Research Journal of Recent Sciences ISSN 2277-2502
Vol. **3(5),** 94-103, May **(2014)** *Res.J.Recent Sci.*

A Two Dimensional Performance Analysis of Mobility Models for MANETs and VANETs

Muhammad Amir Nisar, Amir Mehmood, Adnan Nadeem, Kamran Ahsan, Mmuhammad Sarim
Department of Computer Science, Federal Urdu University of Arts, Science & Technology, Karachi, PAKISTAN

Available online at: www.isca.in, www.isca.me
Received 28th November 2013, revised 17th April 2014, accepted 26th April 2014

Abstract

Mobile ad hoc Networks and Vehicular Ad Hoc networks have emerged as advanced wireless networks. These networks have their applications in various walks of life. Mobility of nodes in these networks is a major benefit for the end users. However, modeling the mobility of the nodes in these networks is a key for the researcher. In this paper, we first review and categorized the mobility models in MAENTs and VANETs. Then we analyze the performance of different types of existing mobility models of MANETs and VANETs through a case study. In the case study we analyze the performance of mobility models with varying mean speed of nodes. We have also varied the routing protocol to add another dimension in this analysis. The results of the analysis from the case study show the suitability of some key mobility models of MANETs and VANETs in various scenarios.

Keywords: Mobility model, mobile ad hoc network, vehicular Ad hoc network, performance analysis.

Introduction

A wireless network with no backbone or centralize control is ad-hoc network. A mobile ad-hoc network (MANETs) is an autonomous group of mobile nodes that establish wireless connectivity without prior network infrastructure[1]. MANETs can be deployed any where such as battle field, relief operation and urgent business meeting without the use of pre-exist infrastructure such as wires and base station. Vehicular ad-hoc networks (VANETs) are a derivative of MANETs where nodes are vehicle that provides vehicle to vehicle (v2v) communication and vehicle to pre-installed infrastructure communication. VANETs improve traffic efficiency, minimize traffic congestion, avoid accidents and make easy access to news, information and entertainment while driving[2]. A mobility model along with motion constrains and traffic generator can generate a better mobility in vehicles[3]. Mobility model shows the moving path, location, and change in velocity over time of mobile nodes to get better mobility management. In order to get optimal results in MANETs and VANETs several mobility models have been proposed for simulation because testing these networks in real world scenario involves huge cost.

Some of the work on the performance analysis of mobility models has already been done. For example Ariyakhajorn et al[4] have analyzed the comparison of Random Way Point and Gauss Markov mobility model in MANETs and F. Bai et al[5], briefly described and analyzed the several mobility models in MANETs. This paper presents the review, classification and analysis of mobility models of MANETs and VANETs using AODV and DSR through a case study. In the case study, performance metrics are used to estimate the suitability of mobility models in various scenarios.

The rest of the paper is organized as follows:at the outset, we review and classify the mobility models of MANETs in detail. After it, we provide an review of the mobility models in VANETs and their classification. Then, we present the performance analysis of mobility models[6-8] as described through a case study. Finally, we summarize the work in this paper and highlight the future research.

Mobility Models in MANETs

Researchers have proposed various ways to model the movement of the nodes in MANETs. In figure-1, classification of different mobility models as per their characteristics is given. In this section, we will briefly explain the operations of these models.

Random Models: In random models, the movement of mobile nodes is random and free without any restriction. In other words, the direction, velocity and destination of any node are chosen randomly and independently by other mobile nodes. Random Models are sometimes called entity models because in these models, node is considered as an entity that can move independently. The most commonly used random mobility model in MANETs is Random Way point Mobility Model.

Random Way Point Model: The Random way point mobility model was first proposed by Johnson and Maltz[1] in 1996. Soon after it became a most commonly used mobility model for researchers in the field of ad hoc networks. Random Way Point Mobility Model (RPW) is a model that uses the concepts of a pause time between two instances of mobility. In start the mobile nodes choose the random destination for movement. The speed of the nodes would be defined properly and should be uniform before its movement. The term *pause time* refers to the time when node stop for specified time after reaching at the destination. After the expiration of *pause time* the node again chooses the random destination to move. If the *pause time* is set as '0' then it means that it is a continuous mobility model. This mobility tool is included in Network Simulator (NS-2) as well as in Global Mobile Simulator (GLOMOSIM). The RPW model is the simplest and easiest to use.

Random Walk Model: According to Camp T. et al.[9] the random walk model first proposed mathematically by Einstein in 1926. We can say that random walk model is the type of random way point model but in some stipulations are included. First, a mobile node starts to move towards the destination by choosing random velocity and random direction. The direction and velocity should be pre-defined from [0, 2π] and [minimum speed, Maximum speed] respectively. Each movement of the mobile node should be done either in constant time or constant distance travelled, after which a new speed and direction will be calculated. In random walk model if a mobile node touch the simulation boundary then it will return in the same speed but in the manners of making an angle in which it touched the simulation boundary. After this the mobile node continues its new path. After random walk model is proposed several its sub-models have been introduced, for example 1-D, 2-D, 3-D and d-D.

Random Direction Model: In this model[9] mobile nodes are forced to travel to true edges of simulation area before changing direction and speed to overcome density waves. The density wave is nodes cluster in one segment of simulation area. Here mobile nodes select random direction similar to random walk mobility models. Random walk and random direction are two variants of random way point model. Mobility of nodes has been shown in figure-2.

