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Survey of Various Mobility Models in VANETs

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Abstract: ***Ad-hoc networking is regarded as an adequate solution to cooperative driving between communicating cars on the road. Deploying and testing these networks, usually known as Vehicular Ad-hoc Networks (VANETs), involves a high cost in the real world, so simulation is a useful alternative in research.***

In this paper, we discuss five major categories of various Mobility Models that is Entity, Group, Urban, City-Section and Realistic Mobility models for simulation of VANET as a critical aspect in a simulation study of VANETs, is the need for a mobility model which reflects, as close as possible, the real behaviour of vehicular traffic. Our work provides a sound starting point for further understanding and development of more realistic and accurate mobility models for VANET simulations.

Keywords: Vehicular Ad-hoc Networks, Mobility Models, VanetMobiSim

1. Introduction

Mobile Ad-hoc networks are a type of wireless Ad-hoc networks that do not require any fixed infrastructure [1], which are being adopted to solve situations where communication is required, but where deploying a fixed infrastructure is impossible. Ad-hoc networking is regarded as the most adequate solution to cooperative driving between communicating cars on the road. Such networks, named Vehicular Ad-hoc Net-works (VANETs), represent a rapidly emerging research field, being a particularly challenging class of Mobile Ad-hoc Net-works. Vehicular Ad-hoc Networks have particular features like distributed processing and organized networking, large number of nodes, high node speed, constrained but highly Variable network topology, signal transmissions blocked by buildings, frequent partition due to the high mobility and, on the contrary to MANETs, no significant power constrains. There is a growing commercial and research interest in the development and deployment of Vehicular Ad-Hoc Networks (VANETs). VANETs are a special case of Mobile Ad-Hoc Networks (MANETs) and consist of a number of vehicles travelling on urban streets and capable of communicating with each other without a fixed communication infrastructure.

A wide variety of mobility models have been proposed for VANET simulations. The most commonly used mobility model in the literature is the Random Waypoint (RWM) model [4]. Every node selects a random destination and speed, moves to that destination, pauses, and then moves again to another random destination. Other similar open-field models include the Random Walk Model, Random Direction Model, and the Boundless Simulation Area Model [7]. Ion Gabriel Toudorache et al.[8]presented a new realistic mobility model called Marginal Mobility Model and showed using simulation that DSR, AODV, LAR1, DYMO and Bellman Ford do not support this mobility model. Bai et al. [5] argued that the choice of mobility model can affect the performance of the MANET routing protocols, and introduced the Freeway and Manhattan mobility models, which simulate nodes' mobility on roads specified by maps. The Freeway model attempted to model vehicles' movement on freeways.

1.1 Characteristics of VANETs

Ad-hoc networks have the main characteristic to be infrastructure-less and do not depend on fixed infrastructure for communication and dissemination of information. The architecture of VANET consists of three categories: Pure cellular/WLAN, Pure Ad-hoc and hybrid.
VANET Characteristics: Vehicular ad-hoc networks may use fixed cellular gateways and also WLAN/WiMax access points at traffic intersections to connect to the internet, gather traffic information or for routing purposes. This network architecture is called pure cellular or WLAN. VANET can comprise of both cellular network and WLAN to form a network. Stationery or fixed gateways around the road sides also provides connectivity to vehicles. In such a scenario all vehicles and road side devices form pure mobile Ad-hoc networks. Hybrid architecture consists of both infrastructure networks and Ad-hoc networks together. No

centralized authority is required in VANET as nodes can self organize and self manage the information in a distributed fashion. Since the nodes are mobile so data transmission is less reliable and sub optimal.

1.2 Difference between MANETs and VANETs

Similarly to the mobile Ad-hoc networks (MANETs), nodes in VANETs are self-organize and self-manage

Information in a distributed fashion without a centralized authority or a server dictating the communication. In this type of network, nodes engage themselves as servers and/or clients, thereby exchanging and sharing information like peers. Moreover, nodes are mobile, thus making data transmission less reliable and suboptimal. Apart from these characteristics, VANETs possess a few distinguishing characteristics [3], and hence presents itself as a particular class of MANETs:

1.2.1 Highly Dynamic Topology

The topology which formed by VANETs is always changing as vehicles are moving at high speed. On highways, vehicles are moving at the speed of 60-70 mph (25 m/sec) and vary for different vehicles. If the radio range between two vehicles is 125 m then the link between the two vehicles would last at most 10 sec.

