Simulation based Evaluation of Proactive and Reactive Routing Protocols in Realistic Vehicular Network

Rajinder Sanwal, Vishal Kumar

Abstract—**Vehicular Mobile Communication has emerged as a new area of attraction in the field of Wireless communication. VANETs have emerged as a boon towards saving human live by its safety and non-safety potential applications. This paper tests routing protocols namely Ad hoc On Demand Distance Vector (AODV), Ad hoc On Demand Multipath Distance Vector (AOMDV), Dynamic Source Routing (DSR) and Destination Sequence Distance Vector Routing (DSDV) on a Topologically Integrated Geographic Encoding and Referencing (TIGER) Map of the area of Afton Oaks, Houston, USA. The mobility pattern was created using MOVE (Mobility model generator for Vehicular networks) and SUMO (Simulation of Urban Mobility) capable of intelligent driver model with intersection management (IDM-IM) and intelligent model with changing lane (IDM-LC). Our simulation performances are evaluated using various performance metrics such as average throughput, normalized routing load, end to end delay and packet delivery ratio. The simulation is conducted following the V2V (vehicle to vehicle) communication. The simulation results show that DSR performs comparatively better than AODV, AOMDV and DSDV.**

Keywords— **TIGER, MOVE, SUMO, VANET, ITS, routing protocols.**

I. Introduction

Vehicular Ad-Hoc Networks (VANETs) are wireless ad hoc networks formed among vehicles on the roads equipped with short range wireless communication devices [1]. Such networks are useful because they help to improve comfort and safety of people on the highway situations [2]. As the number of people using the cars is increasing, VANETs have the potential to optimize traffic conditions, and to reduce congestions. VANETs provide communication among the vehicles and the nearby road side units. The dynamic nature of VANETs is the cause for complex routing problems. The test of routing in an ITS (Intelligent traffic system) can test the efficiency in terms of the routing load. The mobility of vehicles in VANETs is determined by predefined roads and buildings. The vehicle networks on the urban roads have many important factors that influence, such as street layouts and intersections with traffic signs, or inter-vehicle interactions [3]. The speed range of Vehicle could be from 0 to speed limit [4].

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The objective of this paper is to evaluate routing protocols namely Ad hoc On Demand Distance Vector (AODV) [5], Ad hoc On Demand Multipath Distance Vector (AOMDV) [6], Dynamic Source Routing (DSR) [7] and Destination Sequence Distance Vector Routing (DSDV) [8] on the TIGER Map of the area of Afton Oaks, Houston, USA. The mobility pattern is created using MOVE [9] (Mobility model generator for Vehicular networks) and SUMO [10] (Simulation of Urban Mobility) capable of intelligent driver model with intersection management (IDM-IM) and intelligent model with changing lane (IDM-LC).

The rest of the paper is organized as follows. Related works are described in section II, section III discusses the review of candidate routing protocols, section IV discusses the Simulation and Results followed by Conclusion and future works in section V.

II. Related Works

In [11] the authors proposed a Road Map Based (RMB) routing protocol for real-time vehicular ad hoc networks that included some techniques taken from geographical ad hoc routing. It handled mobility using road map and builds stable routing path on the road segments but not on the nodes. Routing path is done through distributed real-time participants of the network. The authors in [12] analyzed Unicast Routing Protocols for VANETs using SUMO. In [13] the authors discussed recent trends that lead to the development of comprehensive simulation platforms consisting of many modules: real-world data sources, traffic generator, traffic and network simulators. The authors in [14] evaluated the efficiency of two routing protocols OLSR and AOMDV by comparing their performances in the city scenario for the map of city of Arlington, Texas using NS-2. The realistic vehicular mobility traces were generated using Intelligent Driver Model (IDM) based tool VanetMobiSim. In [15] the authors simulated multipath, Unipath and hybrid routing protocol in city scenarios using VanetMobisim. The protocols evaluated were AODV, AOMDV and DSDV**.** The authors in [16] evaluated AODV and OLSR using realistic mobility pattern. They studied the effects of the vehicular traffic parameters such as the average speed, vehicle density and road topology on the overall VANET performance. In [17] the authors proposed a Real Scenario Mobility Model. This new model can show vehicle's movement scenario more veritably in routing selection, movement direction of nodes restricted by road network etc. In [18] the authors have done the performance evaluation of reactive routing protocols in VANET using VANET Mobisim. The authors in [19] presented RBVT, which is a class of VANET routing protocols for city-based environments that takes advantage of the layout of the roads to improve the performance of routing in VANETs. RBVT protocols use real-time vehicular traffic information to create road-based paths between endpoints.

