 ISSN: 2321-8169
1357 – 1362

Analysis & Comparison of Mobility Models for Ad-hoc Network

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Abstract— *MANET* is a Mobile ad-hoc network in which each node can communicate with another node without using any existing infrastructure. The performance of ad-hoc network depends on mobility. In this paper the performance of different mobility models Random Walk, Random Waypoint, RPGM, Manhattan Grid, Gauss Markov is compared with routing protocols such as Ad-hoc On-Demand Distance Vector (AODV), Distance Source Routing (DSR), Destination Sequenced Distance Vector (DSDV), Ad-hoc On-Demand Multipath Distance Vector routing (AOMDV). Simulation has been carried out using Network Simulator NS2.34 and its associated tools. Simulation results include comparative analysis of routing protocol vs. mobility models.

Keywords - *Manet, Mobility, Mobility Models, Routing protocols.*

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I. INTRODUCTION

***MANET**:* A Mobile Ad hoc network is a collection of mobile nodes to form a network without using any base station or infrastructure [5]. Which means that any number of people entre in a room and can have communication link between them without using any pre-existing equipment in the room, but the communication between two nodes can be possible only when the nodes are within their radio communication range. Thus it is a temporary network. Ad-Hoc network can be defined as an autonomous infrastructure less system in which mobile nodes are connected by a wireless link without fixed routers. MANETs are flexible therefore nodes are free to move in any direction without using any infrastructure. The nodes act as router which discover and maintain route to other node in the network. Laptop computer and digital assistant that communicate directly with each other are some important examples of Ad Hoc network. While in Cellular network communication between mobile nodes is based on base station as access points.

The important characteristics of MANET are:
1) Dynamic topologies
2) Bandwidth constrained links
3) Energy constrained operation
4) Limited physical security

There are several applications of Manet such as communication between soldiers on battlefield, sharing information in a conference etc. Various routing protocols have unique characteristics hence behaviour of routing protocols has been analysed by varying node mobility, speed, traffic, network etc in order to find out most efficient routing protocol for highly dynamic topology in ad-hoc network. Evaluating Manet routing protocol it is necessary to choose proper mobility model. Hence our main goal is to carry out systematic performance comparison of mobility models. Mobility models also play important role in analysis and design of wireless system. Mobility models are designed to describe movement pattern of mobile users and how their location, velocity, changes over time. Thus mobility pattern play important role in determining protocol performance. Mobility models are mainly classified into two- Traces and Synthetic mobility models. Traces provide accurate information about the mobility traces of users [1]. But Manet has not implemented on wide scale and also obtaining real mobility traces is major challenge. Whereas synthetic model represents the behaviour of mobile node without the use of traces. Our main objective is to find which mobility model is suitable for a network that achieve high throughput, low end to end delay, high packet delivery ratio.

II. A SURVEY OF MOBILITY MODELS

There are seven different synthetic entity mobility models for ad-hoc networks. Different mobility models can be differentiated according to their spatial and temporal dependencies [2].

1) Spatial dependency*:* It is a measure of how two nodes are dependent in their motion. If two nodes are moving in same direction then they have high spatial dependency.
2) Temporal dependency*:* It is a measure of how current velocity (magnitude and direction) are related to previous velocity. Nodes having same velocity have high temporal dependency.

Random Walk - In this mobility model [8] [13] mobile nodes move with any direction and speed. The value of speed and direction is chosen from predefined ranges from maximum to minimum. Mobile node moves randomly from its current location to new location. Nodes direction will change after particular time or specific amount of distance. This pattern is memory less; hence there can be sudden stops and sharp turns.