1.2.2 Frequently Disconnected Network

The highly dynamic topology results in frequently disconnected network since the link between two vehicles can quickly disappear while the two nodes are transmitting information.

1.2.3 Patterned Mobility

Vehicles follow a trail or certain mobility pattern which is a function of the underlying roads, the traffic lights, the speed limits, traffic condition and driving behaviours of drivers. Because of the particular mobility pattern, evaluation of VANET protocols only makes sense from traces obtained from the pattern [2].

1.2.4 Propagation Model

The propagation model in VANETs is usually not assumed to be free space because of the presence of buildings, trees, vehicles and other obstacles. A VANET propagation model should well consider the effects of static objects as well as potential interference of wireless communication from other vehicles or widely deployed personal access points.

1.2.5 Unlimited Battery Power and Storage

The nodes in VANETs are not subject to power and storage limitation as in sensor networks, another class of Ad-hoc networks where nodes are mostly static.

1.2.6 On-board Sensors

The nodes are assumed to be equipped with sensors to provide information for routing purposes in VANETs. Location information from GPS unit and speed from speedometer provides good examples for large amount of information that can possibly be obtained by sensors to be utilized to enhance routing decisions.

2. Materials and Methods

Various Methods to configure the Mobility in Vehicular Ad-hoc networks are broadly classified into five categories: Entity Mobility Models (that represents mobile nodes whose movements are independent of each other), Group Mobility Models (that represent mobile nodes whose movements are dependent on each other), Urban Mobility Models, City-section Mobility models (which are grid based models) and Realistic Mobility Models (that are based on realistic mobility patterns of mobile nodes).

2.1 Mobility Modelling for VANET Simulations

The most important issue to take into account while creating a simulation environment in VANETs is to correctly model how vehicles move. One key component of VANET simulations is the mobility pattern of vehicles, also called the mobility model. Mobility models are used to determine the location of nodes in the topology at any given instant, which strongly affects network connectivity and throughput. The current mobility models used in popular wireless simulators such as NS-2 [9] tend to ignore real-world constraints such as street layouts and traffic signs. Consequently, the simulation results are unlikely to reflect the protocol performance in the real world.

For example, the widely used Random-Waypoint Model (RWM) [4] assumes that nodes move in an open field without obstructions. In contrast, the layout of roads, intersections with traffic signals, buildings, and other obstacles in urban settings constrain vehicular movement. The shortcomings of RWM are widely recognized and there has been re-cent research interest in modelling “realistic” mobility patterns specifically targeted for VANETs.

2.1.1 Mobility Models

The mobility Models are the key criteria that influence the performance characteristics of the mobile Ad-hoc networks. It is designed to mimic the movement pattern of mobile nodes, and how their location, velocity and acceleration change over time. Since mobility patterns may play a significant role in determining the protocol performance, it is necessary to choose the proper underlying mobility model.

2.2 Factors Affecting Mobility in VANETS

This discusses the various factors specific to VANETs that influence their mobility modelling and must be considered while analyzing the resulting network’s simulation performance. The foremost constraint is the presence of streets which restrict vehicular motion to well-defined paths. This makes the area’s topology crucial because the same mobility model might lead to drastically different network performance under different topologies. For example, a topology with small blocks would result in a very different performance from another topology whose blocks are so large that the nodes’ transmission range becomes insufficient for reasonable network performance [11]. Basically, 5 main factors are there which affects the Mobility in VANETs.

2.2.1 Layout of Streets

This con-strained movement pattern largely determines the distribution of nodes and connectivity of the network. Streets can single or multiple lanes and can allow either one-way or Evaluation of Mobility Models for Vehicular Ad-Hoc Network Simulations two-way traffic [10].

2.2.2 Traffic control mechanisms

The one of the most common traffic control mechanisms at intersections are stop signs and traffic lights. A vehicle needs to stop at a red light until it turns green. A vehicle also needs to stop at a stop sign for a few seconds before moving onward. These mechanisms cause the formation of clusters and queues of vehicles at intersections, consequently reducing their average speed. Reduced mobility implies more static nodes and slower rates of route changes in the network [11].

