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Performance Evaluation of MANET Routing Protocol Using Random Way Point and Manhattan Mobility Models

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Abstract: Mobile Ad-Hoc Networks (MANETs) are self driven, self configuring nodes that are distributed randomly to establish temporary links for common network access and communication process. Node availability and mobility plays a vital role in optimizing the network performance and the probability of routing ease in a network. The aim of layer 3 protocols is to optimally construct the path between nodes with least overhead and to preserve the throughput. The operational performance of MANET under the mobility models Random Way Point (RWP) and Manhattan Grid mobility (MG) patterns are tested under Proactive and Reactive routing protocols. Under proactive protocol, Destination Sequence Distance Vector (DSDV) and under reactive protocol, Ad-hoc On demand Distance Vector Routing (AODV) is utilized for the performance evaluation. The best mobility model is categorized in terms of higher throughput and minimum overhead, with a considerable active link that retains transmission probability with minimum loss. The Manhattan mobility model is concluded as the best in preserving higher throughput, with lesser overhead and appreciable nodes connecting probability.

Key words: Mobility model · Random Way Point (RWP) · Manhattan Grid (MG) mobility · MANET (Mobile Ad-hoc Networks) · AODV (Ad-hoc On-demand Distance Vector Routing) · DSDV (Destination Sequence Distance Vector)

INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a self concentrated, transient and organize the nodes which communicate with each other without any physical infrastructure. The mobile nodes lying with each other sends its range, it can communicate directly or through intermediate relays. MANET has vast applications in Tactical Networks, Emergency Services, Commercial and civilian environments, Sensor Networks, Context Aware Services etc. Since it is very cost effective and time varying it has gained a lot of academic research in this field. The mobility models are inherently probabilistic, as the assumption is that averaging over sufficiently many runs will lead to a good estimate [1]. The mobility models of MANET are designed to describe the movement pattern of the mobile nodes and how their location, velocity and acceleration change over time. Since mobility patterns may play an important role in determining the protocol performance, it is desirable for mobility models to emulate the movement pattern of targeted real life applications in a reasonable way.

One frequently used mobility model in MANET simulations is the Random Waypoint model, in which nodes move independently to a randomly chosen destination with a randomly selected velocity. The simplicity of the Random Waypoint model may have been one reason for its widespread use in simulations. However, MANETs may be used in different applications where complex mobility patterns exist. Hence, recent research has started to focus on the alternative mobility models with different mobility characteristics. In these models, the movement of a node is more or less restricted by its history, or other nodes in the neighborhood or the environment.

Related Work: B.A.S Roopa Devi [2] has surveyed about the mobility models and examined the performance of the mobility models with the respective AODV routing protocols. Link breaks and average link changes are

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calculated for different mobility models in order to change the best mobility models. BhavyeshDivesha [3] in his paper studied the consequences of mobility models by considering two routing protocols Dynamic Source Routing and Destination Sequenced Distance Vector and the performances are compared by varying the number of hops and node densities. Ahmed E Kamal [4] proposed a mobility model referred as Realistic mobility models, the velocities and direction are considered that exhibits the real user application. Abinasha Mohan Borah [5] presented a survey on the various furtherance on Random walk model for congestion control and comparative analysis with other mobility models. Guolong Lin [6] proposed a general technique on the basis of renewal theory to analyze mobility models in ad-hoc networks. The technique is first applied to the Random Waypoint model and provides the difference between the steady state average speed and the average speed associated with simulation distribution. Gang Lu [7] proposed a Novel Environment Aware Mobility model which denotes the realistic movement of mobile nodes. Environment objects such as route and hotspot are represented by scalable vector graphics, on considering a complex model with a combination of complex, active conventional mobility models and network environments. Suprio Ray [8] proposed a tool for generating mobility models that are realistic and heterogeneous. This tool is capable of emulating complex and dynamic mobility patterns representing the real world situations. GeethaJayakumar [9] analysed packet delivery ratio, normalized routing load and average end to end delay by varying node density for reference point group and random waypoint models in the routing protocols such as AODV and DSR.

