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PERFORMANCE ANALYSIS OF RANDOM WAYPOINT MOBILITY MODEL FOR MOBILE AD-HOC NETWORK

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Abstract: A Mobile Ad hoc Network (MANET) is a collection of wireless mobile nodes forming a temporary network without using any existing infrastructure. Since not many MANETs are currently deployed, research in this area is mostly simulation based. This paper focus on performance of Random Waypoint mobility model. We analyse various protocol independent metrics to capture interesting mobility characteristics, including spatial and temporal dependence and geographic restrictions. In this we compare the above charetristics with other mobility models. It also analyse the working of various MANET routing protocols, including DSR, AODV and DSDV with Random Waypoint mobility model.

Keywords: Manet; Performance; Mobility; Routing protocols.

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INTRODUCTION

A Mobile Ad hoc NETwork (MANET) is a collection of wireless nodes communicating with focus on the impact of mobility models on the performance of MANET routing protocols. We acknowledge that the communicating traffic pattern also has a significant impact on the routing protocol performance and merits a study on its own. However as in most studies in this area, in order to isolate the effect of mobility, we fix the communicating traffic pattern to consist of randomly chosen source–destination pairs with long enough session times. In the current network simulator (ns-2) distribution, the implementation of this mobility model is as follows: at every instant, a node randomly chooses a destination and moves towards it with a velocity chosen uniformly randomly from (0,Vmax), where Vmax is the maximum allowable velocity for every mobile node[1]. For the rest of the paper, we refer to this basic implementation as the Random Waypoint model. In the future, MANETs are expected to be deployed in myriads of scenarios having complex node mobility and connectivity dynamics. Random Waypoint is a well-designed and commonly used mobility model, but we find it is insufficient to capture those characteristics, such as

A. Spatial dependence of movement among nodes.

B. Temporal dependence of movement of a node over time.

C. Existence of barriers or obstacles constraining mobility.

It has also been observed in previous studies that under a given mobility model, routing protocols like DSR, DSDV and AODV perform differently. Possibly because each protocol differs in the basic mechanisms it uses. For example, DSR uses route discovery,while DSDV uses periodic updates.

I. RELATED WORK

Extensive research has been done in modeling mobility for MANETs. In this section, we mainly focus on experimental research in this area. This research can be broadly classified as follows based on the methodology used.

A. Random Waypoint based performance comparison of routing protocol

Much of the initial research was based on using Random Waypoint as the underlying mobility model and Constant Bit Rate (CBR) traffic consisting of randomly chosen source–destination pairs as the traffic pattern. Routing protocols like DSR[5], DSDV[6], AODV[7] and TORA[12] were mainly evaluated based on the following metrics: packet delivery ratio (ratio of the number of packets received to the number of packets sent)and routing overhead (number of routing control packets sent). Ref[9]concluded that on-demand protocols such as DSR and AODV performed better than table driven ones such as DSDV a thigh mobility rates, while DSDV performed quite well at low mobility rates. Ref. [10] performed a metrics of packet delivery ratio and end to end delay. It observed that DSR outperforms AODV in less demanding situations, while AODV outperforms DSR at heavy traffic load and high mobility. However, the routing overhead of DSR was found to be lesser than that of AODV. In the above studies, focus was given on performance evaluation, while parameters investigated in the mobility model were change of maximum velocity and pause time. In our work, focus on larger set of mobility characteristics.

B. Scenario based performance comparisons

Random Waypoint is a simple model that is easy to analyze and implement. This has probably been the main reason for the widespread use of this model for simulations. Realizing that Random Waypoint is too general a model, recent research has started focusing on alternative mobility models and protocol independent metrics to characterize them. Ref. [11] conducted a scenario based performance analysis of the MANET protocols. It analysis models for a few ‘‘realistic’’ scenarios such as a conference, event coverage and disaster relief.

