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MOBILITY MODELS FOR MANET: MATHEMATICAL PERSPECTIVE

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Abstract: *A mobile ad hoc network (MANET) is a self-directed, infrastructure-less, self-configuring and self-healing system of mobile nodes connected by wireless links. The nodes are free to move about randomly and may join or leave the network at their will. Due to its randomness, the network topology cannot be pointed and may change rapidly. The movement pattern of MANET nodes is differentiated by mobility models and each routing protocols shows specific characteristics for these models. In order to find the most adaptive and effective routing protocol for dynamic MANET topologies, the behavior of routing protocols needs to be examined at changing node speeds, number of traffic nodes, network size, as well as node density. There are mainly two types of mobility models are described here for the mathematical purpose.*

Keywords: *MANET, mobile nodes, Entity mobility model, group mobility model.*

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I. INTRODUCTION

A mobile ad hoc network (MANET) is a self- directed, infrastructure-less, self-configuring and self-healing system of mobile nodes connected by wireless links. The nodes can move randomly at random speeds in random directions. Each node in the network acts as a router, forwarding data packets to other nodes. Development of dynamic routing protocols is the main issue in the designing of ad hoc networks.

The mobility model is mainly designed to describe the movement pattern of mobile users, and how their location, speed and acceleration change with respect to time. Mainly there are two types of mobility models used in the simulation of networks: traces and synthetic models [12].

Traces provide accurate information about the users mobility traces. Everything is deterministic in these mobility models. However, since MANETs have not been applied and distributed on a large scale, obtaining real mobility traces becomes difficult at some level.

Therefore, in absence of traces, the syntactic models have been suggested. These synthetic models represent the movements of mobile nodes realistically in ad hoc networks.

Mobility models are mainly divided into Entity Mobility Models and Group Mobility Models.

II. MOBILITY MODELS

Mobility Models

Entity mobility model

- Random Walk Mobility Model
- Random Way Point Mobility Model
- Random Direction Mobility Model
- Boundless Simulation Area Mobility Model
- Probabilistic Version Of the Random Walk Mobility Model:
- City Section Mobility Model

Group Mobility Models

- Column Mobility Model
- Nomadic community Mobility Model
- Pursue Mobility Model
- RPGM

ENTITY MOBILITY MODELS

[1] Random Walk Mobility Model: Einstein explain The Random Walk Mobility Model mathematically in 1926 [11].A simple mobility model based on random directions and speeds. The Random Walk Mobility Model was mainly developed to imitate the unpredictable change.

In this mobility model, a mobile node moves from its current position to a new position by randomly choosing a direction and speed. The new speed and direction are both chosen from pre-defined ranges, [min-speed, max-speed] and [0, 2*pi] resp. It is a memory-less mobility pattern because the current speed and direction of a mobile node is independent of its past speed and direction. In 1921, it is proved by Polya that a random walk on a 1-D or 2-D surface returns to the origin with complete certainty, i.e., a probability of 1.0 [5]. From This characteristic we can assure that the random walk describes a mobility model that check entity movements around their starting points, without concern of the entities roaming away never to return. Unrealistic movements can be generated from this characteristic such as sudden stops and sharp turns. It is based on Brownian motion.

[2] **Random Waypoint Mobility Model:** The Random Waypoint Model was first proposed by Johnson and Maltz [9]. This Mobility Model based on pause times between changes in direction and speed [4]. The Random Waypoint model is the most commonly used in research community. A non homogenous spatial dispersion of nodes are created by random way point model. A Mobile node starts to travel new selected goal at selected speed. After that the mobile node pauses for a time interval and then again starts the process again. It then rests for pause time and repeats this process till the completion of the simulation.

Two important parameters Velocity and pause time are used in this model. This model is mostly accessible in the applications like airport.

To overcome some problems like, damages the precision of the current simulation methodology of ad hoc networks which makes it unacceptable to relate simulation-based performance results to corresponding analytical results, a detailed analytical study of the spatial node distribution generated by random waypoint mobility is introduced. These models have some limitations like temporal dependency, spatial dependency of velocity and geographic restriction of movement.

Fig. 2 illustrates examples of a topography showing the movement of nodes for Random Mobility Model [3].

