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A DETAILED STUDY OF MOBILITY MODELS IN WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless sensor networks (WSN) is emerging technology finds variety of applications in military, movement tracking, industries and medical fields. WSNs are self configurable, self healing networks. This paper is a survey of mobility models that are used in the simulations of sensor networks. I describe several mobility models that represent mobile nodes whose movements are independent and dependent of each other respectively. The goal of this paper is to present a number of mobility models and their advantage and disadvantages over here to overcome with future model. With this model researchers get choices when they are deciding upon a mobility model to use for my future performance evaluations.

Keywords: *Sensor Network, Mobility Models, Group, Models*

I. INTRODUCTION

Wireless sensors have extremely limited resources like processing speed, storage capacity, communication power and energy supply, there are some considerations regarding the network and protocols planning like coverage and energy efficiency. It is self configuring, self healing networks consisting of mobile or static sensor nodes connected wirelessly to form an arbitrary topology. The more coverage insures reliable communication, higher network connectivity, lower energy consumption and consequently longer lifetime of sensor nodes. The new method to address these issues is employing mobile devices carrying information collected by Sensor nodes. Different approaches towards application of mobile devices in WSNs have been explored in detail in [1]. In order to simulate the displacement patterns of mobile sensor nodes, mobility models are used. As it is pointed out in [2], it is important to consider the suitable mobility model for the specific application. The performance evaluation of a sensor network protocol considering different mobility models is demonstrated in [2].

II. RELATED WORKS

The effects of various mobility models are been surveyed is studied in[2] and the Performance of two routing protocols Dynamic Source Routing (DSR-Reactive Protocol) and Destination-Sequenced Distance-Vector (DSDV-Proactive Protocol) is studied in [3]. Performance comparison has also been conducted across varying node densities and number of hops. Experiment results illustrate that performance of the routing protocol varies across different mobility models, node densities and length of data paths. Mobile wireless ad hoc networks are infrastructure less and often used to operate under unattended mode. So, it is significant in bringing out a comparison of the various routing protocols [14] for better understanding and implementation of them. Routing protocols like Ad hoc On-Demand Vector routing (AODV), Fisheye, Dynamic MANET On-demand (DYMO), Source Tree Adaptive Routing (STAR) protocol, Routing Information Protocol (RIP), Bellman Ford, LANd Mark Ad hoc Routing protocol (LANMAR) and Location Aided Routing protocol (LAR) are discussed.

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III. MOBILITY MODELS

There is much attention currently focused on the development and evaluation of wireless routing protocols for wireless sensor networks. Most of this evaluation has been Performed [14] with the aid of various network simulators (such as ns-2 and others) and synthetic models for mobility and data patterns [12]. These models can have a great effect upon the results of the simulation, and thus, the valuation of these protocols. Some of the models, which are in consideration for my work, are listed below.

There are two types of mobility models:

1. Entity/Individual mobility models: nodes' movements are independent of each other such as Random Waypoint, Random direction, Random Walk.

2. Group mobility models: mobile nodes move dependent of one another like Reference Point Group Mobility model, Column, Nomadic, Pursue, and Exponential Correlated. The pathway, Manhattan, obstacle are under geographical restricted model.

