World Applied Sciences Journal 7 (11): 1341-1352, 2009
ISSN 1818-4952

Anycast Based Routing in Vehicular Adhoc Networks (VANETS) using Vanetmobisim

Laiq Khan, Nohman Ayub and Aamir Saeed

Department of Electrical Engineering, COMSATS IIT Abbottabad, Pakistan

Abstract: Vehicular Adhoc Networks (VANETS) is an emerging flavor of Mobile Adhoc Networks (MANETS) to improve intelligent Inter Vehicle and Vehicle to Vehicle communication without any fixed infrastructure. VANETS can be used to improve the Comfort Applications such as traffic information, weather information, gas station/restaurant location information or interactive communication such as Internet access and downloads. As these networks have no fixed communication structure and may vary heavily due to which routing of data packets through VANETS is very crucial. To evaluate the performance of Adhoc routing protocol in realistic urban vehicular motion pattern to make an improvement in providing Comfort Applications, this study proposes MANET anycast AODV routing protocol to make it adaptive for VANETS using VanetMobisim (a generator for vehicular mobility traces) under different matrices such as varying node maximum speed, varying number of nodes and with varying number of Constant Bit Rate (CBR) Sources.

Key words: Any-cast routing . VANETs . vanetMobisim . performance metrics

INTRODUCTION

Vehicular Adhocnetworks emerge as a new technology that integrates existing wireless networks to radio enabled vehicles. The basic idea is to provide ubiquitous connections to mobile users on the road [1] and enable efficient Intelligent Transportation System (ITS) [2] between vehicles via vehicle to vehicle communication (V2V) depicted in Fig. 1 or Inter Vehicle Communication (IVC) system. In Comparison to cellular system this communication system has three main advantages [3]: Lower Latency, Brooder Coverage, and No Service Fee.

In recent years, collaborative efforts of Government, Industries, Car Manufacturers Standardization Bodies and World Wide Research Centers opened a lots of interest for ITS. US FCC allocated 75 MHz of spectrum in the 5.9 GHz Band to improve Nation's Transportation System [3, 4]. In addition to this, other countries outside the us like: internet ITS [5] Consortium in Japan, Networks on Wheels [6] in Germany and PreVENT [7] Project in Europe are few research projects to support inter vehicle and vehicle to vehicle applications and services.

However, due to dynamic network topology, frequent disconnected networks, varying communication conditions and hard delay constraints VANETS can be distinguished from other kinds of Adhoc networks. FCC frequency allocation categorizes two main areas/applications of vehicular Adhoc networks i.e., Safety Applications and Comfort Applications. First category as its name suggests improves safety levels of passengers via IVC or V2V Communication depicted in Fig. 1. Some common examples of this application are: signal violation warning, road condition warning, intersection coordination and emergency warning systems. Second kind of applications improves passengers comfort level through optimized route to destination, traffic information, weather information, gas station or restaurant location and price information are good examples of comfort applications. In both classes of applications data messages or control messages should be continuously exchanged between mobile nodes or vehicles.

Four services that have immediate applications for comfort issues are unicast, multicast, anycast and scan [8]. This paper evaluates an anycast AODV On Demand Routing Protocol for comfort applications such as gas station and restaurant locations services with unicast on demand routing protocol in realistic urban mobility pattern. Rest of this paper is organized as follows:

Section 2 presents routing protocols in general and then specific routing protocol used for evaluation section 3 contains introduction to VanetMobisim. Section 4, describes Mobility Model used for this simulation. Section 5 presents design methodology. Section 6 shows simulation scenarios and evaluation Results. Finally this paper is concluded in section 7.

Corresponding Author: Dr. Laiq Khan, Associate Professor, Head of Graduate Programme, Department of Electrical Engineering, COMSATS IIT Abbottabad, Pakistan

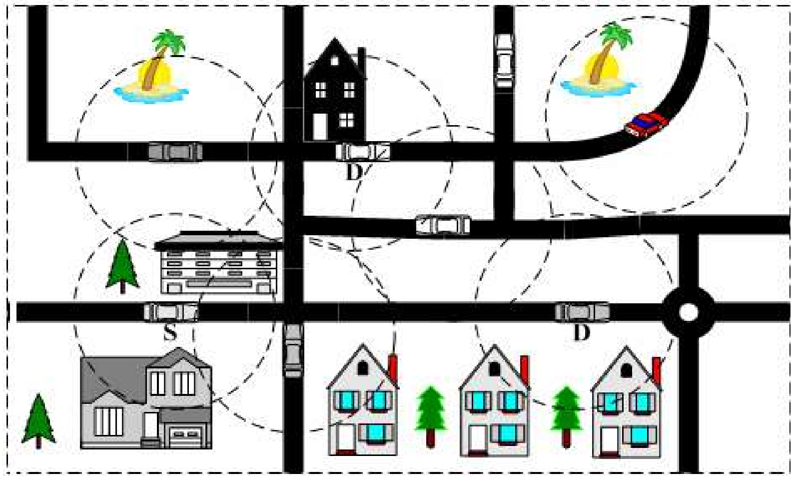

Fig. 1: Vehicle to vehicle adhoc communication

ROUTING PROTOCOLS

Routing protocol is used to discover routes between nodes in the network. Ideal routing protocols should build routes by causing a minimum of overhead and bandwidth consumption. There are two widely used types of protocols in network routing: table-driven protocols and source-driven protocols. Table-driven protocols use proactive methods to maintain network topology.

