Analysis of Routing Protocols over VANET

Ramadhan Mstafa[1] *, Abdalraouf Alarabe, Eman AbdelFattah Ammar Odeh, Muneer Alshowkan*

Abstract –Vehicular Ad-hoc Network (VANET) is a new network technology where the cars are used as mobile nodes to form a communication network. In VANET, routing protocols have a significant role in terms of the performance because they determine the way of sending and receiving packets between mobile nodes. In this paper, we examine and analyze the performance of Ad-hoc On-Demand (AODV), Ad-hoc On-demand Multipath Distance Vector (AOMDV), Dynamic Source Routing (DSR) and Destination-Sequenced Distance Vector (DSDV) routing protocols over two different traffic connections; TCP and Constant Bit Rate (CBR) using different speeds and packet sizes. The performance measurements; Packet Delivery Ratio, Average End to End Delay and Average Throughput are examined with respect to speed and packet size. The objective of this study is to find the best routing protocol over all circumstances. Based on our validated results, DSR performs the best among all evaluated protocols.

Keywords: AODV, AOMDV, DSR, DSDV, VANET, Packet Delivery Ratio, Average End to End Delay, Throughput, routing protocol, Network Simulator (NS2).

INTRODUCTION

1.1. Overview of Vehicular Ad-hoc Network (VANET):

There are many kinds of infrastructure-less network where the vehicles are acting as nodes. In this type of transportation, vehicles are moving across the roads or highways along predefined traffic lanes. Vehicular Ad-hoc Networks (VANETs) and Mobile Ad-hoc Networks (MANETs) are examples of infrastructure-less networks where they are similar in their characteristics. In both cases, the nodes are in motion with their self-organizing characteristics where there is no requirement for any fixed or existing infrastructure. Therefore, both of these networks can simply be deployed wherever there is a need [1]. In general, the major aim of VANETs as well as MANETs is to provide safety throughout a journey.

The Vehicular Ad-hoc Network is a new network technology. VANETs support many applications that might assist drivers and achieve communications among the drivers successfully. Nowadays, there are two efficient types which are vehicle-to-vehicle communications or Inter-Vehicle Communications (IVC). VANETs allow vehicles to interact while they travel by using wireless devices that can make a dynamic network [2].

In VANETs, vehicles are represented as network nodes. Some vehicles are represented as senders and others are represented as receivers. Communications among vehicles are provided so that they transmit and receive information. Vehicles' speed plays a key role in the connectivity range. So, usually VANETs in many implementations are signed up to one thousand meters.

---

[1] University of Bridgeport, Bridgeport, CT 06604, USA, aodeh@bridgport.edu

VANETs are used widely in many agencies. They are mainly used for the GPS navigation system along with toll tax and traffic messages, traffic management agencies, highway safety agencies, law enforcement agencies and emergency services [3].

This paper is organized as follows: section 2 presents a summary of related work, section 3 introduces a brief summary about the routing protocols under study, section 4 presents the proposed scenario, section 5 includes the simulation environment, section 6 presents discussion and analysis of results. Finally, section 7 includes the conclusion for our simulation results.

RELATED WORK

Monika *et. al.* used NS2 simulator to compare among three routing protocols; DSDV, DSR and AODV over VANET. IEEE 802.11p is the standard protocol that is applied on their network. The comparison aims to analyze the performance of the throughput and the packet loss rate. They conclude that AODV has the highest throughput and the best performance. Also, they state that the network performs better with existence of Road Side Unit (RSU). However, a RSU is an expensive unit [4].

AODV, DSR and DSDV routing protocols were analyzed in [5]. The paper presented a comparison on the performance of above listed protocols to evaluate the throughput versus different number of packets' size. The comparison was in term of a high connection session. DSR provided better results as compared to AODV. Moreover, DSDV showed a kind of optimization only in case of connection session increment. The paper concluded that the routing protocols of MANETs cannot satisfy the specifications of VANETs.

