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A Conceptual Study on Mobility Models in MANET

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Abstract

Mobile Adhoc Network (MANET) is collection of wireless nodes temporarily group together and form a network. MANET follows infrastructure less network topology with the high mobility ratio of nodes. In a normal wireless network environment the path found between a pair of nodes is almost permanent as the failures due to the external factors are not much. In a MANET environment this claim is impossible as the nodes keep moving and may not be available during transmission even immediate after the construction. Many routing protocols are available to find path between the nodes. Finding the mobility pattern is essential in path construction and also challenging. As there are many mobility models available, each has its own advantage and disadvantage over the other. A conceptual study over --- mobility models are done in this paper.

1. Introduction

MANET is a network of wireless nodes which follows temporary network topology and is also infrastructure less. As the network operates without a fixed infrastructure, each and every node involved in the path should act as a router during transmission. These nodes can move in any direction, at any speed and at any time. Prediction of mobility pattern is an essential and also a challenging task in path construction and retention. Many mobility models and many protocols are also available to find path for MANET. Path can be constructed using any mobility models and protocols, but the most suitable combination is chosen to select a path.

The initiation of path finding is done by the node which wants to communicate with another node. No guarantee over the found path as it may break at any due to mobility of the nodes selected in the path. To avoid such issues, multiple paths are found between same pairs or path may be reconstructed with the existing nodes after a failure. Mobility model is a process of analyzing the mobility pattern of the nodes with respect to the velocity, time and relevance to the other nodes. Mobility model helps in predicting how and where will the mobile node move in the next time slot. This prediction is very essential as it forms the basis for route discovery. Only based on the prediction of the mobility pattern the nodes are selected for path construction, hence it is important to avoid mislead. Different mobility models analyze the mobility of the nodes in different ways. Selection of appropriate model results in better route discovery.

In majority they are classified as Random Model, Space dependent Model, Terrain dependent Model and Time dependent Model [1],[2].

1.1 Random Models

The mobile nodes move randomly without any constriction over the direction, speed and destination in this model. Sometimes the model predicts unrealistic moving behaviours and could result wrong conclusions on the network evaluations. Random mobility models are insufficient to mimic the minute moving behaviours of mobile users, like speed change and direction change within each movement.

1.2 Space Dependent Model

Derives the measure of how two nodes are dependent in their motion. If two nodes are moving in same direction then they have high spatial dependency. The relative positioning of the nodes are important since the model is not individual and independent as in Random Models.

1.3 Time Dependent Models

Derives the measure of how current velocity (magnitude and direction) are related to previous velocity. Nodes having same velocity have high Time dependency. Prediction of the current location is possible from the previous history as these models are memory based.

1.4 Terrain Dependent Models

Terrain models are based on the characteristics of Geographical locations. As the other models does not follow the geographic factors, they pretend that the simulation area is a free space area where mobile nodes can move anywhere inside simulation area. Terrain models partially overcome this disadvantage by introducing geographic factors and obstacles in the simulation

2. Mobility Models

2.1 Random Waypoint Mobility Model (RWP)

In Random Waypoint, the nodes move in a random way as the name suggest to any destination with any velocity and in any direction. There is no relationship between the movements of one node with the other node as they move independently. In RWP, node movement is not related to its earlier movement with respect to the time [3].

2.2 Random Walk Model (RW)

The RW model was developed to mimic the unpredictable movement of the nodes. A node randomly choose a direction, speed from pre-defined ranges, with these two parameters, the node moves in either a constant time interval t or a constant distance d until the end of simulation. Once if the node reaches a simulation boundary, it bounces off the simulation border with an angle determined by the incoming direction [4].

2.3 Random Trip Model (RT)

The random trip is a generic mobility model for individual node movements. The model is defined by a set of paths over a connected domain, an initialization rule, and a trip selection rule. A trip is a combination of path and a duration or speed. A mobile node selects a path from the available set and follows the initialization rule and proceeds with the same path. At the end of the trip, the node selects another path according to the trip from the end point of the previous trip [5].

