Node Mobility Tracking in Mobile Ad-Hoc Networks in Their Geographical Position (Dynamic Networks)

A. Subramani, A. Krishnan

***Abstract*— In mobile ad-hoc network, nodes of position change due to dynamic nature. There should be a provision to monitor behavior and position of the on the regular basis. In this paper, importance of management schemes in ad-hoc networks is studied. Further, mobility models and reviewed and classified by incorporating real life applications into an account. This essay explores a model for the operation of an ad hoc network and the effect of the mobile nodes. The model incorporates incentives for users to act as transit nodes on multi-hop paths and to be rewarded with their own ability to send traffic. The essay explores consequences of the model by means of simulation of a network and illustrates the way in which network resources are allocated to user according to their geographical position. The mobile nodes are explored in this essay, where nodes have incentives to collaborate. Mobility and Traffic pattern of mobility models are generated by using AnSim Simulator.**

***Index Terms*— Mobile Adhoc Network, Mobility Management, Mobility Model, Classification, Location Management, AnSim.**

I. INTRODUCTION

Mobile Adhoc Networks [1] [2] [3] are collective arrangement of mobile nodes that can communicate with one another without the aid of any centralized point. Adhoc networks make practical and effective use of multihop radio relaying and radio communication channel. It [4] is very important for one mobile host to enlist the aid of other hosts in forwarding a packet to its destination, due to the limited range of each mobile node's transmissions. With the enhancement of technology, this network could be managed by end users rather than single authority and they may be used for extremely sensitive applications. In adhoc networks, node mobility is an important issue due to adhoc characteristics such as dynamic network topology, shared medium, limited bandwidth, multihop nature and security etc. Thus, there is requirement of effective mobility management scheme i.e. seamless mobility in adhoc networks. Seamless mobility provides easy access and effective communication among nodes present in the network. A Mobile Ad Hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. In a MANET it is assumed that the nodes are free to move and are able to communicate with each other, often through multi-hop links, without the help of a fixed network infrastructure.

The network topology is dynamic. The movement of a node out of or into the Communication range of other nodes changes not only its neighbour relationships with those other nodes, but also changes all routes based on those relationships. Signaling overhead traffic for establishing and maintaining routes in a MANET is proportional to the rate of such link changes. Thus the performance of a MANET is closely related to the efficiency of the routing protocol in adapting to changes in the network topology and the link status [5], [6] For the performance evaluation of a routing protocol for a MANET, it is imperative to use an appropriate mobility model to simulate the motion of the nodes in a network [7]. In this paper we present some mobility models that have been proposed, or used in, the performance evaluation of Ad Hoc network protocols. The models presented are the random waypoint mobility model [5], the random Gauss-Markov model [8], [9], and the reference point group mobility model [10].

II. MOBILITY MODEL REVIEWS

Mobility models in adhoc networks depict [10] movement pattern of mobile users and how their location, velocity, speed, direction and acceleration change over time. In these networks, mobile nodes communicate directly with each other. Communication between two nodes does not produce effective results if both nodes are not in same transmission range. This problem can be resolve by using intermediate nodes with routing. Thus, routing is very important in mobile adhoc networks where mobility models must be evaluated with respect to end to end delay and efficient data transmission. Mobility models are intended to focus on individual movement patterns due to point to point communication in cellular networks [11-12] [9] whereas adhoc networks are designed for group communication. Such models [13] are suggested to maintain movement, and efficient transmission among nodes in real life applications. In addition to this, these models are mainly focused on the individual motion behavior between mobility era with minimum simulation time in which a mobile node moves with constant speed and direction. These models represent the features of the mobile nodes in an adhoc network like speed, direction, distance and node movement.

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Mobility models [7] can be categorized based on the following criteria which is based on dimension, scale of mobility, randomness, geographical constraints, destination oriented and by changing parameters (discussed in next section). Generally, there are two types of mobility models (i) Trace based mobility models and (ii) Synthetic mobility models. Trace models provide mobility patterns based on deterministic approach whereas synthetic models presents movements of mobile nodes in realistic manner.

