Nodes distribution and selection of accurate mobility Framework to systematically analyze its impact for improving performance of routing protocols for mobile ad hoc networks through Simulations

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Abstract— **Research on mobile ad hoc routing protocols performance based on simulation relies on choice of realistic mobility model. However, in the absence of realistic data movement, Synthetic models may be used for generating movement pattern. In order to capture the behavior of individuals moving in groups and between groups, there is a need for defining models for clearly representing group mobility based on the dimension of the relationships among the people carrying the mobile devices in mobile ad hoc networking scenarios. Sociability and attractivity between each group of hosts are the two main issues which may govern the pattern of movement of mobile hosts. Different mobility models have been proposed by researchers in the recent past for describing the movement pattern of mobile users, showing variation in their location, velocity and acceleration over time but most of them lack realistic behavior .As mobile ad hoc networks are not currently deployed on a very large scale and research in this area is mostly simulation based focusing on Mobility pattern constituting an important parameter in analyzing the performance of Mobile ad hoc routing protocols. Hence, it becomes necessary to study the behavior of mobility models and their impact on MANET routing protocols. In this paper we surveyed and examined different categories of mobility models proposed in the recent research literature and attempted to provide an overview of current research status of mobility modeling along with design principles for a perfect mobility model**

Keywords: **review ; mobility model ; mobile ad hoc network**

I. INTRODUCTION

Mobility Models hold an important position when we study and analyze the performance of mobile ad hoc routing protocol based on simulation as the mobility behavior of human beings and objects can be best modeled using Mobility Modeling. Different widely used mobility models for generating mobility descriptions are Direct Models, Behavior models and Traces. Position descriptions, flow descriptions and sojourn density descriptions etc. as time functions are postulated by Direct Models. Object's position uniquely describes a place. We can use a specification of a coordinate for uniquely describing a place. Coordinate values could be continuous or discrete.

In behavioral modeling, rules define the mobility behavior of objects and the parameters like the direction, speed and acceleration- which are object change movement parameters. Random Direction Mobility Model and Random Way Point Mobility Model are typical examples under behavioral modeling.

A population of sample entities or "real-world data" of sample entities collectively form Traces or we can say Traces are real life system mobility patterns. Usage of Traces forms one of major modeling approach. Statistical value of trace data is very essential while using mobility traces for studies. To define a trace we need to track the exact movement pattern and behavior of all mobile users for some fixed observation period and can retrieve accurate information. But collection and distribution of this type of statistical data may be prohibited because of different privacy issues.

Some problems may arise when we look for availability of mobility traces i) It is very difficult to collect detailed path information of mobile entities. ii) No proper aggregation point for mobility measures. iii) Videos on public areas has limited area coverage. Firsly, in measurement data received from cellular network operators, only communicating mobile entities are covered and lacks accuracy as this data related to mobility is not made available to general public. Secondly, conclusions derived from statistical value of traces can be perfect only for very less number of scenarios as in case for protocol tests.

II. MODELLING APPROACH

It is extremely difficult to model ad hoc networks without traces. In absence of modeling statistics and proper traces, synthetic models are preferred. These models further help us in attaining additional knowledge of the system. But selecting an appropriate model and its parameterization forms an iterative process. Some of the most important approaches in model creation are – i) Model may be derived from more complex model by omitting some of its parts. ii) Measurement and Observation using Extrapolation methods. iii) For hypothetic studies model may be postulated without any linkage to reality.

