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Performance Evaluation of Topology Based Routing Protocols for VANET in City Scenario

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Abstract— ***VANET is an emerging technology that will help in increasing road safety of commuters and comfort of passengers. In this paper, we compare various topology based routing protocols DSDV, AODV and DSR that are MANET protocols for their behavior in VANET networks, that is a sub-class of MANET based on few parameters. The real city scenario with vehicle traffic has been created using Network Simulator-2 and analyzed for behavior using different protocols. Finally, we conclude which protocol performs better in city scenario taken in our simulation.***

Keywords— AODV, Collision packets, DSR, DSDV, Network Simulator, Throughput, Packet delivery

I. INTRODUCTION

Movement of the vehicles on roads can be constrained by different conditions, such as those suggested in [1]. These conditions may be related with traffic congestions, speed zones, road works, weather conditions, etc. Such kind of limitation allows vehicles to form a group or cluster among themselves in order to manage traffic flow in all directions efficiently and smoothly. Another type of condition is discussed in [2] which is concerning the varying velocity of the vehicles and an abrupt movement of the paths without any sort of notifications. Hence with such pertaining condition and limitation, it sometimes becomes impossible for vehicles to establish a direct link between them via a single hop related to a specified coverage area. Therefore, the internet that works among different vehicle clusters is needed to be considered. To properly manage the communication links existing between these “out of ranged vehicles” (nodes), various routing protocols have been evolved. With the help of relevant studies given in [2], [3], [4], and many other associated works, it has been found that the routing protocols available for ad-hoc networks, that have already been proposed and implemented, are not standing to be compatible with VANET scenario due to above persisting conditions. Hence, various improvements and adaptions are being made in the available condition of the VANET networks and are a main topic of many researchers for revision. The research work proposed in this paper is an effort for highlighting the importance of various routing protocols in VANET, under different scenarios, and observing and analyzing their effects accordingly, by calculating mean of various test cases of simulation and performing comparative analyses. VANET is a sub-class of MANET with different characteristics [5] such as high mobility of nodes, rapid changing network topology, has unlimited power source, high computational capability and has more delay constraints due to real time applications. However, since both are related to mobile communication. MANET protocols like DSDV, AODV and DSR can also be used in VANET. In this paper, we use these protocols for Vehicular communication in city scenarios and compare based on throughput, packet drop ratio and end-to-end delay during communication. The outcomes of simulation will show, and hence differentiate, the appropriate selection of protocols for network layer i.e. the routing protocols lying in given circumstances of a feasible path selection in the city vehicular traffic scenarios.

The rest of the paper is organized as follows. Section 2 gives details of various routing protocols addressed in this paper. Section 3 is dedicated to performance evaluation of routing protocols in city scenario. Section 4 outlines the results obtained. The paper is finally concluded in Section 5.

II. OVERVIEW OF AODV, DSDV AND DSR ROUTING PROTOCOLS IN VANET

The routing protocols basically perform the three main functionality route discovery, maintenance and selection of the efficient path from the various available paths. The routing protocols in the VANET environment are characterized on the basis of area / application where they are most suitable and are classified into five categories can be seen in Figure 1.

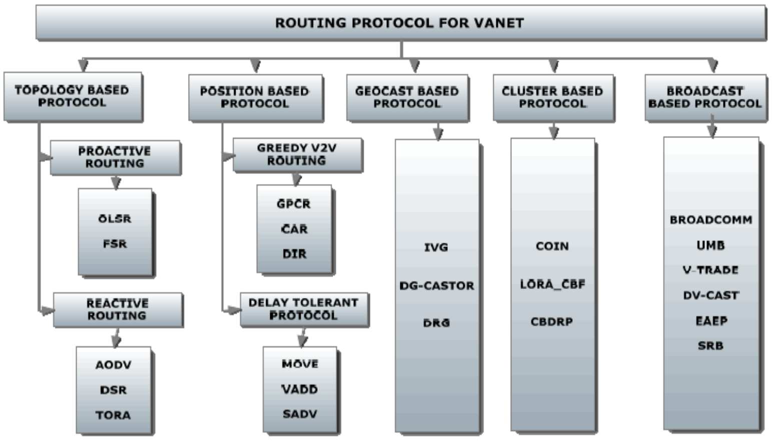

Figure 1. Routing Protocols in VANET

In this paper various topology based routing protocols are compared. They are AODV, DSR and DSDV. Topology based network maintains link information about the nodes present in the network. This information is used in making routing decisions. The parameters used in this paper for analysis of the protocols are throughput, packet drop ratio and end-to-end delay.