Overview of Routing Protocols: Considering procedures for route establishment and update, MANET routing protocols can be classified into three types:

Proactive (or) Table-Driven Protocols: In Proactive protocol consistent, up-to-date routing information from each node to every other node in the network will be maintained. Each node maintains tables to store routing information and any changes in network topology need to be reflected by propagating updates throughout the network. In this work, Destination-Sequenced Distance-Vector Routing protocol (DSDV)is chosen from proactive algorithm.

Destination-Sequenced Distance-Vector Routing protocol (DSDV): Destination-Sequenced Distance-Vector Routing protocol is a proactive table driven algorithm based on classic Bellman-Ford routing. In proactive protocols, all nodes learn the network topology before a forward request comes in. In DSDV protocol each node maintains routing information for all known destinations. The routing information is updated periodically. Each node maintains a table, which contains information for all available destinations, the next node to reach the destination, number of hops to reach the destination and sequence number. The nodes periodically send this table to all neighbors to maintain the topology, which adds to the network overhead. Each entry in the routing table is marked with a sequence number assigned by the destination node. The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops [10].

Reactive (or) On-Demand Protocols: This type of routing creates routes only when a node requires a route to a destination. Then, it initiates a route discovery process, which ends when the route is found. In this work, Ad-hoc On-demand Distance Vector Routing (AODV) is chosen from proactive algorithm.

Ad-hoc On-Demand Distance Vector Routing (AODV): AODV is an on-demand protocol, which initiate a route request only when needed. When a source node needs a route to a certain destination, it broadcasts a Route REQuest packet (RREQ) to its neighbors. Each receiving neighbor checks its routing table to see if it has a route to the destination. If it doesn't have a route to this destination, it will re-broadcast the RREQ packet and let it propagate to other neighbors. If the receiving node is the destination or has the route to the destination, a Route REPly (RREP) packet will be sent back to the source node. Routing entries for the destination node are created in each intermediate node on the way RREP packet propagates back. A hello message is a local advertisement for the continued presence of the node. Neighbors that are using routes through the broadcasting node will continue to mark the routes as valid. If hello messages from a particular node stop coming, the neighbor can assume that the node has moved away. When that happens, the neighbors will mark the link to the node as broken and may trigger a notification to some of its neighbors telling that the link is broken. In AODV, each router maintains route table entries with the destination IP address, destination sequence number, hop count, next hop ID and lifetime. Data traffic is then routed according to the information provided by these entries [10].

Hybrid Protocols: Combination of proactive and reactive schemes denotes the hybrid protocol.

Mobility Models of Manet: The mobility model is designed to describe the movement pattern of mobile users and how their location, velocity and acceleration change over time. Since mobility patterns may play a significant role in determining the protocol performance, it is desirable for mobility models to emulate the movement pattern of targeted real life applications in a reasonable way.

The mobility can be classified according to different kinds of dependencies and restriction that are considered as:

- Direct Mobility
- Derived Mobility

Direct Mobility: This mobility metric is basically a protocol independent metric, its attempt is to extract the characteristics of mobility behavior in between the mobile nodes. It is known as direct mobility because it measures the host movement directly, like average host speed. The other metrics that are defined in this categories like average relative speed, random models, temporal dependence and spatial dependence. An attempt as been carried out to characterize the temporal dependence of the movements of an individual node and the spatial dependence between various nodes [11].

Random Models: There are neither dependencies nor any other restrictions modeled which are similar to RWP model.

Model with Temporal Dependency: The mobile nodes tend to travel in a correlated manner.

Model with Spatial Dependency: The actual movement of a node is influenced by the nodes around it.

In this paper, a mobility model is proposed using random based Random Way Point model (RWP).

At random-based mobility models, the nodes move randomly and independently without any constraints. In general the destination, speed and direction are all chosen randomly without considering the other nodes. This kind of model has been used in many simulation studies [10].The random waypoint model is frequently used mobility model. Two variants of the Random Waypoint model are the Random Walk model and the Random Direction model.

