Functional Analysis of Mobility Models based on AODV, DSDV and DSR Routing Protocols in VANET

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***Abstract*—Vehicular ad-hoc networks (VANETs) have acquired great attention to increasing vehicle safety and the services of Intelligent Transportation System (ITS). The features of VANET network that differentiate it from other ad hoc networks, such as restricted mobility constraints, extremely high mobility, and time-varying vehicle traffic density and communicate with the infrastructure to support security. The mobility models can construct a pragmatic movement pattern of each vehicle in the network. Mobility model influence in routing protocols, packet delivery and make a communication. Thus, the mobility models play a significant role that influence in determining the performance of VANET. This paper use Manhattan Grid and Intelligent Driver Model with Lane Changes (IDM-LC)mobility models, based on the Ad hoc on demand Distance Vector routing protocol (AODV), Destination sequenced distance vector routing protocol(DSDV) and Dynamic Source Routing(DSR) protocol to make communication between vehicles and appraise their impact on packet delivery, end to end delay, throughput in VANET .**

Keywords*—Vehicular ad-hoc networks; Manhattan Grid; IDM; IDM-LC; Mobility Models; AODV; DSDV; DSR; NS-2; VANET.

I. INTRODUCTION

VANET is a self-forming build up by moving vehicles on urban streets capable of communicating with each other with a fixed infrastructure. Vehicles can be short-range and medium-range wireless communication. It facilitates ITS service such as control of traffic flows, blind crossing, prevention of collisions, and nearby vehicle information services. VANET are a special case of Mobile Ad-Hoc Networks (MANET). A Mobile Ad-hoc Network (MANET) is a collection of mobile nodes, which have the capability of self-organization in a decentralized way and without fixed infrastructure. VANET, have a goal to provide Safety-associated applications, emergency warnings and entertainment applications. A vehicle in VANET is equipped with a sensor device able to receive and send messages to other neighborhood vehicle. VANET offer communication facilities between number of vehicles (Vehicle to Vehicle Communication) travelling on roads and between vehicles and infrastructure(Vehicle to Infrastructure Communication).Therefore, the inter-vehicle communication (Vehicle to Vehicle Communication) aims to enhance the safety, and provides a comfort to both drivers and passengers by exchanging information about the road traffic condition. For protocol design the parameters to be concentrated are extremely high mobility, restricted movements, fast topology changes and time varying vehicle traffic density. The high mobility of vehicles and the presence of scatters around the roads impact the quality of communication between vehicles. The main intent back of VANETs is delivering more safety to the drivers in the roads. Various types of information will be sent via VANETs such as: traffic signal violation warning, curve speed warning, pre-crash sensing, and traffic jam warning …etc [1],[2],[3].

A. *Characteristics of VANET*

1) Dynamic topology

One of the most important characteristics of VANET is dynamic topology. In this nodes or vehicles move with high speed in respect to each other.

2) No power constraints and adequate storage

In VANET, we are using vehicles as nodes instead of other devices so vehicles have sufficient amount of energy and power including both processing and storage; so the battery power and storage is not an issue in VANET.

3) Frequent network disconnection

In VANET, vehicles move very frequently on the roads, in the network due to this the link connectivity in VANET also changes frequently. The chances of network disconnection are high when the density of vehicle is low.

4) Mobility modeling and prediction

Due to high dynamic topology, mobility modeling and prediction play very important role for designing the data dissemination in VANET.

5) Different communication environments

VANET has two types of environments i.e. highway environment & city environment. In highway traffic environment, the communication is comparatively simpler and straight forward. But in city traffic environment It become quite complex as compare to highway traffic environment [4, 5, and 6].

II. MOBILITY MODELS

The mobility model is designed to describe the movement pattern of mobile cars, and how their position, direction and speed changes over the time within a fixed area of network. [1, 7].

A. *Key Factors of VANET's Mobility*

Vehicular mobility is actually related to cars, railways, bicycles, motor bikes…etc., that is anything that moves on wheels [8]. As for cars in VANETs, there are many factors that affect their mobility, such as [9, 10, and 11]:

1) Street construction

Vehicles' movement is determined by the streets, their directions and traffic signs/ lights. It is also affected by the presence of intersections and whether they have single lane or multiple lanes, one way or two-way streets. Intersections will lead to speed reduction, high nodes' density and the need to assign a probability value to predict the turning direction to each vehicle in the simulation. Single lane roads do not allow overtaking and the speed is limited and affected by vehicles ahead while in multiple lane roads overtaking is allowed and driving is considered easier and safer.