- **Throughput-** It is defined as the packets received at the destination out of total number transmitted packets. The unit used is kbps. The routing protocols with high throughput are more efficient.
- **Packet drop ratio-** It is the number packets that are not sent to the destination. These packets are lost during transmission from source to destination. The packet drop may be due to signal degradation, corrupted packets or congestion, etc. The lower is the packet drop the better is the routing protocol.
- **End-to-End Delay-** The total time for transmitting a packet from source to the destination node is known as end to end delay. The delay performance metric include the delays due to route discovery, packet propagation and sending time and the time of packet in queue.

A. Destination Sequenced Distance Vector (DSDV)

DSDV is a Proactive routing protocol that uses information stored in routing table to take routing decisions. In it, every node maintains a table of information (which updates periodically or when change occurred in the network) of presence of every other node within the network. Any change in network is broadcasted to every node of the network The table has entries as destination node, next hop, and cost metric i.e. number of hops to destination, sequence number assigned by destination to avoid loops and install time i.e. time when entry was made that is used to remove stale entries. The topology changes are updated by immediate advertisements to the neighbors. The tables are updated by full update in which a node sends all information to other nodes, or incremental update in which a node sends only changed entries to other nodes.

Destination	Next hop	Cost metric	Sequence number	Install time

Figure 2. Fields in Routing Table of each node

The advantages of DSDV protocol are that it is simple, path is loop free due to the use of sequence numbers and no latency as the path is obtained from the routing table maintained by the nodes. The drawbacks of the protocol are overhead as some of the information is never used and tables need to be updated regularly that consume a significant amount of bandwidth.

B. Ad-Hoc On-Demand Distance Vector (AODV) Routing

AODV is an improved version of DSDV, and as its name suggest, establishes the route only when demanded or required for the transmission of data. By this mean, it only updates the relevant neighboring node(s) instead of broadcasting every node of the network i.e. it does not make source routing to the entire node for the entire network.Control packets are used to discover routes. The source node sends broadcast query RREQ (Route Request) packet (Figure 3) to all its neighboring nodes.

Source IP address	Source Sequence number	Destination IP address	Destination Sequence number	Broadcast Id

Figure 2. RREQ Query Packet

On arrival of RREQ, each node sets up a reverse route entry for source node in its routing table. It consists of address of the previous hop from which the packet is sent, number of hops to source node and life time field in its routing table.

This is known as Backward learning that is used to create path. The RREQ packets are broadcasted until it reaches destination. Once destination is reached is sends RREP Route reply packet (Figure 4) to the source node through the path found by Backward learning mechanism.

Destination IP address	Destination sequence number	Source IP address	Hop count	Lifetime

Figure 4. RREP Packet

When RREP packet is sent to the source, each intermediate node sets up a forward path entry to destination in its routing table, containing Destination IP address, IP address from which entry arrived, hop count and lifetime. Now when the packet receives the destination, the data can be sent using the routing table entries. In case a link fails, the node sends RERR (Route Error message) to the destination. Then again, new route discovery process is started. The advantage of this protocol is that overhead is reduced as only the routes that are active and needed are discovered. It also has mechanism for route failure. An up to date path is found as destination sequence numbers are used. The drawback of the protocol is that route finding latency is high and the old entries in the routing table of intermediate node can lead to inconsistency in path.

C. Dynamic Source Routing (DSR) Protocol

DSR is also reactive routing protocol like AODV. It maintains the source routing, in which, every neighbor maintains the entire network route from source to the destination. The route discovery and route maintenance is same in DSR as in AODV except that it does not use backward learning. The source node sends RREQ (Route Request) as broadcast node to its neighboring nodes. The header of the query packet carries the Ids of intermediate nodes through which it travels. The destination on receiving RREQ packet sends with RREP (Request reply) packet to the destination. It uses the reverse of path that was stored in the RREQ packet. The source node receives the path to the destination from the RREP message. The source may receive more than one route that it stores in cache. Now, the source node copies the path to the destination in each data packet to be sent to destination. The packets follow the path mentioned by the source. In case the route fails,the intermediate node sends RERR (Route Error) message to the source. The source then uses another path stored in the cache if it has multiple routes stored. Otherwise the route discovery is done again. The advantages of the DSR protocol are that use of cache decreases the latency, speeds up route discovery and decreases overhead as multiple routes are stored in cache. The drawback of this protocol is that as the data packet contains the full routing information that increases overhead. The outdated routes in the cache also affect the performance as they may be no longer valid paths.