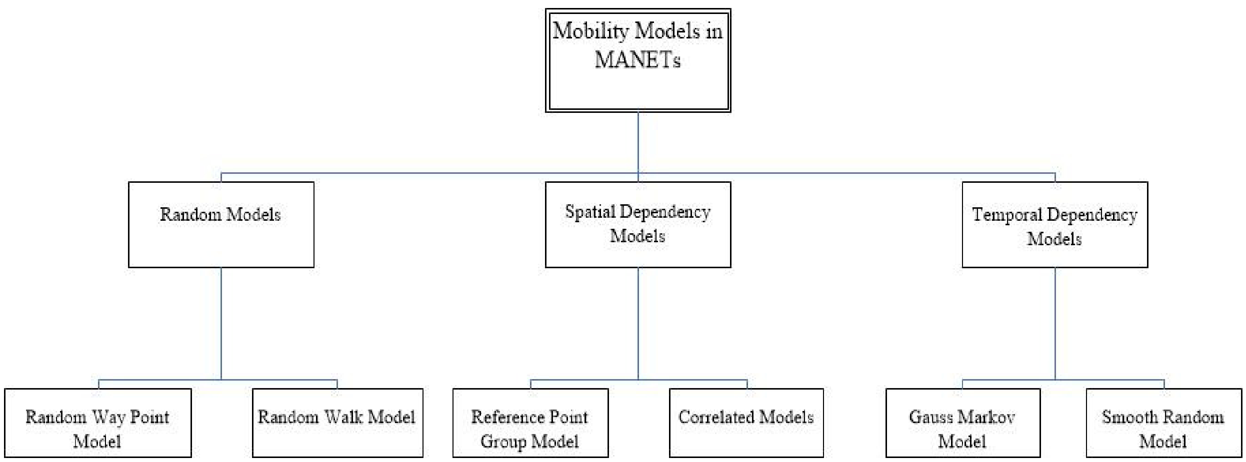

Figure-1
Classification of mobility models in MANETs[5]

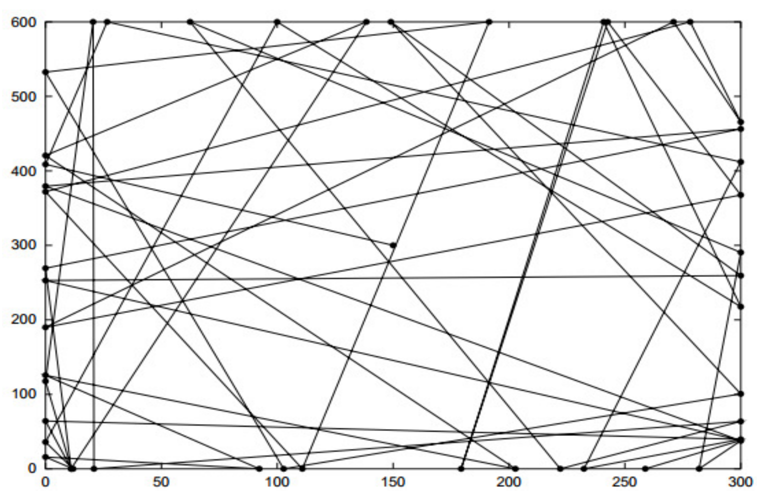

Figure-2
Mobility Pattern of nodes in Random Direction Model[6]

Spatial Dependency Models: The main drawback of each random model is that it considers every mobile node as an entity which is totally different from others in terms of mobile node's velocity, location and movement. Therefore, these random models are not suitable for any ad hoc network application which requires similar people work as a single group. For example in battlefield, the movement of a team member is followed or influenced by the team leader. This also to other applications such as disaster relief. Any mobility model considered this type of communication is called mobility models with spatial dependency. There are various Spatial Dependent models were proposed but some models get more fame to others. Because mobile nodes work in this model as a group therefore it makes partitions in the network which means network is broken in various groups.

Reference Point Group Mobility Model: This model[10] can be explained in a better way by describing snow slide rescue in which committee of human and usually trained dogs work hand in hand. Here the human guides are aware of the approximated location of victims, and then set a pathway that is followed by dogs. Where each dog randomly selects their own pathway to reach the destination point out by human counterparts. Similarly, in RPGM movement of group head decides the mobility performance of the whole group. Figure-3 shows the node movements in the RPGM. The role of group head and group associates are illustrated in figure-3.

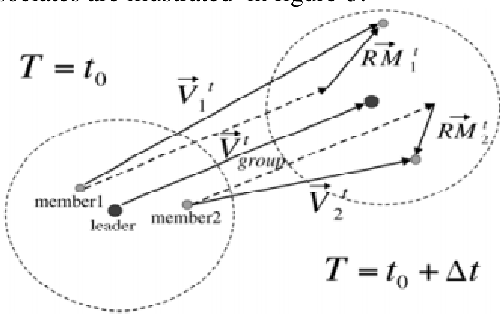

Figure- 3
Nodes movement in RPGM Model[7]

The Group Head: the movement of group head at time t can be represented by motion vector v^{t}_{group}. It describes the motion of group head as well as the general motion tendency of the entire group. Every member of this group move away from this general motion vector v^{t}_{group} by a few degrees. The motion vector v^{t}_{group} can be randomly selected on the basis of predefined pathways.

The Group Associates: The movement of group associates is considerably affected by the movement of its group head. For every node that follows the group movement, mobility is allocated with a reference point by group head. Every mobile node is usually positioned in the neighborhood of predefined reference point. Now the motion vector of group member j at time t ,can be described as $v^{t}_{j} = v^{t}_{group} + RM^{t}_{j}$, Where the motion vector RM^{t}_{j} is a random vector diverged by group member j from its own reference point. The following picture depicts the whole scenario discussed above.

Correlated Models: In Jan 1999, Sanchez and Manzoni[10] proposed a set of correlated mobility models in which the mobile nodes move with cooperation of the other mobile nodes. This set of correlated models includes Pursue Mobility Model, Column Mobility Model and Nomadic Community Model which we briefly describe as follows.

Column Mobility Model: This model can be described as a representation of a set of mobile nodes moving in certain fixed direction. It can be used in searching and scanning the mines. One important thing is that whenever a mobile move across the field, the direction of the mobility is reverse to 180 degrees and mobile node will be able to move towards the center with new direction.