The performance of AODV and DSR was analyzed based on variation values of speed and node density [6]. Based on the analysis, AODV and DSR perform very well and provide a high Packet Delivery Ratio whenever the low speed and low node density were used. Moreover, DSR showed better performance than AODV.

The performance of AODV, DSDV and DSR was examined [7]. The Packet Delivery Ratio, End to End Delay, and Throughput of the network were evaluated with respect to different numbers of mobile nodes over the experiment. The results showed that DSR performed the best among the compared protocols when the cluster's size is small. However, AODV outperformed the other two protocols when the cluster's size increased.

A comparison of AODV, AOMDV, OLSR, DSR and GSR routing protocols was presented [8]. The Packet Delivery Ratio and Average End to End Delay were evaluated. The paper concluded that AODV provided a high Packet Delivery Ratio. Moreover, AODV can be considered as the best routing protocol for carrying the packet over VANET with high security.

The performance of AODV, DSDV and OLSR routing protocols in active road safety application was analyzed [9]. The paper presents a new topology model for road maps by using traffic simulator. The length, acceleration, and maximum speed are used as parameters. The results showed that AODV performed as the best due to its ability of maintaining the communication link during the information exchange. Also, DSDV performed well but an issue of concern was about its overhead for routing packets.

Dorle *et. al.* examined the performance of AODV, AOMDV and DSDV routing protocols. The measured parameters were the Packet Delivery Ratio and End to End Delay. The simulation results showed that AODV routing protocol had the best performance in terms of Packet Delivery Ratio. Also, DSDV protocol showed average performance. Moreover, both DSDV and AODV routing protocols have comparable performance for End to End Delay [10].

ROUTING PROTOCOLS

3.1. Ad-hoc On–Demand Distance Vector Routing protocol

Ad-hoc On–Demand Distance Vector Routing protocol (AODV) is a combination of DSR routing protocol and DSDV routing protocol [11]. Both route discovery and route maintenance from DSR are used in AODV routing protocol. It is called reactive on-demand protocol where AODV starts discovering the routes only if there is a data packet that needs to be sent. Thus, all the routes are not maintained at all times. Therefore, AODV reduces the overhead. Moreover, a sequence number is used to ensure new routes are discovered and to avoid looping. This can be considered as a feature of AODV [1].

3.2. Ad-hoc On-demand Multipath Distance Vector Routing

Ad-hoc on-demand Multipath Distance Vector Routing (AOMDV) protocol is an extension of AODV protocol. AOMDV protocol defines multi-paths when it is used to search of the route discovery. Thus, it is unnecessary to find a new route every time when the link failure of the network happened. AOMDV protocol has two components; computation of multiple loop-free paths, and computation of disjoint paths. Therefore, the AOMDV protocol reduces the routing overhead and it allows only accepting alternate routes with lower hop counts [1].

3.3. Dynamic Source Routing Protocol

Dynamic Source Routing Protocol (DSR) is used to route a packet from source to destination with no need of any routing information between the intermediate nodes. In other words, DSR does not need an infrastructure in order to send the packets. Furthermore, there is no need for periodic routing announcements which decreases the overhead of the wireless network [11].

3.4. Destination Sequenced Distance Vector

Destination Sequenced Distance Vector (DSDV) protocol maintains for each node a routing table which stores next hop. Each node periodically forwards routing table information to its neighbors, by applying this routing algorithm overhead over the network will be increased. However, DSDV protocol is an efficient protocol for routing discovery whenever the routing to a new destination is required. The expected percentage of routing latency discovery is very low since DSDV guarantees loop-free paths [1].

PROPOSED SCENARIO

We are simulating a military scenario where the vehicles are moving over different positions and with different speeds. The communication among these vehicles is one of the most important tasks for safety purposes. Therefore, applying the Random Waypoint mobility model over VANET is one of the most popular network architectures that is used in this case. Hence, sending and receiving data with high quality and less noise over different speeds and positions is the major focus of many studies. Figure 1 shows a real scenario using VANET.