Table-driven routing protocol: Table-driven routing protocols attempt to maintain consistent, up-to-date routing information by broadcasting transmission that requires each node to maintain one or more tables to store routing information. Once there are changes in network topology, propagating update information throughout the whole network has to be performed in order to maintain a consistent network view. For instance, the Destination Sequenced Distance Vector Routing protocol (DSDV) described is a famous table-driven algorithm based on the classical Bellman-Ford routing mechanism. The Cluster-head Gateway Switch Routing (CGSR) protocol defines several heuristic routing schemes in a clustered multi-hop mobile wireless network. The Wireless Routing Protocol (WRP) is another table-based protocol with the goal of keeping routing information consistent among all nodes in the network.

Each node in the network is responsible for maintaining four tables: distance table, routing table link-cost table, message retransmission list (MRL) table. Optimized Link State Routing Protocol (OLSR) is also a kind of proactive protocol. This algorithm floods broadcast message just through the nodes selected by Multipoint Relays (MPRs)

Source-driven routing protocol: Different from table-driven routing, source-driven routing protocols, also called on-demand routing, use a reactive way to find a route if it is desired by source node.

The Adhoc On-Demand Distance Vector (AODV) routing protocol develops on top of DSDV algorithm previously. Basically, it minimizes the number of required broadcasts by creating routes on a demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm.AODV broadcasts a route request (RREQ) packet from the initiator and then the requests are forwarded until the destination is found. AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. The Dynamic Source Routing (DSR) protocol provides a mechanism to make each node maintain route caches which contain newly updated information. The Temporally Ordered Routing Algorithm (TORA) is a highly adaptive loop-free distributed routing algorithm based on the concept of link reversal. TORA is proposed to operate in a highly dynamic mobile networking environment. The key design concept of TORA is the localization of control messages to a very small set of nodes near the occurrence of a topological change. The Associativity-Based Routing (ABR) protocol defines a routing metric named as degree of association stability. That is free from loops, deadlock, and packet duplicates. Signal Stability-Based Adaptive Routing protocol (SSR) employs route selection criteria to choose the routes that have "stronger" connectivity. SSR can be divided into two cooperative protocols: the Dynamic Routing Protocol (DRP) and the Static Routing Protocol (SRP).

Location-driven routing protocol: In recent years, a number of location-based protocols are emerging. With the development of location dependent service such as Global Position System (GPS) and Adaptive Cruise Control (ACC), a lot of work has extended location-based forwarding strategies. There are several routing-related research efforts: location Service, recovery strategies, vehicle movement patterns, digital maps and navigation systems.

Maintaining and finding routes in VANETS is very challenging due to dynamic nature of mobile nodes. In recent years, there have been proposed various adhoc routing protocols, two main categories are classified as location-based and topology-based [8] unicast protocols. Topology based routing protocol is used in this study as location based routing protocol uses some additional information such as location services and servers for node geographical positions. As MANETS, not relying on fixed infrastructure for communication, VANETS also share the same principle; thus most of Adhocrouting protocols are still applicable such as AODV [9] and DSR [10] are two most popular on-demand routing protocol

AODV is a topology based routing protocol that finds routes for a node only when it has data packets for transmission. AODV first initiates route discovery process, in which the source node broadcasts a packet known as Route Request Packet (RREQ). Until and unless an active route is found or maximum number of hosts is reached receiving neighbor nodes forwards the packets to their adjacent neighbors. When intermediate nodes know an active route to destination, it unicasts a Route Reply (RREP) packet back to source node. At the end, source node receives the RREP packet and selects a route that RREP packet traversed.

Several improvements have been made using this protocol; Secure AODV (SAODV) [11] which improves AODV security. In [12] AODV is evaluated with six vehicles. PRAODV and PRAODVM [13] are two prediction based AODV protocols that predicts route life time. Another major improvement is A-AODV [14] an anycast routing protocol based on AODV.

Anycast allows a source node to transmit a packet to a single node out of a set of destination nodes. There are a number of situations in VANETS where a mobile node or inter vehicle communication a node/vehicle wants to locate a service just like restaurant location or gas station information. Several vehicles supports this information then which node/vehicle is used based on shortest path because less nodes involved in transmission may save the power and network bandwidth as very crucial parameters in VANETS. The performance of A-AODV is evaluated in VANETS using VanetMobisim that generates traffic mobility traces specifically for VANETS, with different calculated parameters like Packet Delivery Ratio, End to End Packet Delays and Total Overload with varying Vehicles Speed, Nodes and Constant Bit Rate Sources.

VANETMOBISIM

VanetMobisim contains set of extensions to CANUMOBISIM [15], a framework for user mobility modeling. CANUMOBISIM due to its general purpose nature reduces levels of details in specific scenarios. VanetMobisim, therefore, provides higher degree of realism. VanetMobisim contains all of the features of CANUMOBISIM in addition to its own set of possibilities in simulating vehicular mobility.

VanetMobisim provides both macro-mobility and micro-mobility representations to define mobility models for the simulation. Macro mobility concerns with road topology, road structure (i.e., uni-bi directional, single-multi lane), speed limits and presence of traffic lights. The concept of micro mobility includes all aspects related to individual car speed and acceleration modeling

Characteristics

- It is an open source Mobility Model Generater
- Specific for VANETS
- Platform Independent Software
- Supports both micro and macro Mobility Specification
- Use XML code to specify different simulations.
- An important characteristic is that VanetMobisim has been really validated.

