Evaluation of Multipath, Unipath and Hybrid Routing Protocols for Vehicular Ad Hoc Networks

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***Abstract*— Vehicular Adhoc Network (VANET) is a well known communication which includes communication between moving vehicles on the roads. VANET can be formed either using using existing infractructure or without preexisting infrastructure. With the VANET we can provide various kind of information to the vehicles for their safety and need. Routing protocols in VANET plays a very important role since many challenges like high speed, mobility, etc occurs within it. In this paper, an attempt is made to create realistic environment for the performance analysis of multipath, Unipath and hybrid routing protocol in city scenarios. The protocols evaluated are Ad hoc On demand Distance Vector (AODV), Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) and Destination Sequence Distance Vector (DSDV). All the three protocols are having their own specifications. In simulation, maps are used to model topology using traffic simulator and then vehicles with different parameter like length, maximum speed and acceleration etc. run on these topologies. The performance parameters evaluated in this paper are packet delivery ratio and end to end delay for the above said prototcols.**

Keywords: VANET, MANET, DSDV, AODV, AOMDV

I. INTRODUCTION

Road traffic injuries are major challenge that requires rigorous efforts for effective and sustainable prevention. Of all systems with which people have to deal every day, road traffic systems are the most complex and dangerous. Worldwide, an estimated 1.2 million people are killed in vehicle crashes every year and 50 million are injured. Projection indicates that these figures will increase by about 65% over the next 20 years unless there is new commitment to prevention. It underscores their concern that unsafe road traffic systems are seriously harming global public development. It contends that the level of road traffic injury is unacceptable and it is largely avoidable.

A traffic management system has developed in large metropolitan areas in an effort to improve mobility and safety in vehicles. It is achieved through the installation of information systems and communications technologies. An important function of these traffic management systems is collection of data on traffic conditions at road intersection and on highways. These data is processed into useful information allowing intersection traffic controller to monitor traffic conditions and manage the highway system [1]. Also, there is a need to improve the safety of traffic system for users, and to reduce incurring vehicle crashes. Work is carried out to accept the challenge of road traffic systems by designing VANET system. VANET system connects vehicles with the road side infrastructure for means of communication. It informs vehicles regarding the traffic conditions at intersections. It informs about status of the traffic lights and traffic congestion at intersections. Also VANET system gives remedial solution to monitor and control traffic at road intersections, on highways. It also gives information to the remote travelers by providing necessary information.

VANETs are considered as a part of Mobile Ad hoc Network (MANET), however they are some different characteristics and specification involved within them. So the solutions proposed for MANET desired to be evaluated carefully and then adapted in VANET. There are many similarities in VANET and MANET like both networks are multi-hop mobile networks having dynamic topology. There is no central entity, and each node acts as router and route data themselves across the network. Both MANETs and VANETs are rapidly deployable, without the need of an fixed infrastructure.

As we know the both MANET and VANET are mobile networks, but the mobility pattern of VANET nodes is such that they move on specific paths (roads) and hence not in random direction. This gives VANETs some

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advantage over MANETs. So the mobility pattern of VANET nodes is predictable. MANETs have limited storage capacity and limited battery and processing power. VANETs, on the other hand, do not have such limitations.VANETs have sufficient storage capacity and high processing power. It can be easily made available in vehicles. VANETs have highly dynamic topology as vehicles may move at high velocities. This makes the short lifetime of communication link between the vehicles. Vehicle density in VANETs is also unpredictable; during rush hours the roads are crowded with vehicles, whereas at other times, lesser vehicles are there. Similarly, some roads have more traffic than other roads. So, Protocol design in research [2] always depends on simulation techniques for VANET. For analysis of any protocol a huge no. of nodes [3] deployment require and it needs control environment to test. For any analysis of of VANET selection of mobility model is required.