Pursue Mobility Mode: It is the model where several mobile nodes try to intercept a single node "*also called the target node*" which is ahead of them. This target node's movement is free according to the random way point model. The *pursuer* or *seeker* nodes try to capture the target node with the given directed velocity towards the target node. This mobility model can be used in target tracking or law enforcement.

Nomadic Community Mobility Model: In this mobility, model, and a group of mobile nodes move together randomly from one location to other. The reference point of each mobile node is defined by the general movement of the whole group. This type of mobility model are usefull in battle field operations.

It is observed in the previous discussion that the set of correlated models and RPGM show the characteristics of Spatial Dependency. Now in next section Mobility Models with Temporal Dependency will be discussed.

Temporal Dependency Models: As mentioned earlier every node's movement or mobility is limited by laws of acceleration, its velocity and rate of change in direction. Therefore the velocity of a mobile node may be depends upon its previous velocity. Therefore the velocities of a mobile in different time slots are inter-related. This characteristic in the mobility of mobile nodes is called Temporal Dependency of the velocity. Because of inadequate behavior of random models to allow this Temporal Dependency Models, various mobility model such as Gauss-Markov Mobility Model and Smooth Random Mobility Models were proposed.

Gauss-Markov Mobility Model: The Gauss-Markov Mobility Model[11] was proposed in 1999. This model first calculated the speed and the direction of each mobile node. After calculation is being done, the mobile node moves according to the calculated speed and direction for a time period. After that time period the process starts again and goes on again and again. The time period between the change of time and direction will be constant. The current direction and speed will be determined with the pervious values of speed and direction. Moravejosharieh A et al.[6] described the relationship between current and previous values of speed and direction described in equation-1 as follows,

$$S_n = \alpha S_{n-1} + (1-\alpha)\bar{S} + (1-\alpha^2)\sqrt{S_{x_{n-1}}} \quad (1)$$
$$d_n = \alpha d_{n-1} + (1-\alpha)\bar{d} + (1-\alpha^2)\sqrt{d_{x_{n-1}}}$$

Where S_n and d_n are speed and direction of the movement for n period time. And S_{n-1} and d_{n-1} are the values of speed and direction for n-1 time period. And where α is the constant value i.e. [0, 1] and S and d is the mean speed and mean direction. S_{Xn-1} and d_{Xn-1} are the variables representing the Gaussian distribution. When α is set to "0" then it will maximize the speed and direction of mobile node in equation-2, as follows:

$$S_n = \bar{S} + \sqrt{S_{x_{n-1}}} \text{ and } d_n = d + \sqrt{d_{x_{n-1}}} \quad (2)$$

When α is set to "1" then it will minimize the speed and direction and result should be $S_n = S_{n-1}$ and $d_n = d_{n-1}$ so it can be said that here α used as a tuning parameter.

Smooth Random Mobility Model: Smooth Random Mobility Model[12] is another example of Temporal dependency Models. In Random Way Point, it is examined that the nodes did turn in sharp manners and also there is a problem considering the sudden stop and sudden acceleration. All this happen because of memory less nature of Random Mobility Models. According to the author Bettstetter, it is a Random Mobility Model with two dimensions for movement. The movements of the nodes are not bounded by any physical constructions or structures such as streets or buildings, thus nodes are allowed to move freely within the simulation area. Every time destination is being chosen by direction of the node. Probability is used for change in speed and direction. Also there is no concept of correlation of nodes is included in this model. Fan and Ahmed[5] introduced the basic equation for this model. It is observed in real life that the speed of a mobile node may be change over time to time so it is not obvious that speed should be minimum as "0" or maximum "V_{max}". So the probability distribution of the mobile node velocity should be the speed which is remaining within the values of preferred speed has a high probability. When the preferred speed set as [0, ½, V_{max}], then probability should be as follows

$$Pr_V(v) = \begin{cases} \Pr(v=0)\delta(v) & v = 0 \\ \Pr(v=\frac{1}{2}V_{max})\delta(v-0.5V_{max}) & v = \frac{1}{2}V_{max} \\ \Pr(v=V_{max})\,\delta(v-V_{max}) & v = V_{max} \\ \frac{1-\Pr(v=0)-\Pr(v=0.5V_{max})-\Pr(v=V_{max})}{V_{max}} & 0 < V_{max} < 1 \\ 0 & otherwise \end{cases} \quad (3)$$

Where 1-Pr (v=0) +Pr (v=1/2) +Pr (v=V_{max}) < 1

Whenever a change in speed encountered the new target speed as determined in above given equation- 3. Then the speed incrementally changed from current speed with acceleration or deceleration speed which is denoted by *a (t).* The probability distribution of acceleration and deceleration should be distributed as [0, a_{max}] and [a_{min}, *0*] respectively.

The equation- 4 of probability distribution of acceleration and deceleration will be as follows

$$Pr_\alpha(\alpha) \begin{cases} \frac{1}{\alpha_{max}} & for\ acceleration\ 0 < \alpha \leq \alpha_{max} \\ \frac{1}{\alpha_{min}} & for\ deceleration\ \alpha_{min} < \alpha \leq 0 \\ 0 & otherwise \end{cases} \quad (4)$$

For each time interval, the new speed will calculated as

$$v(t) = v(t - \Delta t) + a(t)\,\Delta t \quad (5)$$

In contrast with the speed the direction movement and distribution will purely be uniformed in interval [0, 2π] such as

$$Pr_\emptyset(\emptyset) = \frac{1}{2\pi}\ for\ 0 \leq \emptyset < 2\pi \quad (6)$$

Where direction is denoted by $\emptyset$. And for every time slot in the interval of change in direction the mobile node changes its movement direction as follows

$$\emptyset(t) = \emptyset(t - \Delta t) + \Delta\varphi(t) \quad (7)$$

Where $\Delta\varphi(t)$ is used for changes in movement direction.

