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Mobility models and their influence on mobile AdHoc Networks

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ABSTRACT

Mobile Adhoc Network is dynamic and its nodes are mobile. The researchers face challenges to design and develop routing protocols that optimize the routing paths from any source to destination according to the topology change in MANETs. The research in this field remains appealing because of the desire to get better performance and scalability in communication. High mobility of MANET nodes affects the function and performance of its routing protocols. We examine the impact of node mobility on Mobile Adhoc Networks and summarize results in this paper. It describes the impact of various mobility models in mobile Adhoc networks. In MANETs, the mobile node capabilities are constrained and the mobile node's function is heterogeneous during operation. Study on mobility models reveals that spatially and temporally correlated mobility models with geographic constraints are close to the real life scenarios when compared to fully random models.

Keywords: Mobile Adhoc Network; mobility models; routing protocol; topology

1. INTRODUCTION

Nowadays people get fast and effective Internet facilities. Many researchers are working on networks based modern communication methods especially wireless communications. Wireless networks allow their hosts to roam freely without the constraints of wired connections. Though the mobile users are free to move around, they must stay connected to the network. Examples of this kind of network are handheld personal computer connectivity, Notebook computer connectivity, ship and vehicle networks. We can easily and quickly deploy wireless networks. These networks play vital role in both civilian and military systems (Aydeep Punde, 2003).

MANET (Mobile Ad Hoc Network) is a collection of nodes that communicates with each other using multi hop wireless links. MANET is infrastructure-less networking, because in MANETs the mobile nodes dynamically establish routes to send the data packets. A node (source node) can directly communicate with other nodes (destination node) if they are in its communication range (Bettstetter, 2003). The nodes in between the source and destination forward messages to the nodes that are more than one hop distance from source node. In MANETs, the nodes are mobile. So, its topology is ever changing. In Mobile Ad hoc networks, it is an important challenge to develop effective routing protocol that provides good performance (Logambal, 2015). Routing in MANET depends on the way how the mobile nodes move. The mobility nature of nodes in MANET has greater impact on its routing protocols.

In this paper, we discuss and analyze about many synthetic mobility models that have been proposed for evaluating the performance of mobile Adhoc network routing protocols. The real time mobile nodes will not travel in straight lines at constant speeds until it reaches its destination. A mobility model mimics the movements of real time mobile nodes. Their speed and direction change at reasonable time slots. This paper discusses about the various mobility models that affect the performance of routing protocols used for routing packets between source to destination in Mobile Adhoc Network

Mobility in MANET: In MANET, the nodes are moving. Two nodes are connected, when they are in the same radio transmission range. If a node moves out of other node's radio transmission range, the connection between two nodes is lost as shown in figure 1. Hence, the network topology changes from time to time. It is called mobile ad hoc network.

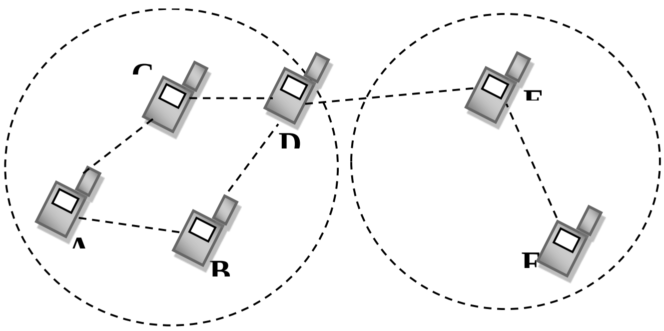

Fig.1.Mobile Adhoc Network

To simplify the description of MANET, figure 1 demonstrates the Mobile Adhoc Network. Nodes A, B, and F are mobile nodes. The circles shown in the figure depict the transmission range of nodes. In this network, node A can hear node B if A is within the transmission range of node B. Node A is a neighbor of node B, if B can hear A. It is bi-directional. Two nodes are disconnected, if any node is not in the radio range of the other node. In this example, the mobile nodes B and F are disconnected.

MANET mobility models: The mobility model describes the movement pattern of mobile users and also it shows the change in their location, velocity and acceleration over time. Since mobile nodes mobility patterns play important role in determining the routing protocol performance, the mobility models need to be emulated to identify the movement pattern of selected real life applications. Otherwise, the observations and the conclusions drawn from the simulation may mislead us. So, while evaluating MANET protocols, we need to choose suitable underlying mobility model. Therefore, we need to have a deeper understanding about the mobility models and their influence on protocol performance.