A. Random Waypoint Model

Johnson and Maltz describe the random waypoint (RWP) model in [5]. In this model, a nodeselects a random destination uniformly distributed over a predefined region, and moves to that destination at a random speed, that is also uniformly distributed between a predefined minimum and maximum speed upon reaching the destination. After pausing for a certain period of time, the node selects a new random destination and speed. A typical trajectory of a node moving in the random waypoint model is shown in **Figure 1.**

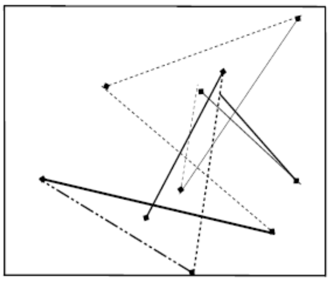

Figure 1. RWP Model

B. Random Gauss-Markov Model

The Random Gauss-Markov (RGM) Model was described by Sanchez [14] and was further developed by Liang and Haas [15]. In this model, each node is assigned a speed s and direction θ, and these variables are updated at every time step Δt as follows,

$$s(t+\Delta t) = \min[\max(v(t)+\Delta v, V_{min}), V_{max}]$$

$$\Delta (t+\Delta t) = \theta(t) + \Delta t$$

Here V_{min} and V_{max} are the minimum and maximum speeds of the node, and Δv and $\Delta\theta$ are random variables uniformly distributed over the intervals $[-\Delta v_{max}, \Delta v_{max}]$ and $[-\Delta\theta_{max}, \Delta\theta_{max}]$, respectively. When a node reaches a boundary, the node is reflected from that boundary by the selection of a new random direction. The update of S and θ can be implemented in various ways. A typical trajectory of a node moving in a random Gauss-Markov Model is shown in **Figure 2.**

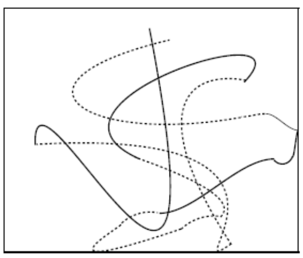

Figure 2. RGM Model

C. Reference Point Group Mobility

The Reference Point Group Mobility (RPGM) model was described by Hong et al in [11]. In the RPGM model, each group of nodes has a logical centre, which defines characteristics of the group's motion such as location, speed and direction. Thus, the trajectory of a group is determined by the trajectory of its logical centre.

In addition to the logical centre, the RPGM model defines a reference point and a random motion vector for each node in the group. A reference point is a point about which a node moves at random with respect to the logical centre. The random motion vector represent the random deviation of a node from the reference point.

The random motion vector is updated periodically and its magnitude and direction are uniformly distributed over the intervals $[0, RM_{max}]$ and $[0, 2\pi]$ respectively. Let $n(t_0)$ be the location vector of a node of the RPGM model at $t = t_0$, then

$$n(t_0) = c(t_0) + \overrightarrow{RP} + \overrightarrow{RM}(t_0)$$

Where $c(t_0)$ denotes the location vector of the logical centre of the group at time t_0, $\overrightarrow{RP}$ is a vector from the logical centre to the reference point, and $\overrightarrow{RM}(t_0)$ is the random motion vector.

Then at $t = t_0 + \tau$

$$n(t_0+\tau) = c(t_0+\tau) + \overrightarrow{RP} + \overrightarrow{RM}(t_0+\tau)$$

For $t_0 \leq t \leq t_0 + \tau$, $n(t)$ is given by

$$n(t) = \frac{(t_0+\tau-t)n(t_0) + (t-t_0)n(t_0+\tau)}{\tau}$$

A typical trajectory of a node moving in the RPGM model is shown in **Figure 3.**

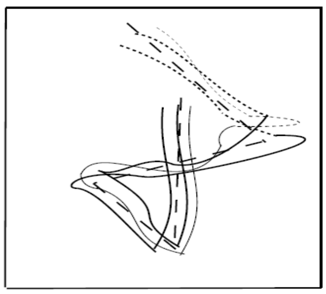

Figure 3. RPGM model (3 nodes)

Figure 4 depicts the movement of the RPGM model for a group with three nodes.