ISSN: 2321-8169
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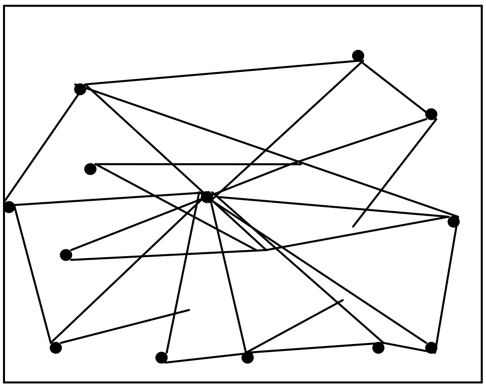

Fig.1 Random Walk

Random Waypoint - In this model mobile node stay at particular location for certain amount of time while changing direction or speed this time is known as pause time. Once this time is over mobile node chooses a new destination and speed.

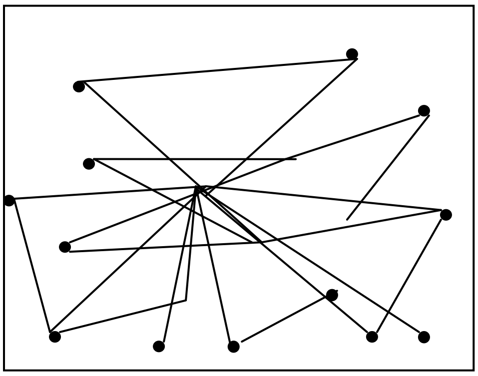

Fig.2 Random Waypoint

Random Direction - This model is designed to overcome the concentration of nodes at the centre, Random Waypoint suffers. In this model nodes are forced to stay away from the centre. Hence all the nodes pause on perimeter. Average Hop count for Data-packets will be much higher than in Random Waypoint or Random Walk. (Nodes are on average far from each other). As shown in fig.3

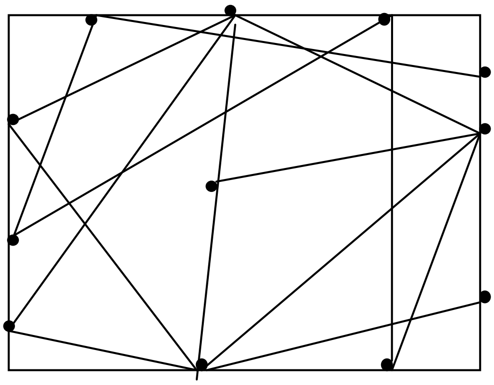

Fig.3 Random Direction

Reference point Group Mobility Model (RPGM) – In this mobility model there is random motion of group of Mobile nodes and also random motion of individual Mobile node in a group. All the members within the group follow a logical group centre which determines the group motion behaviour. The main purpose of logical group centre is to guide group of nodes continuously calculating group motion vector $G\vec{M}$ to define behaviour, speed, and direction of mobile node.

Manhattans Grid Mobility (MGM) - It is also called as Urban Area model. It forms a number of horizontal and vertical streets like grid called maps [11]. Each mobile node can be allowed to move along the grid of horizontal and vertical streets on the map. At intersection of horizontal and vertical street mobile node can turn left, right or go straight. Probability of moving straight is 0.5, Probability of turning left is 0.5, and Probability of turning right is 0.5.

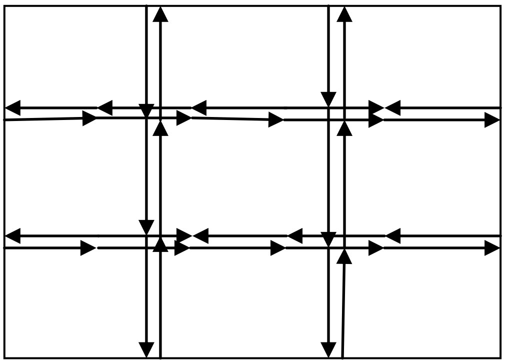

Fig.4. Manhattan Grid

Gauss-Markov– This mobility model enables different level of randomness by setting only one parameter. Each mobile node has preset speed and direction. This model captures the velocity correlation of mobile node in time, representing random movement without sudden stops and sharp turns. This model was proposed for the simulation of a Personal Communication Service (PCS) network. Initially each mobile node is assigned a current speed and direction [1].