2.4 Random Direction Model (RD)

The node randomly chooses a direction and travels to the boundary of simulation area in that direction. The node pauses for a specified time once after reaching the boundary, then chooses another angular direction and repeats the process. Since the nodes only change direction and pauses at the boundary of simulation area, the average hop count will be much higher than other entity mobility model [6].

2.5 Smooth Random Model (SRM)

Smooth model is an independent Poisson process, in this model a node moves at a constant speed in a specific direction until a change event occurs in either a speed or direction. The movement duration of smooth nodes cannot be controlled [7].

2.6 Gauss Markov Mobility Model (GMMM)

The Gauss-Markov Mobility Model is based on the levels of randomness. Each mobile node is assigned with an initial speed and direction. Movement occurs by updating the speed and direction of each mobile node at each fixed intervals of time. The speed and direction is calculated based on the value of speed and direction at the earlier stage [8].

2.7 Semi Markov Smooth (SMS) Model

SMS is based on the physical law of a smooth motion, a movement in the model contains three consecutive moving phase.

Speed Up phase: Acceleration of an object for its movement to reach a stable speed.

Middle Smooth phase: Acquisition of smooth motion after the initial acceleration with stable speed.

Slow Down phase: Reduction of speed at a interval to end a movement to avoid sudden stop.

After each movement, a mobile node may stay for a random pause time [9].

2.8 Reference Point Group Model (RPGM)

Each group has a logical center and a group leader. The leader determines the movement behavior of group members. At first, members of the group are

uniformly distributed in their neighborhood of the group leader.
Later, at each instant, every node derives its own speed and direction randomly deviate from that of the group leader [10].

2.9 Freeway Mobility Model (FWMM)

Each mobile node is restricted to its lane on the freeway. The velocity of mobile node is temporally dependent on its previous velocity. If two mobile nodes in the same freeway lane are within the safety distance (SD), the velocity of the following node cannot exceed the velocity of preceding node [11].

2.10 Community Based Mobility Model (CBMM)

Community model is a modeling of social relationships and detection of community structures. Based on a threshold the social interaction between the groups are discriminated as strong nil interaction. Groups communicate through a bridging node of each group. Through this the community is built in higher levels and position is derived based on the attraction towards a community [12].

2.11 Group Force Mobility Model (GFMM)

The GFMM follows the concept of attraction and repulsion of mobile nodes. There is repulsion among human nodes to avoid collision among themselves and to other obstacles in their path, while attraction is used to reach the destination. The nodes are grouped into two categories as “loose group” and “tight group”. The distance between the hosts range from 0 to 15 m or > 15 m are in loose group if the distance is in between 0 to 5 m then it is a tight group. The repulsive force or the exponential force decreases as the nodes move apart farther [13].

2.12 Manhattan Mobility Model (MMM)

Manhattan model follows a street map for generating node mobility. Streets are in the form of a grid of horizontal and vertical streets and the intersection of these streets. Initially a node randomly placed in any of these streets. The node can move in any direction straight, when it reaches a street intersection, then the any one direction of straight or left or right is chosen probabilistically. The speed is dependent on the direction of the previous movement [14].

2.13 Column Mobility Model (CMM)

The Column Mobility Model exhibits a strong spatial dependency between nodes. The mobile pattern represents a set of mobile nodes that move in certain fixed direction. This mobility models are widely used in searching and scanning activity, such as destroying mines by military robots [12].

2.14 Pursue Mobility Model (PMM)

A single node is selected as a target node. The target node can move freely in any direction. The pursuing mobile nodes which made selecting a fixed target node will try to intercept the target node by following its direction and velocity [15].

2.15 Nomadic Community Mobility Model (NCMM)

The Nomadic Mobility Model is based on the mobility scenarios of a group of nodes move together. This model is more suitable for mobile communication in a conference or military application. The entire group of mobile nodes moves randomly from one location to another. The reference point of each node is determined based on the common movement of this group. Each node can offset some random vector to its predefined reference point within the group [16].