III. PERFORMANCE EVALUATION OF ROUTING PROTOCOLS

A realistic vehicular mobility scenario for a City is generated using BonnMotion-2.1.3 tool. BonnMotion is basically a java based software that creates and analyzes mobility scenarios and is most commonly used tool for investigating mobile ad-hoc network characteristics. A vehicular mobility pattern defines vehicle motions within the road segment during a simulation time, which reflects, as close as possible, the real behavior of vehicular traffic such as traffic jams and stop at intersections.

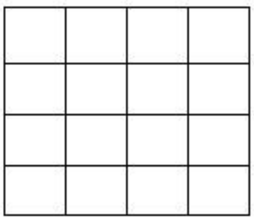

Figure 5. ManhattanGrid City Scenario

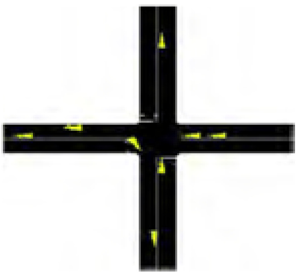

Figure 6. Intersection Structure

As shown in Figure 5, City Scene consist of 5 vertically and 5 horizontally oriented streets as well as 21 crossings. Figure 6 defines view of crossing in road network. Each modeled street has a total length of 600 m, where as parallel streets are separated by a distance of 150 m with bidirection two lanes in each side. Vehicles can move with a speed of

10-40 km/h and vehicle flow is determined from upper left corner to bottom right corner and upper right to bottom left of the city map. Traffic lights to be placed at each crossing and vehicles randomly make a turn at each crossing. The city model is further sub-classified on the basis of their participating vehicles and number of TCP connections used for established path. City scene with Network Simulator is shown in Figure 7.

A. Simulator

In this study, network simulation tool, NS-2.35 [6] has been used as a simulation platform. NS-2.35 is open source, object oriented, discrete event-driven network simulation software which was developed in both languages including the Otcl and C++. It is excellent simulation software which can study network topology and analyze network transmission.

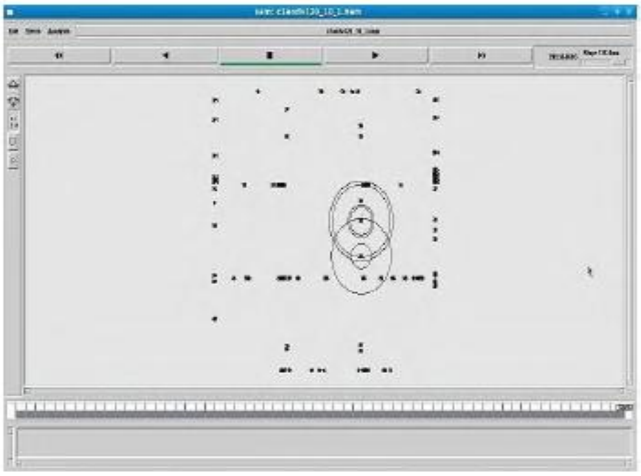

Figure 7. City Scene with Network Animator

B. Data Flow Generator

In this paper, we used data flow generator called cbrgen tool in the NS-2.35 utilizing UDP connection. It can specify the type of data flow generated (including cbr flow and tcp flow), number of nodes, random seed number, maximum number of connections between nodes, as well as sending frequency of data between each pair of nodes. Specific format is as follows: ns cbrgen.tcl [-type cbr | tcp] [-nn nodes] [-seed seed] [-mc connections] [-rate rate] > <outdir>/<scenario-file> where -Type is the type of data flow cbr or tcp, -nn is the number of node, -seed is the number of random seed, -mc is the maximum number of connections between nodes and -rate is data frequency between each pair of nodes.

C. Network Parameters

The experiments were carried out using the network simulator (NS-2.35). The scenarios developed to carry out the tests uses the vehicle density and the number of active connections in the network. The different routing protocols that were presented previously were utilized in the experiments. The choices of the simulator parameters are presented in Table 1.

