Performance Comparision of AODV, AOMDV, OLSR, DSR and GSR Routing Protocols in VANET

Mrs. Uma Nagaraj
Department of Computer Engg.
MAE, Alandi
Pune, India

Ms. Poonam P. Dhamal
Department of Computer Engg.
MAE, Alandi
Pune, India

***Abstract*—VANET (Vehicular Adhoc Network) research field is growing very fast. It has to serves a wide range of applications under different scenario (City, Highway). It has various challenges to adopt the protocols that can serve in different topology and scenario. This paper presents a comparative study of the adhoc routing protocols. The main objective of Vehicular Ad-Hoc Networks is to build a robust network between mobile vehicles so that vehicles can talk to each other for the safety of human beings. VANET hits the protocol's strength due to its highly dynamic features, thus in testing a protocol suitable for VANET implementation we have selected different routing protocols In this paper, an attempt has been made to compare five well know protocols AODV, AOMDV, OLSR, DSR and GSR by using two performance metrics packet delivery ratio and average end to end delay. The comparison has been done by using simulation tool NS2 which is the main simulator, NAM (Network Animator) and excel graph which is used for preparing the graphs from the trace files.**

***Keywords*— VANET, DSR, OLSR, AODV, LAR.**

I. Introduction

VANET is a special case of the general MANET to provide communications among nearby vehicles and between vehicles and nearby fixed roadside equipments. VANET networks, nodes are characterized by high dynamic and mobility, in addition to the high rate of topology changes and density variability [1]. VANETs are a subset of MANETs (Mobile Ad-hoc Networks) in which communication nodes are mainly vehicles. As such, this kind of network should deal with a great number of highly mobile nodes, eventually dispersed in different roads. In VANETs, vehicles can communicate each other (V2V, Vehicle-to-Vehicle communications). They can connect to an infrastructure (V2I, Vehicle-to-Infrastructure) or Infrastructure to Vehicle (I2V) to get some service. This infrastructure is assumed to be located along the roads.

Some motivations of the promising VANET technology include, Increase traveler safety, Enhance traveler mobility, Decrease travelling time, Conserve energy and protect the environment, Magnify transportation system efficiency, Boost on-board luxury but it is not enough many other services can be served by using this technology. The creation of Vehicular Ad Hoc Networks (VANET) has spawn much interest all over the world, in German there is the FleetNet[2] project and in Japan the ITS(Intelligent Transportation System) project.

Vehicular ad hoc networks are also known under a number of different terms such as Inter Vehicle communication (IVC), Dedicated Short Range Communication (DSRC) or Wireless Access in Vehicular Environments (WAVE) [3]. The goal of most of these projects is to create new network algorithms or modify the existing for use in a vehicular environment. In the future vehicular ad hoc networks will assist the drivers of vehicles and help to create safer roads by reducing the number of automobile accidents. Vehicles equipped with wireless communication technologies and acting like computer nodes will be on the road soon and this will revolutionize the concept of travelling. VANETs bring lots of possibilities for new range of applications which will not only make the travel safer but fun as well.

II. Routing Protocols

In VANET, the routing protocols are classified into five categories: Topology based routing protocol, Position based routing protocol, Cluster based routing protocol, Geo cast routing protocol and Broadcast routing protocol. These protocols are characterized on the basis of area / application where they are most suitable. Fig. 1 shows the different routing protocols in VANET.

A. Topology Based Routing Protocols

These routing protocols use links information that exists in the network to perform packet forwarding. They are further divided into Proactive and Reactive.

1) Proactive routing protocols

The proactive routing means that the routing information, like next forwarding hop is maintained in the background irrespective of communication requests. The advantage of proactive routing protocol is that there is no route discovery since the destination route is stored in the background, but the disadvantage of this protocol is that it provides low latency for real time application. A table is constructed and maintained within a node. So that, each entry in the table indicates the next hop node towards a certain destination. It also leads to the maintenance of unused data paths, which causes the reduction in the available bandwidth. The various types of proactive routing protocols are: LSR, FSR.

2) Reactive/Ad hoc based routing

Reactive routing opens the route only when it is necessary for a node to communicate with each other. It maintains only the routes that are currently in use, as a result it reduces the burden in the network. Reactive routing consists of route discovery phase in which the query packets are flooded into the network for the path search and this phase completes when route is found. The various types of reactive routing protocols are AODV, PGB, DSR and TORA

B. Position Based Routing Protocols

Position based routing consists of class of routing algorithm. They share the property of using geographic positioning information in order to select the next forwarding hops. The packet is send without any map knowledge to the one hop neighbour which is closest to destination. Position based routing is beneficial since no global route from source node to destination node need to be created and maintained. Position based routing is broadly divided in two types: Position based greedy V2V protocols, Delay Tolerant Protocols.