II. RELATED WORK

Authors Lino Figueiredo, J. A. Tenreiro Machado, and Jose Rui Ferreira [4] in their paper "Dynamical Analysis of Freeway Traffic", described a simulation approach to reproduce real traffic conditions in an urban or non urban network. Simulation models in road-traffic planning and research, is considered the most prevalent in transportation community. In their work, network description, driver's and vehicle's specifications, and traffic conditions are main input to the simulator. Experimental results calculate vehicle speed, number of lanes on road, traffic flow at road intersection. Work concluded with new avenues to be developed for ITS dynamic models and parameters identification is still required for improvement in ITS system. The data collected in these systems are used not only to *monitor,* but also to *forecast* traffic conditions. A short-term forecast of traffic conditions provides more information for traffic managers. It also decides a course of action to proactively manage traffic and minimize overall delay experienced by travelers, particularly during peak periods when significant traffic congestion occurs. Such a short-term forecast would likely focus on future several traffic data collection periods after current observation. Since these data collection periods are typically less than five minutes; short term traffic forecasting is not concerned with subsequent. Work related to formation of vehicular network and routing protocols required for network formation were not discussed.

There are studies [5] that compare various traditional ad hoc routing protocols in VANET environment. The simulations carried out in these studies [5] , [6] are very basic and do not consider the real VANET Scenario. Simple network topologies are used without considering road conditions. So to compare and evaluate protocols and applications for VANETs we need network traffic simulator.. Use of traffic simulator, help to build real life scenarios. The main aim of this research paper is to evaluate the performance under realistic network conditions of hybrid routing protocols, by using both network and traffic simulators. Paper shows systematic comparison of routing protocols in vehicular environment. There are two types of routing protocol used for analysis one is proactive and other is reactive type protocols.

A. *Proactive (Table Driven)*

These routing protocols are like wired networks. In proactive routing, each node has tables that contain the latest information regarding routing of nodes in the network. Each row contains the information about the next hop for accessing a node subnet and the cost of this route. Various table-driven protocols differ in the way the information about a change in topology is propagated through all nodes in the network. There are some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols build different number of tables. Proactive protocols do not support larger networks, as they need to maintain node entries for every node in the routing table of every node. This results in more overhead in the routing table due to which more bandwidth is consumed.

Destination-Sequenced Distance-Vector Routing (DSDV) [7] is a table-driven routing protocol for ad hoc mobile networks, modified from the Bellman-Ford algorithm. It was design by C. Perkins and P.Bhagwat. The main contribution of the algorithm is necessary to solve the routing loop problem. Each entry in the routing table consist of a sequence number, the sequence numbers are set even if a link is present; else, an odd number is available. From generated destination number, the emitter needs to send out the next update with this number. Routing information is spread between nodes by sending full dumps infrequently and smaller incremental updates more frequently.

B. *Reactive (On-Demand) Protocols*

Reactive routing is also known as on-demand routing protocol since they don't store routing information or routing updates at the network nodes if there is no communication. These protocols take a different approach to route the routing process according to present condition. They do not store or continuously update their route tables with the new route topology. According to demand if a node wants to send a packet to another node then this protocol searches for the best possible route and establishes the connection to transmit and receive the packet. The route discovery usually establish by flooding the route request packets throughout the network. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV).

In proactive case, authors considered two protocols for evaluation i.e AODV and AOMDV. AODV [8] is a distance vector routing protocol when a node wants to establish new communication with another node, it searches for an available path to the destination node, in its local routing table. If there is no availability of path, then it send a route request (RREQ) message to its neighborhood. The node that receives this message search for a path leading to the destination node. If there is no path then, it re-send the RREQ message and establish a path leading to RREQ originating node. This contributed to create the end to end path when the same node receives route reply (RREP) message. Each node follows this process until this RREQ message reaches to a node which has a valid path to the destination node or RREQ message reaches to the destination node itself. Either way the RREQ receiving node will send a RREP to the sender of RREQ message. In this way, the RREP message arrives at the source node, which issued RREQ message. At the end of this request-reply process a path between source and destination node is created and is available for further communication. In scenarios where there is no path available to the destination node or a node looses connectivity to its neighbor, a route error (RERR) message is issued for nodes that potentially received its RREP message. This message use to update or recalculate the path when an intermediate node leaves a network or loses its next hop neighbor. Every node using AODV maintains a routing table, which contains the following information: a next hop node,a sequence number and a hop count. All packets destined to the destination node are sent to the next hop node. The sequence is a measure of the freshness of a route. This helps in using the latest available path for the communication. The hop count represents the current distance between the source and the destination node.