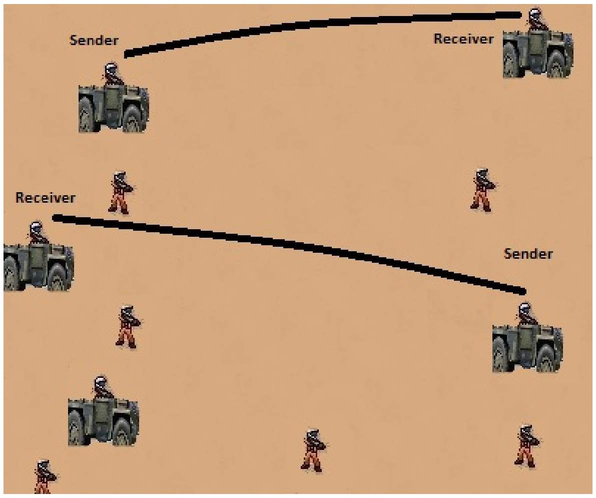

Figure1: Communication between military parties that shows sending and receiving messages between vehicles.

SIMULATION ENVIRONMENT

5.1. Simulation Set Up

In our simulation, we have a constant number of 20 nodes. The simulation area of 840 m X 840 m is used. Different speeds in the range from 1 to 40 m/s and different packet sizes in the range from 1 Kbyte to 6 Kbytes are used. The Simulation time is 200s with maximum of 2 connections for both TCP and CBR traffic. Four routing protocols are examined; AODV, AOMDV, DSR and DSDV. Table 1 shows the network parameters that we have used in our simulation. Figure 2 shows the sending and the receiving packets between the mobile nodes when running our scenario using NS2 simulator.

Table1: Network Parameters

Parameter	**Value**
Protocols	AODV, AOMDV, DSR, DSDV
No. of Nodes	20
Simulation Time	200s
Traffic Type	TCP, CBR
Transmission Range	250 m
Mobility Model	Random Waypoint
Simulation Area	840m X 840m
Maximum Speed	1, 5, 15, 25, 35, 40 m/s
Packet size	1, 2, 3, 4, 5, 6 KBytes (KB)
Data Rate	1 Mbps

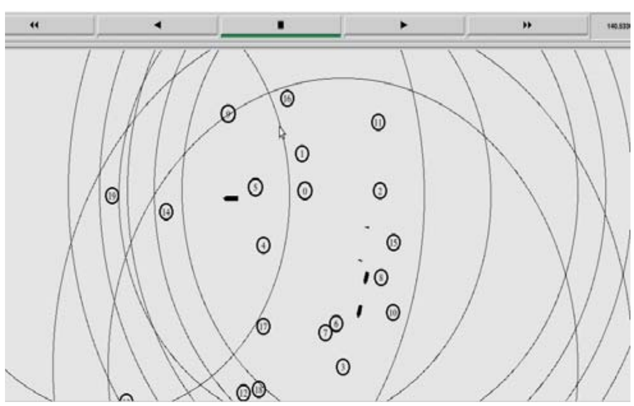

Figure 2: Sending and receiving packets between mobile nodes.

5.2. Simulation Results

The Packet Delivery Ratio, Average End to End Delay, and Average Throughput for each of AODV, AOMDV, DSR, and DSDV routing protocols have been measured. Different speeds over time in the range from 1m/s to 40 m/s under both TCP and CBR traffic connections are used to evaluate the performance of these four routing protocols.

In our experiment, we have used different size of packets as a performance parameter. The range from 1KB to 6 KB is conducted to examine the performance of the protocols. Based on the connection type; TCP or CBR, we received different results for our measured parameters; Packet Delivery Ratio, Average End to End Delay, and Average Throughput. These results are demonstrated in the next section.

DISCUSSION AND ANALYSIS OF RESULTS

In this section, we analyze the performance of the four routing protocols; AODV, AOMDV, DSR, and DSDV for both TCP and CBR traffic connections. In this analysis, we consider the following measured parameters: Packet Delivery Ratio, Average End to End Delay, and Average Throughput with respect to speed or different packet size.