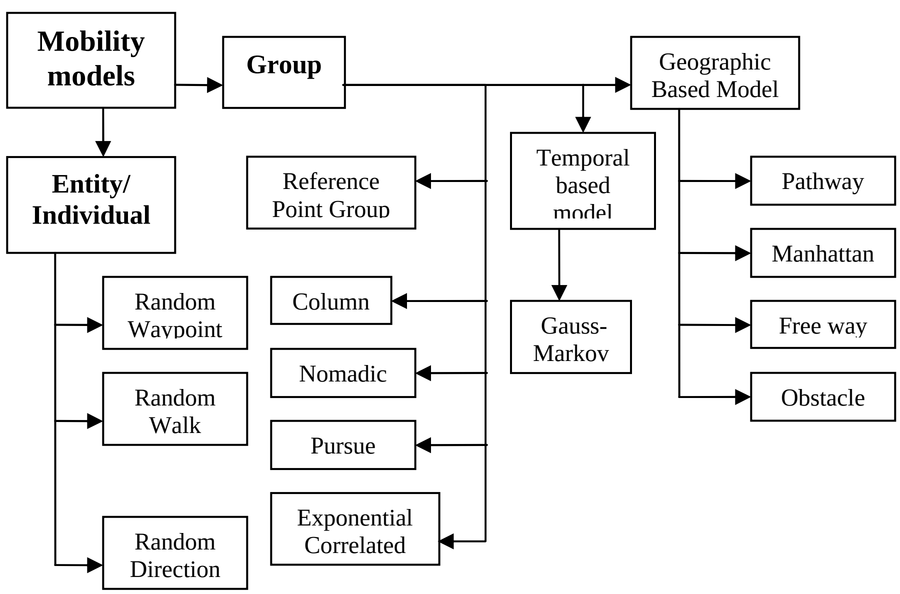

Figure 1: Classification of mobility model

1.1 Random Waypoint model

It is a very simple model [3] based on pause time between changing direction/speed. Background a random point in the simulation area with a uniformly distributed speed between [minSpeed, maxSpeed]. After arriving to the destination again waits for the same period of time (pause time) before moving to a new place. According to [4, 5], there are common problems with simulation studies using Random Waypoint model due to poor choice of velocity distribution, uniform distribution. If minspeed is zero, such velocity distribution leads to a situation where average speed approaches zero and at the stationary state each node stops moving. In below figure (2) they described about the movement behavior of a node in random way point mobility model.

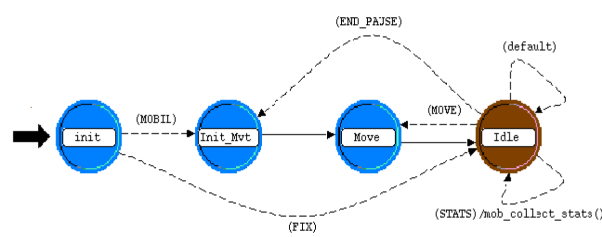

Figure 2: Process model

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Random Direction and walk nodes change their speed/direction every time slot. In this model new directions from θ is chosen randomly between (0,2π).
The speed chosen from uniform (or Gaussian) distribution. In this model node reaches boundary it bounces back with (π-θ).

1.2 Manhattan Grid model

The Manhattan mobility model [6] uses a grid road topology. This model is mainly proposed for the movement in urban area, where the streets are in an organized manner and the mobile nodes are allowed to move only in horizontal or vertical direction. At each intersection of a horizontal and a vertical street, the mobile node can turn left, right or go straight with certain probability.

Except the above difference, the inter-node and Intra-node relationships involved in the Manhattan model are very similar to the Freeway model. This model can be used in Mobile Ad-hoc Networks (MANET) and Vehicular Ad-hoc Networks (VANET) simulators.

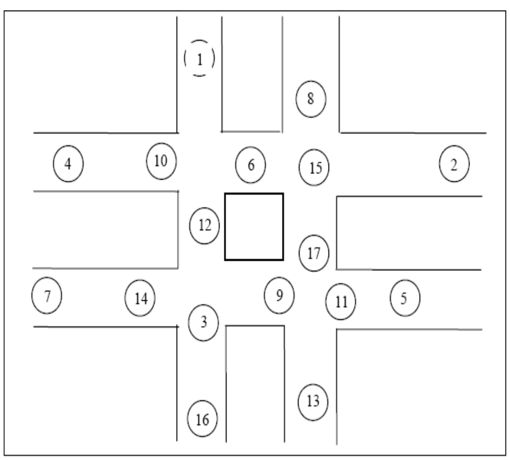

Figure 3 Topography showing the movements of nodes for Manhattan Mobility model

In this Figure 3 shows the sample topography the movement of nodes for Manhattan Mobility Model with seventeen nodes. The map defines the roads along the nodes can move

1.3. Gauss-Markov model

In the Gauss-Markov Mobility Model each mobile node is initialized with a speed and direction. By fixed intervals of time movement occurs to updating the speed and direction of each node. To be specific, the value of speed and direction at the nth instance of time is calculated based upon the value of speed and direction at the n - 1st instance and a random variable. Camp et al [3] elaborates the equations for calculating speed and direction in detail.

1.4 Freeway model

The FW [8] model emulates the motion behavior of mobile nodes on a Freeway. It can be very well used in exchanging traffic status or tracking a vehicle on a Freeway. This model makes use of use maps. There are several freeways on the map and each freeway has lanes in both directions. 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 on the same freeway lane are within the safety distance (SD), the velocity of the following node cannot exceed the velocity of preceding node.