III. Review of Candidate Routing Protocols

In this paper we have simulated one Proactive routing protocol named DSDV and three reactive routing protocols. Proactive protocols keep track of all destinations in the ad hoc network and have the advantage that communications with arbitrary destination experience minimal initial delay from the point of view of the application. When the application starts, a route can be immediately selected from the route table. The DSDV protocol transmits the packets between the nodes of the network using routing tables stored at each node. Each route table, at each of the nodes, lists all destinations and the number of hops to each. Each route table entry is tagged with a sequence that is originated by the destination node.

Reactive protocols have been designed so that routing information is acquired only when it is actually needed. Reactive protocols may often use far less bandwidth for maintaining the route table at each node, but the latency for many applications will drastically increase [8].

In DSR protocol network nodes cooperate to forward packets for each other to allow communication over multiple "hops" between nodes not directly within wireless transmission range of one another. As nodes in the network come in and go out of the range of the network, and as wireless transmission conditions such as sources of interferences change, all routing is automatically maintained by DSR [8].

The AODV protocol provides unicast, multicast and broadcast communication ability. AODV uses route tables to store pertinent routing information. The route table is used to store the destination and next-hop IP address as well as the destination sequence number. When a node wishes to send a packet to some destination node, it checks its route table to determine whether it has a current route to that node. If so, it forwards the packet to the appropriate next hop toward the destination. If the node does not have a valid route to the destination, it initiates a route discovery process. The source node broadcasts a route request packet (RREQ) and then sets a timer to wait for a reply. To respond to the RREQ, the node must have an unexpired entry for the destination in its route table. The sequence number associated with that destination must be at least as great as that indicated in the RREQ. This prevents the formation of routing loops by ensuring that the route returned is never old enough to point to a previous intermediate node. Otherwise, the previous node would have responded to the RREQ. If the node is able to satisfy these two requirements, it responds by unicasting a RREP back to the source. If it is unable to satisfy the RREQ, it increments the RREQ's hop count and then broadcasts the packet to its neighbors [8].

AOMDV extends the AODV protocol to discover multiple paths between the source and the destination in every route discovery. Multiple paths so computed are guaranteed to be loop-free and disjoint. In AOMDV, RREQ propagation from the source towards the destination establishes multiple reverse paths both at intermediate nodes as well as the destination [18]. Multiple RREPs traverse these reverse paths back to form multiple forward paths to the destination at the source and intermediate nodes. AOMDV also provides intermediate nodes with alternate paths as they are found to be useful in reducing route discovery frequency [18,20].This mechanism reduces route discovery latency and the routing overheads.

IV. Simulation and Results

A. *Vehicular Mobility Model*

The Map Editor of MOVE that comes under the Mobility Model was used to convert TIGER database into map. The area layout is derived and normalized from a snapshot of a real street map in the Afton Oaks, Houston, USA based on (TIGER) database [21] from U.S. Census Bureau. The Vehicle Movement editor of MOVE was used to create the flow of vehicles, specify their speed, determine the probability of turning of a vehicle at a particular junction in a particular direction and also specify the trips of vehicles and the route that each vehicle will take for one particular trip. The scenario so created was fed into SUMO in the simulation component [9]. SUMO lets us visualize the traffic model. It generates a mobility trace which is used by a simulation tool such as ns-2 or qualnet to simulate realistic vehicle movements in the Traffic model component of MOVE. MOVE and SUMO support intelligent driver model with intersection management (IDM-IM) and intelligent model with changing lane (IDM-LC). Fig. 1 shows the Mobility Scenario of Vehicles on the map of Afton Oaks as represented in SUMO.

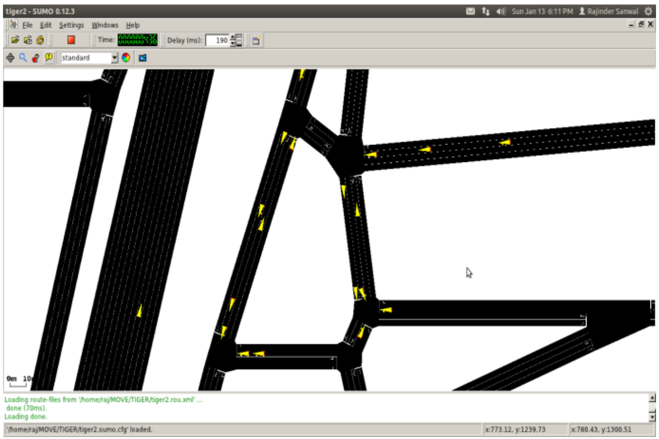

Figure 1. Mobility Scenario of Vehicles on the map of Afton Oaks in SUMO.

