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Performance Evaluation of AODV with Varying Network Size in MANET Using Entity Models

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***Abstract* -** A Mobile Ad-Hoc Network (MANET) is self-configuring network of mobile nodes connected by wireless links to form an arbitrary network topology without the use of existing Infrastructure. MANETs are characterized by multi-hop wireless connectivity, a frequently changing network topology and the need for efficient dynamic routing protocols plays an important role. Severe routing protocols targeted specifically at this environment have been developed and some performance simulations are made on a mature routing protocol i.e. Ad hoc On-Demand Distance Vector Routing. In this paper we perform extensive simulations using network simulator considering four performance metrics. For experiment purposes and to determine the impact of network size on the performance of this routing protocol we considered three different entity mobility models namely Random Direction (RD), Random Walk (RW) and Gauss Markov (GM) models with rectangular area sizes 1000×1000 m^2. These three Mobility Models are selected to represent the possibility of practical applications in future. Our framework aims to evaluate the impact of different mobility models on the performance of MANET routing protocols.

Index Term— Mobile ad hoc networks (MANETs), Routing protocols, AODV and NS-2

I. INTRODUCTION

In the past few decade the field of wireless network have become very popular. In wireless networks computers are connected and communicate with each other not by a visible path, but by an emission of electromagnetic energy in the air. Mobile ad hoc networks have been one of the hottest research topics for years, Wireless and mobile ad hoc networks turn out to be the first option for a wide range of application areas, such as military, health, environmental, home automation and security [1]. Mobile Ad-Hoc Network [2, 3] is the rapid growing technology from the last 20 years. The gain in their popularity is because of ease of deployment, their dynamic and infrastructure less nature.

A Mobile Ad-hoc Network (MANET) is a collection of wireless mobile nodes that can dynamically form a network to exchange information and capable of communicating with each other without using any pre-existing fixed network infrastructure. MANETs are autonomous, self organized, decentralized and self configurable wireless networks where the mobile nodes are free to move about and organize themselves into a network.

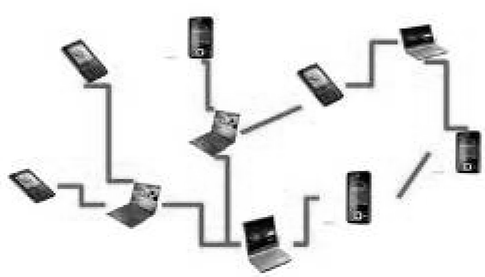

Fig.1 Mobile ad hoc network with mobile host [3]

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In reality, the performance of mobile ad-hoc networks will depend on many different factors such as node mobility model, network topology, traffic pattern, obstacle positions, radio interference, and so on. Our results show that the protocol performance may vary drastically across mobility models and performance rankings of protocols may vary with the mobility models used. This outcome can be explained by the interaction of the mobility characteristics with the connectivity graph properties.

The rest of the paper is organized as follows. Section 2 gives a brief introduction of AODV Reactive routing protocol. In Section 3 we describe the measures for mobility along with comparisons of discussed mobility models. The simulation environment and scenario description is presented in Section 4. Section 5 discusses the simulation results and performance analysis. Lastly, in Section 6, we summarize our results and research contributions of this work and mention the future directions.

II. ROUTING PROTOCOL

In ad hoc networks [4], to ensure the delivery of a packet from sender to destination, each and every node must run a routing protocol and maintain its routing tables in memory. An ad-hoc routing protocol is a standard that controls how nodes decide which way to route packets between devices in a mobile ad-hoc network.

AODV (Ad-hoc On-demand Distance Vector)

The Ad-hoc On-demand Distance Vector (AODV) [5] encompasses multi-hop wireless routing between the participating mobile nodes wishing to establish and maintain an ad-hoc network. AODV [6] is a state-of-the-art routing protocol that adopts a purely reactive strategy. It sets up a route as on demand basis at the start of a communication session and uses it till it breaks, upon which a new route setup is initiated. An AODV adopts a very different mechanism to maintain routing information. AODV uses traditional routing tables and one entry per destination. It uses only symmetric links. Without source routing, an AODV relies on routing table entries to propagate a route reply (RREP) message back to the source and subsequently to route data packets to the destination. An AODV uses sequence numbers maintained at each destination to determine the freshness of routing information and to prevent routing loops. Sequence numbers are important to ensure loop-free and up-to-date routes in a network. All routing packets carry these sequence numbers.