To differentiate between scenarios used, the study introduced the relative motion of the mobile nodes as a mobility metric. Their conclusions about the performance of proactive and reactive protocols used a mobility model in which each node computes its next position based on a probability distribution. This model does not allow significant changes in direction between successive instants. It concluded that proactive protocols perform better than reactive ones in terms of packet delivery ratio and end-to-end delay. However, reactive protocols were seen to incur a lower routing overhead. Rate of link changes was used to characterize a few group mobility patterns as well as Random Waypoint. It observed that the rate of link change for Random Waypoint was higher than that for RPGM. From experiments, it observed that protocols like AODV, DSDV and HSR[6] perform worse with Random Waypoint than with RPGM. It proposed the Displacement Measure that is a normalization of the actual distance traveled by the geographic displacement as a metric to evaluate the different movement patterns including those generated by Random Waypoint. It studied the effect of transmission range on throughput of Random Waypoint model. It studied the effect of transmission range on throughput across different mobility models and concluded that as the transmission range is increased, the rate of link changes decreased and the throughput for all protocols increased.

However, the link change rate does not seem to vary greatly across the different mobility models. As far as routing overhead was concerned, Mobility Vector was seen to produce a worse overhead than Random Waypoint. Our study is also freamwork based. However, we do not aim to provide a generic mobility model from which all ''realistic'' mobility patterns can be derived. The contributions of our proposed framework are threefold:

a. Focus on mobility characteristics such as spatial dependence, geographic restrictions and temporal dependence. Define mobility metrics that capture these characteristics. Choose mobility models that span the metric space and use them to analyse the performance of routing protocols.

b. Define connectivity graph metrics. Study the interaction of mobility metrics and connectivity graph metrics and its effect on protocol performance.Analyze the reasons for the differences in protocol performance as a ''whole'' by investigating the effect of mobility on ''parts'' that build the protocol.

II. LIMITATIONS OF RANDOM WAYPOINT MODEL

Random Waypoint model was introduced in [9] and is among the most commonly used mobility models in the MANET research community. In this model, at every instant, each mobile node chooses a random destination and moves toward sit. After reaching the destination, the node stops for a duration defined by the ''pause time'' parameter. After this duration, it again chooses a random destination and repeats the whole process again until the simulation ends. The Random Waypoint model is widely accepted mainly due to its simplicity of implementation and analysis. However, we observe that the basic Random Waypoint model is sometime insufficient to capture the following mobility characteristics:

A. Temporal dependency: Due to physical constraints of the mobile entity itself, the velocity of mobile node will change continuously and gently instead of abruptly, i.e. the current velocity is dependent on the previous velocity. However, intuitively, the velocities at two different time slots are independent in the Random Waypoint model.

B. Spatial dependency: The movement pattern of a mobile node may be influenced by and correlated with nodes in its neighborhood. In Random Waypoint, each mobile node moves independently of others.

C. Geographic restrictions: In many cases, the movement of a mobile node may be restricted along the street or a freeway. A geographic map may define these boundaries. In our study, we focus on the above-mentioned characteristics.

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	Application	Temporal Dependence	Spatial Dependence	Geographic Restriction
Random Waypoint Model	General	No	No	No
Group Mobility Model	Battlefield	No	Yes	No
Freeway Mobility Model	Metropolitan Traffic	Yes	Yes	Yes
Manhattan Mobility Model	Metropolitan Traffic	Yes	No	Yes

Table 1. The characteristics of mobility models used in IMPORTANT framework

III. COMPARISON OF VARIOUS MOBILITY MODELS

A. RPGM model:

Ref. [5] introduced this model. Here, each group has a logical center (group leader) that determines the groups motion behavior. Initially, each member of the group is uniformly distributed in the neighborhood of the group leader. Subsequently, at each instant, every node has a speed and direction that is derived by randomly deviating from that of the group leader.

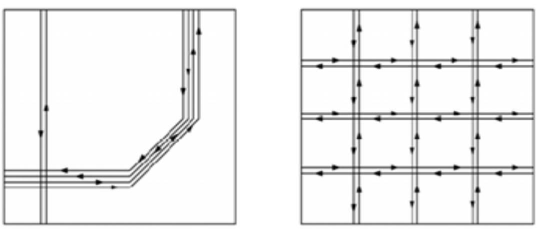
Applications: Group mobility can be used in military battlefield communications where the commander and soldiers form a logical group. More applications are mentioned in.