2.2.3 Interdependent Vehicular Motion

The Motion of every vehicle is guided to a large extent by the movement of other vehicles surrounding it. For example, a vehicle would maintain a minimum distance from the one in front of it, increase or decrease its speed, and may change to another lane to avoid congestion [10].

2.2.4 Average speed

The vehicle speed determines how quickly its position changes, which in turn determines the rate of network topology change. The speed limit of each road determines the average speed of vehicles and how often the existing routes are broken or new routes are established. Additionally, vehicles' acceleration/deceleration and the map's topology also affect their average speed [11].

2.2.5 Block Size

A city block can be considered as the smallest area surrounded by streets, usually containing several buildings [10]. Over an area comprising many blocks, the size of block plays an important role in vehicular communication pattern. It also determines whether nodes at neighbouring intersections can hear each other's radio transmission.

2.3 Classification of Mobility Models

Various Methods to configure Mobility in Vehicular Ad-hoc networks are broadly classified into five categories: Entity Mobility Models, Group Mobility Models, Urban Mobility Models, City-section Mobility models and Realistic Mobility Models. These Mobility Models work in different aspects in Vehicular Ad-hoc Networks and most of them are unrealistic Mobility Models.

The mobility Models are the key criteria that influence the performance characteristics of the mobile Ad-hoc networks. Nodes and how their location, velocity and acceleration change over time. It is designed to mimic the movement pattern of Mobility models plays an important role in determining the performance of routing protocols. Since mobility patterns may play a significant role in determining the protocol performance, it is necessary to choose the proper underlying mobility model. Table1 shows Various Mobility Models which are to be discussed in this paper and the categories to which they belong.

Table1: Classification of Mobility Model

Category	*Mobility Models*
Entity Mobility Models	• Random Walk Mobility Model • Random Way Point Mobility Model • Random Direction Mobility Model • Gauss-Markov Mobility Model
Group Mobility Models	• Reference Point Group Mobility Model • Column Mobility Model
Urban Vehicular Mobility Models	• SSM • PTSM • TLM
City-section Mobility Models	• Freeway Mobility Model • City-section Mobility Model • Manhattan Mobility Model
Realistic Mobility Models	• Marginal Mobility Model

2.3.1 Entity Mobility Models

In entity mobility model, the individual movement of each mobile node in a Vehicular Ad-hoc network is considered in the analysis of mobility pattern based on speed, direction, transition length, etc. [12]. Each model will have its own statistical properties and mobility metrics.

(a) Random Walk Mobility Model

This Mobility Model was developed to mimic the unpredictable movement of some natural entities [13]. In this mobility model, a mobile node moves from its current location to a new location without taking pause and by randomly choosing a direction and speed to travel. Each node is assigned an initial location (x_0, y_0) and a destination (x_1, y_1). The speed is chosen from predefined ranges (V_0, V_1) independently from all previous destinations, speeds and directions in the range $(0, 2\pi)$. If mobile node reaches the simulation boundary, it bounces off with an angle determined by the incoming direction and then continues along its new path.

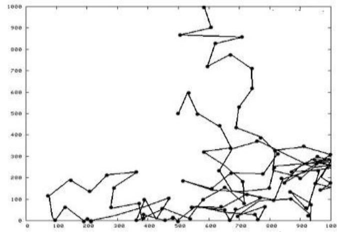

Figure 1: Travelling pattern of Mobile Nodes using Random Walk Mobility Model

(b) Random Waypoint Mobility Model

It assumes that nodes move in an open field without obstructions. In contrast, the layout of roads, intersections with traffic signals, buildings, and other obstacles in urban settings constrain vehicular movement. In response to the limitations of RWM, more researchers have become interested in modelling 'realistic' mobility patterns for VANETs [10].

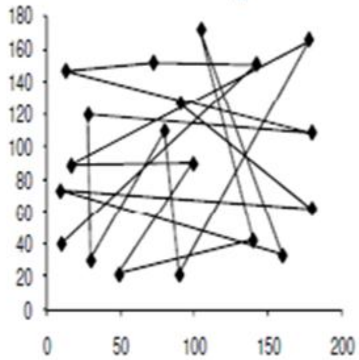

Figure 2: Travelling pattern of Mobile Node using Random Waypoint Mobility Model

(c) Random Direction Mobility Model

This Mobility Model was developed in order to overcome the clustering of nodes in the centre of simulation area in case of Random Waypoint Mobility Model [13]. In this mobility model, a mobile node chooses a random direction and speed to travel, as in case of Random Waypoint Mobility Model. The mobile node continues to travel in that direction until it reaches the boundary of simulation area. On reaching the boundary, the mobile node pauses for a specified time and then chooses another angular direction between 0 and 2π and continues the process. Figure 3shows the travelling pattern of mobile nodes using Random Direction Mobility Model.