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) protocol [9] is an modification of the AODV protocol for computing multiple loop-free and link disjoint paths. The routing entries for each destination consist a list of the next-hops along with the respective hop counts. All the next hops have the same sequence number. This is useful in keeping track of a route. For each destination, a node store the advertised hop count,which is denotes as the maximum hop count for all the paths, which is used for sending route advertisements of the destination. An alternate path to the destination defines for each duplicate route advertisement received by a node. Loop freedom is check for a node by accepting alternate paths to destination if it contains a less hop count than the advertised hop count for that destination. Because the maximum hop count is used, the advertised hop count therefore does not change for the same sequence number. When a route advertisement get for a destination with a greater sequence number, the next-hop list and the advertised hop count are initialized again. AOMDV can be useful to find node-disjoint or link-disjoint routes. To establish node-disjoint routes, each node does not immediately reject duplicate RREQs. Each RREQs arriving via a different neighbor of the source defines a node-disjoint path. This is because nodes cannot be send duplicate RREQs, so any two RREQs arriving at an intermediate node via a different neighbor of the source could not have traversed the same node. For getting multiple link-disjoint routes, the destination replies to duplicate RREQs, the destination only replies to RREQs arriving via unique neighbors. After the first hop, the RREPs follow the reverse paths, which are node disjoint and thus link-disjoint. The trajectories of each RREP may get intersect at an intermediate node, but each takes a different reverse path to the source to ensure link disjointness.The advantage of using AOMDV is that it allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. But, AOMDV has more message overheads during route discovery due to increased flooding and since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overheads.

C. *Multipath protocol for adhoc networks*

Vehicular adoc network (VANETs) consist of a collection of wireless mobile nodes which dynamically exchange data among themselves without the reliance on a fixed base station or a wired backbone network. MANET nodes are typically distinguished by their limited power, processing, and memory resources as well as high degree of mobility.

In such networks, the wireless mobile nodes may dynamically enter the network as well as leave the network. Due to the limited transmission range of wireless network nodes, multiple hops are usually needed for a node to exchange information with any other node in the network. Thus routing is a crucial issue to the design of a VANET. In this paper, we specifically examine the issues of multipath routing in VANET. Multipath routing allows the establishment of multiple paths between a single source and single destination node. It is typically proposed in order to increase the reliability of data transmission (i.e., fault tolerance) or to provide load balancing. Load balancing is of special importance in MANETs because of the limited bandwidth between the nodes. We also discuss the application of multipath routing to support application constraints such as reliability, load-balancing, energy-conservation, and Quality-of-Service (QoS).

III. MOBILITY MODEL AND SIMULATION SET UP

In this paper overall aim is to develop a road traffic scenario and comparison of multipath, unipath, hybrid routing protocols. Real scenarios are considered and then mobility patterns are generated using traffic simulator. Comparison of proactive and reactive routing protocols is done. Authors have considered various communication parameters like routing protocol, CBR (Constant Bit Rate) etc for simulation purpose.

Road Traffic Simulator:

Road Traffic simulator is used for accurate modelling the roads, vehicles, pedestrians and other factors that are observed on the roads. VANETs differ from other network types in their mobility patterns. Vehicles, no matter small or large move on predefined paths i.e. roads. This leads to the constrained mobility of vehicles as compared to the random mobility of MANET nodes. Also there are many factors associated with the vehicles and with the roads. For example, maximum speed of vehicle, its length, and its acceleration and deceleration capabilities. For roads, we have factors like its length, speed limit on that road, the number of lanes, junctions, and traffic signals on that road. Road traffic simulators are very useful by considering the above parameters and providing the true picture.

VanetMobiSim:

NS2 is a discrete event simulator hence it needs to know the location information of the nodes at every timestamp. This information is present in VanetMobiSim trace file in a format recognizable to NS2. In order to use the generated road topology for simulations purposes using NS2, we need a tool which generates a movement pattern file. Simulation parameters are listed in detail in table 1.