The Random Waypoint Model (RWP): It is a benchmark tool to assess all the mobility models for MANET Routing Protocols because of its scalability. The mobility model starts each mobile node randomly decides location in the simulation field as the destination. It then moves towards this destination with constant velocity chosen uniformly and randomly from [0,V_{max}], where the parameter V_{max} is the maximum allowable velocity for every mobile node. The velocity and direction of a node are decided independently of other nodes. Upon reaching the destination, the node stops for a duration defined by the 'pause time' parameter. If T_{pause}=0, this leads to continuous mobility. After this duration, it again chooses another random destination in the simulation field and moves towards it. The whole process is repeated again and again. Fig. 1 illustrates examples of a topography showing the movement of nodes in Random way point Mobility Model.

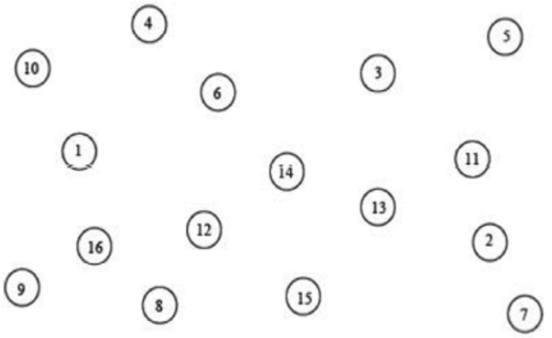

Fig. 1: Sample of Random Waypoint Mobility Model.

In the Random Waypoint model, V_{max} and T_{pause} are the two key parameters that determine the mobility behavior of nodes. If the V_{max} is small and the pause time T_{pause} is long, the topology of the Ad-hoc network becomes relatively stable. On the other hand, if the node moves fast (i.e., is large) and the pause time T_{pause} is small, the topology is expected to be highly dynamic V_{max}. Varying these two parameters, especially the V_{max} parameter, the Random Waypoint model can generate various mobility scenarios with different levels of nodal speed[10]. Therefore, it seems necessary to quantify the nodal speed.

$$RS(i,j,t) = \left|\overline{V}i(t) - \overline{V}j(t)\right| \tag{1}$$

Then, the Mobility metric is calculated as the measure of the relative speed averaged over all node pairs and over all time.

$$\overline{M} = \frac{1}{|i,j|}\sum_{i=1}^{N}\sum_{j=i+1}^{N}\frac{1}{T}\int_{0}^{T} RS(i,j,t)\,dt \tag{2}$$

Where |i,j| is the number of distinct node pair (i,j), n is the total number of nodes in the simulation field (i.e., ad-hoc network) and T is the simulation time.

Derived Mobility: The derived mobility metrics captures the property of graph theoretic models as well as some mathematical models. The Mobility of nodes and the performance of routing protocol depend over the network topology dynamics. To study the effect of mobility it requires analyzing the connectivity graph between the mobile nodes [11].

In this paper, a mobility model is proposed using geographical restrictions based Manhattan Grid (MG) model.

Manhattan Grid (MG) Model: The Manhattan mobility model normally utilizes a grid road topology [12]. This model is proposed for the nodes that are employed in urban areas, where the directions are in a configured manner and the mobile nodes are projected in such a way to move only in horizontal or vertical direction. At an intersection of horizontal and vertical directions, the nodes can make a turn left, right or go straight with certain probabilities. It too imposes geographic restrictions on node mobility. This model can be implemented in Ad-hoc and sensor networks. Fig 2 shows the topography movement of nodes for Manhattan Mobility model.

These Mobility models depend on the structure of the road and the concentration of the vehicles. There are many obstacles such as trees and buildings exist in these kinds of environments which degrades the availability of the signals [12]. Hence, the network communication in the city environment is quite complex. The mobility of the nodes and the velocity of the vehicle in the urban area are slow, which promotes effective communication of all the mobility models. Random Waypoint model and Manhattan Grid model are considered in this work.