Table 1: Simulation Parameters

Parameter	**Value**
Simulator	NS-2.35
Simulation Time	1000 sec
Antenna Model	Omni-directional Antenna
Radio Propagation Model	Two-Ray Ground
MAC Type	IEEE 802.11
Interface Queue Type	Priority Queue (50 Packets)
Routing Protocols	AODV, DSR, DSDV
Simulation Area	700m x 700m
Channel Type	Wireless Channel
No. of Vehicles	20
Speed of Vehicle	10-40 km/hr
Performance Metrics	End-to-End Delay, Throughput, Packet Delivery Ratio
Speed Change Probability	0.5
Turning Probability	0.5

IV. SIMULATION RESULTS

The performance of AODV, DSR and DSDV has been analyzed for different durations with 20 nodes under TCP connections. Packet delivery ratio, average throughput & average end-to-end delay of AODV, DSR and DSDV have been measured. The simulated output has been described by using graphs shown in Figures 8, 9 & 10.

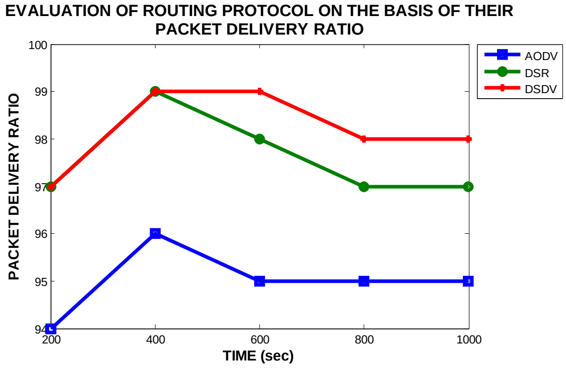

Figure 8. Packet Delivery ratio of Routing Protocols

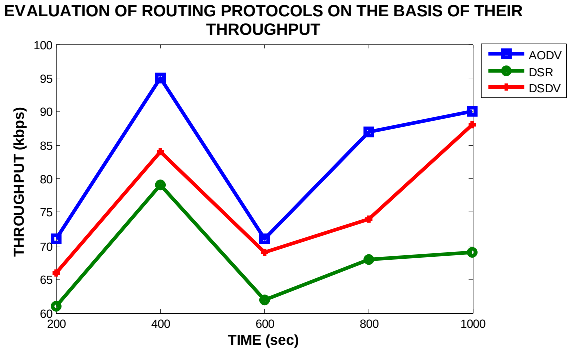

Figure 9. Average Throughput of Routing Protocols

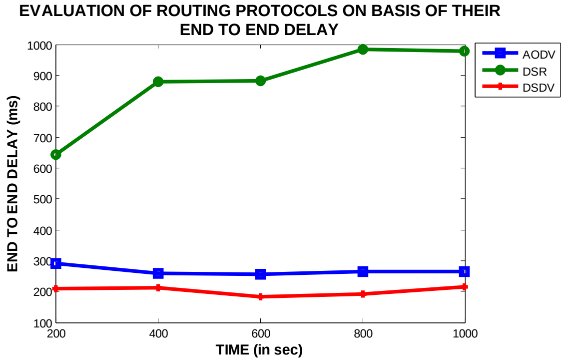

Figure 10. Average End-to-End Delay of Routing Protocols

From Figure 8, it can be seen that the packet delivery ratio is minimum for aodv whereas DSDV is having a very high packet delivery ratio.Similarly throughput in case of DSR is very less while AODV offers a much greater throughput. Moreover, end-to-end delay is seen to be very high in case of DSR. It hence can be deducted that on an average AODV can give much better results as compared to the other two.

V. CONCLUSION

This paper illustrates the differences between AODV, DSR and DSDV based on TCP connections with various network parameters. The simulation test beds for city scenario is deployed by NS-2.35. Simulation results show that DSDV are preferable for Packet Delivery Ratio while AODV has better throughput.DSR has high end to end delay and low throughput which is not preferable. Simulation results show that AODV is found most appropriate selection compare to other protocols at the network layer of given city models in VANET. Future task is to simulate with more parameters and extend AODV protocol which may overcome the problem of lower Packets delivery ratio in Vehicular Ad Hoc Network without increasing network overhead.

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