MOBILITY MODEL

In order to evaluate any routing protocol in VANETS the most important parameter is selection of realistic Mobility Model. It is concluded in [16] that protocol performance varies with the Mobility Models and traffic scenarios. Mobility Model reflects movements of mobile nodes within the simulated area during given simulation time. Mobility Models for MANETS have been largely studied in [17, 18], however there are some new Mobility Models specifically proposed for VANETS like [19, 20]. It is shown in some of the previous literature that choice of specific Mobility Model has significant effects on simulation results [21]. For this purpose a VANETS Mobility Model is used simulation. Manhattan [22] is a generated-map-based model, specifically introduced to simulate urban environments in VANETS.

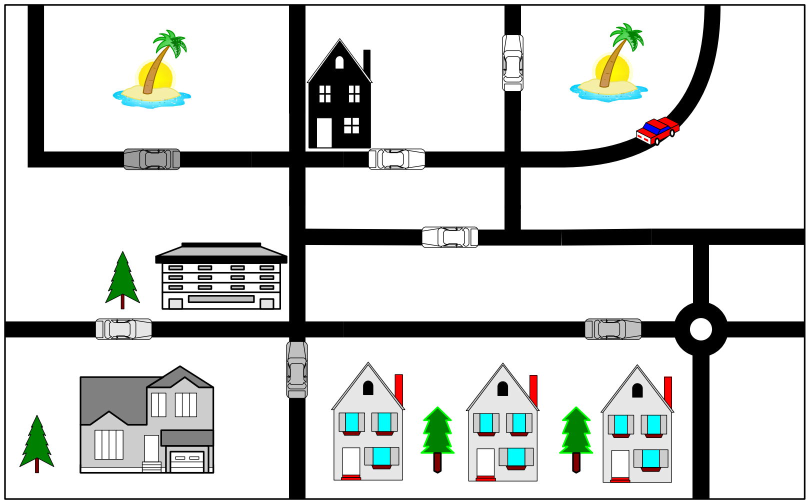

Fig. 2: Realistic urban motion pattern

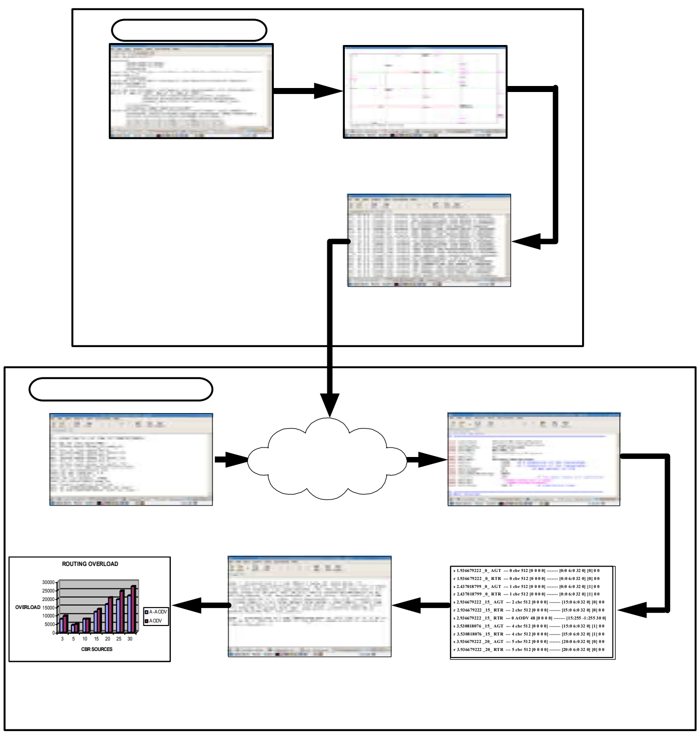

Fig. 3: Design methodology flow

In this paper, Manhattan mobility model is used as one of the very important VANET Mobility Model for VANETS simulations. In this model, there exist's several horizontal and vertical streets in the simulation fields. Each of these latter ones includes two lanes that allow mobile nodes (vehicles) to move in both directions. As in Fig. 2 at each intersection vertical and horizontal streets may cross with each other while lanes are not supposed to overlap in the simulation field.

This mobility model is generated through VanetMobisim with different parameters. Vehicle moving pattern is determined with the help of IDM-IM [23] Intelligent Driving model with Intersection Management. It regulates vehicle speed based on the movement of neighboring vehicles. Vehicles that follow this pattern either slow down or stop at intersections. However, in the presence of traffic lights they act accordingly.

VanetMobisim

Specifying Micro and
Macro mobility model
in VanetMobisim

DESIGN METHODOLOGY

The design methodology at Fig. 3 adopted to observe and evaluate the performance parameters of anycast based routing in vanets is depicted in Fig. 1. The mobility pattern of vehicles is obtained from VanetMobisim using Java and XML. The VanetMobisim generates a text file whose format is according to the network simulator (ns-2).

The network simulator is configured for Anycast AODV, AODV, mobility pattern, traffic generation, Agent, number of nodes, transmission range, topology, Routing Traces, MAC traces and area. TCL is used for configuration of network parameters. TCL produces traces and NAM files that are used for analysis and animation respectively. Trace files record information exchange between communicating nodes such as time, sender node, receiver node, type of packet, packet size etc.

The trace file generated is analyzed and observed using Awk language, a data driven programming language. Routing load, packet delivery ratio and delay of all the communication is yielded through Awk language. These parameters are plotted using Excel graph.

PERFORMANCE EVALUATION

In order to evaluate the performance of anycast based AODV routing protocol, one of very famous open source network simulator ns-2 and VanetMobisim as a validated vehicular traffic generator is used for this study. First, scenario characteristics are described briefly and then evaluation results are attempted which are obtained from these scenarios.