C. Cluster Based Routing

Cluster based routing is preferred in clusters. A group of nodes identifies themselves to be a part of cluster and a node is designated as cluster head will broadcast the packet to cluster. Good scalability can be provided for large networks but network delays and overhead are incurred when forming clusters in highly mobile VANET. In cluster based routing virtual network infrastructure must be created through the clustering of nodes in order to provide scalability. The various Clusters based routing protocols are COIN and LORA_CBF.

D. Geo Cast Routing

Geo cast routing is basically a location based multicast routing. Its objective is to deliver the packet from source node to all other nodes within a specified geographical region (Zone of Relevance ZOR). In Geo cast routing vehicles outside the ZOR are not alerted to avoid unnecessary hasty reaction. Geo cast is considered as a multicast service within a specific geographic region. It normally defines a forwarding zone where it directs the flooding of packets in order to reduce message overhead and network congestion caused by simply flooding packets everywhere. In the destination zone, unicast routing can be used to forward the packet. One pitfall of Geo cast is network partitioning and also unfavorable neighbors, which may hinder the proper forwarding of messages. The various Geo cast routing protocols are IVG, DG-CASTOR and DRG.

E. Broadcast Routing

Broadcast routing is frequently used in VANET for sharing, traffic, weather and emergency, road conditions among vehicles and delivering advertisements and announcements. The various Broadcast routing protocols are BROADCOMM, UMB, V-TRADE, and DV-CAST.

III. RESULT

A. Selected Routing Protocols

In this paper four routing protocols are selected for the comparison and performance evaluation.

1) Ad hoc On-Demand Distance Vector (AODV) Routing Protocol

In AODV[7] (Perkins, 1999) routing, upon receipt of a broadcast query (RREQ), nodes record the address of the node sending the query in their routing table. This procedure of recording its previous hop is called *backward learning*. Upon arriving at the destination, a reply packet (RREP) is then sent through the complete path obtained from backward learning to the source. The AODV algorithm enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication.

AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the Bellman-Ford "counting to infinity" problem offers quick convergence when the adhoc network topology changes (typically, when a node moves in the network). When links break, AODV causes the affected set of nodes to be notified so that they are able to invalidate the routes using the lost link. Route Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs) are message types defined by AODV [7].

2) Dynamic Source Routing

The Dynamic Source Routing protocol (DSR) [8] is (Perkins, 2007), an on demand routing protocol. DSR is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. Using DSR, the network is completely self-organizing and self-configuring, requiring no existing network infrastructure or administration. The DSR protocol is composed of two main mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network:

Route Discovery is the mechanism by which a node S wishing to send a packet to a destination node D obtains a source route to D. Route Discovery is used only when S attempts to send a packet to D and does not already know a route to D.

Route Maintenance is the mechanism by which node S is able to detect, while using a source route to D, if the network topology has changed such that it can no longer use its route to D because a link along the route no longer works. When Route Maintenance indicates a source route is broken, S can attempt to use any other route it happens to know to D, or it can invoke Route Discovery again to find a new route for subsequent packets to D. Route Maintenance for this route is used only when S is actually sending packets to D.

In DSR Route Discovery and Route Maintenance each operate entirely" on demand".