B. *Simulation Model*

We have used NS-2.35 [22] over Ubuntu11.10 [23] environment to simulate the mobility scenario. The framework follows V2V (vehicle to vehicle) communication.

C. *Simulation Parameters*

To do the simulation following simulation and network parameters were kept fixed.

TABLE1. SIMULATION AND NETWORK PARAMETERS.

Parameter	**Value**
Simulator	NS-2.35
Number of Nodes	100
Speed of Node	0-25 (m/s)
Simulation Area	1934x1811
Transmission Range	250 m
Traffic Type	CBR (Constant Bit Rate)
Packet Size	1000 Bytes
Packet Rate	64Kb/s
Queue Length	50
Mobility Model	Intelligent Driver Model
MAC Type	Mac/802.11
Simulation Time	500s
Lltype	LinkLayer
ifqType	Queue/PriQueue/CMUPriQueue

D. *Performance Metrics*

In our simulation the protocols are evaluated for average throughput, average end to end delay, packet delivery ratio and normalized routing load under IDM model. In these simulations, we kept the number of vehicles fixed to 100 and kept maximum speed of vehicles to 25m/s.

1. Average throughput – Average throughput is the total number of successfully delivered data packets on a communication network (1).

$$avgthrp = ((total\ number\ of\ received\ packets\ at\ destination\ node) * packet\ size)/observation\ duration \quad (1)$$

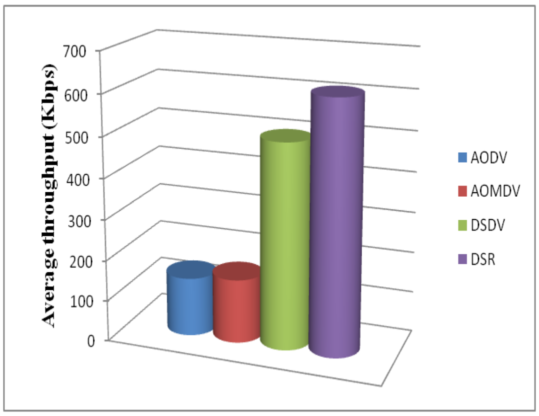

Figure 2. Average Throughput (Kbps) at Vehicle's Maximum Speed of 25m/s.

It is clearly seen in Fig. 2 that DSR outperforms DSDV, AODV and AOMDV with highest average throughput values.

2. Average end to end delay – Average end to end delay as in (2) is an average end to end delay of data packets that is average time needed to transfer a data packet from source to destination. Once the difference between every CBR packets sent and received is found, it is divided by the total number of CBR packets received. This gives the average end to end delay for received packets. The lower is the end to end delay, the better the application performs [18].

$$e2eDelay = \sum(CBRrcvTime - CBRsentTime)/\sum CBRrcv \quad (2)$$

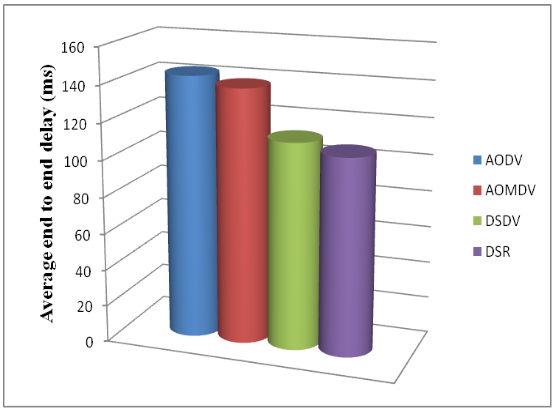

Figure 3. Average end to end delay (ms) at Vehicle's Maximum Speed of 25m/s.

It is clearly seen in Fig. 3 that DSR has the lowest values for average end to end delay than DSDV, AODV and AOMDV.