In this section generally we go through to the mobility models with temporal dependency and it is determined that The Gauss-Markov model and The Smooth random model both are temporal dependent models. In Gauss-Markov model α is a memory parameter with one can adjust the speed and direction. In Smooth random model as observed in equation- 5 and equation- 7, both the speed and direction are depending on their previous values. There is many more mobility scenarios can be generated with the help of above given parameters in Temporal Dependency Models.

Mobility Models in VANETs

In this section we have classified the mobility models in VANETs based on their use of existing knowledge. Figure-5 shows this classification. Although researchers has proposed other means of categorizing VANETs mobility model[5]. As mentioned in mobility model in MANET section, the characteristics, Behavior and nature of work of every VANET mobility model is different from other mobility model used in VANETs. The mobility models used in VANETs is a little bit different from mobility models used in MANETs in terms of its geographical restrictions. According to the figure given above, all mobility models are discussed in detail in the next part of this section.

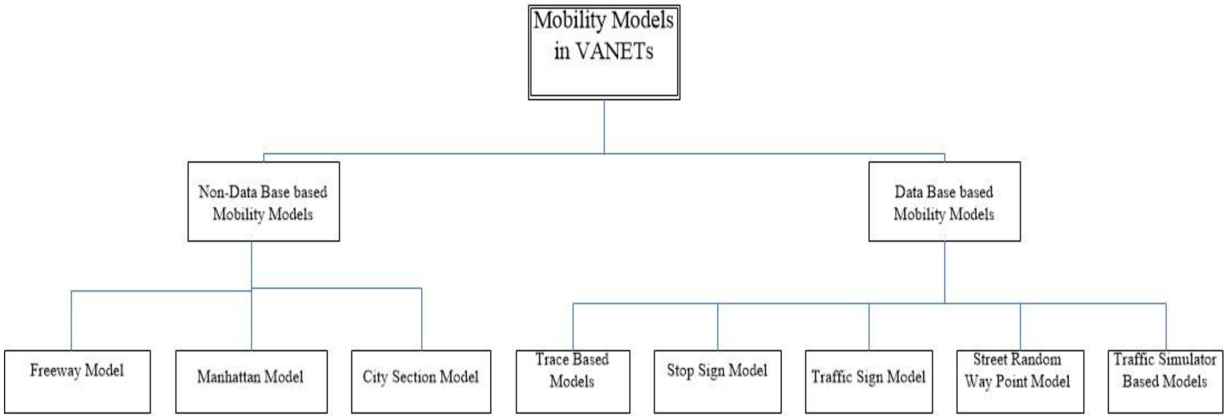

Figure- 4
Classification of Mobility models in VANETs

Freeway Mobility Model: Freeway mobility model[13] is a mobility model where simulation area is defined by also a generated map. In this map there are no intersections and urban routes are considered. As mentioned in its name, it includes many freeways with many lanes on each side. A map is generated before the start of simulation. Nodes are randomly placed in the lanes at the beginning of the simulation and nodes are not allowed to change its lane during the simulation it means if a node is placed in any lane then it will remain on that lane until the end of simulation. Nodes move according to its previous speed which is stored in the memory (history-based). One important thing is that every node has a safe distance (which is predefined) from other node which is ahead of it. If somehow this distance is less than its required distance then node which is behind the other node will be decelerated. The approach of this model is unrealistic. Next Manhattan mobility model is discussed.

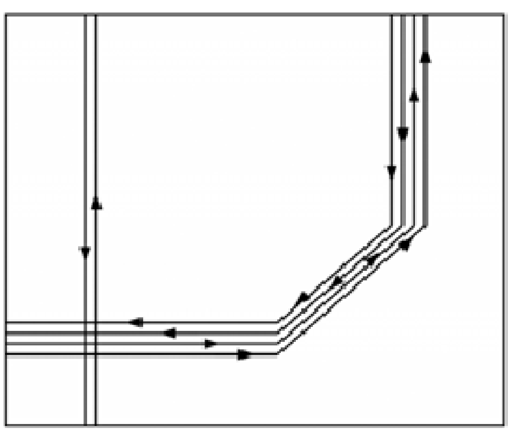

Figure-5
Freeway Mobility Model[5]

Manhattan Mobility Model: Manhattan mobility model[13] is also used generated map as simulation area like freeway mobility model but this map contains the vertical and horizontal roads. Figure-7 shows the Manhattan mobility modes. These roads having only 2 lanes and these lanes allowed the motion in 2 different directions. Like freeway model, a map is also generated before simulation is start then a node is also placed in any lane of the roads and it starts its movement according the direction of the lane with speed which is also history based. After reaching at crossroads, the nodes randomly choose a direction (straight, left, right) to follow. The authors set the probability parameters of choosing a direction which are 0.5, 0.25, and 0.25 respectively. The safe distance also used in this mobility model and nodes used the same methodology to keep the safe distance as mentioned in Freeway mobility model but adding a feature which is a node can change its lane at crossroads. The unrealistic thing is in this model is that node cannot stop or slow down at crossroads which is totally contrast to the real world scenario. Next City Section Mobility Model is discussed.