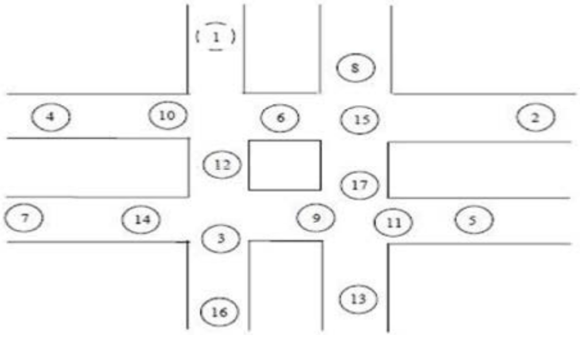

Fig. 2: Sample of Manhattan Mobility Model

SIMULATION RESULTS AND DISCUSSIONS

Simulation Setup: This simulation uses two mobility models that will be tested on DSDV and AODV routing protocol scheme. The simulation period is 100 seconds, packed size is 500 bytes and the simulated mobility network area is 1000 m x 1000 m rectangle with 250m transmission range. The simulation nodes are displaced by random waypoint and manhattan grid model at various locations within the simulation area. The mobility models in different mobility speed of 10,20,30,40 and 50 m/s with fixed the number of nodes to 100 nodes are evaluated.

Experimental Results: The simulation results are focused on analyzing the performance on routing overhead, throughput, active links and bandwidth and arrival rate. The results are compared with different chosen mobility models. The performance for every mobility model that had been selected is displayed.

Throughput: Throughput is defined as the rate at which transmission between nodes are initiated. It is dependent on the mobility factor or the nodes [13-17].

As mobility increases, the range of contact points between the nodes either increases or decreases in random waypoint model and manhattan model. As mobility increases, the throughput drops as the number of links may cease. The observation is presented for both DSDV and AODV routing protocols among which the Manhattan model is found to be effective when compared to rest of the other analysis.

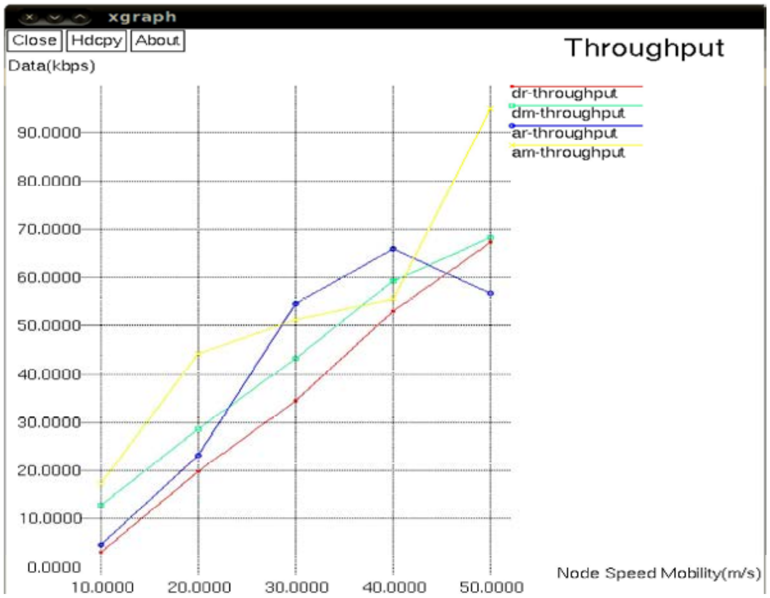

Fig. 3: Throughput of AODV and DSDV under RWP and Manhattan Mobility Model

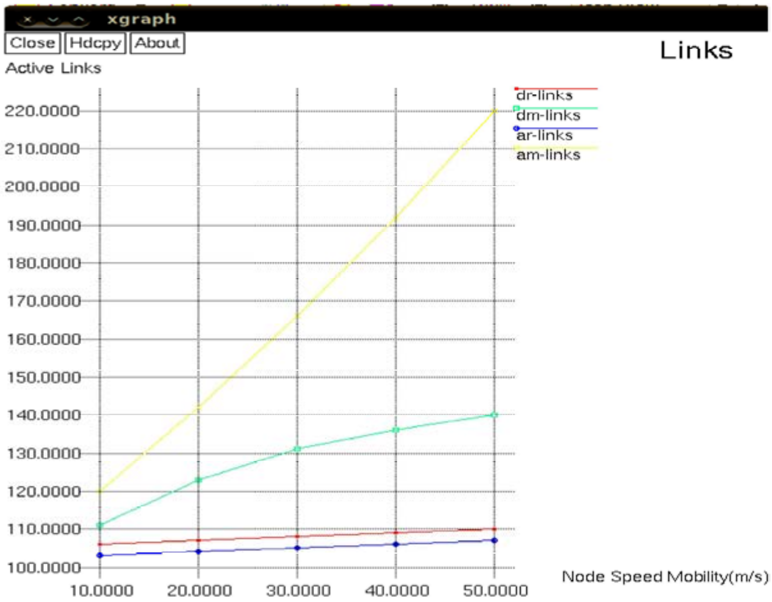

Fig. 4: Active links observed in AODV and DSDV under RWP and Manhattan Mobility Models