3. Packet Delivery Ratio (PDR) – It is the ratio of total data packets received over total data packets sent by the source during the simulation period (3). This metric shows how successfully a protocol delivers data packets from the source to destination. PDR characterizes the completeness and correctness of the routing protocol.

$$pdr = (\sum CBRrcv/\sum CBRsent)x100 \quad (3)$$

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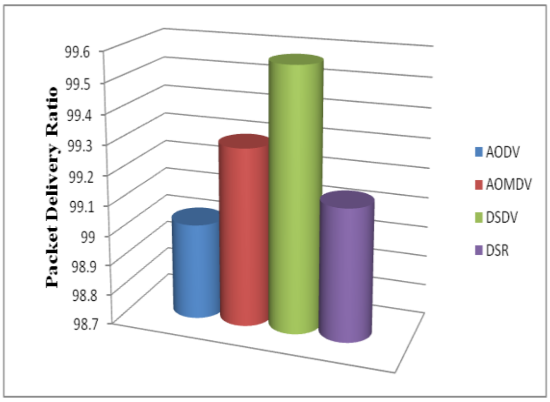

Figure 4. Packet Delivery Ratio at Vehicle's Maximum Speed of 25m/s.

In Fig. 4 we can see that DSDV has highest PDR than other routing protocols being simulated.

4. Normalized routing load (nrl) – It is defined as the total number of routing packets transmitted per data packet. It is calculated by dividing the total number of routing packets sent (includes forwarded routing packets as well) by the total number of data packets received (4).

$$nrl = \frac{\sum RTRpkts}{\sum CBRrcv} \quad (4)$$

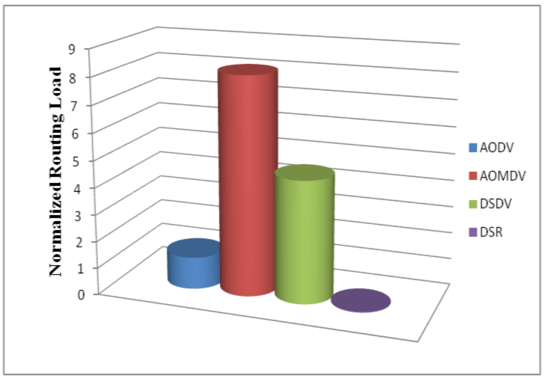

Figure 5. Normalized Routing Load at Vehicle's Maximum Speed of 25m/s.

In Fig. 5 we can see that DSR has the lowest values for Normalized Routing Load.

V. Conclusion & Future Works

From the simulation results using different factors and performance metrics, we conclude that DSR has better average throughput, average end to end delay and lesser routing overload than others. In case of packet delivery ratio DSDV is performing comparatively better than AODV, AOMDV and DSR.

In VANETs we need to tradeoff among various performances metrics. To select a routing protocol that is efficient for VANETs we can emphasize on average throughput, normalized routing load and average end to end delay. From the simulation we found out that packet delivery ratio is a metric where the routing protocols did not mark any significant difference. Hence, we can conclude that in VANETs, DSR is more appropriate than AODV, AOMDV and DSDV.

In this paper we have simulated the routing protocols using V2V communication by using the TIGER database to create the map of Afton Oaks, Houston in MOVE. In our future work, we will use V2I (Vehicle to Infrastructure) communication model in MOVE to simulate the routing protocols using TIGER database.

References

[1] Catalin Fratila and Ciprian Dobre Ciprian Dobre, "*An approach to Evaluating Usability Of VANET Applications*" , 7th International Wireless Communications and Mobile,IEEE, Istanbul, pp. 801-807, 2011.

[2] Vishal Kumar, S. Mishra and N. Chand "*Applications of VANETs: Present & Future*" , 8th International Conference on Wireless Communications, Networking and Mobile Computing- WiCOM 2012, Shanghai, China, 2012.

[3] Yunho Jung and Keecheon Kim, "*Movement Awareness position-based routing protocol for Intersection of Urban Environment*" , International Symposium on Parallel and Distributed Processing with Applications, 2008. ISPA '08, IEEE, Sydney, pp. 795 - 798, 2008.

[4] Xi Yu, Huaqun Guo and Wai-Choong Wong, "*A reliable routing protocol for VANET*", 7th International Wireless Communications and Mobile Computing Conference (IWCMC), IEEE, Istanbul, pp. 1748 – 1753, 2011.

[5] C. Perkins, E. Royer and S.Das, *Ad hoc On-Demand Distance Vector (AODV) Routing*", Internet Draft, 2003.