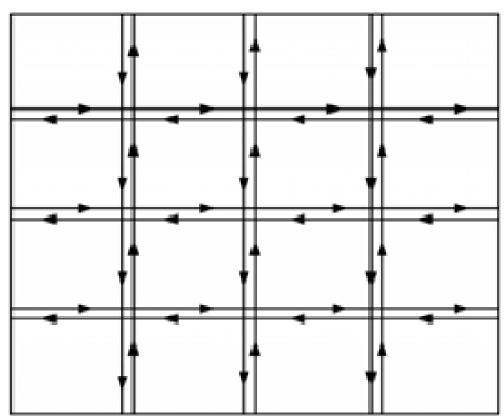

Figure- 6
Manhattan Mobility Models[5]

City Section Mobility Model: City Section Mobility Model[14] is basically a hybrid model of Random Waypoint Mobility and Manhattan mobility model. It also uses the generated map as a simulation area. It also uses the characteristics of random waypoint mobility model such as pause-time and random selection of the destination. A node is assumed to be placed in any intersection of the streets at the beginning of the simulation and it is assumed that each street has its own speed limit. A random point or intersection is selected on each step of the movement of the node. Then node move towards that chosen intersection with available shortest path. After reaching the target point, the node stops there for given pause time. After pause time, a new target point intersection is chosen and this will repeat again and again until the end of simulation also this model utilize the safe distance methodology. Again this model is not overcome the problem which is stated for previous two mobility models which is no presentation of traffic control mechanism at crossroads or intersections. Next two URBAN area mobility models were discussed. Figure-7 shows the node movement pattern in city section model.

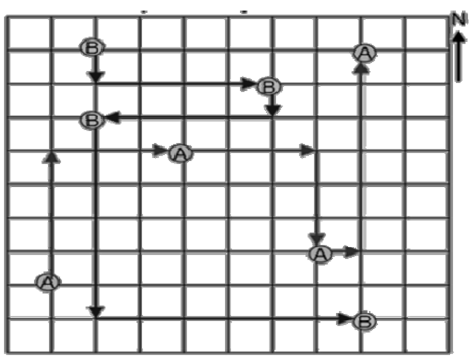

Figure-7
Node movement pattern in City Section Model[5]

Stop Sign Mobility Model: Stop Sign Mobility Model[15] is the first model we discussed which has traffic control mechanism. This model is based on real maps taken from *Topological Integrated Geographic Encoding and Referencing* TIGER/Line database[16]. A stop signal is placed on every intersection where node may stop for some time or can be slow down. In this model all roads assign a single Lane in each direction. A node cannot overtake the node which is ahead of it also kept the safe distance from that node which is mentioned in all three previously discussed mobility models. The problem in this model is that if each node follows the above given rules for this mobility model then it will make a queue of the nodes at intersections and nodes have to wait until its successor node cross the intersection. This will affect the connectivity of the network as well as the average speed of the nodes and other problem in this model is the availability of stop sign in each intersection. Therefore they proposed another mobility which is Traffic Sign Mobility Model.

Traffic Sign Mobility Model: In order to overcome the problems of stop sign model Mahajan A et al[15] proposed a traffic sign model in which stop signals are replaced by traffic signals, when vehicle reaches to intersection and experiences a red signal then it stops else continues to move. When a node reaches intersection and stops as signal turns red for a while, it conforms probability p .As signal turns green with probability 1-p vehicle does not stop and cross the intersection. when signal turns red, it stops vehicles and so a queue is formed for a random delay. As signal turns green the vehicles cross the intersection one by one until queue gets empty.

Street Random Waypoint Model: This model[17] based on real maps of TIGER in which roads include single lane and are further divided into sections. This model comprises of three steps: intra-segment mobility manager, inter-segment mobility manager and the route management and execution. In this model nodes are randomly placed one after the other which moves, using car following model[14], such that reaching the maximum speed. First section manages the motion of vehicles from entering point to exit point of the segment. The second section illustrates the traffic control mechanism in which stop sign and traffic sign are installed on intersection or crossroads. The third section describes two approaches of routes to be followed by vehicles in simulation. One is simple STRAW and next STRAW OD. In simple straw direction is chosen randomly at each intersection while in OD destination is selected by vehicle using shortest path algorithm.

Traffic Simulator Based Model: Mobility Model Generator for Vehicular Network (MOVE)[18] is a mobility model that uses a compiler called SUMO[19], which is a realistic simulation model for vehicular traffic. SUMO is java based open source application that integrates the realistic accelerations; the real maps with several types of routes and those routes have multiple Lanes and priorities defined for traffic light for the several nodes. MOVE has two basic components. One is road map editor which generates the road map from TIGER data base or from Google earth files manually and randomly. The other component is vehicle (node) movement generator which allows specifying the properties of a vehicle (node) such as the maximum speed, the probability of turning at intersections, acceleration and the decision of path taking etc. After collecting the information by these two editors, the information sent to the SUMO compiler, a trace file is generated in ns-2 or Qualnet[20] format. According to the authors, they compared the MOVE with Random Waypoint mobility model using AODV (Ad hoc On-Demand Vector routing protocol). It is shown that MOVE causes low reception rate as compare to Random way point model. Several types of routes and those routes have multiple Lanes and priorities defined for traffic light for the several nodes. MOVE has two basic components. One is road map editor which generates the road map from TIGER data base or from Google earth files manually and randomly. The other component is vehicle (node) movement generator which allows specifying the properties of a vehicle (node) such as the maximum speed, the probability of turning at intersections, acceleration and the decision of path taking etc. After collecting the information by these two editors, the information sent to the SUMO compiler, a trace file is generated in ns-2 or Qualnet[20] format. According to the authors, they compared the MOVE with Random Waypoint mobility model using AODV (Ad hoc On-Demand Vector routing protocol). It is shown that MOVE causes low reception rate as compare to Random way point model.

Trace Based Model: Since most of the synthetic models do not support realistic motion of vehicles. Therefore, trace based models are accepted more. Traces describes the motion pattern of vehicles in a particular region for the selected time using data set.

Performance Analysis

In this section we aim to analyze the performance of most commonly used mobility models of MANET and VANETs under two routing protocols. We will first describe the simulation scenarios including their detail parameters. Then we present the performance analysis of some of the key mobility models and their results in different scenarios through a case study.

Simulation Environment: In this section, we describe the simulation parameters of the scenarios simulated. We use GloMoSim to simulate the scenarios of MANETs and VANETs. Since Random Waypoint is the only model present in Glomosim. Therefore, traces of the rest of the mobility models have been integrated from Bonnmotion scenario Generator[21]. Table-1 presents the general parameters of all the scenarios which represent the simulation environment.