Scenario characteristics: This simulation consists of 5 horizontal and vertical streets with 25 intersections. Rectangular area covered by this simulation is 2000 x 2000 meter and parallel streets are separated by a distance of 500 meters. Traffic signals are employed at intersection of streets. Manhattan is used as Mobility Model in this simulation, speed of mobile nodes/vehicles are set to 70 km/h in varying number of mobile nodes; On the other hand when speed of mobile nodes are changed, at that time the number of nodes are restricted to 100 in each simulation. 802.11 is used as MAC layer protocol with transmission range of 250 meters of each node

Performance parameters: To evaluate the performance of A-AODV routing protocol, three main and very important performance parameters are considered:

Packet delivery ratio: Ratio of data packets reached to the packets sent by the traffic sources.

Routing load: Total number of packets required to construct and maintain routes between source and destination mobile nodes.

End to end delay: It computes average delay in receiving correct data packets generated by the sources.

Varying maximum speed of vehicles

Packet delivery ratio: In order to evaluate the performance of A-AODV protocol by varying maximum speed of vehicles, it is evident from Fig. 4 that Packet Delivery Ratio of A-AODV has significant improvement over packet delivery ratio of AODV both in low and high vehicles speed varying form 20 to 110 km/h. At the speed of 20 km/h (Low speed) packet delivery ratio of A-AODV reaches to 0.38 in contrast to 0.00 of AODV protocol. Similarly, at 110km/h (High speed) AODV success ratio is 0.12 compared to 0.25 (i.e., double of AODV) of A-AODV protocol. As the speed increases from 20km/h to 30, 40 and 50 km/h packet delivery ratio increases in AODV but still less than A-AODV i.e., 0.34 to 0.25 in contrast to 0.15 to 0.20 of AODV protocol. When the speeds of vehicles are above 70 km/h, packet delivery ratio increases to maximum of 0.45 at 90 and 0.4 at 100 km/h having difference of 0.10 in case of AODV protocol. In all cases, the packet delivery ratio of AODV protocol is significantly better than AODV protocol.

End to end delay: Average end to end delay is calculated and analyzed at Fig. 5 by varying maximum speed of the vehicles. It is clear from calculated scripts that average end to end delay of A-AODV is relatively low than that of AODV protocol. Results in the given figure shows that at low speeds of 30, 40 and 50 km/h average end to end delay is with in 90 to 40s in response to 183 to 321s of AODV, with difference of 50 to 200% that is a significant huge difference between the possible delays. The highest packet delivery ratio of AODV is at 80 km/h as per figure 1(a), so average end to end delay of 340s is also highest at 80 km/h with difference of 40s with A-AODV protocol. Similarly, at 90, 100 and 110 km/h average end to end delay calculated by the graph are 166, 136 and 150s of AODV with difference of 30, 46 and 95s of A-AODV protocol.

Routing load: Figure 6 shows the simulation results on the aspect of routing load in terms of packets to recover, maintain and rebuild routes in the given simulation time. It is proved that routing load of