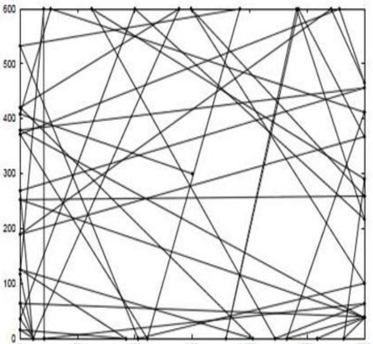

Figure 3: Travelling pattern of Mobile Node using Random Direction Mobility Model

(d) Gauss-Markov Mobility Model

The Gauss-Markov Mobility Model was designed for adapting to different levels of randomness via one tuning parameter [13]. Every mobile node is assigned an initial speed and direction which is updated after a fixed interval of time. The value of speed and direction after the nth interval is dependent upon the value of speed and direction after the (n-1) st interval and a random variable using the following equations:

$$s_n = \square s_{n-1} + (1-\square)s \underline{+} \sqrt{}\underline{(1-\square^2)s}_{xn-1} \qquad [14]$$

$$d_n = \square d_{n-1} + (1-\square)d + \sqrt{}(1-\square^2)d_{xn-1} \qquad [15]$$

where, s_n and d_n are the new speed and direction of the mobile node at time interval n. □, where $0 \le \square\square \le 1$, is the tuning parameter used to vary the randomness; s and d are constants representing the mean value of speed and direction as n→□; and sxn-1 and dxn-1 are random variables that from a Gaussian distribution [13].

Figure 4 shows the travelling pattern of mobile node using Gauss-Markov mobility model. This travelling pattern clearly shows that Gauss-Markov Mobility Model eliminates the sudden stops and sharp turns encountered in Random Walk, Random Waypoint and Random Direction Mobility Models.

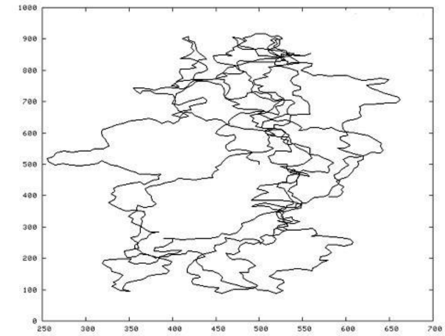

Figure 4: Travelling pattern of Mobile Node using Gauss-Markov Mobility Model

2.3.2 Group Mobility Models

Group Mobility models are to simulate group movement behaviours in the real world [14]. These mobility models tend to mimic motions of the mobile nodes in mobile Ad-hoc networks where communications are done among teams that coordinate their movements. The group movements imply that mobile nodes work together in a cooperative manner in order to accomplish a common goal [12]. Many Group Mobility Models exist, but here we will be discussing only two models: Reference Point Group Mobility Model and Colum Mobility Model.

(a) Reference Point Group Mobility Model

In Reference Point Group Mobility model, nodes form a group and then move in a coordinated manner. It is represented using 4-tuple: (V_{max}, T, R_{max}, V_I); where V_{max} is maximum speed, R_{max} is the maximum allowable range within the group from group logical centre, T is pause time and V_I is the advance direction vector. Each group has a logical centre, called group leader, which determines the group's behaviour [15]. Initially, each member of the group is uniformly distributed in the neighbourhood of the group leader. The motion of the group leader completely characterizes the movement of its corresponding group of mobile nodes, including their direction and speed. Individual mobile nodes randomly move about their own pre-defined reference points whose movements depend on the group movement.