6.1. Packet Delivery Ratio:

A. In this scenario, we are examining the routing protocols over TCP traffic connection for the measured parameter Packet Delivery Ratio versus speed as shown in Figure 3. The results show that AOMDV and DSR are more stable over different speeds compared to AODV and DSDV routing protocols. It can be observed that for speed of 5 m/s the Packet Delivery Ratio of DSDV is around 99.55 and it is around 99.8 for AODV. However, for speed of 25 m/s the Packet Delivery Ratio of DSDV is around 99.9 and it is 99.65 for AODV. These differences show the non-stability of DSDV and AODV protocols from mobility point of view. Hence, for this scenario we can conclude that both AOMDV and DSR have better stability in the mobility environment than DSDV and AODV over the TCP traffic connection.

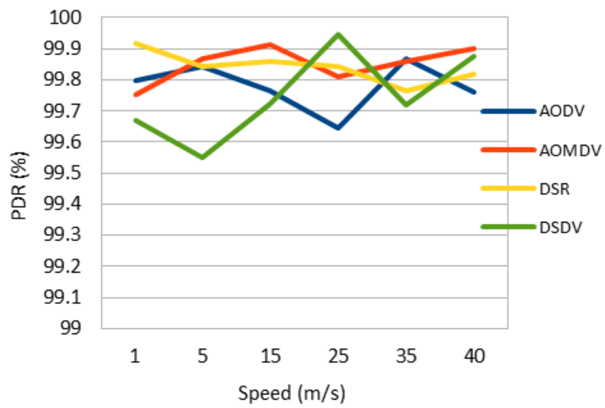

Figure 3: Packet Delivery Ratio versus speed for TCP traffic connection

Figure 4 shows the results over CBR traffic connection for Packet Delivery Ratio versus speed. Based on this scenario, both DSR and DSDV show better performance (around 78% and 77%) over different speeds. For both AODV and AOMDV, we notice a deteriorated performance when the speed increases. Thus, with higher speed both AODV and AOMDV have a high number of packets' loss.

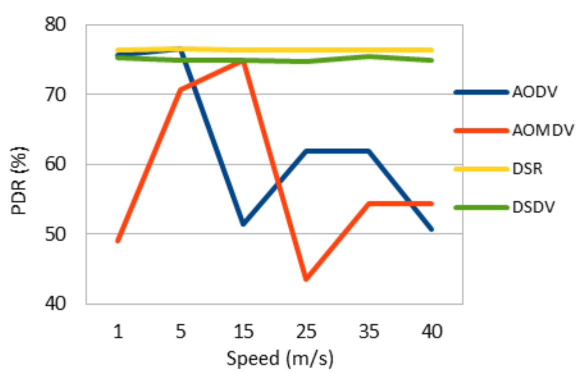

Figure 4: Packet Delivery Ratio versus speed for CBR traffic connection

B. Regarding to the packet size parameter, Figure 5 shows better results for DSR protocol than the other three protocols. AODV, DSDV and AOMDV show a decrease in the percentage of Packet Delivery Ratio when packet sizes increase. When using TCP traffic connection, the performance of DSR is around 99.9% while the other protocols have a lower Packet Delivery Ratio percentile.

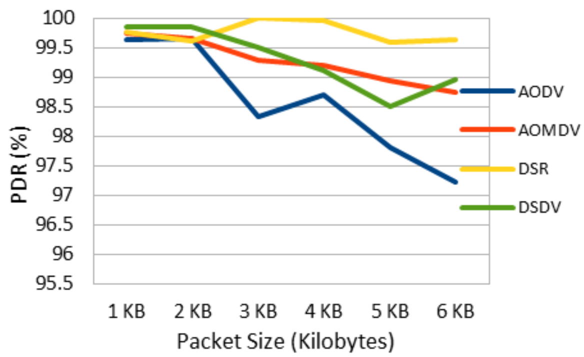

Figure 5: Packet Delivery Ratio versus different packet size for TCP traffic connection

However, in CBR traffic connection; the protocols show better performance generally except AOMDV as shown in Figure 6. AODV, DSR and DSDV perform well and provide Packet Delivery Ratio around 80% for packet sizes in the range from 4KB to 6 KB.