At times t_0 and $t_0 + \tau$ the trajectory of the group is illustrated by superimposing the position of the nodes, their associated reference points and the group's logical centre, over time, on the same diagram.

For the purpose of clarity, only the vectors associated with node 1, $\overrightarrow{RM}$ and $\overrightarrow{RP}$, have been labeled. It is useful at this point to recall that the $\overrightarrow{RP}$ for a particular node remains constant throughout time.

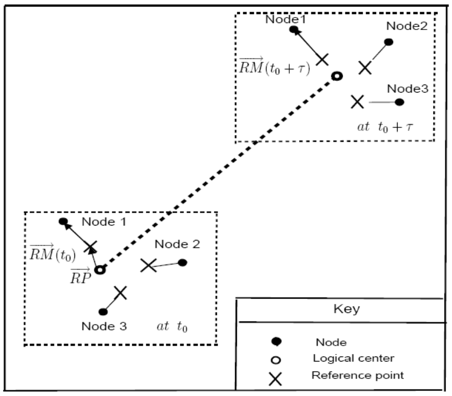

Figure 4. Description of RPGM model

D. Mobility Discussion

Figures 1,2 and 3 illustrate the typical travelling patterns of a mobile node(s) in the RWP, RGM, and RPGM models, respectively. Larger spacing between the dots indicates that higher speeds are involved.

The RWP model has a higher spatial node distribution at the centre of the network than near the boundaries [2], while the RGM model has a relatively uniform spatial node distribution over the entire network.

Moving at the same speed, an RWP node will travel farther than an RGM node over the same time interval, due to the travelling pattern. Figure 3 illustrates a group of three nodes in the RPGM model with the logical centre moving according to the RWP model. Also shown is the trajectory of the logical centre of the group.

E. Location Managment

Location management [16] schemes in mobile adhoc network allow any source S to know the location of any destination D. In this approach, information of node is stored and updated on a periodical basis. Location information management of nodes in routing protocol is a very cumbersome task. Quorum based and hashing based methods are most approachable in this scheme. [17] has suggested uniform quorum based systems for effective mobility management in terms of reliability rather than resource sharing. Due to dynamic network topology, infrastructure less nature of ad hoc networks, calculation of node's position is more challenging than static or fixed networks. Consequently, network layer mobility management is still another problem in ad hoc network.

F. Incorporation of Mobility Models in Real Life Ad-hoc Applications

Table 1 illustrates impact of these above discussed models in real life scenarios.

Table 1. Mobility Models in Real life Applications

Real Life Applications	Trace Based/ Synthetic Based	Entity Based/ Group Based	Constrained Based/ Statistical Based	Mobility Model Used
Employee Record System	Trace Based			
Shopping Mall		Entity Based	Statistical	Brownian Mobility
Voting System		Entity Based	Constrained	Probabilistic Version
Military		Group Based	Statistical	Nomadic
Conference Management System		Group Based	Statistical	Nomadic
Agriculture		Group Based	Statistical	Nomadic
Examination Management System		Group Based	Constrained	RPGM
Thief Tracking System		Group Based	Constrained	Pursue Mobility
Delhi Metro		Entity Based	Statistical	Gauss Markov
Railway		Entity Based	Statistical	Gauss Markov
Location Based	Trace			
Campus Life		Entity Based	Constrained	RWP/Random Walk
Airport		Entity Based	Statistical	RWP
Traffic Control		Entity Based	Statistical	RWP/Random Walk
Quorum Based	Trace			
Speed Calculation of Pedestrian		Group Based	Constrained	Column Mobility
Disaster relief		Group	Constrained	Random
Aircraft Monitoring		Entity Based	Constrained	Random Direction

III. MOBILE NETWORKS

The objective of this essay is to study the effect of mobility on the performance of an ad hoc network, where nodes have a built-in incentive to collaborate. In this section we return to the original topology considered in **Figure 5**, where the node N_1 is mobile and follows the path shown in the **Figure 6,** through the geographical centroid of the static network.

Node N_1 moves across the networks and reaches the other edge of the network by the end of the simulation after 10^5 seconds of simulation time. To reach this final location node N_1 moves with a velocity of {-57 x 10^{-5}, 98 x 10^{-5}} m/s/.