2.16 Pathway Mobility Model (PWMM)

The pathway model follows the model graph of a city with buildings and paths. The nodes are placed randomly on the edges of the graph. A destination is randomly chosen for each node and the node moves towards this destination through the shortest path along the edges. After arrival, the node pauses for a particular time and again chooses a new destination for the next movement. This procedure is repeated until the end of simulation [17].

2.17 Obstacle Mobility Model (OMM)

Obstacle mobility model is derived for the purpose of handling obstacles. To avoid the obstacles on the way, the mobile node is required to change its trajectory. If an obstacle is in-between two nodes, the link between these nodes is considered broken until one moves out of the shadowed area of the other [18].

2.18 Random Waypoint Mobility Model-

Steady State (RWPSS)

Random Waypoint always shows dissimilarity at the initial and later stage during simulation, which is neglected in general. This problem is overcome by sampling the initial speed and stationary distribution using the RWPSS model [19].

2.19 Correlated Random Walks on Grid (CRWG)

CRWG, a two dimensional correlated random walk model on grid is a generalization of Manhattan mobility model. A mobile node takes a step in the same direction as the previous one with probability p and in opposite direction with probability q, while the probability of turning right or left is r satisfying p+q+2r = 1. By assigning different values for p and q the degree of tendency for a mobile node to follow the same direction can be controlled [20].

2.20 Simple Individual Mobility Markovian Model (SIMM)

The SIMM model is an extension of the MRP model. To overcome the movement and stop restriction over the MRP models, SIMM uses a discrete-time Markov chain that allows horizontal and vertical movements and also allows stops. But the speed changes are not supported in this model [21].

3. Comparative Study

Each routing protocol is distinguished based on its pattern of prediction. Following is a detailed comparison of the twenty mobility models discussed in the section 2. They are compared over the parameters like category and Characteristics.

Table 1. Analysis of mobility models

S. #	Mobility Model	Category	Characteristics
1	RWP	Random Based	Independent movement, Memory less, unable to predict at beginning and end of simulation.
2	RW	Random Based	Independent movement, Mimic erratic movement, Memory less
3	RT	Random Based	Independent movement, Mimic erratic movement, Memory less
4	RD	Random Based	Independent movement, Mimic erratic movement, Memory less
5	SRM	Time Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
6	GMMM	Time Dependent	Dependent movement, Can be related with previous position with respect to time, Scenario based memory less / strong / some memory
7	SMS	Time Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
8	RPGM	Space Dependent	Dependent movement, Can be related with previous position with respect to location, Memory based
9	FWMM	Space Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
10	CBMM	Group Mobility	Dependent movement, moves in a group, relative positioning , Memory based
11	GFMM	Group Mobility	Dependent movement, moves in a group, relative positioning , Memory based

12	MMM	Space Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
13	CMM	Space Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
14	PMM	Space Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
15	NCMM	Space Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based
16	PWMM	Terrain Dependent	Dependent movement, Based on geographical position, Memory based
17	OMM	Terrain Dependent	Dependent movement, Based on geographical position, Memory based
18	RWPSS	Random Based	Independent movement, Mimic erratic movement, Memory less, overcome problems of RWP.
19	CRWG	Random Based	Independent movement, Mimic erratic movement, Memory less
20	SIMM	Time Dependent	Dependent movement, Can be related with previous position with respect to time, Memory based

4. Conclusion

There are many mobility models in existence for the MANET. Each has a different characteristic pertain to an environment. Characteristics of 20 mobility models are discussed here. From the study it is observed that no single model is best amongst all, as each has better performance over the other at a particular environment. Table 1. describes the nature of each mobility model for a better understanding of the mobility model. A mobility model which is suitable for one environment may not be suitable for every environment; hence selection of mobility model is done based on the scenario.

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