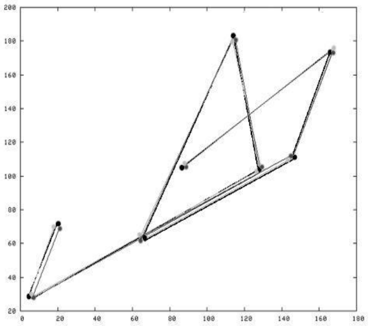

Figure 5: Travelling pattern of 3 mobile nodes using Reference Point Group Mobility Model

(b) Column Mobility Model

Column Mobility Model is derived from Reference Point Group Mobility Model with the main difference being that groups in column mobility model move in columns and not in random fashion [15]. This model represents a set of mobile nodes that move around a given line (or column), which is moving in a forward direction. A slight modification of the Column Mobility Model allows the individual mobile nodes to follow one another. For the implementation of this model an initial reference grid (forming a column of mobile nodes) is defined. Each mobile node is then placed in relation to its reference point in reference grid; the mobile node is then allowed to move randomly around its reference point via an entity mobility model.

2.3.3 Urban Vehicular Mobility Models

The three mobility models take as inputs real street maps that are extracted using the information available from the US Census Bureau's TIGER database [16]. The database also provides information about the roads' type, from which we can infer the corresponding speed limit and number of lanes on that type of road (interstate highways, residential areas, etc.). All roads are modelled as two-way streets. The SSM and PTSM assume single lanes in each direction of every road, whereas the TLM provides the option of modelling multiple lanes.

(a) Stop Sign Model (SSM)

In the Stop Sign Model (SSM), every street at an intersection has a stop sign. Any vehicle approaching the intersection must stop at the signal for a specified time (which is configurable). We used a default value of 3 seconds in our experiments. On the road, each vehicle's motion is constrained by the vehicle in front of it. That is a vehicle moving on a road cannot move further than the vehicle that is moving in front of it, unless it is a multi-lane road and the vehicles are allowed to overtake each other. When vehicles follow each other to a stop sign, they form a per-street queue at the intersection. Each vehicle waits for at least the required wait time once it gets to the head of the intersection after other vehicles ahead in the queue clear up. Vehicle crossings at the intersection are not coordinated among different directions. Although an urban layout is unlikely to have stop signs at every intersection, this model does serve as a simple first step to understanding the dynamics of mobility and its effect on routing performance [11].

(b) Probabilistic Traffic Sign Model (PTSM)

SSM further refined by replacing stop signs with traffic signals at intersections. In general, vehicles stop at red signals and drive through green signals. Although it is possible to simulate the detailed coordination of traffic lights from various directions, we did not implement it at this stage. We first wanted to understand whether such levels of detail would produce any significant impact on routing protocol performance.

As an intermediate step [11], we developed the Probabilistic Traffic Sign Model (PTSM). PTSM approximates the operation of traffic signs by not coordinating among different directions. When a node reaches an intersection with an empty queue, it stops at the signal with a probability p and crosses the signal with a probability $(1 - p)$. If it decides to wait, the amount of wait time is randomly chosen between 0 and w seconds. Any node that arrives later at a non-empty queue will have to wait for the remaining wait time of the previous node plus one second. The additional one second simulates the start-up delay between queued cars. Whenever the signal turns green, the vehicles begin to cross the signal at intervals of one second, until the queue becomes empty. The next vehicle that arrives at the head of an empty queue again makes a decision on whether to stop with a probability p and so on. Similar to SSM, there is no coordination among vehicles crossing an intersection from different directions. This model avoids excessive stop pings, as in the case of SSM, and at the same time, approximates the behaviour of traffic lights.

(c) Traffic Light Model (TLM)

SSM and PTSM are highly approximate models of the behaviour of vehicular traffic. In order to understand which other level of detail besides street topology is absolutely essential, we refined PTSM described earlier with successively greater levels of mobility details. We call this new model, the Traffic Light model (TLM).

(1) Coordinated Traffic Lights

The mainly feature of the TLM is that traffic lights at each intersection are coordinated. First, consider the case in which all roads have single lanes in each direction. The lights turn green in such a manner that only opposing traffic crosses the intersection simultaneously. Nodes that need to turn left or right follow the free turn rule once they reach the head of the queue. The nodes facing each other on the same road have the green signal, while the others have a red signal. After a fixed period, the traffic lights switch and give the green signals to another set of opposing roads. A T-intersection is treated by permitting one of the roads to periodically have a green light by itself. For intersections with more than four incoming direction, it was hard to come up with a generic rule, so a simple token passing mechanism was used. At a given time only one road has access to the intersection, cycled periodically across all incoming roads. By implementing these traffic lights, we replaced PTSM's probabilistic behaviour with a more deterministic model [11].