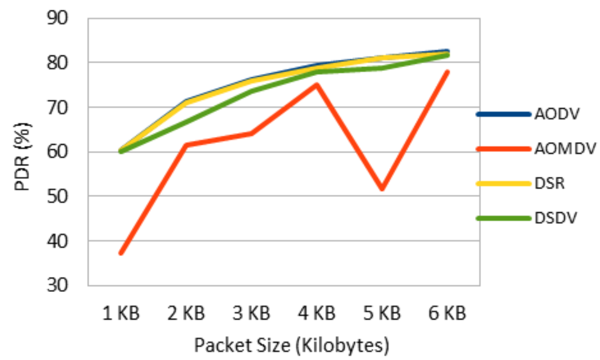

Figure 6: Packet Delivery Ratio versus different packet size for CBR traffic connection

6.2. Average End To End Delay:

A. Over different speeds of nodes, Figure 7 shows that AODV, DSDV and DSR are more stable. They have acceptable delays (less than 300 ms) than AOMDV protocol over the TCP traffic connection. However, when using CBR traffic connection, we can observe that the average End to End Delay increases. It goes to more than one second for AOMDV. Also, for DSR and DSDV; the Average End to End Delay is around 600 ms compared to 300 ms in case of TCP traffic connection as shown in Figure 8.

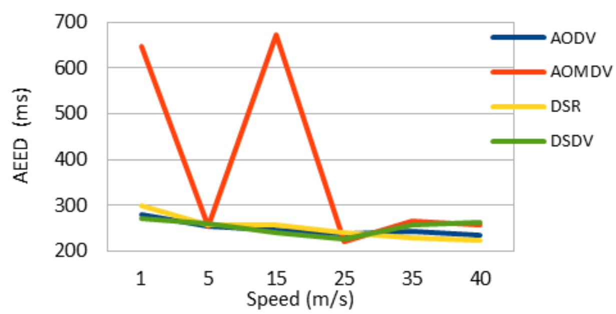

Figure 7: Average End to End Delay versus speed for TCP traffic connection

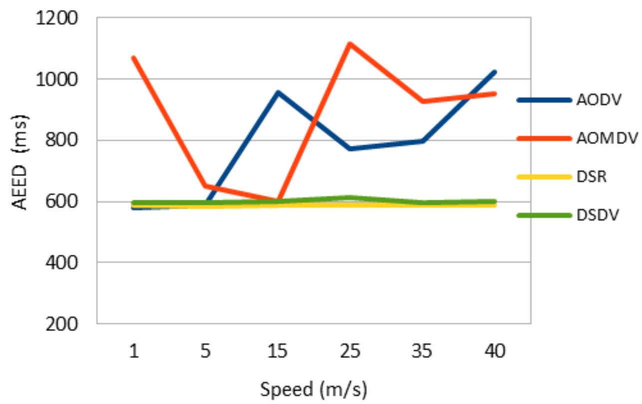

Figure 8: Average End to End Delay versus speed for CBR traffic connection

B. Regarding to the packet size, the Average End to End Delay of mobile nodes increases when the packet size increases for TCP traffic connection. Figure 9 shows that DSR protocol has less End to End Delay compared to other protocols when sending larger size of packets. All protocols have comparable Average End to End Delay around 220 ms for packet size of 1KB. However, at a packet size of 6 KB, DSR has Average End to End Delay around 620 ms while AODV, AOMDV and DSDV have End to End Delay around 1 second.