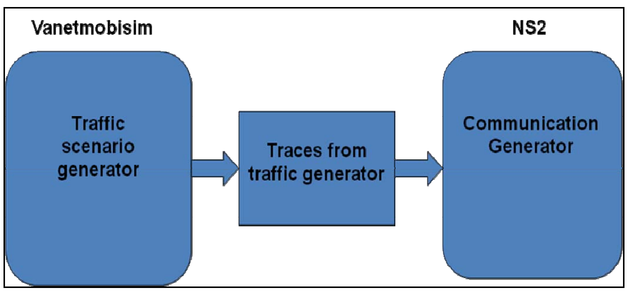

Figure 1. Simulation Architecture.

Simulation Setup

Table 1. Lists the simulation parameters in detail

Ns2 Version	2.34
VanetMobiSim Version	1.1
Simulation Area	1800*1800 m^2
NO. of Nodes	25,50,100

Scenario:

Figure 2. shows the city scenario design in VanetMobiSim editor. This scenario shows the common settings found in a city. The two lane roads are created, traffic light arrangement to make realistic scenario. This screen shot is taken from the VanetMobisim.

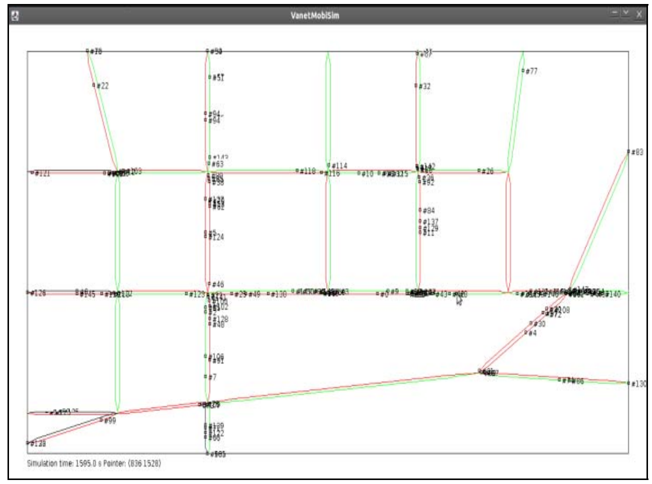

Figure 2. Movement of Vehicles in City Scenario

Simulation Assumptions:

Initially, the vehicles move from slow speed and then gain maximum speed after sometime. In simulations, we assumed that vehicle CBR connections. There are various type of vehicles, at different times and at different locations and each vehicle is sending or receiving CBR data.

IV. SIMULATION METRICS:

The following metric is used to evaluate the performance of AODV, AOMDV and DSDV routing protocols in Low, High and Middle density region. We consider here city scenario with 25 vehicles as low density, 50 for middle density and 100 for high density region respectively.

A. Packet Delivery Ratio (PDR):

This metric find the ratio of the data packets successfully received at the destination and total number of data packets generated at source. The following equation is used to calculate the PDR,

$$PDR = (DR / DS) * 100,$$

Where DR = Data packets received by the CBR agent at destination node, DS = Data packets Sent by the CBR agent at source node.

B. Average End-to-End Delay:

This metric gives the overall delay, from packet transmission by the application agent at the source node till packet reception by the application agent at the destination node. The following equation is used to calculate the average end-to-end delay,

$$\text{Average End-to-End Delay} = (T\_DR – T\_DS),$$

Where T_DR = Time data packets received at destination node,T_DS = Time data packets sent from source node.

V. Simulation Results:

The simulation results of city scenarios are presented in different density regions. In these graph authors measured packet delivery ratio corresponding to routing protocols. According to that one can evaluate the protocol which is most suitable for vehicular network

Output trace file format which is obtain from ns2 is given in figure 3 which is used for analysis.