In AODV, each node maintains a cache to keep track of RREQs it has received. An important feature of AODV is the maintenance of timer-based (TTL) states in each node and regarding utilization of individual routing table entries. The routing table entry is expired if not used recently. A node uses hello messages to notify its existence to its corresponding neighbours. Therefore, the link status to the next hop in an active route can be monitored. Than when a node discovers a link disconnection, it broadcasts a route error (RERR) packet to its appropriate neighbours, which in turn propagates the RERR packets towards nodes whose routes may be affected by the disconnected link. The affected source can re-initiate a route discovery operation if the route is still needed. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link.

III. MOBILITY MODELS

A mobility model [7] defines the rules that can be used to generate trajectories for mobile nodes. .The study of Mobility Models and their realistic vehicular model deployment is a challenging task.

Random Walk Mobility Model

The Random Walk model [8] was originally proposed to emulate the unpredictable movement of particles in physics. Random Walk mobility model is proposed to mimic their movement behaviour. This model has similarities with the Random Waypoint model because the node movement has strong randomness in both models. In the Random Walk model, the nodes change their speed and direction at each time interval t. For every new interval t, each node randomly and uniformly chooses its new speed and direction. The new speed and directions are both chosen from pre-defined ranges respectively [min-speed, max-speed] and [0, 2*pi] respectively. We can think the Random Walk model as the specific Random Waypoint model with zero pause time. Many derivatives of the Random Walk Mobility Model have been developed including the 1-D, 2-D, 3-D, and d-D walks.

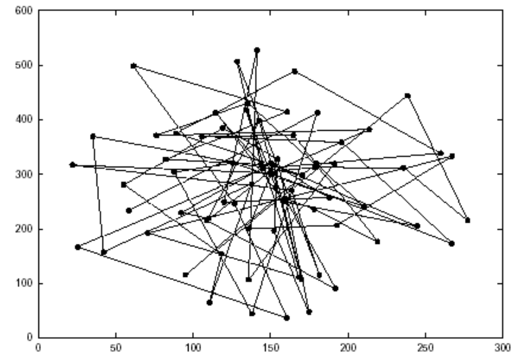

Fig. 2 travelling pattern of a MN using 2-D RW Mobility Model

Random Direction Mobility Model

The Random Direction Mobility Model [7] was created in order to overcome a flaw discovered in the Random Waypoint Mobility Model i.e. to avoid concentration of mobile nodes (MNs) at centre of the simulation area. MNs using the Random Waypoint Mobility Model often choose new destinations and the probability of choosing a new destination that is located in the centre of the simulation area, or requires travel through the middle of the simulation area is too high.

In this model, MNs choose a random direction in which to ravel instead of a random destination. Upon choosing a random direction, a MN travels to the border of the simulation area in that direction. As soon as the boundary is reached the MN stops for a certain period of time, chooses another angular direction (between 0 and 180 degrees) and continues the process. Figure 3 shows an example path of an MN, which begins at the centre of the simulation area.

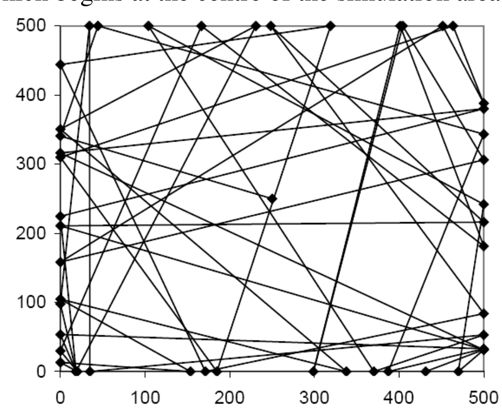

Fig. 3 travelling pattern of an MN using RD Mobility Model

Gauss-Markov Mobility Model

The Gauss-Markov mobility model [8] was designed to adapt to different levels of randomness via tuning parameters. Gauss-Markov mobility model creates random movement changes that are dependent on node's current speed and direction. A simulator generates a new speed and direction based on their current values and standard deviations. At each fixed intervals of time n a movement occurs by updating the speed and direction of each mobile node. Particularly, the value of speed and direction at the nth instance is calculated based on the basis of the value of speed and direction at the (n-1)st instance and a random variable using the following equations:

$$S_n = S_{n-1} + a*rg * S$$

$$d_n = d_{n-1} + a* rg * a$$

Here S_n is new speed and S_{n-1} the current speed. d_n is new direction, d_{n-1} the current direction and rg a random number taken from standard Gaussian distribution. S and a are the standard deviation of speed and angle for the Gaussian distribution.