Table-1
Simulation Environment

Transmission Range	250(m)
Simulation Time	1000(sec)
Bandwidth	2(mbps)
Packet size	256 (bytes)
Traffic Type	CBR (Constant Bit Rate)
Routing Protocol	DSR & AODV
Number of Nodes	25
Simulation Area	1000 X 1000(m x m)

Case Study: In this section, we analyzed the performance of mobility models in MANETs and VANETs using Glomosim. We use performance metrics (PM) represented through equation -8.

$$PM = \{Throughput, PDR\} \quad (8)$$

Where *Throughput* means the average network throughput and PDR represents the packet delivery ratio of the network. We analyze the importance of average network throughput and PDR in measuring the overall network performance through literature[4,5,22,23] and simulation results. We observe that throughput and PDR are more significant than any other parameter. Therefore, for simplicity we select these two parameters as metrics to analyze the performance of the mobility models in the case study in this paper.

Scenario 1: Analysis of MANETs Mobility Model: In this scenario we analyze MANETs mobility model. We have given an in-depth analysis of one model for each class from figure-1, i.e. Random Way Point (RWP) from Random Mobility Models, Gauss Markov from Temporal Mobility Model and Reference Point Group Mobility Model from Spatial Mobility Model. We also vary routing protocol to include another dimension to this analysis. We build simulation environment from table 1 and parameters of these mobility models from table-2.

Table-2
Particular parameters of models in MANETs

Mobility Model Parameter	Gauss Markov	RWP	RPGM
Mean Speed(m/s)	0,10 & 25	0,10 & 25	0,10 & 25
Angle Standard Deviation	0.39269	N/A	N/A
Speed Standard Deviation	0.5	N/A	N/A
Pause Time(s)	N/A	30	30
Groupsize_e	N/A	N/A	5.0
P_Groupchange	N/A	N/A	0.1
Maximum Distance (m)	N/A	N/A	10

In this part of the scenario, we have examined MANETs mobility models through DSR and AODV at no speed (0m/s), medium (10m/s) and high (25m/s) mean speed. Figure-8 shows the performance of the MANETs mobility models i.e. Gauss Markov, RPGM and RWP at different mean speed in terms of average network throughput, under DSR routing protocol. The DSR is a source routing protocol in which the complete path is known to the intermediate nodes. The graph in the figure shows that the temporal dependency model (Gauss Markov) does not cope well with the high mean speed of nodes in the network. RPGM which is based on spatial dependency model shows better performance as compared to Gauss Markov. However, RWP which is based on random models cope well with the increasing node means speed in the network. This is because the randomness supports the dynamically changing behavior of nodes in MANETs.

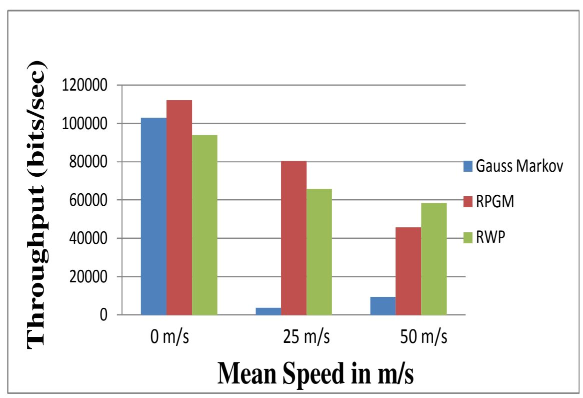

Figure- 8
Throughput v/s nodes mean speed observed in MANETs mobility models under DSR

Figure-9 shows the performance of the MANETs mobility models i.e. Gauss Markov, RPGM and RWP at different mean speed in terms of average network throughput, under AODV routing protocol. It can be observed from the two graphs of Figure-8and 9 that all three mobility models has slightly better performance in AODV as competed to DSR. However, the same trend of decrease in throughput with increasing mean speed is observed from figure-9. The graph clearly shows that on average RWP has performed well.

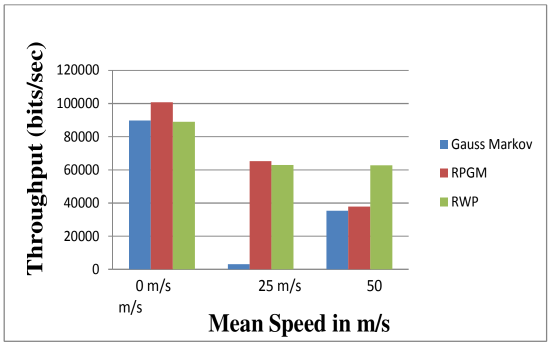

Figure-9
Throughput v/s nodes mean speed observed in MANETs mobility models under AODV

In this part of the scenario we analyzed the selected mobility models considering the PDR using DSR and AODV. The graph in figure-10 shows the performance of the MANETs mobility models i.e. Gauss Markov, RPGM and RWP at different mean speed in terms of packet delivery ratio. The graph shows that RPGM has better PDR as compare to other mobility models. In Gauss Markov the PDR is not affected with speed. RWP has better PDR with increasing mean speed of the nodes in the network.

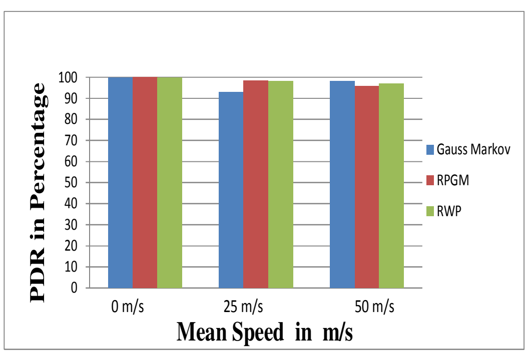

Figure-10
PDR v/s Mean speed observed in MANETs mobility models under DSR

Figure-11 shows the performance of mobility models in terms of PDR versus means speed under AODV. In general, the graphs show slightly better performance of these mobility models in AODV as compete to DSR. There is no significant difference in the PDR with these three mobility models.