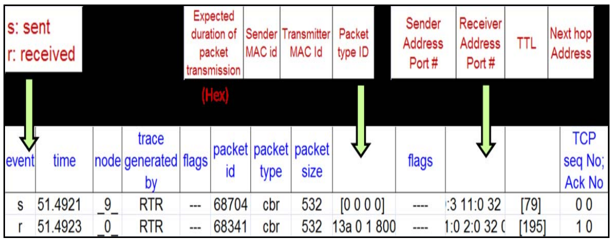

Figure 3. NS2 Trace File

1. *Low Density:*

In low density region we consider 25 no. of vehicle (nodes) in given Figure 4 scenario and results are as follows for packet delivery ratio.

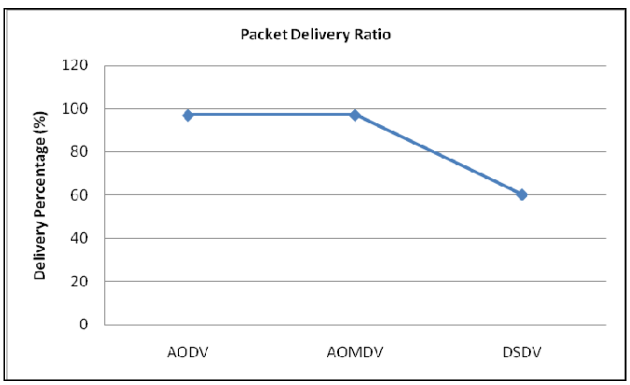

Figure 4. Graph for Packet Delivery Ratio (Low Density)

In low density region in graph we can see AODV and AOMDV score almost same percentage i.e. in between 95 % to 100 % range. Whereas DSDV packet delivery ratio lies in between 60 % to 65 % range.

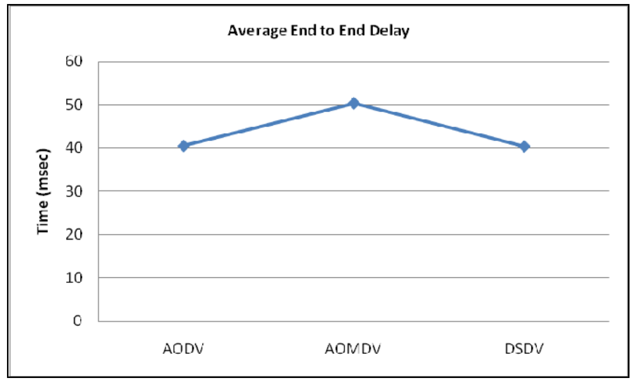

Figure 5. Graph for Average End to End Delay (Low Density)

2. *Middle Density:*

In middle density region we consider 50 vehicles (nodes) in city scenario and results are as follows shown in figure 6 and figure 7.

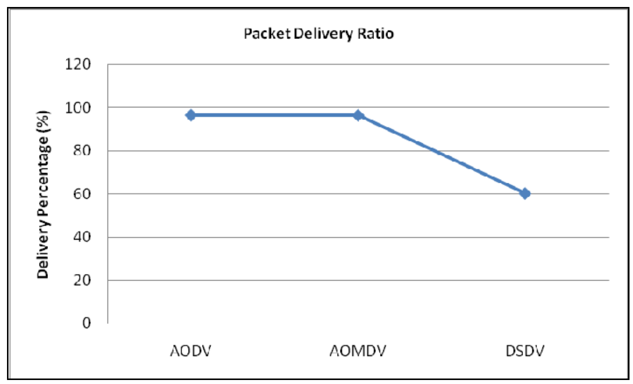

Figure 6. Graph for Packet Delivery Ratio (Middle Density)

In middle density region the graph shows AODV and AOMDV score almost same percentage i.e. in between 90 to 100 range. Whereas DSDV packet delivery ratio is in between 60 to 80 range.

