Performance Evaluation of Proactive and Reactive Protocols in VANET

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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 adhoc networks is to build a robust network among 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 four well-known protocols AODV, DSR, OLSR and DSDV by using three performance metrics packet delivery ratio, average end to end delay and routing overhead. The comparison has been done by using simulation tool NS2 which is the main simulator, Network animator (NAM) and excel graph which is used for preparing the graphs from the trace files.**

Index Terms—**VANET, MANET, AODV, DSR, OLSR.**

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.

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II. Characteristic

A. High Dynamic Topology

The speed and choice of path defines the dynamic topology of VANET. If we assume two vehicles moving away from each other with a speed of 60 mph (25m/sec) and if the transmission range is about 250m, then the link between these two vehicles will last for only 5 seconds (250m/ 50ms-1). This defines its highly dynamic topology.

B. Frequent Disconnected Network

The above feature necessitates that in about every 5 seconds or so, the nodes needed another link with nearby vehicle to maintain seamless connectivity. But in case of such failure, particularly in case of low vehicle density zone, frequent disruption of network connectivity will occur. Such problems are at times addressed by road-side deployment of relay nodes.

C. Mobility Modeling and Prediction

The above features for connectivity therefore needed the knowledge of node positions and their movements which as such is very difficult to predict keeping in view the nature and pattern of movement of each vehicle. Nonetheless, a mobility model and node prediction based on study of predefined roadways model and vehicle speed is of paramount importance for effective network design.

D. Communication Environment

The mobility model highly varies from highways to that of city environment. The node prediction design and routing algorithm also therefore need to adapt for these changes. Highway mobility model, which is essentially a one-dimensional model, is rather simple and easy to predict.

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But for city mobility model, street structure, variable node density, presence of buildings and trees that behave as obstacles to even small distance communication make the model application that very complex and difficult.

E. Delay Constraints

The safety aspect (such as accidents, brake event) of VANET application warrants on time delivery of message to relevant nodes. It simply cannot compromise with any hard data delay in this regard. Therefore high data rates are not as important an issue for VANET as overcoming the issues of hard delay constraints.

F. Interaction with Onboard Sensors

This sensor helps in providing node location and their movement nature that is used for effective communication link and routing purposes.

G. Battery Power and Storage Capacity

In modern vehicles battery power and storage are unlimited. Thus it has enough computing power which is unavailable in MANET. It is helpful for effective communication and making routing decisions.

III. Applications

The VANET application can be divided into two major categories [4]:

A. Safety

Safety applications have the ability to reduce traffic accidents and to improve general safety. These can be further categorized as safety-critical and safety-related applications. In the design of security, it should be made sure safety messages which are not forged.

1) Safety-critical

These are used in the case of hazardous situations (e.g. collisions) [5]. It includes the situations where the danger is high or danger is imminent [6]. Safety-critical applications involve communication between vehicles (V2V) or between vehicles and infrastructure/infrastructure and vehicles (V2I/I2V).

2) Safety-related

These include safety applications where the danger is either low (curve speed warning) or elevated (work zone warning), but still foreseeable [6]. In safety-related applications, the latency requirements are not as stringent as in the case of safety-critical ones. Safety-related applications can be V2V or V2I/I2V.

B. Non-safety

These are applications that provide traffic information and enhance driving comfort. Non-safety applications mostly involve a V2I or I2V communication [4] [5]. These services access the channels in the communication system, except the control channel. They access the channel in a low priority mode compared to safety applications.

1) Traffic optimization

Traffic information and recommendations, enhanced route guidance etc.

2) Infotainment

The Infotainment services are Internet access, media downloading, instant messaging etc.

3) Payment Services

Payment services like Electronic toll collection, parking management etc.

4) Roadside Service Finder

Finding nearest fuel station, restaurants etc. This involves communication of vehicles with road side infrastructure and the associated database.

IV. VANET 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 usage. 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 neighbor 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.

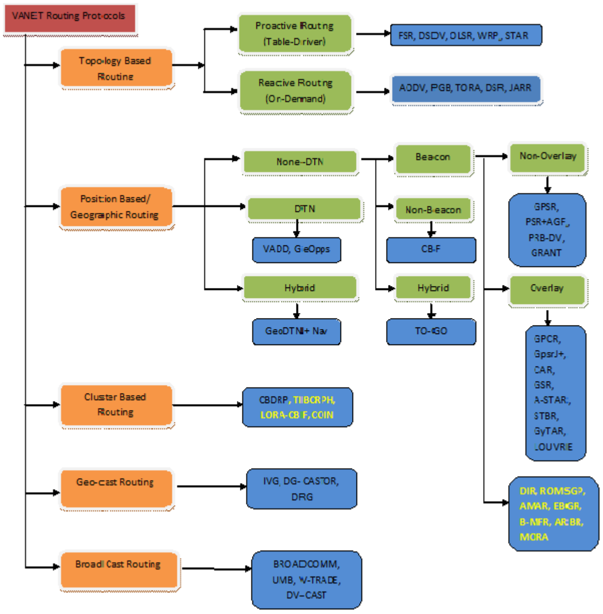

Fig. 1. Routing protocols in VANET

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.