When node N_1 approaches the networks centre, it will be used more frequently as a transit node to carry traffic between other nodes. This can be observed from **Figure 7 and Figure 8**, which show that the bandwidth and the power price of node N_1 increase when it is near the centre. At the same time, other nodes have a choice to send traffic through either N_1 or N_8.

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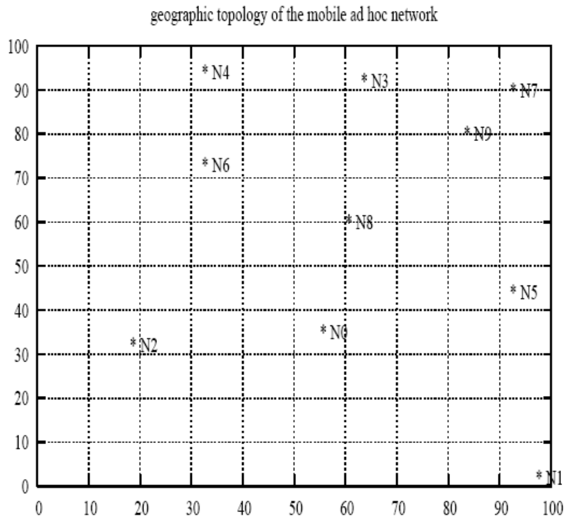

Figure 5. Topology of the mobile ad hoc network.

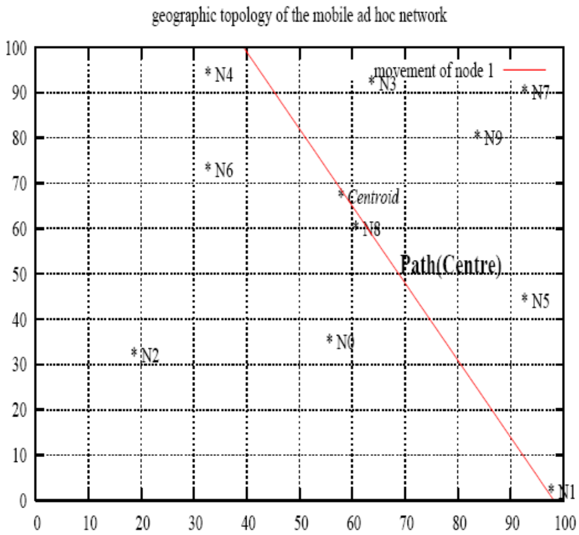

Figure 6. Path of node N1 through the network.

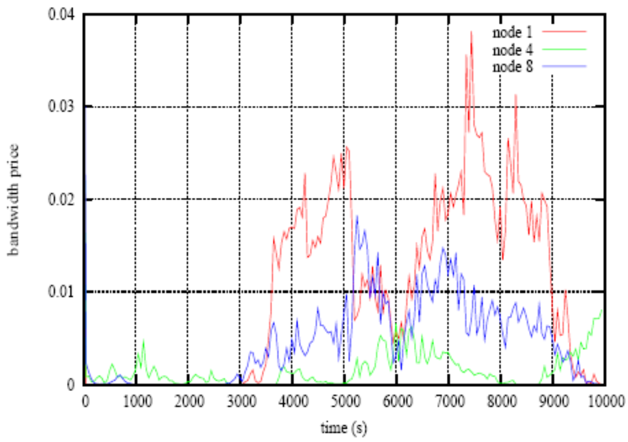

Figure 7. Bandwidth price of the mobile node N1, and two stationary nodes N4 and N8

Node N_1 affects the power price of node N_8; it helps to reduce it. As node N_1 moves away from the centre of the network, these effects on the node power and bandwidth price subside.

