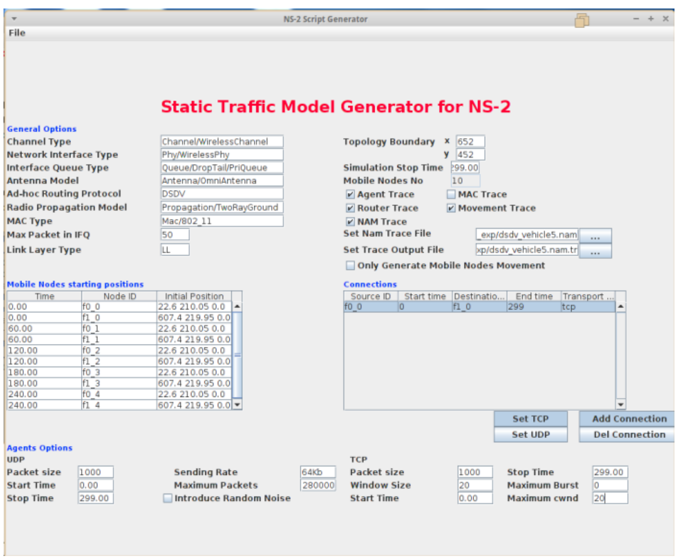

Fig. 9: MOVE visualization of Traffic Model

For Traffic Modeling, static Mobility (this creates file.nam, file.tr, file.tcl) that was running using ns2 (as shown in Fig. 9).

VI. Performance Evaluation of AODV and DSDV

In this section, the author describes the simulation set-up and discusses the simulation results.

A. *Simulation Set-up*

To compare performance of AODV and DSDV, the authors created a scenario to simulate real traffic movements in VANET. Basically, the traffic topology created by MOVE in Fig.1 is an intersection with a traffic light and the total area was 652m*452m. We considered two flows of vehicles in the simulation. One flow is from left to right, the other is from right to left. Vehicles are likely to make a turn at the intersection. Every flow has the same number of vehicles, and runs the same routing protocol. We varied the number of vehicles in each flow to observe the influence caused by density of traffic and also used different routing protocols (i.e., AODV and DSDV) to evaluate and compare their performence. A TCP connection was built between two vehicles from different flows.

The following are the configuration parameters assumed for simulation (as shown in Table I):

TABLE I

SIMULATION PARAMETERS

PARAMETER	VALUE
Channel type	Wireless
Network interface type	Physical wireless
Routing protocol	AODV and DSDV
Interface queue type	Priority queue
Queue length	50 packets
Number of nodes	10,20,30
Simulation time	300seconds
Traffic type	TCP
Number of lanes for road	2
Speed	40 m/s
Radio propagation model	Two way ground
MAC protocol	**IEEE 802.11**
Simulation area(m*m)	**652*452**
Antenna	**Omni Antenna**
Packet size(byte)	**1000**

B. *Simulation Results*

After several experiments, we obtained multiple sets of throughput, end-to-end delay and packet delivery ratio, and drew graphs to analyze results.

(1) Receiving throughput: Fig. 10 shows comparison of receiving throughput for 30 vehicles using AODV and DSDV. We observed that the throughput using DSDV is higher than AODV. Besides, the DSDV has a smooth throughput performance because DSDV periodically maintains its routing table.

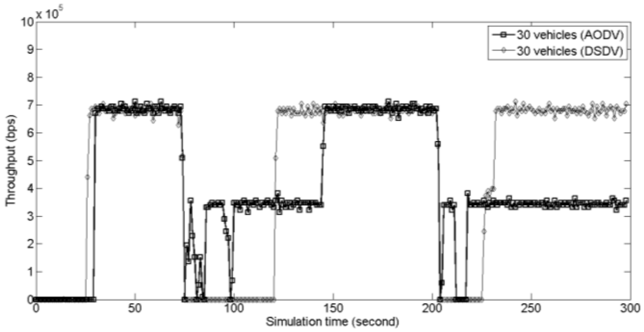

Fig. 10: Comparison of throughput for 30 vehicles between AODV and DSDV

(2) Sending rate: Fig. 11 shows comparison of sending rate for 30 vehicles using AODV and DSDV. It's not surprising that this graph is consistent with Fig.10. Because AODV needs to broadcast request to establish a route to destination when necessary, it takes more time to send a packet.

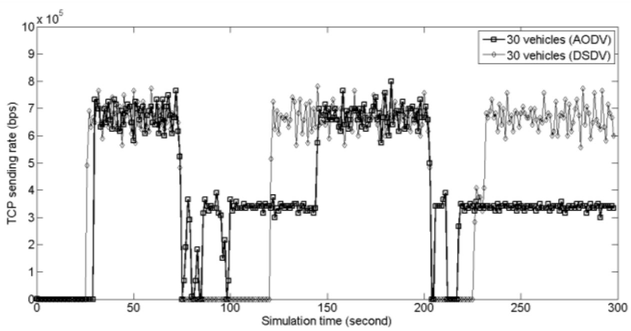

Fig. 11: Comparison of TCP sending rate for 30 vehicles between AODV and DSDV

(3) Average throughput: In Fig. 12, as the number of vehicles increases, the average throughput of DSDV keeps increasing while AODV changes relatively little (also as shown in Table II and III). This is because DSDV has more options to have access to destination with more vehicles in the traffic model.