III. Mobility Definition

Mobility is an important parameter in MANET. The mobility definition that express the network topological change was proposed by Larsson et al [7].The definition is based on node movement and here Mobility is represented by a parameter called mobility factor (mob) which depends on both node speed and movement pattern. The average distance from each node to all other node can be calculated.

For the node x at time t formula is --

$$Ax(t) = \frac{\sum_{i-1}^{n} dist(n_{x,} n_i)}{n-1} \qquad (1)$$

The Mobility for node x is given as

$$Mx = \frac{\sum_{t=0}^{T-\Delta t} | A_x(t) - A_x(t+\Delta t) |}{T-\Delta t} \qquad (2)$$

$$Mob = \frac{\sum_{i=1}^{n} Mi}{n} \qquad (3)$$

Unit for Mobility Factor is m/s. Mobility factor gives average speed of distance change between nodes.
Mobility for the entire scenario is defined as the sum of mobility of all other nodes divided with number of nodes
Where
$dist(n_x, n_y)$: The distance between node x and node y at time t.
n : Number of nodes.
i: Index
$A_x(t)$: Average distance for node x to all other nodes at time t
M_x: Average mobility for node x relative to all other nodes during the entire simulation time
T : Simulation time
Δt : Granularity, simulation step
Mob: Mobility for entire scenario

Fig.5 shows some basic example of how mobility factor will reflect the actual movement. If the nodes are standing still, this will of course lead to mobility 0, but this would also be the case when the nodes relative movement is zero, for example when the nodes are moving in parallel with same speed. It is only when the nodes have a movement relative to each other that the mobility factor will be greater than zero.

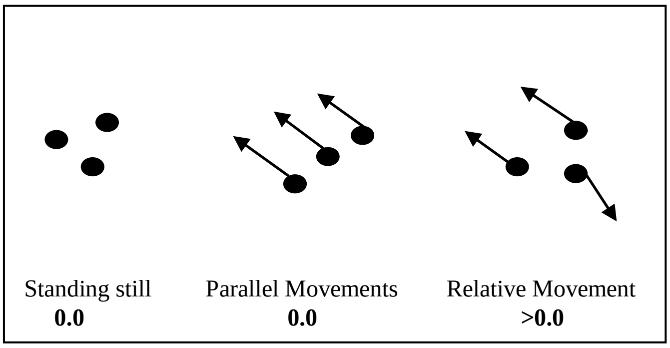

Fig.5 Example of Mobility

IV. Overview of Routing Protocols

In order to discover route between nodes routing protocol is used. Main objective of routing protocol is to form efficient route between pair of nodes in order to deliver messages in a timely manner. This route construct should be done with minimum bandwidth consumption.

MANET Routing protocol are mainly classified into two—
1) Unipath Routing Protocols
2) Multipath Routing Protocols
Unipath Routing Protocols: - It discover single route between source and destination [15]. It consist following two main components -----
Route Discovery: Discovery of a route between source and destination.
Route Maintenance: Repairing a broken route or discovery of new route in case of route failure.
Multipath Routing Protocols: - Multiple routes between source and destination are discovered in this protocol. It consist of following components [15] -
Route Discovery: - Discovering multiple link disjoint route between source and destination.
Traffic Allocation: - After discovering route source node selects a path to destination and sends data along the path to destination.
Path Maintenance: - link failure can be avoided by regenerating path after initial path discovery.

Main features of Multipath routing protocol are –
1) Fault tolerance- The probability of disruption of communication in case of link failure is reduced by routing information to the destination via alternative path.
2) Load balancing- Congestion of link can be avoided by selecting diverse traffic through alternative path.
3) Bandwidth aggregation- Effective bandwidth can be aggregated by splitting data into multiple streams and routing each of them through different path to the same destination. MANET routing protocols classified into proactive, reactive and hybrid protocols as follows—

Proactive or table driven protocols maintains routing information from one node to other node in the network. Here each node maintains tables to store routing information, and any changes in network topology need to be reflected by propagating updates throughout the network.
Reactive or on demand protocols which creates routes only when a node requires a route to a destination. Then it initiates a route discovery process, which ends when route is found.
Hybrid protocols combine both proactive and reactive schemes.