2) Block size

This can be considered as one of the smallest areas surrounded by streets. The size will help defining the intersections and therefore how frequent a vehicle will reduce its speed and then stop. Additionally, streets with fewer intersections allow vehicles to accelerate to higher speeds in comparison to city blocks that contain many intersections. Vehicles will be forced to decelerate more often and more mobility details will be considered.

3) Traffic control mechanism

As mentioned in the first point, streets will differ in their traffic signs. The main signs that have their locations pre-defined and help bringing more reality to any proposed mobility model are the traffic lights and stop signs. They will lead to queue formation and reduction of speed.

4) Interdependent vehicular motion

Each vehicle is affected by the movement of the surrounding vehicles. The vehicle may be forced into speed reduction/ increment, changing lanes, changing the street or even stopping.

5) Average speed

The higher vehicle's speed, the faster it will change its position or location. Moreover, the road's speed limit affects the vehicle's average speed. This may lead to changes in the connectivity of the network or in other words, the network topology. So in order to propose a new mobility model for VANETs, these factors or at least some of them should be taken into consideration to have a more reliable result [3].

B. *Manhattan Grid Mobility Model*

This model uses a grid road topology to model the movement of cars in urban environment. The mobile nodes in a map are allowed to move in horizontal or vertical roads, where each road has two lanes for each direction (north/south for the vertical roads and east/west for the horizontal ones). The Manhattan model uses a probabilistic approach for the movement of a node on the roads, in which each MN at an intersection can turn left, right or go straight with certain probability. The node can continue to move in the same roads with a probability of 0.25 and with the probability of 0.25 to turn right. Fig. 1 shows the Manhattan map used in the simulation [1].

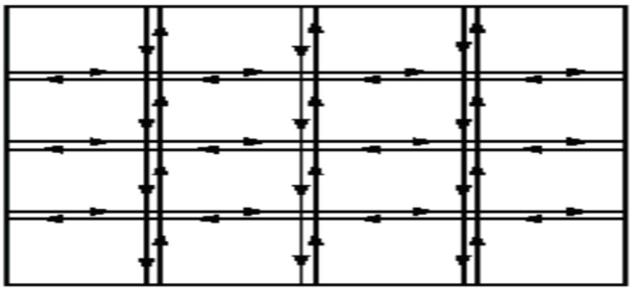

Fig.1. Manhattan mobility model map

C. *Intelligent Driver Model with Lane Changes (IDM-LC)*

Intelligent Driver Model (IDM) is a macroscopic car-following model. It adapts a vehicle's speed according to other vehicles driving ahead. IDM uses small set of parameters which can be evaluated with the help of real traffic measurements [12].

IDM-Intersection Management (IDM-IM) adds intersection handling capabilities to the behavior of vehicles driven by the IDM. In particular, IDM-IM models two different intersection scenarios: a crossroad regulated by stop signs, or a road junction ruled by traffic lights [13].

The instantaneous acceleration of a vehicle is computed according to the following equations

$$\frac{dv}{dt} = a\left[1 - \frac{v^4}{v0} - \frac{s^{*^2}}{s}\right]$$

$$s^* = s0 + vT + \frac{u\Delta v}{2\sqrt{ab}}$$

In the left hand Equation, v is the current speed of the vehicle, $v0$ is the desired velocity, s is the distance from preceding vehicle and s* is the so called desired dynamical distance. This last parameter is computed as shown in the right hand equation, and is a function of the minimum bumper-to-bumper distance s0, the minimum safe time headway T, the speed difference with respect to front vehicle velocity Δv, and the maximum acceleration and deceleration values a and b.

Intelligent Driver Model with Lane Changes (IDM-LC) extends the IDMIM model with the possibility for vehicles to change lane and overtake each others. Two issues are raised by the introduction of multiple lanes: the first is the separation of traffic flows on different lanes of the same road; while the second is the over takings model itself.

As far as the first problem is concerned, vehicular flows on parallel lanes of the same road are separated by forcing the car following model to only consider vehicles traveling on the same lane. However, as the number of lanes can vary from one road to another, a vehicle approaching a crossroad will receive from the macro-mobility description the information about the structure of the road it is going to move to. It can then adopt one of the following behaviors:

- If the lane the vehicle is currently moving on is also present in the next road on its path, then it moves through the intersection and keeps traveling on the same lane in the next street;
- If the lane currently used by the vehicle does not exist in the next road, then it tries to merge to its right as it approaches the junction. If it cannot do it, e.g. because the lane to its right is very crowded, it stops at the intersection and waits until a spot becomes available.