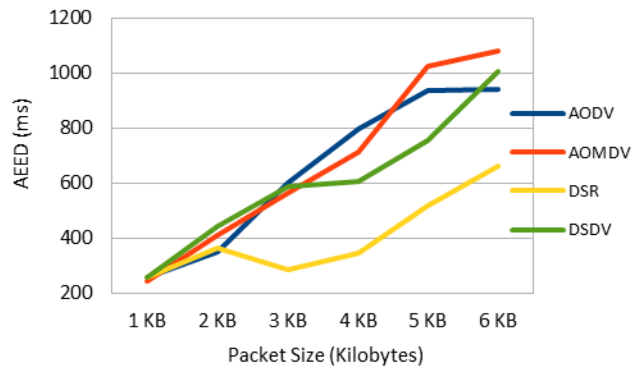

Figure 9: Average End to End Delay versus different packet size for TCP traffic connection

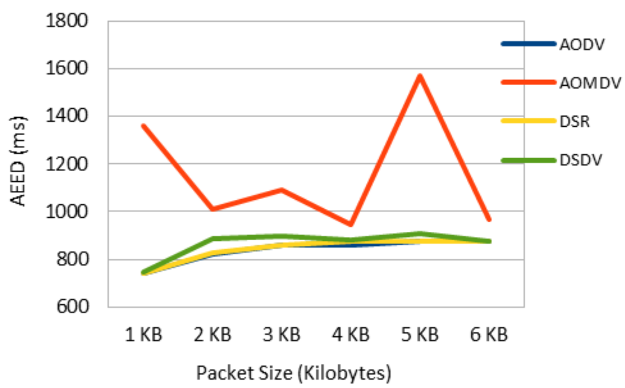

Figure 10: Average End to End Delay versus different packet size for CBR traffic connection

Figure 10 shows that mobile nodes using CBR traffic connections have higher Average End to End Delay than using TCP traffic connection with respect to different packet size.

6.3. Average Throughput:

A. Figures 11 and 12 show that DSR and DSDV routing protocols have a constant Average Throughput with different speed values. Thus, their overall performance when using either TCP or CBR traffic connections is almost constant. Both figures show an Average Throughput around 680 Kbps for DSR and DSDV. However, AOMDV shows a drop off the Average Throughput from 680 to 500 kbps at speed of 15 m/s. Also, AODV shows a drop off the Average Throughput from 680 to 600 kbps at speed of 15 m/s as shown in Figure 11.

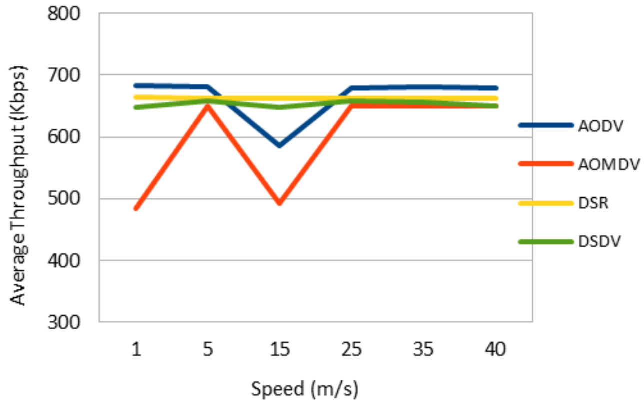

Figure 11: Average Throughput versus speed for TCP traffic connection

When using CBR traffic connection, the performance of AODV and AOMDV are worse than DSR and DSDV as shown in Figure 12. The degradation of AOMDV performance takes place at speed of 25 m/s from 680 to 390 kbps then the performance is improved. For AODV, the degradation of the network occurs at speed of 15 m/s from 680 to 480 Kbps. That shows non stability of both AOMDV and AODV over CBR traffic connection.

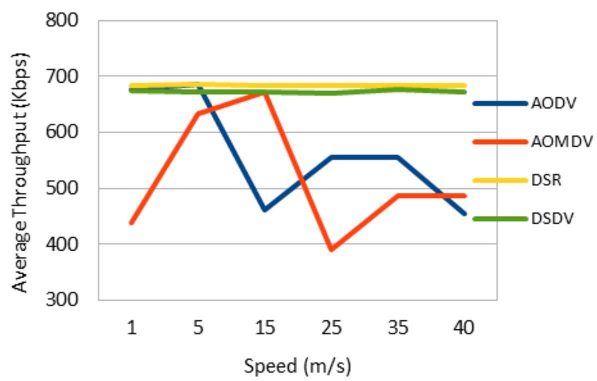

Figure 12: Average Throughput versus speed for CBR traffic connection

B. When changing the packet size for TCP traffic connection, Figure 13 shows that the four protocols have comparable Average Throughput. All routing protocols have values that ranges from 639 to 920 Kbps which is a good Average throughput compared to the results when using CBR traffic connection. The maximum Average Throughput in case of CBR is 407 Kbps. Figure 14 shows that DSR and AODV have stable results compared to AOMDV and DSDV.