Classification of Mobility Models: MANET mobility models are classified according to their features, building technique, inter-node dependence, random level of movement, their levels of description, type of users. Based on their mobility features, the mobility models are Random models, temporally dependent models, spatially dependent models, geographically restricted models. Based on the random movement, the mobility models are classified into random, deterministic and hybrid mobility models. According to inter-node dependence, the mobility models are called individual and in-group mobility models. Trace based mobility models and synthetic models are derived based on their building technique.

Table.1.Classification of Mobility Models

Characteristic	Mobility Model
Features	Random
	Temporal Dependence
	Spatial Dependence
	Geographic Restriction
Building Technique	Trace Based
	Synthetic
Inter-node dependence	Individual
	In-Group
Random Level	Random
	Deterministic
	Hybrid
Type of User	Human
	Vehicle
Levels of Description	Microscopic
	Macroscopic
	Mesoscopic

There are two types of users of mobility named human and vehicle. There are three types of mobility models based on the levels of description. They are microscopic, macroscopic, mesoscopic mobility models. Table 1 shows various classification mobility models. The following sections will describe some of the mobility models and their impact on routing protocols.

Trace Based Mobility Models: A better way of creating mobility models is to construct traces of movement of mobile nodes called trace based models. Such models are designed from traces of real-life ad-hoc network and its mobile nodes movement. It is a challenging task for us to obtain real-life mobility traces as MANETs have not been deployed on a wide-scale. Now, the trend is to propose different mobility models and to capture the unique characteristics of real-life ad-hoc mobile node movement. These models are called synthetic models. Unlike wireless cellular networks, the nodes in mobile adhoc network are analyzed at a deeper level to understand the effect of location, velocity of one node with respect to other nodes. This helps to determine when links between nodes are formed and broken.

Random Models: The characteristics of the most widely used Random Models are discussed and analyzed in this section. They are:

1. Random Waypoint Model and two of its variants
2. Random Walk and Random Direction

In Random Waypoint mobility model each mobile node randomly chooses a location in the field as its destination. Then it travels towards the destination with constant velocity. This velocity is uniformly and randomly from the range [0, Vmax].

Where Vmax - Maximum allowable velocity for every mobile node

The velocity and direction of one node is independent of other nodes. When the node reaches its destination, it stops for a while. This stopping time is called 'pause time' Tpause. If Tpause=0, it again starts to move choosing randomly another destination in the field. Here Tpause and Vmaxare the key parameters. Consider two mobile nodes A and B, the relative speed (RS) between A and B at time t is defined as:

RS(A,B,t) = | VA(t) – VB(t) |

The Random Walk model emulates the unpredictable movement of elements in physics. It is also called as Brownian motion. Random Walk model is considered as Random Waypoint model with zero pause time. That means the difference between Random Walk model and Random Waypoint model is that at each time interval, the speed and direction of nodes change. Therefore at time interval t the mobile node uniformly and randomly chooses its direction θ(t) from (0,2Π]. And also the speed v(t) follows a Gaussian Distribution or uniform distribution from [0, Vmax]. At any discrete time interval t the velocity vector looks like:

{v(t).cos θ(t), v(t).sin θ(t)}

The node is reflected back into the field with an angle θ(t) or Π - θ(t), when it reaches the boundary. It is the border effect. This effect leads to an unbalanced spatial node distribution. It implies that the spatial distribution of mobile nodes is not a function of velocity of mobile nodes. That means no matter how fast the mobile nodes move, the spatial distribution is identified by its Cartesian location.

Temporal Dependency Models: A mobile node's mobility is restricted by laws of velocity, its acceleration and rate of change of its direction. According to this law, the current velocity of a mobile node depends on its previous velocity. Hence, the velocities of single node at different time slots are correlated. This mobility characteristic is called the 'Temporal Dependency of velocity'.

Random Mobility models may be unsuccessful to capture all the mobility characteristics of some real-life scenarios. Random Models are primarily used because of their simplicity in implementation. But the mobile nodes are temporally and spatially dependent of velocity and geographic limitations of movement. These models record velocity over time for temporal dependency. The two temporally dependent mobility models are:

1. Gauss-Markov Mobility Model
2. Smooth Random Mobility Model

Models with Spatial Dependency: Spatially dependent mobility models records mobile nodes' team collaboration. Hence the mobility of such nodes is influenced by their neighboring nodes. So the velocities of these mobile nodes are spatially correlated. For example, the Reference Point Group Mobility Model is based on node's role distribution such as group leader and group member. The types of RPGM models are Column, Nomadic community and Pursue mobility models.