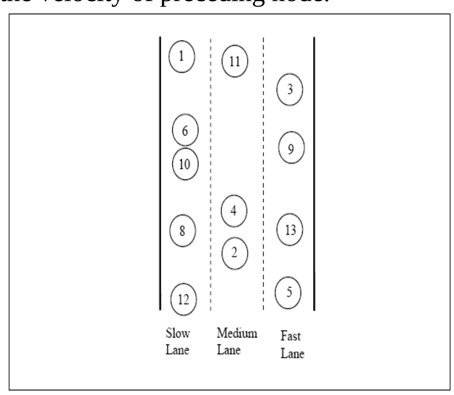

Figure 4 Topography showing the movements of nodes for Freeway Mobility model

In this figure 4 shows the topography the movements of nodes for freeway model with twelve nodes. Because of the use of maps, nodes traveling in one line can't move to the other line.

2.1 Reference Point Group Mobility model

The main use of this model is in military battlefield. Jayakumar et al. have described [7] Reference Point Group Mobility (RPGM) model nodes are divided into groups and each group has a leader. The leader's mobility follows random way point the members of the group follow the leader's

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mobility closely, with some deviation. At each instant of time, every node has a speed and direction that is specified by randomly deviating from that of the group leader. This general description of group mobility can be used to create a variety of models for different kinds of mobility applications such Group tours, conferences, meetings ,Emergency crews, rescue teams, Military divisions/platoons. It is used as generic method for handling group mobility. The input parameters of the RPGM model allow the flexibility to implement the Column, Nomadic Community, and Pursue Mobility Models.

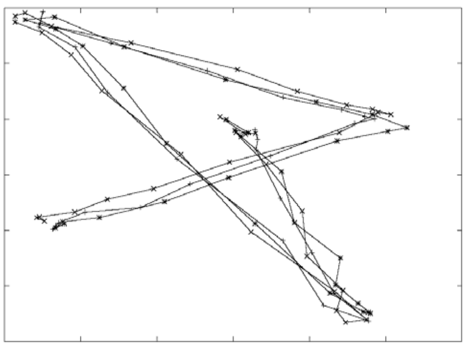

Figure 5 Traveling pattern of one group of three mobile nodes using RPGM model

In this figure 5 shows movement of a group of three mobile nodes in an RPGM model. As obvious from the figure, individual nodes randomly move about their own pre-defined reference point, whose movement in turn depends on the group movement. Group movement is based on the path traveled by the logical center for the group.

Hong, Gerla, Pei and Chiang illustrate that the RPGM model is able to represent various mobility scenarios including

1. **In-Place Mobility Model:** The entire field is divided into several adjacent regions. Each region is exclusively occupied by a single group. One such example is battlefield communication.

2. **Overlap Mobility Model:** Different groups with different tasks travel on the same field in an overlapping manner. Disaster relief is a good example.

3. **Convention Mobility Model:** This scenario is to emulate the mobility behavior in the conference. The area is also divided into several regions while some groups are allowed to travel between regions.

2.2 Column mobility model

The Column Mobility Model represents a set of mobile nodes (e.g., robots) that move in a certain fixed direction. This mobility model can be used in searching and scanning activity, such as destroying mines by military robots. When the mobile node is about to travel beyond the boundary of a simulation field, the movement direction is then flipped 180 degree. Thus, the mobile node is able to move towards the center of simulation field in the new direction.

2.3. Nomadic community model

The Nomadic Mobility Model is to represent the mobility scenarios where a group of nodes move together. This model could be applied in mobile communication in a conference or military application. The whole group of mobile nodes moves randomly from one location to another. Then, the reference point of each node is determined based on the general movement of this group. Inside of this group, each node can offset some random vector to its predefined reference point. The movement in the Nomadic Community Model is sporadic while the movement is more or less constant in Column Mobility Model

2.4. Pursue model

The Pursue Mobility Model emulates scenarios where several nodes attempt to capture single mobile node ahead. This mobility model can be used in target tracking and law enforcement. The node being pursued (target node) moves freely according to the Random Waypoint model by directing the velocity towards the position of the targeted node, the pursuer nodes (seeker nodes) try to intercept the target node.