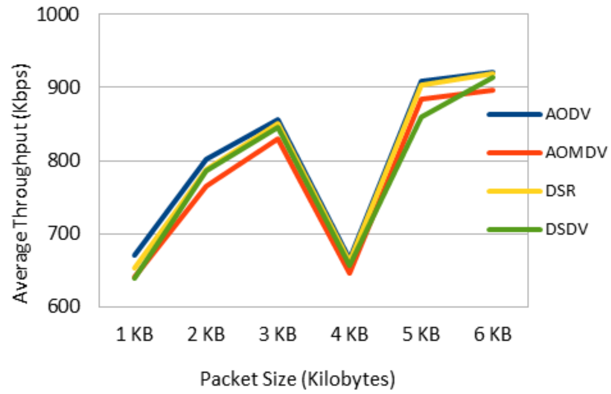

Figure 13: Average Throughput versus different packet size for TCP traffic connection

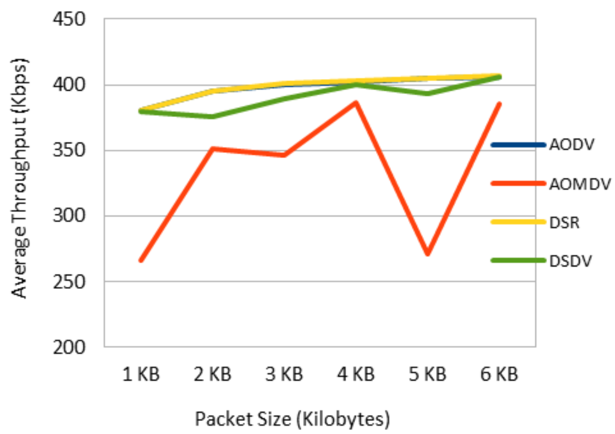

Figure 14: Average Throughput versus different packet size for CBR traffic connection

CONCLUSION

In this paper, we examined and analyzed the performance of AODV, AOMDV, DSR and DSDV routing protocols using TCP and CBR traffic connections. We considered the speed and the packet size as the controlled parameters in our experiments to determine the best routing protocol.

In our simulation, for TCP traffic connection we observe that DSR is more stable than the other three protocols for the measured parameter; Packet Delivery Ratio. Furthermore, AOMDV outperforms AODV and DSDV. In the case of CBR traffic connection, DSR and DSDV have better performance than AODV and AOMDV routing protocols for the Packet Delivery Ratio. In Average End to End Delay, DSR presents the best performance among the four routing protocols as it has the minimum delay. Moreover, DSDV outperforms AOMDV and AODV routing protocols. Finally, DSR and DSDV are more stable than AOMDV and AODV for the measured parameter Average Throughput.

We recommend DSR for communications in VANETs based on our simulation results. It achieves the best performance for the three measured parameters; Packet Delivery Ratio, Average End to End Delay and Average Throughput.

REFERENCES

[1] A. K. Bisht, B. Kumar, and S. Mishra, "Efficiency evaluation of routing protocols for Vehicular Ad-Hoc Networks using city scenario," in Computer Communication and Informatics (ICCCI), 2012 International Conference on, 2012, pp. 1-7.

[2] D. Ben, C. Zehua, W. Yan, and Y. Hui, "An improved AODV routing protocol for VANETs," in Wireless Communications and Signal Processing (WCSP), 2011 International Conference on, 2011, pp. 1-5.

[3] P. Rani, N. Sharma, and P. K. Singh, "Performance Comparison of VANET Routing Protocols," in Wireless Communications, Networking and Mobile Computing (WiCOM), 2011 7th International Conference on, 2011, pp. 1-4.