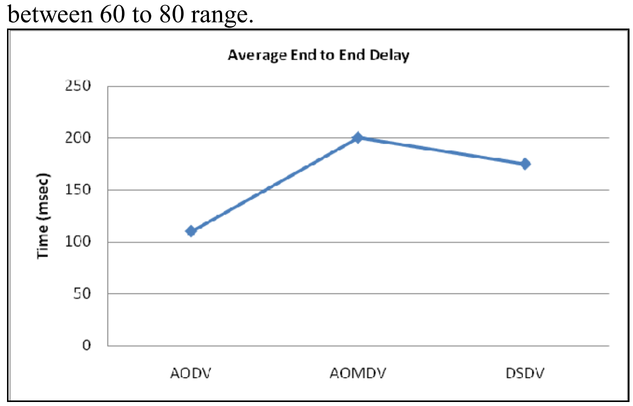

Figure 7. Graph for Average End to End Delay (Middle Density)

3. *High Density:*

In high density region we consider 100 no. of vehicles and results are as follows as shown in figure 8 and figure 9.

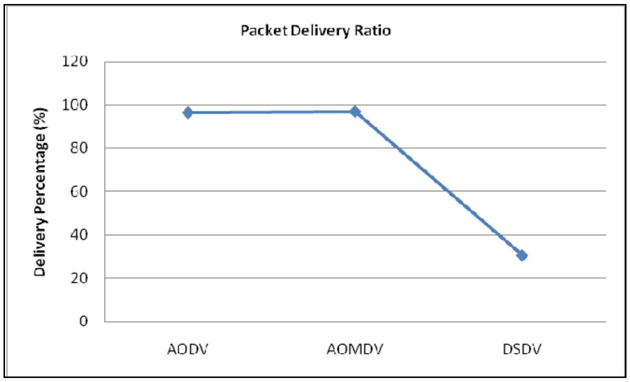

Figure 8. Graph for Packet Delivery Ratio (High Density)

In high density region in graph we can see AODV and AOMDV score almost same percentage i.e. in between 90 to 100 range. Whereas DSDV packet delivery ratio is degrades to 20 to 30 range.

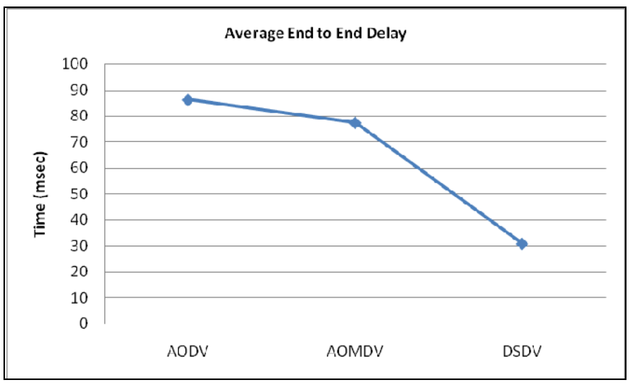

Figure 9. Graph for Average End to End Delay (High Density)

Overall authors observed the average of all 3 protocols in Low, Middle, and High density traffic. The behavior of PDR and End to End Delay of every routing protocol with respect to communication calculated. We observe that AODV and AOMDV is able to give better PDR consistently as compared DSDV protocol. The proactive routing protocols have decreasing PDR all the time.

VI. CONCLUSION

Comparison of performance parameters for three routing protocols DSDV, AOMDV and AODV in VANET is carried out. Simulation results are matched with the expected output and are found satisfactorily. As expected, reactive routing protocol performance is the best considered because of its ability to maintain link by periodic exchange of information, which is required for TCP based traffic. AODV performs predictably. Virtually all packets delivered at low node mobility, and decreases the converge as node mobility increases and DSDV performs well but still requires the transmission of many routing overhead packets.

In case of packet delivery ratio (PDR) plotting, the more hike in the value of percentage represents an added achievable performance of the protocol. AODV and AOMDV made good marks in all of the VANET density schemes of the given city scenario. It is also observed that DSDV has its acceptability for city's low density variation only. DSDV (in medium and high density) not suitable for the given case of city models from showing their PDR results.

For average end-to-end delay, we require minimum value. DSDV performance was observed satisfactory for all of the traffic levels. In case of low traffic level, all the routing protocols had almost equal values. In middle traffic level one can see AODV and DSDV performance was good. Whereas in high traffic level AODV performance decreases drastically so overall AODV performance was good in low and middle region and DSDV gives satisfactory performance in terms of End to End delay in all traffic level.

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