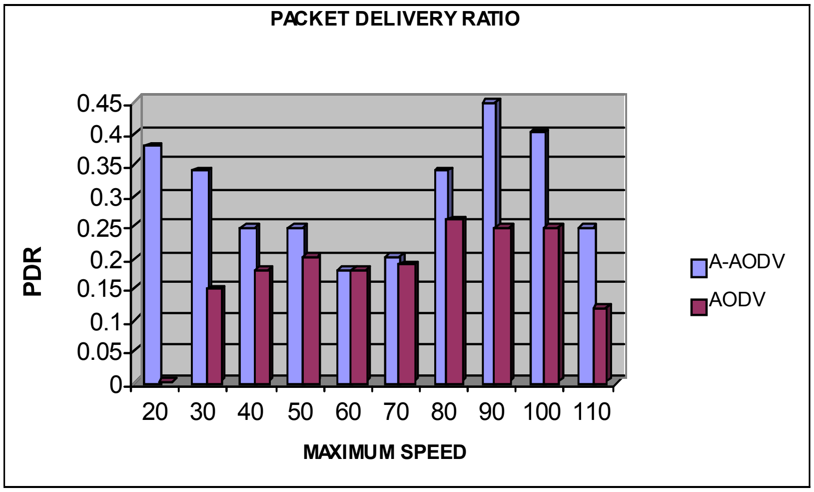

Fig. 4: Packet delivery ratio

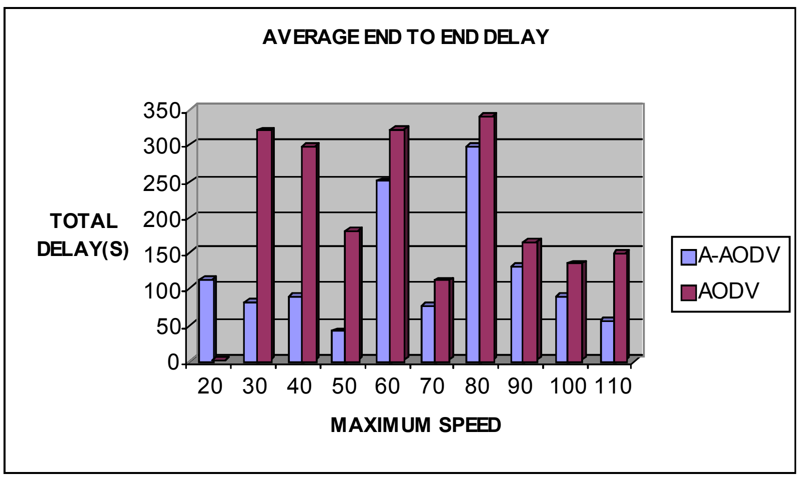

Fig. 5: Average end to end delay

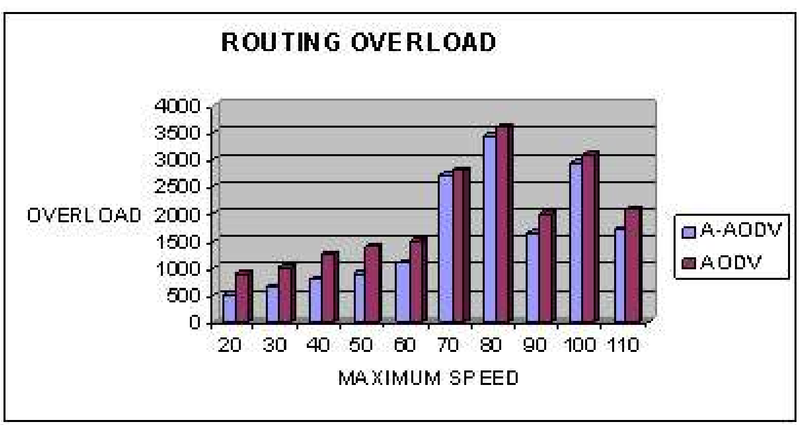

Fig. 6: Routing overload

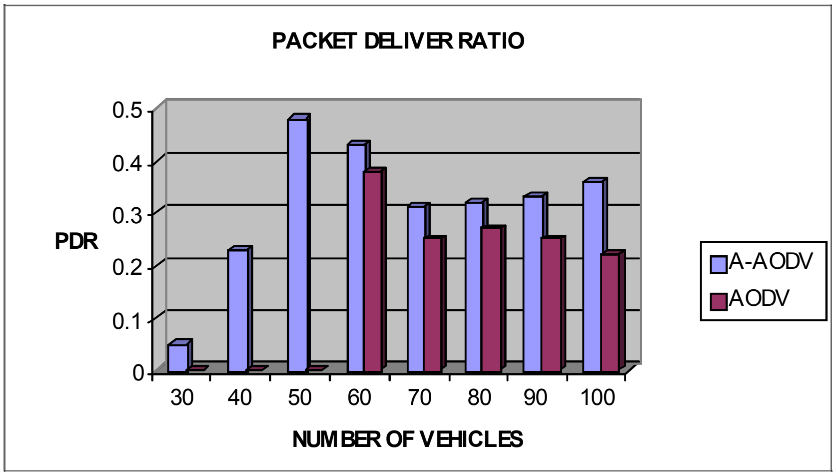

Fig. 7: Packet deliver ratio

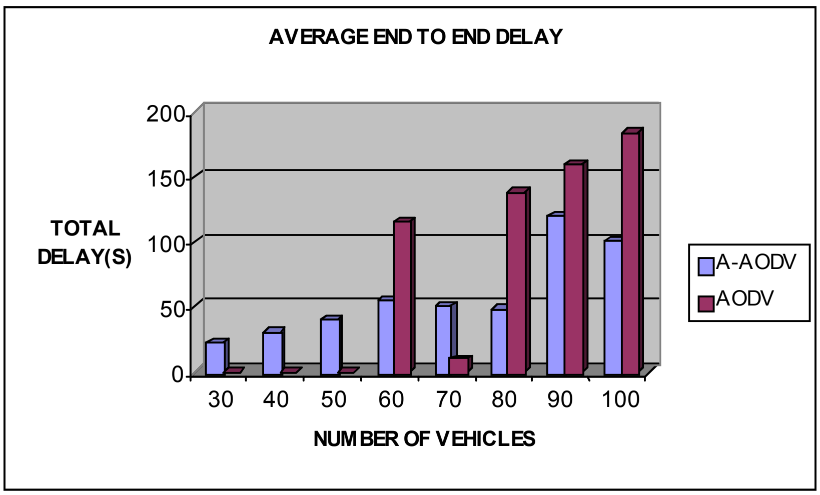

Fig. 8: Average end to end delay

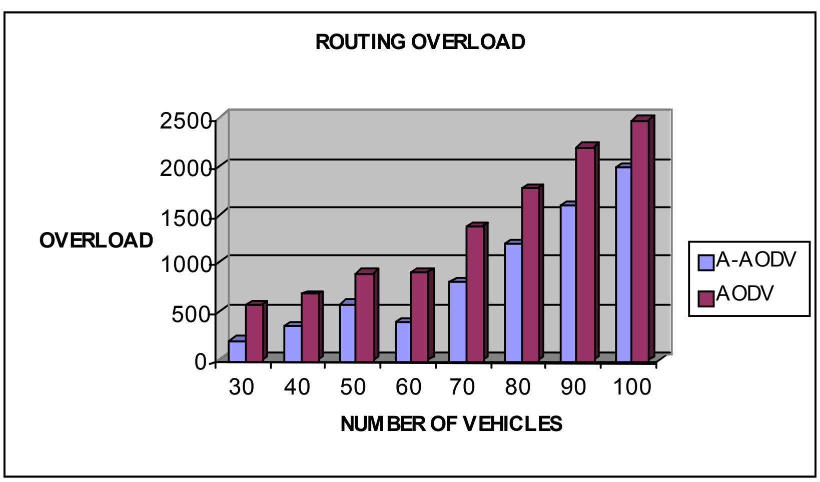

Fig. 9: Routing overload

A-AODV is improved than AODV in all of the given scenarios. At the speed of 20 to 60 km/h routing load of A-AODV is within 500 to 1100 in response to 900 to 1500 of AODV protocol. As the maximum speed increases from 60 km/h routing load increases with increase in mobility in both protocols, however routing load of A-AODV at maximum speed is continuously low than AODV with difference of 168, 331, 151 and 400 packets at the speed of 80, 90, 100 and 110 km/h, respectively.