Commonly used routing protocols are as follows-
1) Ad-hoc On-Demand Distance Vector (AODV)
2) Distance Source Routing (DSR)
3) Destination Sequenced Distance Vector (DSDV)

AODV (Ad-hoc on demand Distance Vector) [12] - It is a reactive protocol. It is a hop by hop routing. Whenever a node needs to send a data packet to a destination to which it has no link or route, it has to broadcast a RREQ to all its neighbours, then each node do so until reaching the destination. This one sends a RREP packet that travel inverse path until the source. Upon reception of reply each update its routing table. In this way route between the source and destination is built.

DSR (Dynamic Source Routing) - It is a reactive protocol, in which each mobile node keeps track of the routes of which it is aware in a route cache [5]. DSR uses more memory while reducing the route discovery delay in the system.

DSDV (Destination Sequenced Distance Vector) - It is a proactive routing protocol based on the Bellman-Ford algorithm. Each mobile node maintains a routing table in which all possible destinations and the number of hops to them in the network are stored.

AOMDV (Ad hoc on Demand Multipath Distance Vector Routing) – It is a on demand Multipath routing protocol used in mobile communication. In order to remove the frequent link failures and route breaks in a highly dynamic ad hoc network AOMDV has been developed from a unipath routing protocol AODV [15].

V. PERFOMANCE METRICS

The performance of MANET routing protocols can be done by using performance metrics as a quantitative measure. We are considering three performance metrics that can be used to compare the performance of different mobility models with TCP traffic.

1) Throughput**:** The capacity represents the throughput (bits per second) of the whole system including all the nodes. It is defined as the average number of messages successfully delivered per unit time [9][10]. The performance of Mobility models in terms of throughput with respect to protocols is examined for the tcp traffic. The simulation results are shown in figure 7 and 8.

2) End-to-End Delay**:** Delay represents average time duration of a packet transmitting in a network from source to destination [7]. End-to-end delay represents the time required for a packet to be transmitted from source to destination in a network. In short it is the delay between sending and receiving of packets. The performance of Mobility models in terms of end-to-end delay (e2e delay) with respect to protocols is shown in figure 9 and 10.

This can be calculated as below--

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

d_{trans} =Transmission dealy

d_{prop} =Propogation delay

d_{prooc} =Processing delay

N = no of links

3) Packet Delivery Ratio: Packet delivery ratio counts the number of packets originated by source and number of packets received by receiver [9]**.** The performance of Mobility models in terms of End to end delay with respect to protocols is shown in figure 11 and 12.

VI. SIMUATION PARAMETERS

Simulation is carried out for the network which consists of 25 nodes, with 10 numbers of maximum connections (senders). The simulation is performed for the comparison of different mobility models with different routing protocols. The simulations have been carried out using Network Simulator version 2(NS2.34). Basic mobility scenario generation tool used is Bonn Motion. The detail of computer on which simulation is performed is given below.

Table 1: Hardware & OS configuration

Processor	Pentium IV, 2.3Ghz
RAM	1GB
OS	UBUNTU 10.04

While performing simulation we have to set some parameters as follows

Table 2: Simulation Parameters

Parameter	Value
Simulator	NS2.34, NAM 1.13
Channel Type	Wireless Channel
Routing Protocols	AODV,DSDV,DSR,AOMDV
Simulation Duration	100ms
Number of node	25
Average Speed	1.5 m/s
Propagation	Two Ray Ground
Mac	Mac/802.11
Antenna	Omni Antenna
Area size	500 * 500
Network Interface	Phy /Wireless Phy
Traffic	TCP