On the overtaking model itself, the MOBIL (Minimizing Overall Braking Induced by Lane change) model is employed, mainly due to its implicit compatibility with the IDM. This model adopts a game theoretical approach to address the lane changing problem, allowing a vehicle to move to a different lane if the lane change minimizes the overall braking of vehicles [14]. Such requirement is fulfilled when the two conditions are verified.

$$a^{l} - a \pm a_{bias} > p\, a_{cur} + a_{new} - a^{l}_{cur} - a^{l}_{new} + a_{thr}$$

$$a^{l}_{new} > -a_{safe}$$

The model allows a vehicle to move to lane l if the first inequality is verified, that is, if, in terms of acceleration, the advantage of the driver who changes its lane $a^{l} - a$, is greater than the disadvantages of the following cars in the current($a_{cur} - a^{l}_{cur}$) and in the candidate ($a_{new} - a^{l}_{new}$) lanes. The MOBIL model also consider a politeness factor p, which scales the right hand term, in a way that, for values of p towards(or above) one, a polite behavior towards other drivers is maintained, while, as p moves to (or below) zero, the driver can become selfish or even malicious. The threshold acceleration a_{thr} introduces a minimum acceleration advantage to allow a lane change, in order to avoid lane hopping in border cases. The bias term a_{bias} is instead added to favor movements to one side: in our case, this bias value is added to the advantage computed for movements to the right and subtracted for movements to the left, thus reproducing the real world tendency of drivers to stay on their right on a multi-lane road. Finally, in any case, the safety condition expressed by the right hand side equation above must be verified for the lane change to occur, meaning that the new back vehicle does not have to brake too hard (its deceleration must be over the safe valuea_{safe}) as a consequence of the lane change [6].

III. ROUTING PROTOCOLS

A. *Ad Hoc on Demand Distance Vector Routing Protocol (AODV)*

AODV [15, 16] is a reactive distance vector routing protocol in which when a certain node wants to communicate with any other node, it searches for an available path to the intended node in its local routing table and starts communicating if it finds one. However, if there is no available path, it sends a route request (RREQ) packet to all its neighboring nodes. After receiving RREQ, the nodes search for a path in their corresponding routing tables and if they do not make it, they forward the RREQ packet further to their neighbors and each node follows this process till this RREQ message reaches to some node which has a valid path to the desired destination node or it reaches to the destination node itself. In either case, the RREQ receiving node will send a RREP to the original sender of the RREQ message. As a result of this process, a path from source to the destination node is created and is available for needed communication. A Route Error message is issued in scenarios where there is no path available to the destination node. In AODV, every node maintains a routing table, which contains the following data: a next hop node, sequence number and hop count. The sequence number is used to update the route which helps in using the refreshed available path for the communication. The current distance between the source and the destination node is represented by the hop count.

B. *Destination-Sequenced Distance-Vector (DSDV)*

DSDV is a table driven proactive routing protocol based on classical distributed Bellman-Ford routing mechanism. Each node maintains routing table of all other nodes. A Sequence numbering system is given to distinguish old routes from new ones and assign by destination node. Routing table updates are sent periodically. High volumes of control traffic meaning an inefficient utilization of network resources. To alleviate this problem, the protocol uses two types of route update packets they are Full dump which carries all available routing info and can require multiple network protocol data units. Infrequently transmitted while there is not much movement. Incremental packets. These smaller packets are for relaying only the information that was updated since the last full dump [18].

C. *Dynamic Source Routing (DSR)*

Dynamic Source Routing [15, 17] is another reactive routing protocol similar to AODV in which it forms a route only when a node demands for one. However, it uses source routing instead of relying on the routing table at each intermediate junction. DSR is genuinely based on source routing wherein all the mobile nodes themselves maintain routing related information and this information is continually updated. It has only two major phases, which are Route Discovery and Route Maintenance. Route Reply would be generated only if the message has reached the desired destination node. To send this Route Reply, the destination node should have a route to the source node.

If this path is found in the route cache of Destination Node, the path would be used or else the node will reverse the route by using the information on the header of Route Request message received earlier. In the event of erroneous transmission, the Route Maintenance Phase is initiated and the Route Error packets are generated at a node. The hop which is fatal will be removed from the node's route cache and all paths including that hop are a talked at that point and again, the Route Discovery phase is initiated to find the most viable route.