IV. SCENARIO DESCRIPTION

Different scenarios for the experiments are being considered, in these scenarios nodes are distributed over the simulation area. This section of the paper gives simulation workflow and simulation environment setup to evaluate the effect of mobility on the performance of variant mobility models. Three mobility models RD, RW and GM models are used and the scenarios, movements for these models were generated using a software called Bonn motion [9] (a Mobility Generator), which after inputs of number of nodes, mobility model and scale (area) generates the TCL script for mobility. The background traffic scenario, using TCL script is also employed along with the traffic which we have checked. A standard 802.11 MAC layer was used and transmission range in each simulation was 250 meters. A standard CMUPri model for queue of buffer size 50 was used. All the nodes in the simulation had Omni directional antennas. The simulation runs for 200 sec. Flat 1000x1000 meter2 scenario was created in all the mobility cases. CMU's wireless extension to NS-2 [10], which is based on two-ray ground reflection model, is being utilized.

V. EXPERIMENTAL RESULTS

In this section, the performance of routing protocols is evaluated through simulation. It describes the simulation results obtained for packet delivery fraction, delay, normalized routing load and throughput. PDF and NRL are deducing through scalar values obtained in each application scenario simulation results. We have use X-graph to plot the graph for all the selected MANET routing protocols These simulations are using three mobility models that will be tested on a reactive (AODV) routing protocols scheme. The number of nodes was varied from 20 to 100 and the effect on PDF, AED, NRL and Throughput was studied. The results can be found in figures 4, 5 and 6 and so on. A small number of nodes in a large simulation area will result in low connectivity due to the large distances between nodes.

Packet Delivery Fraction

The packet delivery fraction decreases as the network size (number of nodes in the network) increases. This is due to the fact that as the no. of nodes increases, the congestion in the network also increases and hence the number of lost packets due to retransmission also increases. Figure shows packet delivery ratio with network size varying from 20 to 100. From the above figure it is inferred that when we have less no of nodes GM outperforms RD by about 43% and RW by about 9%, while RW exceeds RD by about 39%. With AODV RD model gives lesser pdf than RW and GM. RD worst in form of Pdf. But generally the graph for the GM lies above than that of RW for most cases. Thus the protocol in GM model performs better than RW and RD. The GM model is superior compared to other models.

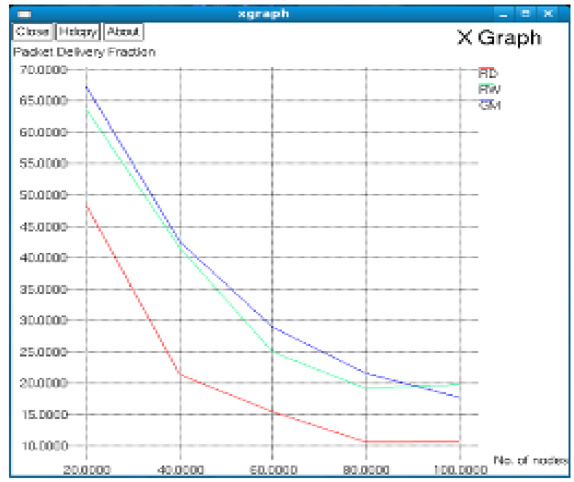

Fig.4 PDF of AODV

End to End Delay

The End-to-End delay is a very important metric to judge the performance of a routing protocol. Figure shows the measurements of delay at different network sizes. With increase of network size, RD suffers from higher delays than RW and GM. This happens because AODV has periodic activities (exchange of HELLO messages) and does not use cache to store the routes. GM model has lesser delay approx. 18% than RD and 20% than RW model. With increase of network size, GM suffers from higher delays than the RD and RW. Again the RD model suffers from higher delay than RW by about 12% approx. GM found to be the best mobility model resulting in lowest delay for all the protocols.