VII. IMPLEMENTATION CHART

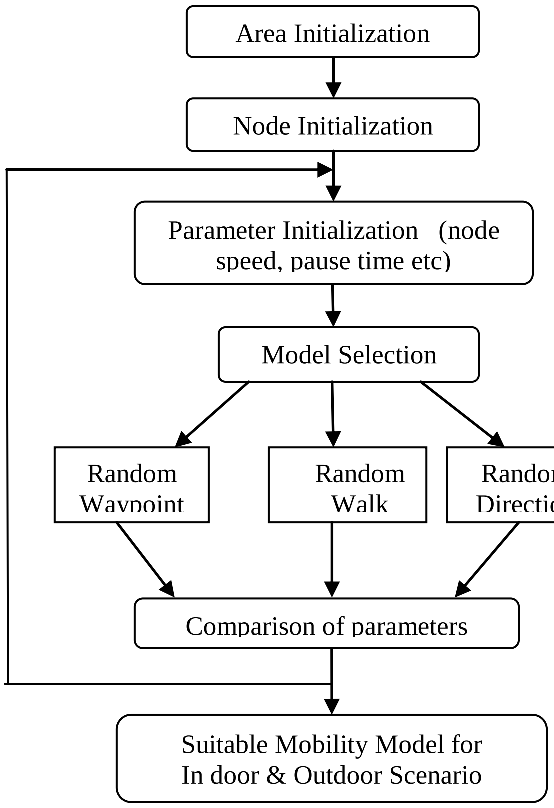

Fig.6 Implementation Chart

1) Area Initialization**:-** It means whether you are considering Indoor or Outdoor area for simulation. For Indoor minimum range will be 50m but for Outdoor the range will be from 500m to 1000m

2) Node Initialization**:-** For Indoor scenario maximum of 5 to 10 nodes should be considered; while for Outdoor 50 to 100 nodes can be considered.

3) Parameter Initialization**:-** For comparison of different mobility models parameter should be initialized e.g. No. of nodes, node speed etc.

4) Model Selection: - As we know there are several synthetic mobility models that have been proposed for the performance

ISSN: 2321-8169
1357 – 1362

evaluation of ad hoc network protocols. For comparison here three models are considered Random walk, Random waypoint, Random direction.

5) Comparison of Parameters: - Finally comparison of parameters will be done with above mentioned mobility models.

6) Suitable Mobility Model: - After comparison of parameters if suitable results are obtained a suitable mobility model for indoor & outdoor model is selected, otherwise if exact results are not obtained again parameter must be initialized.

VIII. SIMULATION RESULTS

This paper studies the performance of four routing protocols with respect to mobility models. Simulation is carried out for 25 node network with 10 numbers of maximum connections (senders) with TCP traffic the results are displayed as follows.