TABLE II

AODV AVERAGE THROUGHPUT

# of vehicles	Throughput (bps)
10	388431
20	411424
30	408863

TABLE III

DSDV AVERAGE THROUGHPUT

# of vehicles	Throughput (bps)
10	376394
20	414526
30	461991

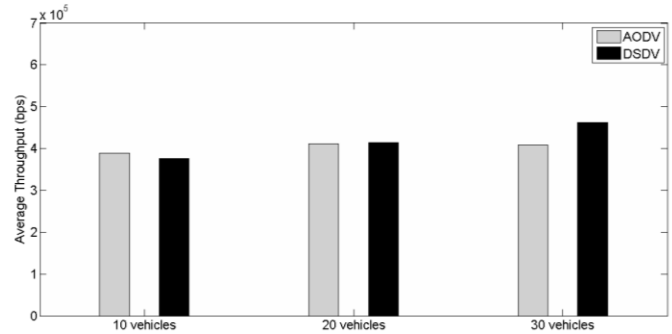

Fig. 12: Comparison of average throughput between AODV and DSDV

(4) Packet delivery ratio: In Fig. 13, both of two routing protocols achieve good performance. As the number of vehicles increases, packet delivery ratio also gets improved (as shown in Table IV and V).

TABLE IV

AODV PACKET DELIVERY RATIO

# of vehicles	# of packets sent	# of packets received	Delivery ratio (%)
10	13860	13700	98.85
20	14586	14491	99.35
30	14477	14386	99.37

TABLE V

DSDV PACKET DELIVERY RATIO

# of vehicles	# of packets sent	# of packets received	Delivery ratio (%)
10	13322	13232	99.32
20	14628	14571	99.61
30	16261	16240	99.85

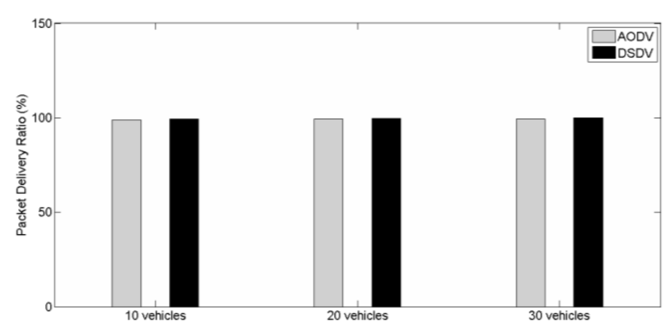

Fig. 13: Comparison of average packet delivery ratio between AODV and DSDV

(5) End-to-end delay: From Fig.14, the end-to-end delay of DSDV is obviously lower than DSDV since DSDV always maintains a routing table. In addition, the end-to-end

delay of DSDV changes less than AODV with the increasing number of vehicles (as shown in Table VI and VII).

TABLE VI

AODV END2 END DELAY

# of vehicles	End-to-end delay(ms)
10	80.0
20	75.6
30	86.1

TABLE VII

DSDV END2END DELAY

# of vehicles	End-to-end delay(ms)
10	54.9
20	62.5
30	56.5

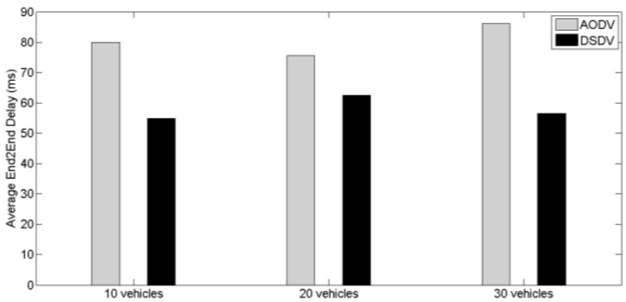

Fig. 14: Comparison of average end-to-end delay between AODV and DSDV

VII. CONCLUSIONS AND FUTURE WORKS

In this paper, AODV and DSDV routing protocols are evaluated with different parameters in a real traffic mode built by MOVE and SUMO in VANET. The performance of AODV and DSDV are analyzed for 10, 20, and 30 nodes with respect to various parameters like receiving throughput, sending rate, end-to-end delay, average throughput, and packet delivery ratio. The simulation results for various cases can be summarized as below:

- Receiving throughput: Results shows that DSDV gains a higher throughout than AODV.
- Sending rate: Results shows that DSDV gains a higher throughput due to well-maintained routing table than AODV.
- Both routing protocols performed well in terms of packet delivery ratio.
- DSDV has a lower end-to-end delay than AODV with limited vehicles as it takes less time to find a route.

Therefore, DSDV protocol performs better than AODV in a sparse traffic network.

In future, some experiments can be conducted to observe in a vehicle-dense traffic model, how AODV and DSDV behave. Besides, it could be also interesting to test multiple connections in VANET. More importantly, some other results like protocol overhead and number of hops to reach destination should be emphasized.

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