V. Performance Comparison of Proactive and Reactive Protocols

Four adhoc routing protocols are used, AODV, DSR, OLSR and DSDV. AODV and DSR is Reactive (On demand) where as OLSR and DSDV is Proactive (Table driven) Routing protocol. Table I shows the comparison between proactive and reactive routing protocols.

TABLE I: Comparison Of Proactive and Reactive Routing Protocols

	Proactive Protocols	Reactive Protocols
Network Organization	Flat/ Hierarchical	Flat
Topology Dissemination	Periodical	On-Demand
Route Latency	Always available	Available when needed
Mobility Handling	Periodical updates	Route maintenance
Commutation Overhead	High	Low

A. *Selected Proactive and Reactive Protocols*

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".

3) Optimized Link State Routing Protocol (OLSR)

The Optimized Link State Routing Protocol (OLSR) [9] 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.

4) Destination-sequenced Distance-vector Routing (DSDV)

DSDV [10] is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P. Bhagwat in 1994. It eliminates route looping, increases convergence speed, and reduces control message overhead. In DSDV, each node maintains a next-hop table, which it exchanges with its neighbors. There are two types of next-hop table exchanges: periodic full-table broadcast and event-driven incremental updating. The relative frequency of the full-table broadcast and the incremental updating is determined by the node mobility. In each data packet sent during a next-hop table broadcast or incremental updating, the source node appends a sequence number. This sequence number is propagated by all nodes receiving the corresponding distance-vector updates, and is stored in the next-hop table entry of these nodes. A node, after receiving a new next-hop table from its neighbor, updates its route to a destination only if the new sequence number is larger than the recorded one, or if the new sequence number is the same as the recorded one, but the new route is shorter. In order to further reduce the control message overhead, a settling time is estimated for each route. A node updates to its neighbors with a new route only if the settling time of the route has expired and the route remains optimal.

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[11] 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.

C. Simulation Setup

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

TABLE II: 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, DSR, OLSR and DSDV
Traffic Type	TCP
Data type	CBR
Data Packet Size	512 bytes
MAC protocol	IEEE 802.11
Radio Propagation Model	Two Ray Ground

D. Simulation Metrics Used

The following metrics are used in this paper for the analysis of AODV, DSR, OLSR and DSDV 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.

E. Simulation Results

TABLE III: CONNECTION PATTERN

Variable	Value
No. of nodes	12
Maximum Connections	8

Fig. 2. represents the performance of AODV, DSR, OLSR and DSDV in terms of PDR vs. Node Low Density.

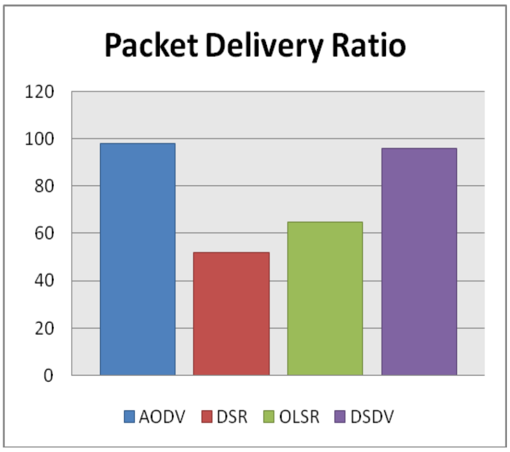

Fig. 2. PDR vs. node density at city low density

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

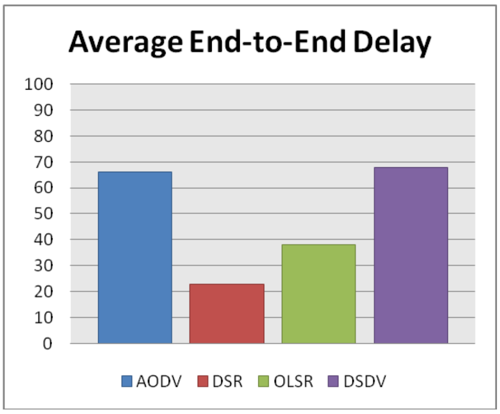

Fig. 3. Average E2E delay (in ms) vs. node density at city low density

VI. CONCLUSION

In this paper the analysis of ad hoc routing protocol is done in realistic scenario of VANET. After doing the simulation based analysis of AODV, DSR, OLSR and DSDV in realistic scenario of VANET we can see that the performance of AODV in terms of PDR is very good approximate 98% and DSDV is approximate 97%. OLSR has average performance as the PDR. 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. OLSR is also having low 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 OLSR is average

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