Varying number of mobile vehicles

Packet delivery ratio: By varying number of mobile vehicles Packet Delivery Ratio is demonstrated at Fig. 7. This parameter is used to evaluate the packet delivery ratio in both low and high traffic densities. Results show that packet delivery ratio of A-AODV is dramatically better than AODV specifically at low traffic density. Analysis clearly demonstrated that packet delivery ratio remains zero of mobile vehicles in AODV with contrast to 0.05, 0.23 and 0.48 at 30, 40 and 50 number of mobile vehicles in A-AODV protocol. This is due to fact that AODV keeps track of single route discovery packet to only one destination, however on the other hand A-AODV sends to a group of at least three members out of which, one with minimum hop count is selected on which packets traversed the path. In low traffic density it may be possible in case of AODV that require vehicle/node is out of range of source vehicle/node that is not reached by hop to hop communication in a result there is no response found in low traffic density. As the traffic density is increased above 50, packet delivery ratio is increased in AODV but it is obvious from Fig. 7 that packet delivery ratio of A-AODV is still better than AODV at 60, 70 and 80 number of mobile vehicles in given area with difference of 0.5 of AODV protocol. When number of vehicles are varied to 90 to 100 vehicles the difference of packet delivery ratio of A-AODV is reaches to 0.8 to 0.14, is the maximum difference of packet delivery ratio of both protocols.

End to end delay: Figure 8 gives the average end to end delay by varying vehicle densities. As previously depicted that from 30 to 50 vehicles, packet delivery ratio of AODV remains zero so average end to end delay of A-AODV is 20 to 40s in response to 0 delay of AODV. At 60, 70 and 80 number of mobile vehicles improved average end to end delays is 55, 50 and 48s with difference of 60, 50 and 90s of AODV protocol. Similarly at 90 and 100 mobile vehicles total delay is 120 and 100s in response to 159 and 184s of AODV protocol. In all of varying traffic densities average delay is improved than AODV due to A-AODV's property of selecting the route out of which contains less number of hop count to the requested destination.

Routing load: Routing overload by varying number of mobile vehicles is plotted in Fig. 2 (c). It is clear from figure that routing load of A-AODV in both low and high traffic densities is less than that of AODV protocol. At low traffic density with difference of approximately 300 packets from 30 to 60 mobile vehicles is calculated by AODV protocol. As the number of mobile vehicles is increased the control overload of A-AODV is 800 to 2000 with difference of approximately 500 packets from AODV protocol. Hence it is shown in the results that as the number of vehicles is increased routing load is also increased, because, more vehicles become part of route discovery, route maintenance and route rebuilding when link is broken due to vehicle mobility, but throughout the varying parameter routing load of A-AODV is continuously lower than AODV protocol.

Varying number of mobile cbr sources

Packet delivery ratio: The next varied parameter is number of CBR sources. To start with, initially 03 CBR sources and carried up to 30 CBR sources in the end. In Fig. 10 Packet Delivery Ratio of both protocols is illustrated by varying number of CBR sources. It is drawn from figure that packet delivery ratio is improved in case of A-AODV than AODV both where number of CBR sources are less than 15 and greater than 15. Packet delivery ratio at 3, 5 and 10 number of CBR sources are 0.22, 0.19 and 0.25 with difference of 0.12, 0.6 and 0.27 than that of AODV protocol. Similarly at 15 number of CBR sources packet delivery ratio of A-AODV is also better than AODV protocol with difference of 0.14 as the number of sources are increased form 15 to 20, 25 and 30. There is a significant improvement in packet delivery ratio of A-AODV protocol of 0.26, 0.28 and 0.31 with difference of 0.16, 0.17 and 0.20 of AODV protocol. These is due to the fact that when numbers of CBR sources are increased anycast group members are also increased and become a candidate to receive and reply to route request generated by A-AODV CBR sources with in anycast group address.

End to end delay: Average end to end delay is demonstrated in Fig. 10 by varying number of CBR sources. When number of CBR sources are increased there is an increase channel access and more vehicles tends to generate traffic for channel allocation, as a result there is an increase in packet delay due to heavy requests generated by CBR sources. This effect is also reflected in given results that when number of CBR