3. Exponential Correlated Random model

A group mobility model that uses a motion function to create movements

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Pathway model:

One simple way to integrate geographic constraints into the mobility model is to restrict the node movement to the pathways in the map. The map is predefined in the simulation field. Tian, Hahner and Becker et al [9] utilize a random graph to model the map of city. This graph can be either randomly generated or carefully defined based on certain map of a real city. The vertices of the graph represent the buildings of the city, and the edges model the streets and freeways between those buildings. Initially, the nodes are placed randomly on the edge. Then for each node a destination is randomly chosen and the node moves towards this destination through the shortest path along the edges.

Upon arrival, the node pauses for T pause time and again chooses a new destination for the next movement. This procedure is repeated until the end of simulation.

Unlike the Random Waypoint model where the nodes can move freely, the mobile nodes in this model are only allowed to travel on the pathways. However, since the destination of each motion phase is randomly chosen, a certain level of randomness still exists for this model. So, in this graph based mobility model, the nodes are traveling in a pseudo-random fashion on the pathways.

Similarly, in the Freeway mobility model and Manhattan mobility model [1], the movement of mobile node is also restricted to the pathway in the simulation field. Fig.9 illustrates the maps used for Freeway, Manhattan and Pathway Models.

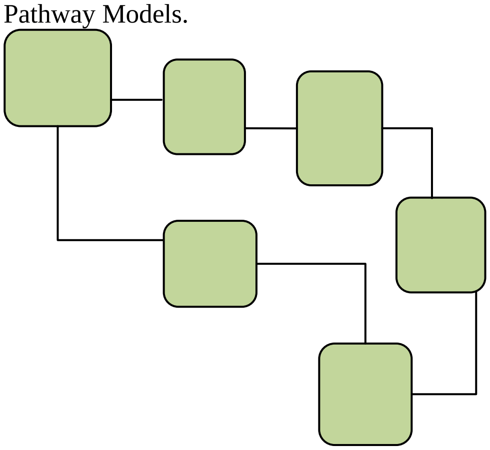

Fig9: The pathway graphs used in the Freeway, Manhattan and Pathway Model

Obstacle mobility model:

Another geographic constraint playing an important role in mobility modeling includes the obstacles in the simulation field. To avoid the obstacles on the way, the mobile node is required to change its trajectory. Therefore, obstacles do affect the movement behavior of mobile nodes. Moreover, the obstacles also impact the way radio propagates. For example, for the indoor environment, typically, the radio system could not propagate the signal through obstacles without severe attenuation.

Johansson, Larsson and Hedman et al [10] develop three realistic mobility scenarios to depict the movement of mobile users in real life, including

1. **Conference scenario** consisted of 50 people attending a conference. Most of them are static and a small number of people are moving with low mobility.

2. **Event Coverage scenario** where a group of highly mobile people or vehicles are modeled. Those mobile nodes are frequently changing their positions.

3. **Disaster Relief scenarios** where some nodes move very fast and others move very slowly.

Jardosh, Belding-Royer and Almeroth et al [11] also investigate the impact of obstacles on mobility modeling in details. After considering the effects of obstacles into the mobility model, both the movement trajectories and the radio propagation of mobile nodes are somehow restricted.

IV. IMPORTANCE OF CHOOSING A MOBILITY MODEL

In this section, I illustrate that the choice of a mobility model can have a significant effect on the performance, investigation of a sensor network protocols. In summary [2], if a group mobility model is desired, we recommend using the Reference Point Group Mobility Model with appropriate parameters. If an entity mobility model is desired, I recommend using either the Random waypoint Mobility Model, the Random Walk Mobility Model or the Gauss-Markov Mobility Model [13]. However, a preferred entity

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mobility model combines the strengths of the current entity mobility models

V. CONCLUSION:

Mobility Model plays an important role in wireless network protocols. By studying various mobility models, we attempt to conduct a survey of the mobility modeling and analysis techniques in a thorough and systematic manner. Beside the Random Waypoint model and its variants, many other mobility models with unique characteristics such as temporal dependency, spatial dependency or geographic restriction are discussed. We believe that the set of mobility models included herein reasonably reflect the state-of-art researches and technologies in this field. In future, we are going to analysis with some of mobility models like Gauss-markov, Manhattan, RPGM, Random Waypoint, obstacle Mobility models with DSR routing protocols and scenarios simulation using NS2 simulation tool and with that performance going to create new mobility model for which the problems exist in existing mobility model.

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