Throughput varies as the node mobility varies. A node can either be in nearest point of contact to its neighbor or in farthest point of contact. Nearing the POC, transfer rates are high with minimum broadcasts and the farthest results in continuous broadcasts minimizing the throughput. The overall observed throughput in RWP is 16.6% where as in Manhattan is 32.7% that concludes Manhattan model handles 16.1% more than RWP.

Active Links: The maximum possible paths from the source to a destination node in a network that are instantly available are regarded as active links. It does not represent all the links present between source and destination.

The above results display the comparison of the number of active links available for transmission between the source and destination. Maximum links are available in static model routing protocols compared to dynamic routing protocols.

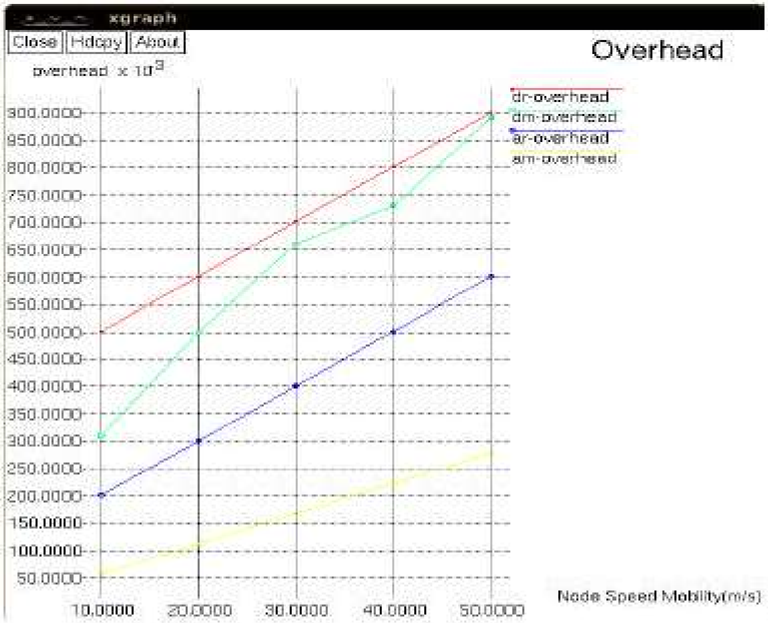

Fig. 5: Overhead of AODV and DSDV under RWP and Manhattan Mobility Model

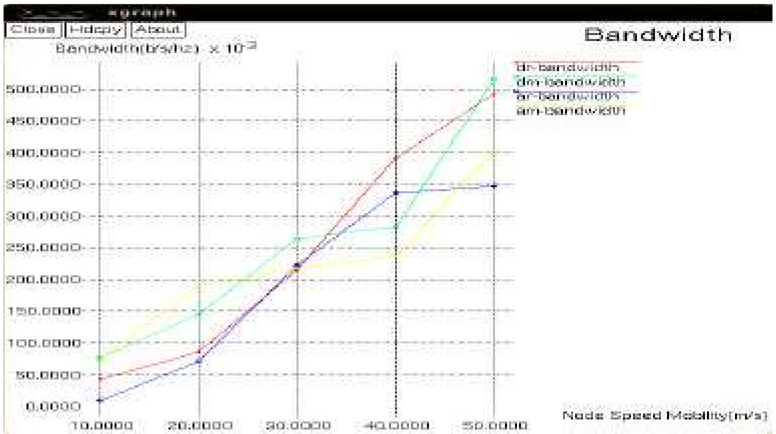

Fig. 6: Bandwidth of AODV and DSDV under RWP and Manhattan Mobility Model

The number of communicating inward and outward links can vary depending upon on the node availability at one position active link the network or at any converging point. The overall observed active link in RWP is 2% where as in Manhattan is 36.4% that concludes Manhattan model handles 34.4% more than RWP.