(2) Acceleration and Deceleration

The next level of detail was the acceleration and deceleration of vehicles. In this feature, vehicles at rest do not change their state to peak speeds instantaneously. Instead, they accelerate gradually from rest up to the maximum possible speed. Similarly, when approaching a stop sign or red light, they decelerate gradually to a stop.

(3) Multiple Lanes

The introduction of multiple lanes on roads was another feature of the TLM. Each road can have more than one lane. For real maps, the number of lanes can be determined by the type of the road as specified in the TIGER database. When a vehicle enters a road, it selects the lane with the least number of vehicles (both moving and stopped).

Table2: Features of TLM Mobility Model

Mobility Model	*Multiple Lanes*	*Acceleration-Deceleration*
TLM1	No	No
TLM2	No	Yes
TLM3	Yes	No
TLM4 (TLM)	Yes	Yes

(4)Variants of TLM

The primary goal of our study is the understanding of the sensitivity of mobility details on VANET performance, and to determine the details that are worth being included in a mobility model. For this purpose, various features in the TLM can be independently enabled or disabled to obtain different variants of TLM. In particular, four variants of TLM can be obtained by enabling or disabling the acceleration/deceleration and multi-lane features. Hence, the basic TLM without either of the two features has one additional feature over PTSM, namely coordinated traffic lights.

2.3.4 City section based Mobility Models

(a) Freeway Model

Freeway Model is a generated-map-based model, in which the simulation area, represented by a generated map, includes many freeways, each side of which is composed of many lanes. No urban routes, thus no intersections are considered in this model. This scenario is definitely unrealistic. At the beginning of the simulation, the nodes are randomly placed in the lanes. A security distance should be maintained between two subsequent vehicles in a lane. If the distance between two vehicles is less than this required minimal distance, the second one decelerates and let the forward vehicle moves away. The change of lanes is not allowed in this model. The vehicle moves in the lane it is placed in until reaching the simulation area limit, then it is placed again randomly in another position and repeats the process. This scenario is definitely unrealistic [10].

(b) City Section Mobility Model

City-Section mobility model in which the nodes are assumed to be randomly placed in the street intersections. Each street (i.e. one side of a square block) is assumed to have a particular speed limit. Based on this speed limit and the block length, one can determine the time it would take to move in the street each node placed at a particular street intersection chooses a random target street intersection to move. The node then moves to the chosen street intersection on a path that will incur the least amount of travel time [10] .If two or more paths incur the same least amount of travel time, the tie is broken arbitrarily. After reaching the targeted street intersection, the node may stay there for pause time and then again choose a random target street intersection to move. The node then moves towards the new chosen street inter-section on the path that will incur the least amount of travel time. The above procedure is repeated independently by each node. City-Section Mobility Model is a grid based Mobility Model comes under the category of City-Section Mobility Models.

(c) Manhattan model

Manhattan Model is generated-map-based model uses a grid road topology, to simulate an urban environment. But contrary to the previous model, a vehicle can change a lane at a crossroads. Before starting a simulation, a map containing vertical and horizontal roads is generated. Each of these latter includes two lanes, allowing the motion in the two directions (north/south for the vertical roads and east/west for the horizontal ones). At the beginning of a simulation, vehicles are randomly put on the roads. They then move continuously according to history-based speeds. When reaching a crossroads, the vehicle randomly chooses a direction to follow. That is, continuing straightforward, turning left, or turning right. The probability of each decision is set by the authors respectively to 0.5, 0.25, and 0.25. The security distance is also used in this model, and nodes follow the same strategy as in the freeway model to keep this distance [10].

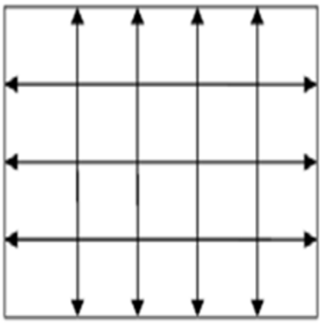

Figure 6: Map used in Manhattan Mobility Model

2.3.5 Realistic Mobility Models

The commonly used entity mobility models and group mobility models don't reflect the mobility Pattern of mobile nodes in realistic environment. These mobility modes are either unrealistic or semi realistic. For example: Random Waypoint Mobility Model is an unrealistic model while Reference Point Group Mobility models is a semi-realistic one [17]. Therefore, in order to correctly evaluate the performance of various routing protocols in realistic environment, we need realistic mobility models. In this section, we will be discussing a realistic mobility model: Marginal Mobility Model.