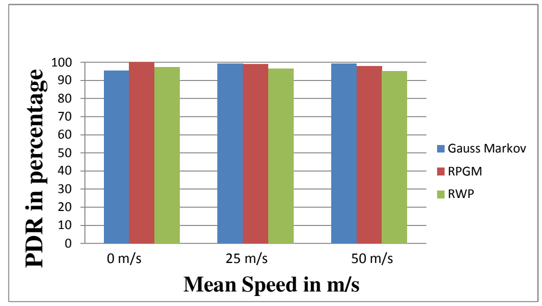

Figure-11
PDR vs nodes mean speed observed in MANETs mobility models under AODV

Scenario 2: Analysis of VANETs Mobility Model: In this scenario we analyze VANETs mobility model. We have analyzed of one model for each class from Figure-5, i.e. Manhattan from non database based models and Street Random Mobility Model from database based mobility model. We have assumed the map of the roads is available for SRWP so it models the mobility of vehicles in VANETs. We also vary routing protocol to include another dimension to this analysis. We build simulation environment from table 1 and parameters of these mobility models from table III. In both environments models have been tested via routing protocol DSR and AODV. Although DSR and AODV are bit promising protocols for a small number of nodes in VANETs. In the subsequent part of this section, we will analyze the performance of MANET and VANET by creating four simulation scenarios.

Table-3
Particular parameters of models in VANETs

Mobility Model	Manhattan	SRWP
Mean speed(m/s)	25 and 50	25 and 50
Speed standard deviation	0.1	0.1
Update distance	3.0 m	N/A
Maximum pause	30 sec	30 sec
Speed change probability	0.2	0.3
Turn probability	0.2	0.2
(X, Y) block	(25, 25)	(25, 25)

In this part of the scenario we analyze VANETs mobility models i.e. Manhattan model and Street Random Way Point Model at low, medium and high mean speed of the nodes under DSR and AODV. The results using DSR are displayed in figure-12. In general, graph shows that the SRWP model has better performance in terms of average network throughput in medium speed but less in high speed as compared to the Manhattan. Figure-13 shows the performance of the VANETs mobility models i.e. Manhattan mobility model and Street Random Way Point Mobility Model in terms of average network throughput at medium and high mean speed of the nodes in AODV. The graph clearly indicates the same pattern for SRWP and Manhattan as shown in figure 12 but in AODV the throughput of the network is high as compare to DSR model performance is far better than Manhattan model.

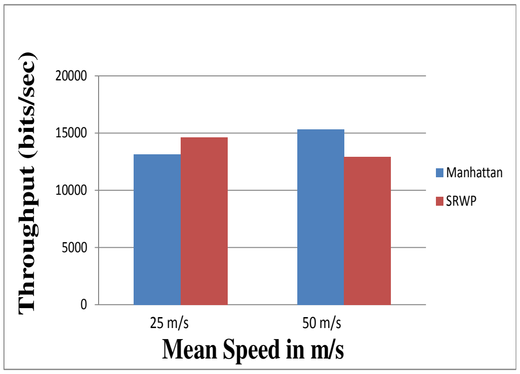

Figure-12
Throughput v/s nodes mean speed observed in VANETs mobility models under DSR

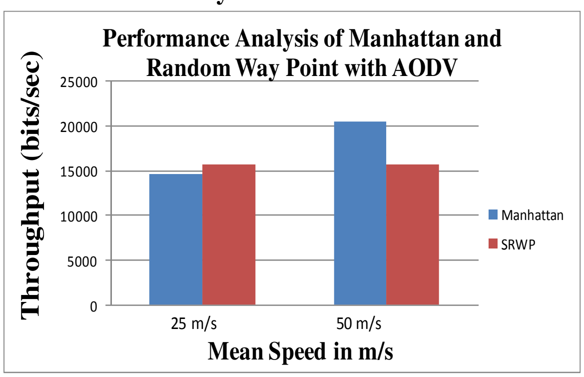

Figure-13
Throughput v/s nodes mean speed observed in VANETs mobility models under AODV

In this part of the scenario, PDR is analyzed using DSR and AODV. Figure-14 and 15 shows the analysis of PDR with these mobiltiy models with DSR and AODV respectively. The graphs shows that PDR follows the same trend in both routing protocols and there is no significant different in PDR between the two mobility models.

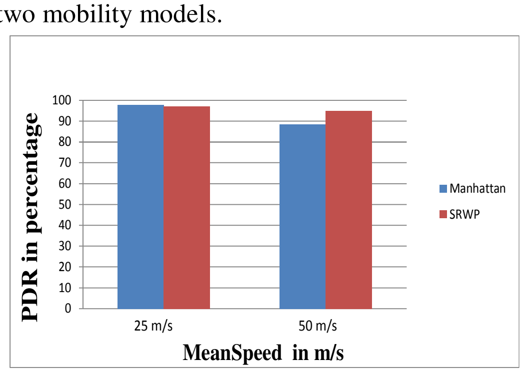

Figure-14
PDR vs nodes mean speed observed in VANETs mobility models under under DSR