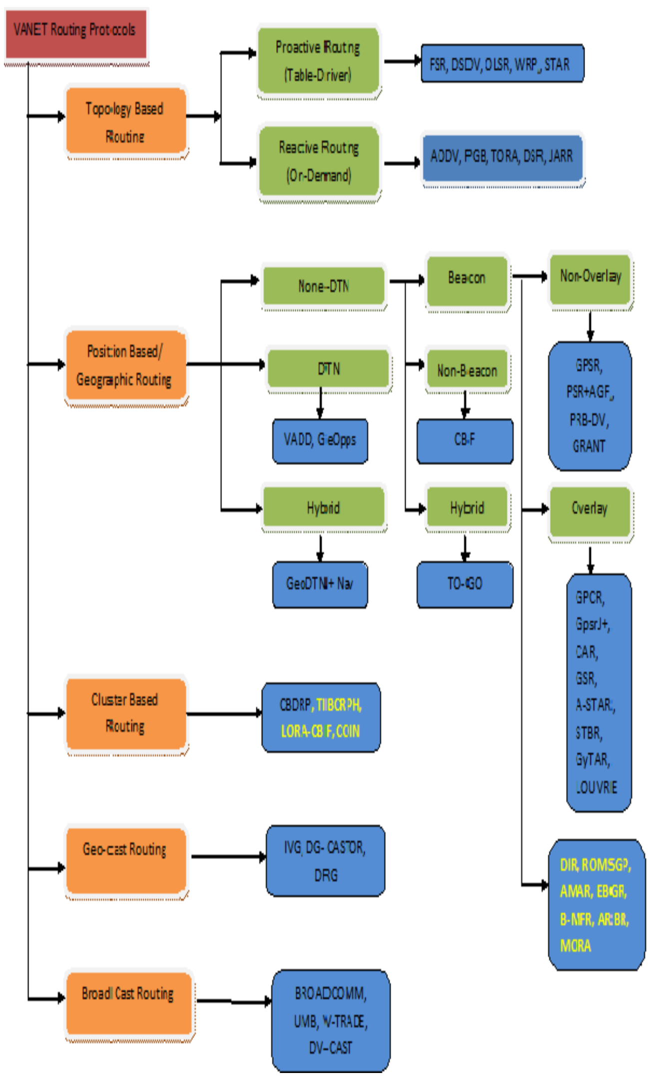

Fig. 1 Routing Protocols in VANET

3) Ad hoc On-demand Multipath Distance Vector (AOMDV)[9]

AOMDV protocol is an extension based on Ad hoc On demand Distance Vector (AODV). However, the performance of AOMDV is much better than AODV [2]. AOMDV can find node-disjoint paths and link-disjoint paths when discovering routes. Because the conditions of node-disjoint paths are much stricter than that of link-disjoint paths, the number of node-disjoint paths is less than that of link-disjoint paths. Thus link-disjoint policy is used more popular. After multiple paths are found, AOMDV will store the paths in routing table. The source node will select one established path according to the timestamp. The first selected forward path is the earliest established one. For route maintenance, when a route failure is detected, packets can be forwarded through other paths. To ensure the freshness of routes, timeout mechanism is adopted. The HELLO messages are broadcasted to eliminate expired routes.

As well as AODV, AOMDV is an on-demand routing protocol. When a source node needs a route to a destination, and there are not available paths, the source node will broadcast RREQ routing packet to initiate a route discovery process. Other nodes may receive duplicate RREQ packets due to flooding. When this case occurs, other nodes will establish or update multiple reverse paths according to different first hops of RREQ packets. However, AODV will establish a reverse path using the first RREQ packet and other duplicate RREQ packets are discarded. After reverse paths establishing, intermediate nodes will search their routing tables for an available forward path to destination node. If the path exists, an RREP packet will be sent back to source node along a reverse path and the RREQ packet will be discarded. If the path does not exist and the intermediate node does not forward other duplicate RREQ packets, the RREQ packet will be broadcasted. When destination node receives RREQ packet, it will establish or update reverse paths, too. However, destination node will reply with looser policy to find multiple link disjoint paths. According to the reply policy, the destination node will reply all RREQ packets from different neighbors although the RREQ packets posses same first hop. Different RREP packets will be sent back through different neighbors, which can ensure link-disjoint path establishment. After passing by different neighbors, RREQ packets will be sent to source node along link-disjoint reverse paths. When intermediate and source nodes receive RREP packets, they will establish loop-free and link-disjoint paths to destination node according to different first hops of RREP packets. For intermediate nodes that are shared by different link-disjoint paths, they will check if there are unused reverse paths to the source node. If so, one reverse path will be selected to forward the current RREP packet; otherwise, the packet will be discarded.

4) *Geographic Source Routing [10]*

Geographic Source Routing (GSR) uses a map and a position-based address scheme to send packets to the destination. As before, the source node uses a location service to acquire the position of the destination node. Now the source node evaluates the shortest path between itself and the destination. All junctions on this shortest path are added to the header of the packet like in DSR. The Packet is forwarded from street to junction, from junction to junction and from junction to street in a position-based routing (PBR) fashion. Therefore every node continuously sends beacons with its own position and its node id. With the position information of the beacon every node can build a one-hop neighbor table. So a receiving node can select the neighbor with the highest progress to the position of the next junction as the next hop. After reaching the junction, the junction is deleted from the packet header and the position of the next one is used as new destination. After the last junction the position of the destination node is chosen. When the packet is forwarded in junction-to-junction mode and there is no node closer to the next junction than the current node, a global position-based routing is started. In this case the position of the destination node can directly be used. This is equivalent to the greedy mode in GPSR.