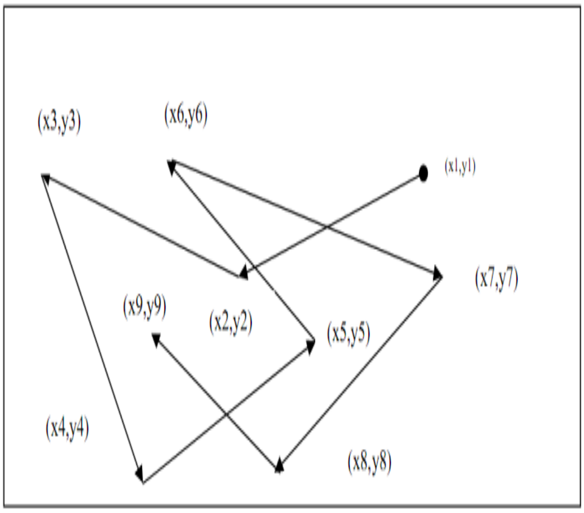

Fig 2. Random waypoint mobility model

[3] Random Direction Mobility Model: In this mobility model mobile node chooses any random direction to travel until the boundary of edge is found. The Density waves produced by random waypoint model are overcome by Random Direction Mobility Model [6]. A little alteration to the Random Direction Mobility Model is called the Modified Random Direction Mobility Model [7]. In the modified random direction model MNs continue to select the random directions but cannot compelled to travel to the simulation boundary before ending to change direction. Rather an MN chooses a random direction and chooses a goal anyplace along that direction for travelling.

[4] **A Boundless Simulation Area Mobility Model:**

In bounded simulation area mobility model Speed and direction of each mobile node changes quickly. In this model, mobile nodes move in a clear way in the simulation boundary. A relationship between the previous travelling direction and velocity of an MN with its current travelling and velocity exists [19]. Velocity *v* as well as its direction q is described by velocity vector *v* = (*v*, θ).The MN's position is represented as (*x*, *y*).

After every Δt time steps both the velocity vector and the position are modified as follows:

$v(t+\Delta t) = \min[\max(v(t)+\Delta v, 0), V_{max}];$
$\theta(t+\Delta t) = \theta(t) + \Delta\theta;$
$x(t+\Delta t) = x(t)+v(t) * \cos\theta(t);$
$y(t+\Delta t) = y(t)+v(t) * \sin\theta(t);$

Where,

V_{max} is the maximum velocity,

Δv is the change in velocity uniformly distributed between [-A_{max} *Δt, A_{max} *Δt],

A_{max} is the maximum acceleration of a given MN, $\Delta\ \theta$ is the change in direction which is uniformly distributed between [-α *Δt, α *Δt] And α is the maximum angular change in the direction an MN is traveling.

In Boundless Simulation Area Mobility Model instead of reflecting of MN's when they reach a simulation boundary, the MNs will continue travelling after reaching one side of the simulation area and reappear on the opposite side of the simulation area. A torus-shaped simulation area is created by this method which allows MNs to move clearly.

[4] Gauss-Markov Mobility Model:

Liang and Haas [2] and widely utilized [18][14] introduced the Gauss – Markov Mobility Model. This mobility model was originally proposed for the simulation of a PCS [1]. In this model various levels of randomness adjusted via only one parameter. The problem of sudden changes in random waypoint mobility model is overcome by Gauss-Markov Mobility Model

[5]A Probabilistic Version of the Random Walk Mobility Model:

A set of probabilities are used to determine the next position of a mobile node. This model is based [10] on markov chain approach. It maintains 3x3 probability matrix which represents three states with respect to x direction as well as y direction. State 0 signifies the Node stays, State 1 signifies the Node moves backward and state 2 Node moves forward.

[6] City Section Mobility Model:

The simulation area used in City Section model [15] is represented by a grid of streets forming a particular section of a city. Each MN begins the simulation at a defined point on some street.

Destination is randomly chosen by a mobile node, can be represented by a point on some street. The Mobile node will take a pause for some specified time after reaching the destination and then will choose another destination randomly and again repeats the process.

GROUP MOBILITY MODELS

[1]Column Mobility Model:

A set of mobile nodes will move forward uniformly in part. Direction forms a line. This mobility model is mainly useful for scanning and searching purposes. [13]

[2]Nomadic Community Mobility Model: A group of mobile nodes move together from one position to another. Since comparison [8] with column based mobility model, this model shares the same reference grid whereas column based mobility model uses one reference point w.r.t each column.