IV. PERFORMANCE PARAMETERS

The performances parameters that can be obtained through the NS2 Trace Analyzer are as follows, which are the main parameters are:

- Packet Delivery Ratio
- Throughput
- End to End Delay

A. *Packet Delivery Ratio (PDR)*

The ratio of the data packets sent to the destination to those created by the traffic sources.

$$PDR=\sum Pr/\sum Ps$$

B. *Throughput*

The throughput is counted as a number of packets that have been efficiently sent to the destination vehicles.

$$T_h=\sum N_t$$

Where N_t is the number of data packet bytes in a particular time.

C. *End-to-End Delay*

End-to-End delay refers to the time taken for a packet to be transmitted across a network from source to destination.

$$D_{end-end}=N\ [d_{trans}+d_{prop}+d_{proc}]$$

Where

$D_{end-end}$=end-to-end delay, D_{proc}=procedure delay

D_{trans}=transmission delay, D_{prop}=propagation delay

D_{queue}=queue delay

N= number of links (Number of routers + 1)

Note: we have neglected queuing delays.

Each router will have its own d_{trans}, d_{prop}, d_{proc} hence this formula gives a rough estimate.

V. SIMULATION PARAMETERS AND RESULTS

In this paper analyze the performance of various mobility models using protocols and their impact on quality of communication between moving vehicles in VANET.

TABLE I. SIMULATION PARAMETERS

Parameter	Value
Simulator	NS-2.35
Simulation Area	500*500 m^2
Number of Nodes	10
Transmission Range	250m
Traffic Type	CBR(Constant Bit Rate)
Protocols	AODV,DSDV,DSR
Mobility Model	Manhattan Grid, Intelligent Driver with Lane Changes Mobility Models
Antenna Type	Antenna/Omni Antenna
Channel Type	Channel/Wireless Channel
Lltype	Link Layer
ifqType	Queue/Droptail/PriQueue/CMUPriQueue

TABLE II. MANHATTAN GRID MOBILITY MODEL PARAMETERS

Protocols	Pdr	Throughput	Delay
AODV	99.41	493.11	168.857
DSDV	99.68	354.313	189.56
DSR	99.87	539.20	160.161

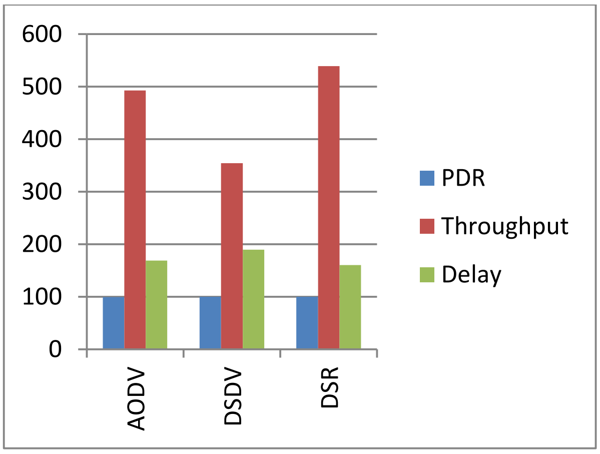

Fig.2. Performance Analysis of Manhattan Grid Mobility Model using AODV, DSDV, DSR protocols

TABLE III. INTELLIGENT DRIVER MODEL WITH LANE CHANGES PARAMETERS

Protocols	Pdr	Throughput	Delay
AODV	98. 41	487.508	170.253
DSDV	97.56	325.432	190.75
DSR	98.56	503.753	166.65

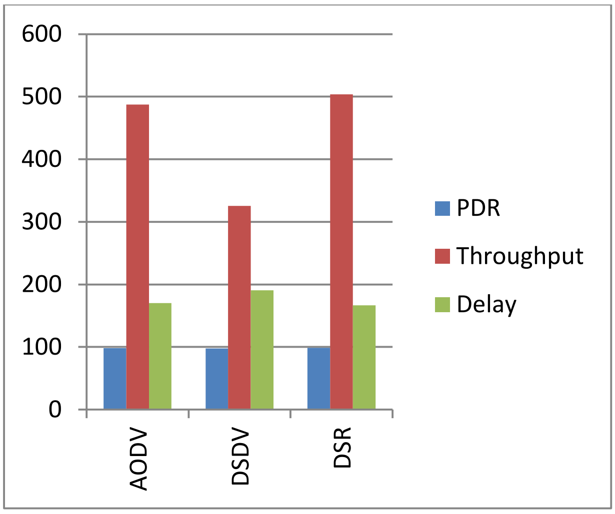

Fig.3. Performance Analysis of Intelligent Driver Model with Lane Changes using AODV, DSDV, DSR protocols