[4] S. B. Monika and A. Dhiman, "Comparative Study of AODV, DSDV and DSR Routing Protocols in Vehicular Network Using EstiNet Simulator," International Journal of Scientific & Engineering Research, vol. 3, 2012.

[5] S. M. M. Feiz and A. Movaghar, "Comparison of DSR, AODV and DSDV Routing Protocols in Fully and Partially Connected VANET," Proceedings of 2011 World Congress in Computer Science, Computer Engineering and Applied Computing, Las Vegas, Nevada, July 18 – 21, 2011.

[6] B. Paul, M. Ibrahim, M. Bikas, and A. Naser, "Experimental Analysis of AODV & DSR over TCP & CBR Connections with Varying Speed and Node Density in VANET," International Journal of Computer Applications, Volume 24, No.4, June 2011.

[7] Y. M. Sharma and S. Mukherjee, "Comparative Performance Exploration of AODV, DSDV & DSR routing protocols in Cluster Based VANET Environment," International Journal of Advances in Engineering & Technology (IJAET), vol. 4, 2012.

[8] M. U. Nagaraj and M. P. P. Dhamal, "Performance Comparison of AODV, AOMDV, OLSR, DSR and GSR Routing Protocols in VANET," UACEE International Journal of Advances in Computer Networks and its Security, vol. 2, 2012.

[9] G. Z. Santoso and M. Kang, "Performance analysis of AODV, DSDV and OLSR in a VANETs safety application scenario," in Advanced Communication Technology (ICACT), 2012 14th International Conference on, 2012, pp. 57-60.

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

[11] Y. Rua and L. Zhi-yuan, "A stability routing protocols base on Reverse AODV," in Computer Science and Network Technology (ICCSNT), 2011 International Conference on, 2011, pp. 2419-2423.

Ramadhan Mstafa

He is pursuing his Ph.D. in Computer Science and Engineering at the University of Bridgeport in Bridgeport, Connecticut. He received his Master's degree in image processing from University of Duhok in 2008 and his Bachelor's degree in Computer Science from University of Salahaddin in 2003.

Abdalraouf M M Alarbe

is a M.S. Student in the Department of Computer Science at the University of Bridgeport. His interest area in wireless network, programming languages and Data base design.

Eman Abdelfattah

Received Ph.D. Degree in Computer Science and Engineering, University of Bridgeport, Fall 2011. Also, she received MS. Degree in Computer Science, University of Bridgeport, and May 2003. She was awarded the Academic Achievement Award in Computer Science, University of Bridgeport, School of Engineering, and May 2003. Currently, she is working as an adjunct instructor in the department of Computer Science and Engineering and the department of Mathematics at the University of Bridgeport. Eman has research interests in security, networking and communications.

Muneer Alshowkan

is currently pursuing a Ph.D. degree in Computer Science and Engineering at the University of Bridgeport. In 2011, he received his Master's degree in Information, Network and Computer Security at New York Institute of Technology, and received his B.S. in Computer and Management Systems at King Faisal University in Kingdom of Saudi Arabia. He is currently an active member of the IEEE.

Ammar Odeh

is a Ph.D. Student in University of Bridgeport. He earned the M.S. degree in Computer Science College of King Abdullah II School for Information Technology (KASIT) at the University of Jordan in Dec. 2005 and the B.Sc. in Computer Science from the Hashemite University. He has worked as a Lab Supervisor in Philadelphia University (Jordan) and Lecturer in Philadelphia University for the ICDL courses and as technical support for online examinations for two years. He served as a Lecturer at the IT, (ACS,CIS ,CS) Department of Philadelphia University in Jordan, and also worked at the Ministry of Higher Education (Oman, Sur College of Applied Science) for two years. Ammar joined the University of Bridgeport as a PhD student of Computer Science and Engineering in August 2011. His area of concentration is reverse software engineering, computer security, and wireless networks. Specifically, he is working on the enhancement of computer security for data transmission over wireless networks. He is also actively involved in academic community, outreach activities and student recruiting and advising