5) *Optimized Link State Routing Protocol (OLSR)*

The Optimized Link State Routing Protocol (OLSR) [11] is developed for mobile ad hoc networks. It operates as a table driven, proactive protocol, i.e. exchanges topology information with other nodes of the network regularly. Each node selects a set of its neighbor nodes as "multipoint relays" (MPR). In OLSR, only nodes, selected as such MPRs are responsible for forwarding control traffic, intended for diffusion into the entire network. MPRs provide an efficient mechanism for flooding control traffic by reducing the number of transmissions required. Nodes, selected as MPRs, also have a special responsibility when declaring link state information in the network. Indeed, the only requirement for OLSR to provide shortest path routes to all destinations is that MPR nodes declare link-state information for their MPR selectors. Additional available link-state information may be utilized, e.g., for redundancy. Nodes which have been selected as multipoint relays by some neighbor node(s) announce this information periodically in their control messages. Thereby a node announces to the network, that it has reachability to the nodes which have selected it as an MPR. In route calculation, the MPRs are used to form the route from a given node to any destination in the network. Furthermore, the protocol uses the MPRs to facilitate efficient flooding of control messages in the network.

B. Simulation Based Analysis using Network Simulator (NS-2)

In this section we have described about the tools and methodology used in our paper for analysis of adhoc routing protocol performance i.e. about simulation tool, Simulation Setup(traffic scenario, Mobility model) performance metrics used and finally the performance of protocols is represented by using excel graph.

1) Simulation Tool

In this paper the simulation tool used for analysis is NS-2[12] which is highly preferred by research communities. NS is a discrete event simulator targeted at networking research. Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. NS2 is an object oriented simulator, written in C++, with an OTcl interpreter as a frontend. This means that most of the simulation scripts are created in Tcl(Tool Command Language). If the components have to be developed for ns2, then both tcl and C++ have to be used.

2) Simulation Setup

The table1 below list the details of simulation setup used in this simulation based analysis.

Table 1: Simulation Setup

Platform	Windows Vista Ultimate (using Cygwin 1.7)
NS version	Ns –allinone-2.29
Simulation time	300 s
Topology size	4000 m x 7000 m
Routing Protocols	AODV, AOMDV, OLSR, DSR and GSR.
Traffic Type	TCP
Data type	CBR
Data Packet Size	512 bytes
MAC protocol	IEEE 802.11
Radio Propagation Model	Two Ray Ground

C. Simulation Metrics used

The following metrics are used in this paper for the analysis of AODV, AOMDV, OLSR, DSR and GSR routing protocols.

1) Packet Delivery Ratio (PDR): It is the fraction of generated packets by received packets. That is, the ratios of packets received at the destination to those of the packets generated by the source. As of relative amount, the usual calculation of this system of measurement is in percentage (%) form. Higher the percentage, more privileged is the routing protocol.

2) Average End-to-End Delay (E2E Delay):

It is the calculation of typical time taken by packet (in average packets) to cover its journey from the source end to the destination end. In other words, it covers all of the potential delays such as route discovery, buffering processes, various in-between queuing stays, etc, during the entire trip of transmission of the packet. The classical unit of this metric is millisecond (ms). For this metric, lower the time taken, more privileged the routing protocol is considered.

D. Simulation Results

Figure 2 represents the performance of AODV, AOMDV, OLSR, DSR and GSR in terms of packet delivery ratio.

Figure 3 represents the performance of AODV, AOMDV, OLSR, DSR and GSR in terms of Average End to End Delay vs. Node Low Density.