Overhead: Overhead is the inconsistent probability of achieving the possible routing and transmission path between two nodes. Overhead costs, much of the available network parameters than the estimated.

Figure 5 is plotted between node mobility and overhead due to the observed mobility. As mobility increases, overhead increases. The cumulative overhead is less in reactive protocol when compared to DSDV and it is still better in Manhattan model than in Random Way Point Model.

Additional routing procedure messages are required for all the re-transmission routes. The overall observed overhead in RWP is 33.3% where as in Manhattan is 30.3% that concludes Manhattan model handles 3% less than RWP.

Bandwidth: The amount of consuming capacity for the flow of packets through a network is defined as bandwidth.

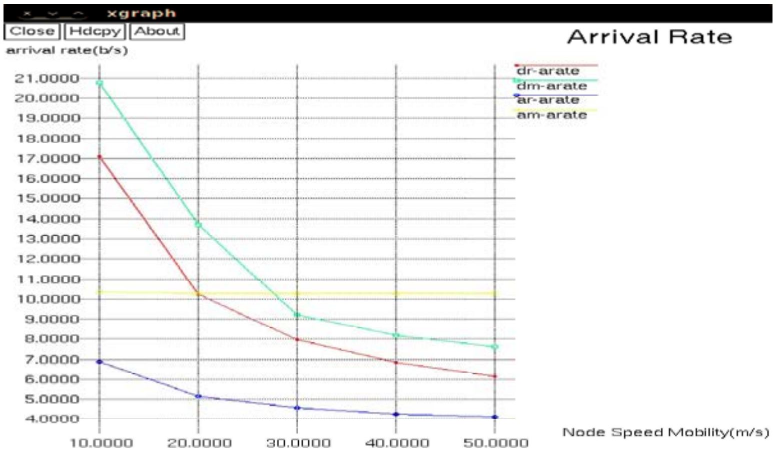

Fig. 7: Arrival rate of AODV and DSDV under RWP and Manhattan Mobility Model

Figure 6 is plotted between node mobility and bandwidth due to the observed mobility. The amount of bandwidth utilized in static protocols (DSDV) is better than in dynamic protocols (AODV) for the reason of fixed table driven paths. But on comparison with random model, Manhattan model proves to be efficient as it is a followed defined movement model.

Manhattan Model achieves 72% of the overall bandwidth utilization where as RWP utilizes 63% of the total bandwidth. Bandwidth is link dependent that in turn is mobility dependent.

Arrival Rate: The transfer of packets between links observed at any instance of time is referred as arrival rate. The rate will last till the completion of the sequence.

The Figure 7 is plotted between node mobility and arrival rate (b/s) due to the observed mobility. Arrival rate decreases as the node speed increases due to the fact that the number of available links may cause the increase in mobility. The ratio of nodes communicating with the mobile nodes may get lesser.

Arrival rate is dependent upon the active link availability. As the mobility proceeds, arrival rate varies upon the establishment of the links rather it ceases when the mobility increases, due to out-of-range issues. The observed arrival rate in RWP is 35% where as in Manhattan it is 58.2% that concludes Manhattan model handles 23.2% more than RWP.

CONCLUSION

Mobility prediction in MANETs is unavoidable for the reason that nodes are not stationary and are autonomous. Mobility in these networks increases the availability, accessibility and seamless communications. Random Way Point (RWP) and Manhattan Model were analyzed with its performance metrics in terms of throughput, number of active links, arrival rate, bandwidth and overhead due to mobility. Our extensive simulation results show that Manhattan Model holds better for all the above said parameters when integrated and tested under a reactive protocol the adversary being the number of active links that is best supported for proactive protocol.

Our future enhancement is to integrate and evaluate Manhattan Model with Energy Efficient Routing Protocols (EERPs) where the energy consumed for mobility ceases the estimated network lifetime, draining the energy allocated to the node's operational process. The model can also be extended for addressing Link Breakage (LB) problem in fast moving MANETs where prediction and Active Link up Time (ALT) are less.

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