Fig. 5 Delay of AODV

Normalized Routing Load

It is defined as Number of routing packets "transmitted" per data packet "delivered" at destination. According to the definition of NRL it is evident that when NRL is least MANET routing protocol have better performance. It can be observed from the figure that mobility model has significant impact on the routing load. The behaviour of the MANET routing protocols that AODV increases NRL with the increase in the number of nodes. In GM, AODV has the lowest normalized routing load which is almost independent from the no. of nodes in the network because AODV scales well when the no of nodes increases. RD exceeds GM by about 60% and RW by about 55%. Compared with the AODV, GM demonstrates the lowest overhead for all mobility models.

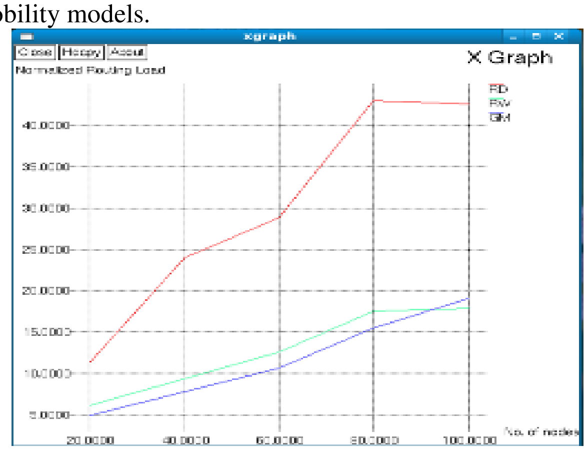

Fig. 6 NRL of AODV

Viewing the above phenomena, it is inferred that GM model seems better in terms of NRL. Thus RD suffers from higher NRL and GM gives better performance than RW.

Throughput

The throughput ratio is a measure of reliability. The higher throughput is contributed the lower delay because of the lower number of hop. As we increase the network size the mean values for all the three models experience a decrease in throughput. As we continue to increase network size the throughput ratio for both models becomes steady. We find out from the figure that the throughput decreases gradually over size and then it is consistent. GM model shows better results than RD and RW by about 42% and 8% respectively. The throughput of AODV gradually increases with network size. RW outperforms RD by approx. 39%.

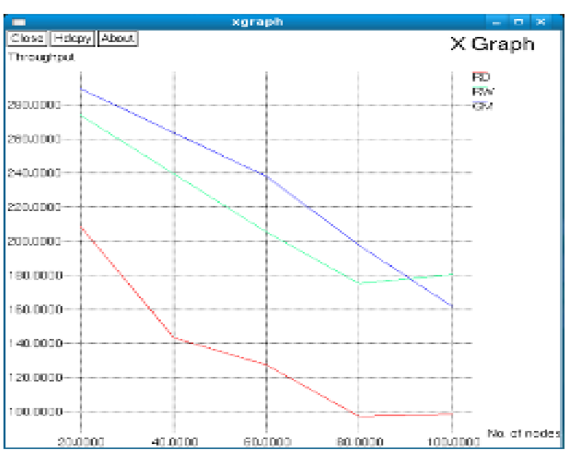

Fig. 7 Throughput of AODV

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we have analyzed the behavior of reactive routing protocols i.e. AODV under the three mobility models viz. RW, RD and GM and then compare the performance of protocols using NS-2 simulator merged with the bonn-motion scenario generation tools. These were compared in terms of Packet delivery ratio (PDR), Average End to End delay (delay), Normalized routing load(NRL) and Throughput when subjected to change in numbers of nodes. For packet delivery ratio metric, all mobility models are decreased significant with the increasing number of nodes. In terms of delay, RD shows high end to end delay. For routing load GM performs best in terms of NRL. The throughput is high in case of GM. The RD has least throughput. Finally we have analyzed that GM shows better performance than RW and RD models. Thus GM becomes the most recommendable mobility model among the three mobility models. However there are other reactive, proactive and hybrid protocols in MANETs. Research on new simulation environments similar to ns2 could also be done, resulting in the development of new features such as more detailed graphs.

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