[6] Mahesh K. Marina and Samir R. Das, "*On- demand Multi-path Distance Vector Routing for Ad hoc Networks*", Proceedings of IEEE International Conference on Network Protocols (ICNP), pp. 14 - 23, 2001.

[7] David B. Johnson and David A. Maltz, "*Dynamic Source Routing in Ad hoc wireless Networks*", Mobile Computing, vol. 353, Kluwer academic, 1996.

[8] Charles E. Perkins, *Adhoc Networking*, Fourth Edition ed., Pearson Education, 2011.

[9] Feliz Kristianto Karnad, Zhi Hai Mo and Kun-chan Lan, "*Rapid Generation of Realistic Mobility Models*

for VANET", Proceedings Wireless Communications and Networking Conference, IEEE, Kowloon, pp. 2506 - 2511, 2007.

[10] SUMO -[Online]. http://sumo.sourceforge.net, date of visit (15-11-2012).

[11] Miradham Kamilov, Ilhom Karimov, Jungwook Song, Heemin Kim, and Sunyoung Han, "*A Real-time Routing System for Vehicular Ad Hoc Networks*", Software Technologies for Future Dependable Distributed Systems, IEEE, Tokyo, pp. 88 - 92, 2009.

[12] Juan Angel Ferreiro-Lage, Cristina Pereiro Gestoso, Oscar Rubiños, Fernando Aguado Agelet, "*Analysis of Unicast Routing Protocols for VANETs*", Fifth International Conference on Networking and Services, ICNS '09, IEEE, Valencia, pp. 518 - 521, 2009.

[13] Agata Grzybek, Marcin Seredynski, Gregoire Danoyy and Pascal Bouvry, "*Aspects and Trends in Realistic VANET Simulations*", International Symposium onWorld of Wireless, Mobile and Multimedia Networks (WoWMoM), IEEE , San Francisco, CA, pp. 1 - 6, 2012.

[14] Anil Kumar Bisht, Brajesh Kumar and Shailendra Mishra, "*Efficiency Evaluation of Routing Protocols for Vehicular Ad-Hoc Networks Using City Scenario*", International Conference on Computer Communication and Informatics (ICCCI), ,*IEEE*, Coimbatore, pp. 1 - 7, 2012.

[15] S.S. Dorle, Bhushan Vidhale and Megha Chakole, "*Evaluation of Multipath, Unipath and Hybrid Routing Protocols for Vehicular Ad Hoc Networks*", 4th International Conference on Emerging Trends in Engineering and Technology (ICETET), IEEE, Port Louis, pp. 311 - 316, 2011.

[16] Wai Foo Chan, Moh Lim Sim, and Sze Wei Lee, "*Performance Analysis of Vehicular Ad hocNetworks with Realistic Mobility Pattern*", Proceedings of the 2007 IEEE International Conference on Telecommunications and Malaysia International Conference on Communications, Malaysia, pp. 318 - 323, 2007.

[17] Xia Jia, Kuang Yujun, Zhang Enzhan and Jiang Weili, "*Research on Mobility Model for VANETs Based on Real Map*", International Conference onComputational Problem-Solving (ICCP), 2011 , Chengdu, pp. 1 - 6, 2011.

[18] Shaikul Islam Chowdhury, Won-II Lee, Youn-Sang Choi, Guen-Young Kee and Jae-Young Pyun, "*Performance Evaluation of Reactive Routing Protocols*," 17th Asia-Pacific Conference on Communications (APCC), IEEE, Malaysia, pp. 559 - 564, 2011.

[19] Josiane Nzouonta, Neeraj Rajgure, Guiling (Grace) Wang, and Cristian Borcea, "VANET Routing on City Roads Using Real-Time Vehicular Traffic Information", IEEE Transactions on Vehicular Technology, vol. 58, no. 7, pp. 3609 - 3626, 2009.

[20] Vishal Kumar and Narottam Chand, "*Data Scheduling in VANETs: A Review*", International Journal of Computer Science and Communication, vol. 1, no. 2, pp. 399-403, 2010.

[21] TIGER /Line Shapefiles and TIGER/Line Files. [Online]. http://www.census.gov/geo/www/tiger/shp.html, date of visit (10-12-2012).

[22] NS-2,"The Network Simulator -NS-2. [Online]. http://www.isi.edu/nsnam/ns/, date of visit (05-12-2012).

[23] Ubuntu. [Online]. http://www.ubuntu.com/, date of visit (20-11-2012).

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