(a) Marginal Mobility Model

Ion Gabriel Toudorache et al. [18]-[8] proposed Marginal Mobility model and also carried out simulations of this mobility model using various routing protocols. The marginal mobility model is a realistic mobility model in which the mobile node moves at the boundary of the Wireless Sensor Network (WSN) coverage area. The mobile node will have, during its movement, a maximum of one neighbour which will connect the mobile node with rest of the network. At different periods of time during its movement, the mobile node will connect and disconnect from the network. This makes it difficult to receive information from nodes which are in the network [18]. Thus, a mobile node follows the marginal mobility model if the following two conditions are met, 1) The mobile node during its movement has a maximum of one neighbour which will connect the mobile node with the rest of the network and 2) The mobile node during its movement will connect and disconnect from the network at different periods of time.

Figure 7 shows a mobile node following the marginal mobility model at a maximum distance from WSN coverage area. The radio range R of each node is considered to be 424 meters [8]. When the mobile node will be at a distance of 424 meters from WSN coverage area, it will join the network for a very short time and will remain disconnected from the network for a long period of time.

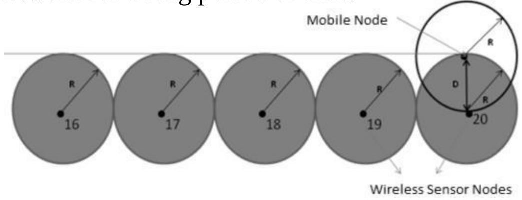

Figure 7: The mobile node following the Marginal Mobility Model at a maximum distance from WSN coverage area.

3. Results and Discussion

Major five categories of various Mobility models are described for vehicular networks and various factors affecting the mobility in VANETs are also discussed. We also provided a large overview of actual mobility models available to the research community in Vehicular Ad-hoc Networks. We illustrated that today's trend is to go toward an increased realism in the modelling of vehicular mobility. We additionally depicted how a realistic motion modelled by VanetMobiSim allows reproducing basic phenomena encountered in real-life traffic, especially the effect of intersections or the effect of overtaking on vehicles mean speed. It has capability to create realistic mobility model with high degree of realism. This review did not include discussion on radio interferences usually caused by both static and dynamic obstacles. Improving realism for vehicular mobility models appears to be as motivating as it is crucial to accurate analysis and design of next generation networks.

VanetMobiSim is an extension to CanuMobiSim, a generic user mobility simulator. CanuMobiSim is a platform and simulator-independent software, coded in Java and producing mobility traces for different network simulators, including ns-2, QualNet and GloMoSim. It provides easily extensible mobility architecture, but, due to its general purpose nature, suffers from a reduced level of detail in specific scenarios. VanetMobiSim is therefore aimed at extending the vehicular mobility support of CanuMobiSim to a higher degree. VanetMobiSim implements a novel mobility model called Vehicular Mobility Model (VMM) that is compliant with the principles of the general framework for mobility models generation described in, and capable of modelling detailed vehicular movements in different traffic conditions.

Modelling of VanetMobiSim includes car-to-car and car-to-infrastructure relation-ship. Thus it combines the stop signs, traffic lights and activity based macro-mobility with the support of human mobility dynamics. It can extract road topologies from TIGER, GDF, random and custom topologies. It allows users to generate trips based on their own assumptions or activity based and can configure the path between the start and end position on the basis of the Dijkstra algorithm, road-speed shortest or density-speed shortest. VanetMobiSim contains a parser to extract topologies from GDF, TIGER or cluster Voronoi graphs that will be used by network simulators. VanetMobiSim is an extension to CANUMOBI-SIM (Communication in Ad-hoc Networks for Ubiquitous Computing for Mobility Model Simulation)–a java based application with graphic user interface (GUI). VanetMobiSim is an open source mobility genera-tor model, specific to VANET scenario. It has capability to create realistic mobility model with high degree of realism. The application is compatible to both 'Window' and LINUX' platform and requires Java Run Time Environment version 1.5 or higher [19].

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