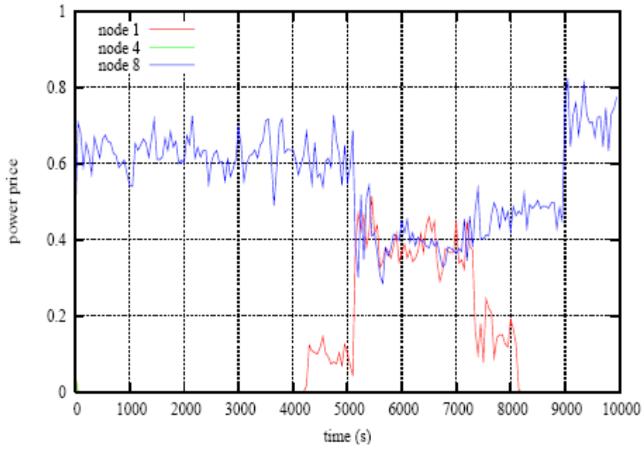

Figure 8. Power price of the mobile node N1, and two stationary nodes N4 and N8

The increase in the prices associated with node N_1, when it is near the centre of the network, and its increased traffic load which is forwarded to other nodes, means that its credit balance also grows, as shown in **Figure 9.** This increases the ability of node N_1 to generate traffic, as its willingness to-pay is related to its credit balance. Consequently, its total throughput increases, and we can observe this in **Figure 10.**

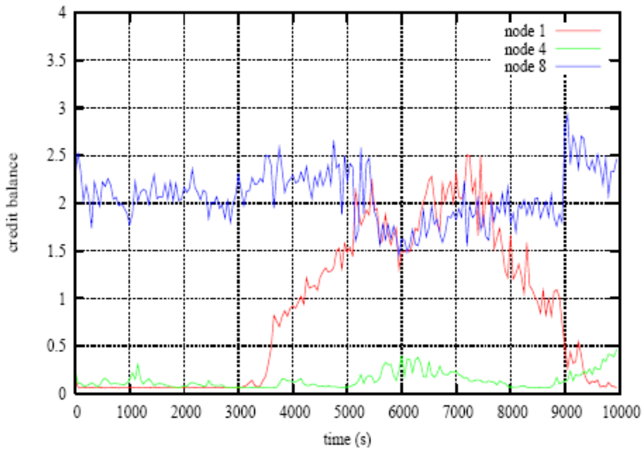

Figure 9. Credit balance of the mobile node N1, and two stationary nodes N4 and N8

The increase in throughput and bandwidth price, when the node moves closer to another node, is also observed when N_1 moves away from the centre for the network and close to node N_1. A comparison of **Figure 5 and 10** indicates that the overall total throughput within the network increases when node N_1 moves to the centre of this network. In comparison, when N_1 moves away from the centre to the edge, the overall total throughput decreases.

Thus our result indicates ways in which the overall performance varies with the current geographical distribution of the users. Moreover, mobile users can influence not just their own performance but also the overall performance of the network

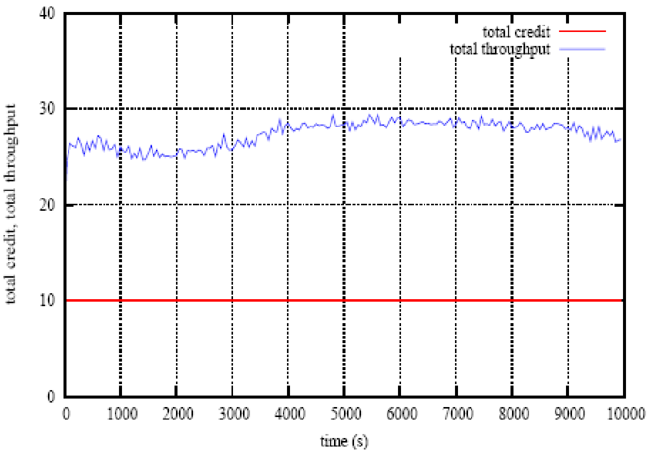

Figure 10. Total throughput and total credit

IV. CONCLUSION

Mobility management schemes are analyzed and discussed in this proposed work. Further, mobility management models in ad-hoc networks are classified. Classification of mobility model is illustrated based on entity and group based mobility model. In addition to this, traffic pattern of mobile nodes can be generated by using AnSim simulator. AnSim provides good platform to trace out node movement by changing the pause time and speed of node. The final part of the simulation allows all the nodes to move autonomously, and demonstrates that the power price decays to zero and increases the total throughput of the system when all nodes are near the network centre.

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