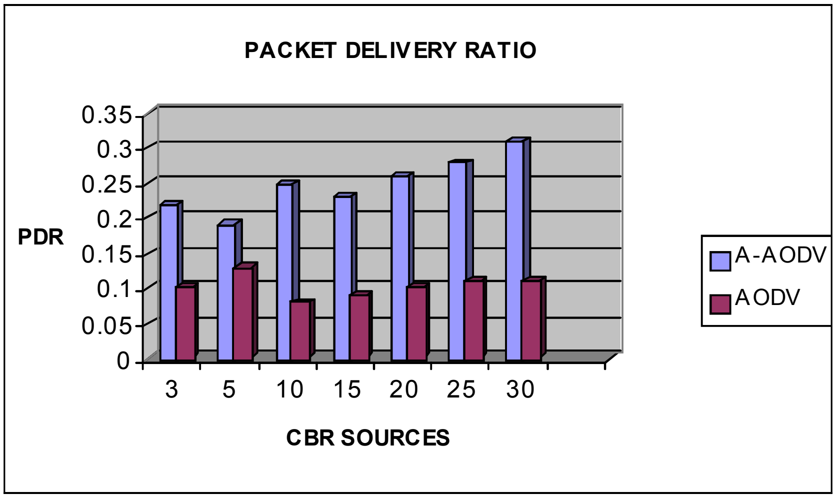

Fig.10: Packet delivery ratio

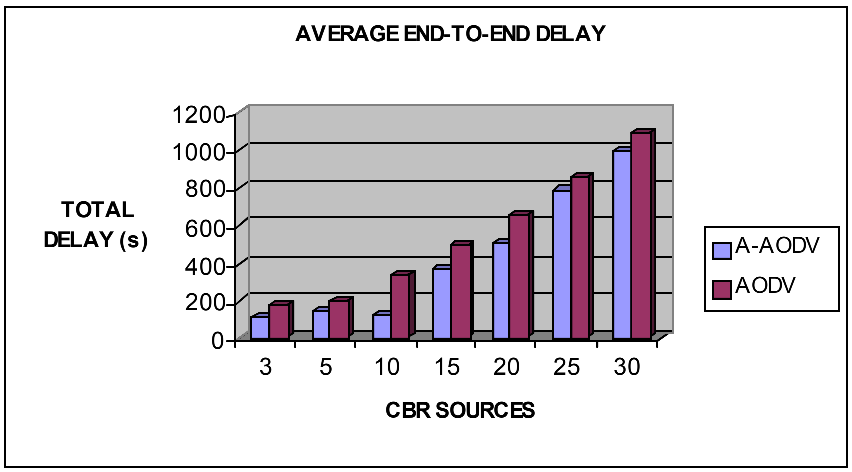

Fig. 11: Average end-to-end delay

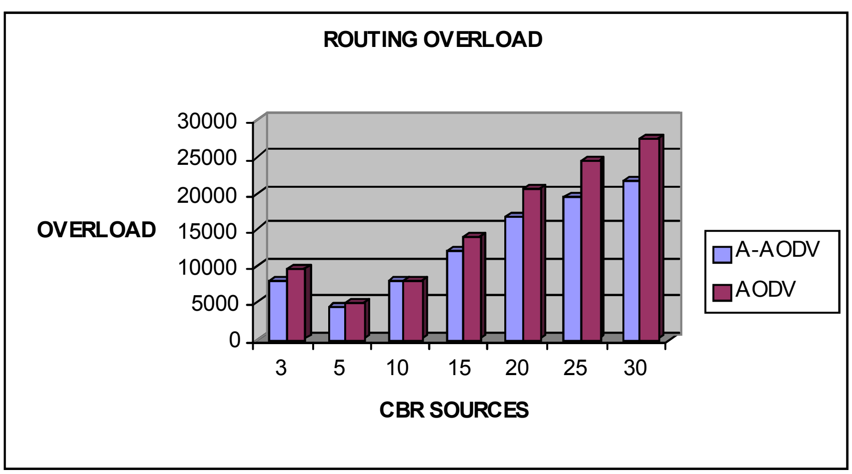

Fig. 12: Routing overload

sources are 3, 5 and 10 their end to end delay of A-AODV protocol is 110, 143 and 124s with difference of 70, 60 and 210s of AODV protocol. As the number of CBR sources is increased from 10 to 15, 20, 25 and 30 there is an increased average end to end delay in both of the protocols. However, there is a better improvement in the total delay of A-AODV in increased number of CBR sources i.e., 15, 20, 25 and 30 with difference of 136, 134, 62 and 100s of AODV protocol.

Routing load: Routing load at various number of CBR sources is shown in Fig. 11. It is clear from the given figure that routing load by increasing number of CBR sources in A-AODV is better than AODV protocol in all taken situations. This is similar to the case as where delay is increased by increasing number of CBR sources due to high channel access at the same time. Routing load is also increased as more packets containing route requests may populate the wireless channel and due to longer delay there should be more expired links for routes. As it is seen in given figure that improved routing load of A-AODV at 3, 5 and 10 number of CBR sources are 8000, 4441 and 7870 with difference of 1579, 550 and 130 of AODV protocol. When the CBR sources are increased to 15, 20, 25 and 30, there is a continuous increase in routing load of both protocols. At 20, 25 and 30 number of CBR sources the routing load of A-AODV is 16595, 19496 and 21837 in response to 20595, 24500 and 27500 of AODV protocol . So, it is concluded from results that total routing load of A-AODV protocol is better than AODV protocol by varying number of CBR source

CONCLUSION

In this study a MANETS based anycast protocol is used to make it adaptive for new emerging Vehicular Adhoc Networks (VANETS) applications. VANETS open a wide range of applications i.e., (Safety and Comfort Applications) and will play a key role in future radio enabled automotive Vehicle Networks. Using Manhattan Mobility Model anycast based AODV protocol were tested on VANETS using different parameters like Packet Delivery Ratio, End to End Delay and Routing Load by varying number of vehicles, maximum speed and CBR Sources. Traffic traces were generated for VANETS using VanetMobisim, a validated simulator for vehicular networks using IDM-IM driving model, which includes both macro and micro mobility representations to define Mobility Model. It is concluded from this research that using on demand anycast protocol Packet Delivery Ratio, End to End Delay and Total Routing Load surprisingly outperforms unicast based Adhoc on Demand protocol in VANETS. As VANETS also have its own characteristics as well, i.e., high node mobility, minimum transmission range and low latency due to which its routing mechanism should be well aware from these mixed features of VANETS. Conclusion extracted from this work is that in realistic urban motion pattern, both in high and minimum speeds Packet Delivery Ratio. Packet Delay and Routing Load in A-AODV performs well than AODV protocol, which is a powerful candidate to use in providing comfort applications in VANETS. Similarly, in low and high vehicular density and CBR sources all of the performance parameters show exceptionally improved results than unicast AODV compared to anycast protocol.