[3]Pursue Mobility Model:

The Pursue Mobility Model [16] attempts to describe MNs following a special target. In this mobility model a group of n nodes tries to follow a single node. This model is used for the specified target tracking.

For example, the police want to catch an escaped criminal.

[4] Reference Point Group Mobility Model (RPGM):

A logical group center is followed by all the group members of this mobility model that describes the group motion behavior. Reference point group mobility can be used in army battlefield communication.

Fig. 2 shows example topography showing the movement of nodes for Reference Point Group Mobility Model [17].

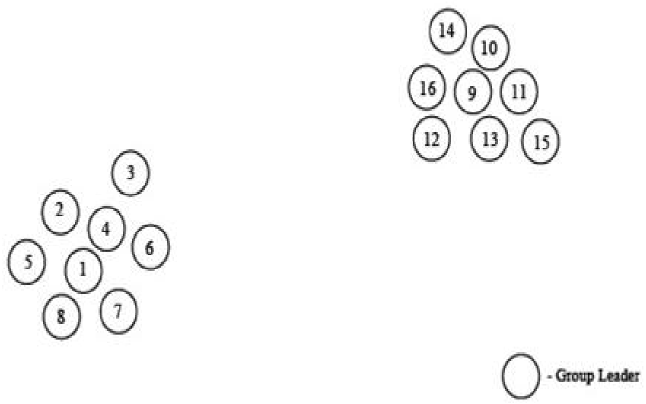

Fig. 2 Reference Point Group Mobility Model

III. MANET ROUTING PROTOCOLS

[1] Reactive protocol:

These reactive protocols also called On Demand Routing Protocols because the tracks/routes are created between mobile nodes only when they want to send data packets among the nodes. The host node which transmit data packets from source to destination in network, broadcasts a route/path request to all nodes in network. The host node will wait until reply of the nodes in the network to provide a path to destination before transmit packets. It performs two main functions in Ad hoc network routing i.e. route discovery and route maintenance.

[a]The route discovery function

This function of protocol is responsible for finding of new path/route to transmit packets when required by a node.

[b]Route maintenance function

This function of reactive protocol is responsible for detecting of broken links and restore of an existing route. Reactive protocols are bandwidth efficient and reduce storage space.

The common reactive routing protocols used by MANET are DSR, AODV, and TORA.

The advantages of Reactive protocols are efficiency, reliability and less control overhead.

The disadvantage long delays due to route discovery operation in order to transmit data packets.

(2) Pro- active Routing protocols:

These pro – active routing protocols also called table driven protocols because every node maintains one or more tables describing the whole network topology. These tables are updated on regular basis in order to maintain up-to-date routing information. Examples of pro – active routing protocols Optimized Link State Routing Protocol (OLSR), Destination-Sequenced Distance-Vector Routing (DSDV) Protocols.

The advantages of this type of protocols are shortest path can be find in the easiest way through network and delay is minimum by using pro-active routing protocols.

Disadvantage of proactive routing protocols is providing a resistance to network topology changes.

[3] Hybrid Protocols:

Hybrid Protocol is the mixture of reactive and pro-active routing protocols. It is mainly combination of distance vector routing, which shares the knowledge of entire network with its neighbors and link state routing, in which every router in the network having the information of its closest neighbors

Examples are Temporary Ordered Routing Algorithm (TORA), Zone Routing Protocol (ZRP).

IV. CONCLUSION

Various Mobility Models and their applications are analyzed. The performance of mobile ad – hoc network changes with each mobility model. Mobility models are classified on the basis of entity and group mobility models. The main difference between Random Walk and Random Way point model is of pause time, Random Way point model includes pause time. Random Way point model is very flexible to create realistic model patterns whereas the Random Direction Mobility Model is an unrealistic model. The Boundless Simulation Area Mobility Model is the only one model in which mobile nodes travel openly in a clear way in the Simulation area. The Gauss-Markov Mobility Model avoiding undesired edge effects because of different levels of randomness uses only one parameter. Probabilistic Random Walk Mobility Model useful for tracing the data that we want to model. In the City Section Mobility Model the moving behavior of MNs is restricted; Mobile nodes cannot wander freely without traffic regulations. The movement patterns of the Column, Nomadic Community, and Pursue Mobility Models are group mobility can be received by altering the parameters of Reference Point Group Mobility Model. Shortly, it is concluded that for entity mobility models random way point or random walk mobility models are preferred and for group mobility models RPGM is preferred.

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