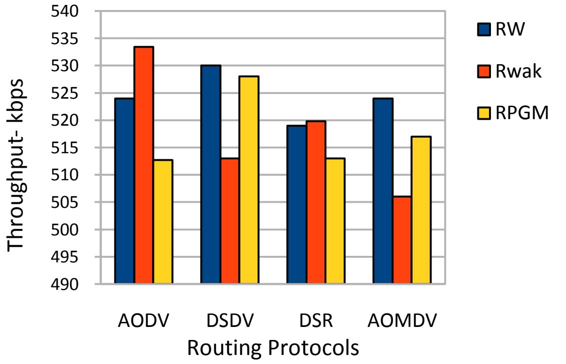

Fig 7.Throughput vs. Routing Protocols for Different Mobility Models

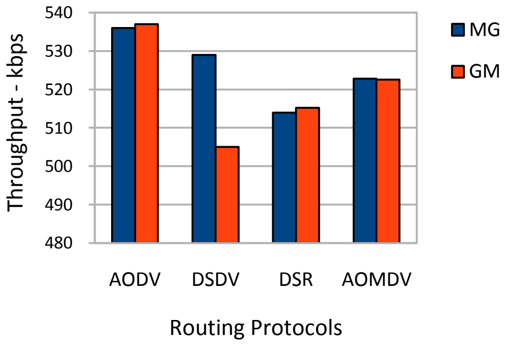

Fig 8.Throughput vs. Routing Protocol for Different Mobility Models

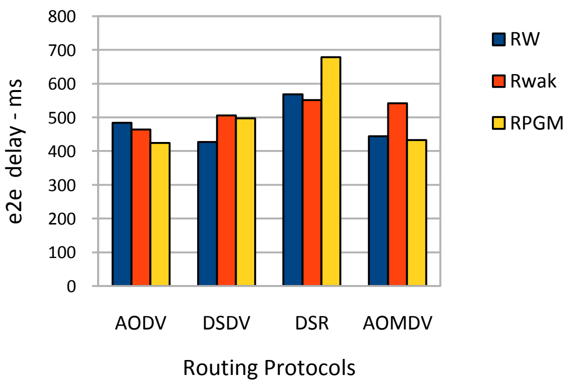

Fig 9. End to end Delay vs. Routing Protocol for Different Mobility Models

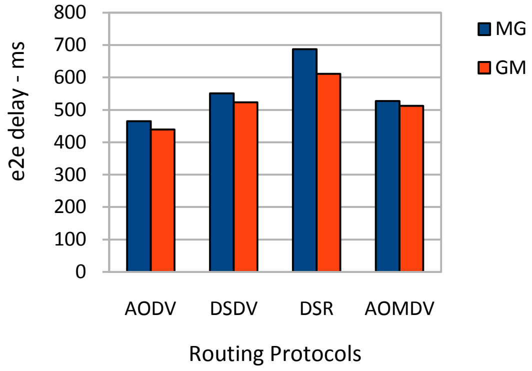

Fig 10.End to end delay Vs. Routing Protocols for Different Mobility Models

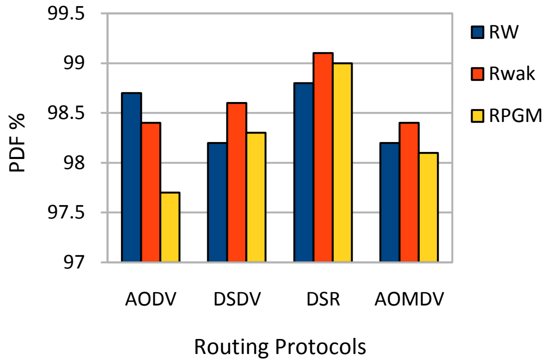

Fig11. Packet Delivery Ratio Vs Routing Protocols for Different Mobility Models

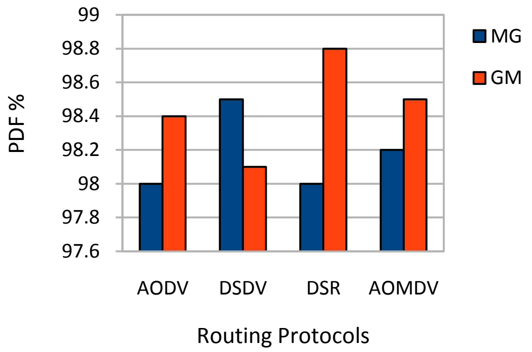

Fig12. Packet Delivery Ratio Vs Routing Protocols for Different Mobility Models

CONCLUSION

In this paper the comparison of different mobility models such as Random Walk, Random waypoint, Random direction, Gauss Markov, Manhattan Grid with different routing protocols AODV, DSDV, DSR, and AOMDV is done in terms of throughput, end-to-end delay, and packet delivery ratio by writing simulation script using NS2. With reference to the performance of Random Walk AODV produces highest throughput, low end to end delay and better packet delivery ratio as compared to Random Waypoint and Reference Point Group Mobility model. Also for the same protocol Gauss Markov model shows better results as compared to Manhattan Grid model. DSR produces less throughput for all mobility models with more delay but packet delivery ratio of Random

ISSN: 2321-8169
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Walk and Gauss Markov model shows the best results as compared to other mobility models.

In this paper the analysis and comparison of different mobility models is done with only TCP traffic, our further task will be analysis and comparison of different mobility models with CBR traffic.

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