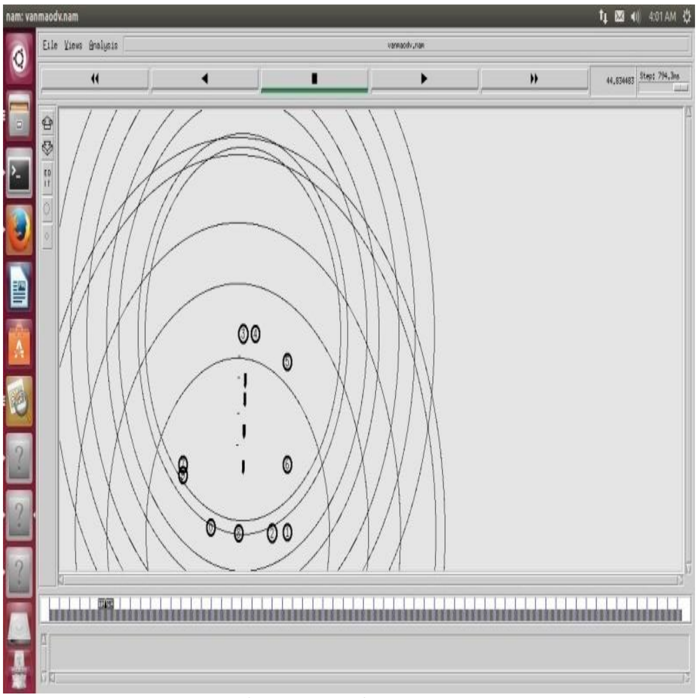

Fig.4. Graphical view of packet transfer and acknowledgement in Vehicles using NAM window-1

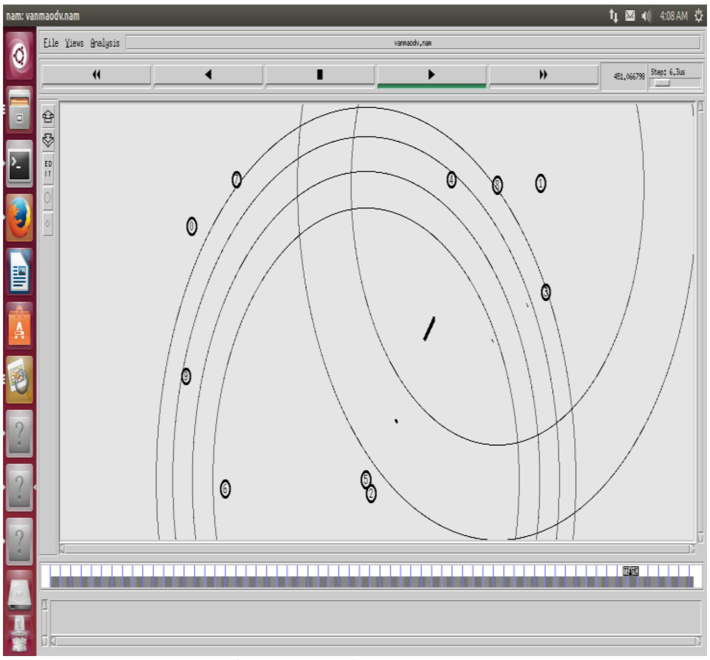

Fig.5. Graphical view of packet transfer and acknowledgement in Vehicles using NAM window-2

VI. CONCLUSION

The simulation results demonstrate that the mobility models determine the performance of vanet. In the vanet use mobility models Manhattan Grid, Intelligent Driver Model with Lane Changes (IDM-LC) each differ in performance parameters results. Two mobility models using protocols AODV, DSDV, DSR for packet transmission in vehicles. In these mobility models DSR protocols give the best performance in packet delivery ratio, throughput and delay compare with other protocols AODV, DSDV. In vehicular ad-hoc networks within two mobility models better performance given by the Manhattan grid mobility model compared with Intelligent Driver Model with Lane Changes (IDM-LC) i.e. Manhattan Grid mobility model has better throughput, packet delivery ratio and minimum delay to deliver the data packets to a destination in vehicular ad-hoc network than the other mobility model in this paper.

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