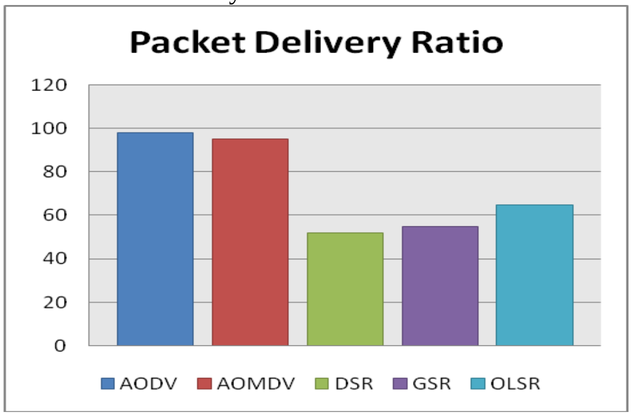

Fig. 2 PDR vs. Node Density at city low density

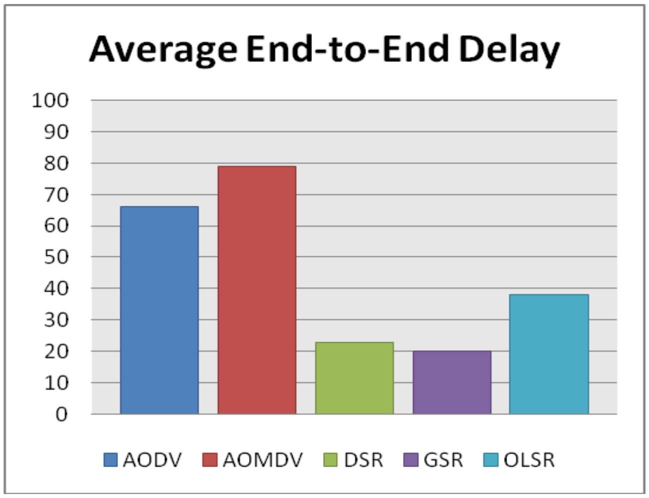

Fig. 3 Average E2E Delay (in ms) vs. Node Density at city low density.

Table 2 Connection pattern

Variable	Value
No. of nodes	12
Maximum Connections	8

IV. Conclusions

In this paper the analysis of adhoc routing protocol is done in realistic scenario of VANET. After doing the simulation based analysis of AODV, AOMDV, OLSR, DSR, and GSR in realistic scenario of VANET we can see that the performance of AODV in terms of PDR is very good approximate 98%. The Average end to end delay of AODV is very high. The DSR performs well in both of the scenario in terms of Avg. end to end delay. Packet delivery Ratio of AODV is better than other three protocols so we can say this protocol is applicable to carry sensitive information in VANET but it fails for the scenario where transmission time should be very less as it has highest end to end delay. For quick transmission DSR performs well but not suitable to carry information as packet loss is very high. The performance of AOMDV is average. In our comparative simulation, GSR incorporated with our scheme demonstrated excellent improvement in the success rate and efficiency of data packet delivery, while maintaining reasonably end-to-end delay. This is due to the scheme's ability to better avoid local maximum, and enable packets encountering local maximum to be recovered more successfully.

References

[1] Y. Zang, L. Stibor, and H. J. Reumerman, "Neighborhood evaluation of vehicular ad-hoc network using IEEE 802.11p," in Proceedings of the 8th European Wireless Conference, p. 5, Paris, France, 2007.

[2] IEEE Draft P802.11p/D2.0, November 2006. Wireless Access in Vehicular Environments (WAVE).

[3] Hartenstein, H., et al., "Position-Aware Ad Hoc Wireless Networks for Inter-Vehicle Communications: The FleetNet Project," *In Proceedings MobiHoc'01: 2nd ACM Int'l. Symp. Mobile Ad Hoc Networking & Computing*, New York: ACM Press, pp. 259–62, 2001.

[4] Vehicle Safety Communications Project Task 3 Final Report. Technical report, The CAMP Vehicle Safety Communications Consortium, Mar 2005. Sponsored by U.S. Department of Transportation (USDOT). Available through National Technical Information Service, Springfield, Virginia 22161.

[5] Rainer Kroh, Antonio Kung, and Frank Kargl. VANETS Security Requirements Final Version. Technical report, Secure Vehicle Communication (Sevecom), Sep 2006. Available at http://www.sevecom.org/Pages/Project Documents.html.

[6] Elmar Schoch, Frank Kargl, Michael Weber, and Tim Leinmuller. Communication Patterns in VANETs. IEEE Communications Magazine, 46:119–125, Nov 2008.

[7] C.E. Perkins and E.M. Royer. Ad-hoc on-demand distance vector routing. In *Proceedings*of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, pages 90–100, 1999.

[8] David B. Johnson and David A. Maltz. Dynamic source routing in ad hoc wireless networks.In *Mobile Computing*, volume 353. 1996.

[9] Y. Yuan, H. Chen, and M. Jia, "An optimized ad-hoc on-demand multipath distance vector (AOMDV) routing protocol," Proc. 11th Asia-Pacific Conference on Communications, IEEE Press, Oct. 2005, pp. 569-573, doi:10.1109/APCC.2005.1554125.

[10] Lochert, C., "A routing strategy for vehicular ad hoc networks in city environments," June 2003.

[11] T. Clausen, et al., "Optimized Link State Routing Protocol (OLSR)", Oct. 2003.

[12] Sandeep Gupta. "A brief guide to ns2."