Important characteristics: Each node deviates its velocity (both speed and direction) randomly from that of the leader.

B. Freeway mobility model:

This model is used to emulate the motion behavior of mobile nodes on a freeway. The freeway map used in our study is shown in Fig. 1(a).

Applications: It can be used in exchanging traffic status or tracking a vehicle on a freeway.



(a) Freeway Model (b) Manhattan Model

Figure 1. Maps for Freeway model & Manhattan Model

Important characteristics: In this model we use maps. There are several freeways on the map and each freeway has lanes in both directions. The differences between Random Waypoint and Freeway are the following:

(a) Each mobile node is restricted to its lane on the freeway.

(b) The velocity of mobile node is temporally dependent on its previous velocity.

(c) If two mobile nodes on the same freeway lane are

within the safety distance (SD),the velocity of the following node cannot exceed the velocity of preceding node.

C. Manhattan mobility model:

We introduce Manhattan model to emulate the movement pattern of mobile nodes on streets defined by maps. The Manhattan map used in our study is shown in Fig. 1(b).

Applications: It can be useful in modeling movement in an urban area where a pervasive computing service between portable devices is provided.

Important characteristics: Maps are used in this model too. The map is composed of a number of horizontal and vertical streets. Each street has two lanes for each direction (north and south direction for vertical streets, east and west for horizontal streets). The mobile node is allowed to move along the grid of horizontal land vertical streets on the map. At an intersection of a horizontal and a vertical street, the mobile node can turn left, right or go straight. This choice is probabilistic: the probability of moving on the same street is 0.5, the probability of turning left is 0.25 and the probability of turning right is 0.25.The velocity of a mobile node at a time slot is dependent on its velocity at the previous timeslot. Also, a nodes velocity is restricted by the velocity of the node preceding it on the same lane of the street. The inter-node and intra node relationships involved are the same as in the Freeway model. Thus, the Manhattan mobility model is also expected to have high spatial dependence and high temporal dependence. It too imposes geographic restrictions on node mobility. However, it differs from the Freeway modeling giving a node some freedom to change its direction.

IV. PERFORMANCE METRICS

Here we define several metrics related to mobility. We first monitor the change in link status (up, down) caused by the motion of nodes. When two nodes previously within the transmission range (assuming they have same transmission range) move far away, the connection is lost. This event increments a link down counter. Vice versa, when two nodes move into the transmission range, a connection is gained. This is a link up case. So we analyse how the mobility affects the link up/down dynamics. Finally, we observe how routing schemes will perform under various mobility models. We analyse the performance of routing protocols in two ways: (a) end-to-end throughput(kbits over 200-second simulation period) and;(b) control overhead. The control overhead is measured as megabits per second per cluster in the cluster infrastructure. With mobility, physically available routes may become invalid(i.e. may not be found by the routing algorithm m), causing packets to be dropped and leading to throughput degradation and increasing control overhead. The routing protocols used are Destination-Sequence Distance Vector (DSDV)[3], Ad hoc On Demand Distance Vector Routing (AODV) [2], and the Hierarchical State Routing (HSR)[1].Protocol performance metrics Since only mobility will produce link up/down and will affect clustering, the choice of a specific routing protocol has no effect on link up/down metrics. The mobility reported in the performance diagrams is based on average group speed and on mean motion displacement of nodes around their reference points.

V. CONCLUSION

In this paper, a random waypoint mobility model is used to analyze the routing performance of mobile ad hoc network in a systematic manner. In our study, we observe that the Random way point mobility model does not allow significant changes indirection between successive instants. It concluded that proactive protocols perform better than reactive pattern does influence the performance of MANET routing protocols.

The effect of transmission range on throughput of random waypoint model across different mobility models and concluded that as the transmission range is increased, the rate of link changes decreased and the throughput for all protocols increased. However, the link change rate does not seem to vary greatly across the different mobility models.

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