Hong, Gerla et al shows that the RPGM model represents many mobility scenarios:

1. In-Place Mobility Model: The field is split into many adjacent regions. A group exclusively occupies each region. Example: Battlefield Communication.

2. Overlap Mobility Model: On the same field, many groups with various jobs travel in an overlapping manner. Example: Disaster Relief

3. Convention Mobility Model: It emulates the mobility pattern of the people in the conference. The field is split into several regions and few groups can travel between regions.

Models with Geographic Restriction: In reality, the movement of mobile nodes is subject to geographic restrictions. The constraints depend on the environment such as pathways, tunnels, freeways, campus etc. The mobile nodes are assumed to move in a pseudo-random way on predefined pathways. Two such mobility models are Pathway mobility model and Obstacle mobility model.

Obstacle Mobility Model: The geographic restriction plays vital role in MANETs mobility models. It deals with the obstacles in the field. The mobile node must change its trajectory to avoid obstacles on its path. Hence, the obstacles in its path affect the movement pattern of MANETs mobile nodes.

There are three realistic mobility scenarios that shows the movement of mobile nodes in real life [4]. They are:

1. **Conference mobility scenario:** There are 50 persons who attend a conference. 75% of the persons are static and 25 % of the persons are moving with low mobility.

2. **Event Coverage scenario:** In this scenario, a group of persons or vehicles are having high mobility. Such mobile nodes often change their positions.

3. **Disaster Relief scenarios:** In this scenario, **s**ome nodes are having high mobility and other nodes have low mobility.

Huddle-Sole Mobility Model: Huddle-Sole mobility model is a mobility model that deals with the movement patterns of individual nodes as well as group of nodes. Huddle-Sole mobility model is applicable in an urban area where people move by their own vehicles individually and as a group by public transport systems (bus, van). The setup is composed of vertical and horizontal streets. Hence in this model the movement pattern is categorized into two: Huddle mobility pattern, Sole mobility pattern. The map consists of a number of vertical and horizontal streets. The mobile nodes are allowed to move individually or in groups along the grid of vertical and horizontal roads on the map. At an intersection of a vertical and a horizontal road, the mobile node or a cluster may take left, right or go straight with certain probability. It imposes geographic limitations on node mobility.

In all the three scenarios, the mobile node must to choose a correct movement trajectory to avoid getting into obstacles. The signal may be fully absorbed by the obstacle, when it propagates through an obstacle. The link between such nodes may be broken until one move out of the shadowed area of the other. Due to such effects, the three mobility scenarios differ from the traditional Random Waypoint model.

As stated above, all these mobility models are having different mobility characteristics. They behave differently and influence protocol's performance in many ways. Hence, it is the important challenge to the researchers to develop suitable routing protocols that suits appropriate mobility models.

Mobility Models and their Application Area

	Geographically Restricted	Temporally Dependent	Spatially Dependent	Application Area
Random Waypoint	NO	NO	NO	Common
RPGM	NO	NO	YES	Battlefield
Freeway	YES	YES	YES	Metropolitan Traffic
Manhattan	YES	YES	NO	Metropolitan Traffic
Huddle-Sole	YES	YES	NO	Metropolitan Traffic (Group as well as Individual)

2. CONCLUSION

By learning the mobility models, we conducted a survey of trace based mobility models, random models, spatially and temporally dependent models and geographically restricted mobility models. Each mobility model has its own mobility features. It implies that the set of mobility models surveyed in this paper, significantly impact the state-of-the-art technologies and researches in MANETs. By examining all these MANET mobility models, it is observed that the mobility models have many properties and reveals different mobility characteristics. As a result, these mobility models behave differently and impact the routing protocol performance in many different ways. Hence, we need a method to choose a suitable set of mobility models. By properly choosing the suitable mobility models with notable characteristics, we are able to provide variety of mobility scenarios covering the mobility space. As the mobility of nodes significantly impacts the protocol performance, we need to carefully select the suitable routing protocol to best suit the mobility model.

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