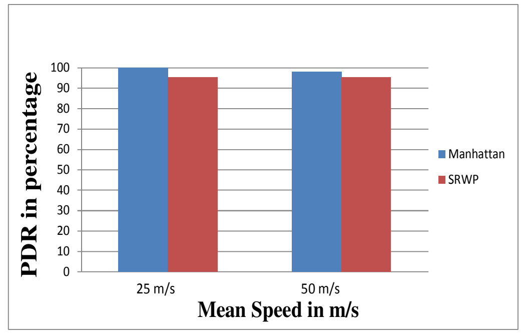

Figure-15
PDR vs nodes mean speed observed in VANETs mobility models under AODV

Conclusion

In this paper, we have first reviewed from the literature and classified the mobility models for MANETs and VANETs. In MANETs we categorize them as either random, spatial dependency based and temporal dependency based models. Secondly, we analyze the performance of moblity models of MANETs and VANETs using a case study. In the case study, we have analyzed mobility models peformance using the performance metric under two different routing protocols. From the MANETs mobility model prespective the analysis results indicate that RWP and RPGM have performed better than Gauss Markov mobility model in both routing protocols. However, in VANETs it is obvious that SRWP has significantly improved performanc in medium speed as compare to the Manhatten model and Manhattan has marginally better performance in high speed scenario. However, Manhatton best suits the mobility of vehicles having control mechanism rather than the movement of vehicles with random pattern of roads and juctions. The analysis in this paper has given us the suitability of some mobility models in MANETs and VANETs from mean speed and routing prespective. However, in future we will comprehensively analyze the range of mobilty model based on different criterias.

References

1. Brooch J., Maltz D.A., Johnson D. B., Hu Y. C. and Jetcheva J., A performance comparison of multi-hop wireless ad hoc network routing protocols, *Proc. of the Fourth Annual ACM/IEEE Int. Conf. on Mobile Comput. and Net*. (Mobicom98) **(1998)**

2. Bechler M., Franz W.J., and Wolf L., “Mobile internet access in FleetNet. *13. Fachtagung Kommunikation in verteilten Systemen, Leipzig, Germany* **(2003)**

3. Harri J., Filali F. and Bonnet C., Mobility models for vehicular ad hoc networks: a survey and taxonomy, *Communications Surveys & Tutorials, IEEE*, **11(4)**, 19-41 (**2009)**

4. Ariyakhajorn J., Wannawilai P., Sathitwiriyawong C., A Comparative Study of Random Waypoint and Gauss-Markov Mobility Models in the Performance Evaluation of MANET", *Communications and Information Technologies, 2006 ISCIT'06. International Symposium on,* IEEE, 894-899, (**2006**)

5. Bai F., Helmy A., A Survey of Mobility Modeling and Analysis in Wireless Adhoc Networks, Book Chapter in the book, wireless Ad Hoc and Sensor Networks, *Springer*, (**2006**)

6. Moravejosharieh A., Modares H., Salleh R. and Mostajeran E., Performance Analysis of AODV, AOMDV, DSR, DSDV Routing Protocols in Vehicular Ad Hoc Network**,** *Res. J. Rec. Sci.,* **2(7),** 66-73 **(2013)**

7. Verma N., Routing Protocols in Mobile Ad Hoc Networks, *Research J. Engineering Sci.,* **1(6),**36-39**(2012)**

8. Sengar A. and Shrivastav S., Performance Evaluation of AODV and DSDV Routing protocols for Ad-hoc Networks, *Research J. Engineering Sci.,* **1(6),** 51-55 **(2012)**

9. Camp T., Boleng J. and Davies V., "A Survey of Mobility Models for Ad Hoc Network Research", *Wireless Comm. and Mobile Computing (WCMC): Special issue on Mobile Ad Hoc Networking: Research, Trends and Applications,* **2(5)**, 483-502 **(2002)**

10. Sanchez M. and Manzoni P., A Java-Based Ad Hoc Networks Simulator, *Proc. of the SCS Western Multiconf. Web-based Simulation Track,* 529-551 **(1999)**

11. Liang B. and Haas Z.J., Predictive Distance-Based Mobility Management for PCS Networks, *IEEE/ACM Trans. on Net.*, **11(5)**, 718-132 **(2003)**

12. Bettstetter C., Smooth is Better than Sharp: A Random Mobility Model for Simulation of Wireless Networks, *Proc. ACM Intern, Workshop on Modeling, Analysis, and Simulation of Wireless and Mobile Systems (MSWiM),* Rome, Italy**, (2001)**

13. Bai F., Sadagopan N., and Helmy A., Important: a framework to systematically analyze the impact of mobility on performance of routing protocols for ad hoc networks, in *Proceedings of IEEE Information Comm. Conf. (INFOCOM 2003),* San Francisco**, (2003)**

14. Davies V., "Evaluating mobility models within an ad hoc network", Colorado School of Mines, Colorado, USA, Tech. Rep. Master's thesis,(**2000**)

15. Mahajan A,. Potnis N,. Gopalan K, and Wang A., "Urban mobility models for vanets", *Proc. of the 2nd IEEE International Workshop on Next Generation Wireless Networks,* **(2006)**

16. Saha A. K. and Johnson, D. B., "Modeling mobility for vehicular ad-hoc networks", *the 1st ACM international workshop on Vehicular ad hoc networks. ACM Press,* **(2004)**

17. Choffnes D. R, and Bustamante F. E., "An integrated mobility and traffic model for vehicular wireless networks", *The 2nd ACM international workshop on Vehicular ad hoc networks, VANET'05. ACM Press,* (**2005**)

18. Karnadi F. K., Mo Z. H., and Lan K. C., "Rapid generation of realistic mobility models for VANET", *IEEE Wireless Comm. and Networking Conf.,* **(2007)**

19. SUMO Simulation of Urban MObility. http://sumo.sourceforge.net **(2013)**

20. Qualnet. *http://www.scalable-networks.com* **(2013)**

21. Bonnmotion Scenario generator http://sys.cs.uos.de/bonnmotion **(2013)**

22. Hu Y., Perrig A., and Johnson B., "Rushing Attack and Defense in Wireless Ad Hoc Networks Routing Protocols', *Proc. of 2nd ACM workshop on Wireless Security*, New York**,(2003**)

23. Agarwal K., and Wang W., "Statistical Analysis of the Impact of Routing in MANETs Base on Real-Time Measurement", *Proc. of IEEE ICCCN* **(2005)**