REFERENCES

1. Marco Conti and Silvia Giordano, 2007. Multihop AdhocNetworking: The Reality. In IEEE Comm. Magazine, 45 (4): 88-95.
2. Wischhof, L., A. Ebner and H. Rohling, 2005. Information Dissemination in Self Organizing Intervehicle Networks. IEEE Transaction on Intelligent Transportation Systems, Vol: 6 (1).
3. Lohmann, W., J. Ebert, and M. Grade, 2005. Is the IEEE 802.11 MAC Layer suitable for Car to Car Communications. In 1st Workshop on Wireless Vehicular Communications and Services for Breakdown Support and Car Maintenance (W-CarsCare'05), Cyprus.
4. Torrent-Moreno, M., M. Killat, and H. Hartenstein, 2005. The Challenge of robust Inter-Vehicle Communications. In 62nd IEEE Semiannual Vehicular Technology Conference (VTC-Fall), Dallas, Texas, 1: 319-323.
5. Jakub Jakubiak and Yevgeni, State of the art and research challenges for VANETs. Koucheryavy Tampere University of Technology, Tampere, Finland.
6. Kosh, T., 2005. Technical Concept and Prerequisites of Car2Car Communication. 5th European Congress and Exhibition on ITS Hannover, Germany.
7. Davis, J., A. Fagg, and B. Levine, 2001. Wearable computers as packet transport mechanisms in highly-partitioned ad-hoc networks. Intemational Symposium on Wearable Computing.
8. Chen, Z.D., H. Kung, and D. Vlah, 2001. AdhocRelay Wireless Networks over Moving Vehicles on Highways. MobiHoc, http:/www.ietf. org/html.charters/manet-charter.html.

9. Charles E. Perkins, 1998. AdhocOn Demand Vector (AODV) Routing. Internet draft-ietf-manet-aodv-01.txt, Work in Progress.
10. Josh Broch, David A. Maltz, David B. Johnson, Yih-Chun Hu and Jorjeta Jetcheva, 1998. A performance Comparison of Multi-hop Wireless AdhocNetwork Routing Protocols. Mobicom'98, Dallas Texas, pp: 25-30.
11. Wang, S.Y., C.C. Lin, Y.W. Hwang, K.C. Tao, and CL. Chou, 2005. A practical routing protocol for vehicle-formed mobile Adhocnetworks on the roads. Its Proceedings of the Ash IEEE International Conference on Intelligent Transportation,6vste,ns, pp: 161-165.
12. Namboocfiri, V., M. Agarwal, and L. Gao, 2004. A study on the feasibility of mobile gateways for vehicular ad-hoc networks. In Proceedings of the First International Workshop on Vehicular AdhocNetworks, pp: 66-75.
13. Fufler, H., M. Mauve, H. Hartenstefn, M. Kasemann, and D. Voflmer, 2003. Location based routing for vehicular adhoc networks. ACM SIGMOBILE Mobile Computing and Communication Review, 7 (1): 47-49.
14. Hoh, C. and C. Wang, 2006. Anycast Routing Protocol using Swarm Intelligence for Ad hoc Pervasive Network. IWCWMC 06.
15. CANU Project, http://canu.informatik.uni-stuttgart.de vistited at 01/02/2010].
16. Fufler, H., M. Mauve, H. Hartenstefn, M. Kasemann, and D. Voflmer, 2003. Location based routing for vehicular adhoc networks. ACM SIGMOBILE Mobile Computing and Communication Review, 7 (1): 47-49.
17. Karp, B. and H.T. Kung, 2000. GPSR: Greedy perimeter stateless routing for wireless networks. In proceeding of the ACM/IEEE International conference on Mobile Computing and Networking (MOBICOM).
18. Liu, G., 0.-S. lee, 8.-C. Sect, C.H. Foh, K.J. Wong, and K.-K. Lee, 2004. A routing strategy toy metropolis vehicular communications. In International conference on Information Networking (ICOIN), pp: 134-143.
19. Fufler, H., M. Mauve, H. Hartenstefn, M. Kasemann, and D. Voflmer, 2003. Location based routing for vehicular adhoc networks. ACM SIGMOBILE Mobile Computing and Communication Review, 7 (1): 47-49.
20. Lochert, C., H. Hartenstein, J. Tian, D. Herrmann, H. FORler. and M. Mauve, 2003. A routing strategy for vehicular Adhocnetworks in city environments. In Proceedings of IEEE Intelligent Vehicles Symposium (1V2003), pp: 156-161.
21. Liu, G., O.-S. Lee, 8.-C. Sect, C.H. Foh, K.J. Wong, and K.-K. Lee, 2004. A routing strategy for metropolis vehicular communications. In International conference on Information Networking (ICOIN), pp: 134-143.
22. l,is, C.R. and M. Gerla, 1997. Adaptive clustering for mobile wireless networks. IEEE Journal of Selected Areas in Communications, 15 (7): 1265-1275.
23. Edwards, R., 2005. Performance evaluation of routing protocols in vehicular adhoc networks. The International Journal of Adhocand Ubiquitous Computing, 1 (1/2): 80-91.