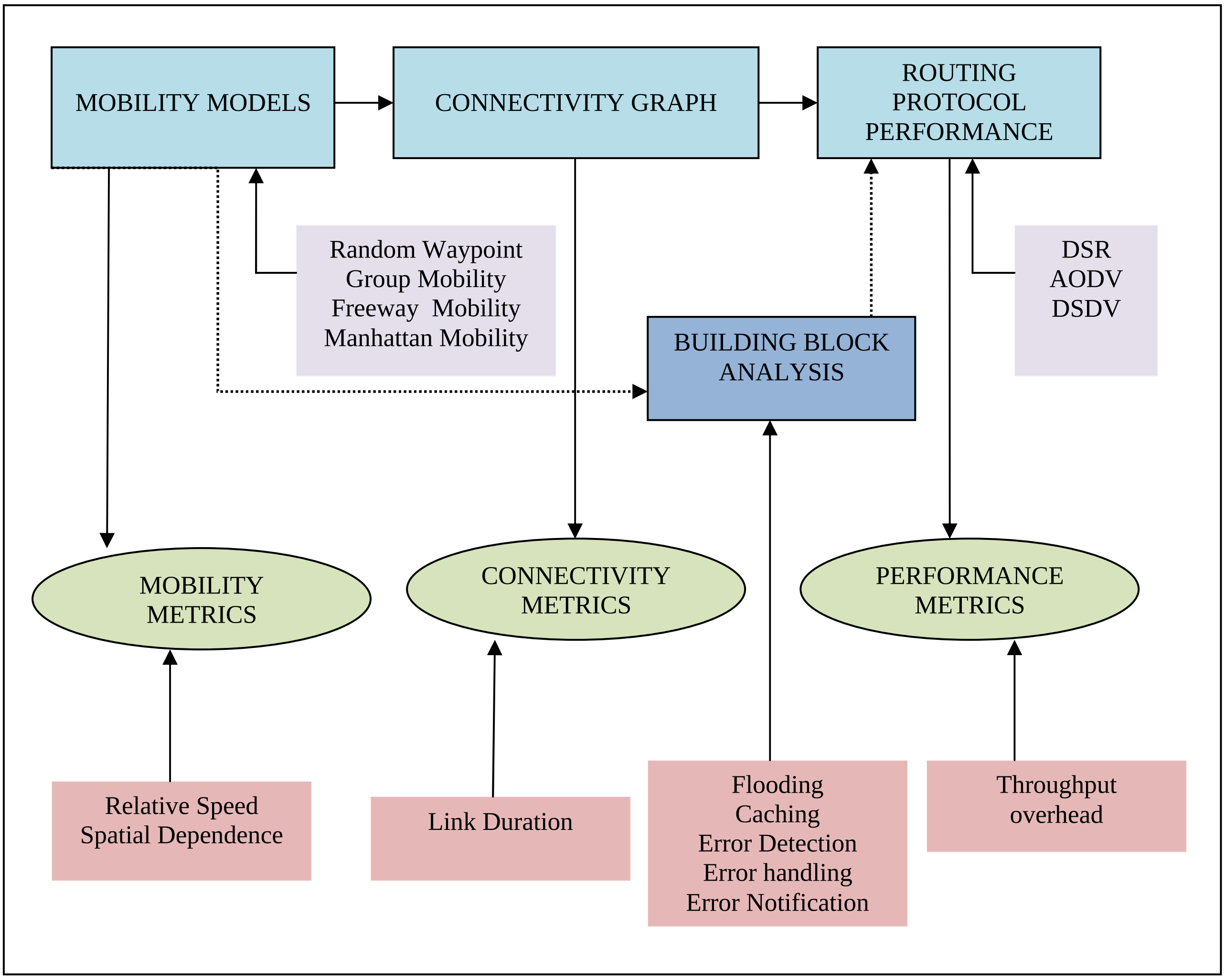


Fig1. Framework for Mobility

III. ENTITY MOBILITY MODELS

A. *Cellular Mobility Model*

It is focused on individual movements because of frequent paging of handoffs of mobile node so group management issues are not paid much attention. Hence this mobility model came into existence for testing the behavior of cellular protocols.

Random Walk Model (including its many derivatives) is based on random directions and speeds. Here new speed and direction are chosen by mobile node when moving from current location to a new location from pre-defined ranges, [minimum_speed, maximum_speed] and [0,2] respectively. Each movement occurs in a constant time interval t, after which new direction and speed are calculated and attained by a mobile node. Some of the important derivatives of the Random Walk Mobility Models are 1D, 2D, 3D and d-D walks. According to [1] Random Walk Mobility Model is a memory less mobility pattern because knowledge regarding the past locations and speed values of mobile node is not retained. This property inhibits the practicality of this model because mobile nodes typically have a pre-defined destination and speed into consideration , which in turn affects future destinations and speeds.

Constant Velocity Fluid-Flow Model focuses on traffic patterns. According to [2] macroscopic movements are described by fluid mobility models and the generated traffic's behavior is quite similar to fluid flowing through a pipe. So, this mobility model represents the situations with a constant flow of mobile nodes.

Random Gauss-Markov Model is used to fix the discrepancies of the random walk and fluid-flow models. It allows the study of individual mobile node movements. It also allows the past velocities and directions to influence future velocities and directions..

B. *Adhoc Mobility Model*

In *Random Mobility Model*, the current speed and direction of a mobile node has no dependency on its past speed and direction [3] so some unrealistic pattern of movements such as sudden stopping, sharp turning and completely random wandering are generated.

Constant Velocity Random Direction Mobility Model- [4] and [5] revised the Random Mobility Model for assigning the same speed to each node for the entire simulation period. A mobile node moves after choosing a random direction in the range 0 to 2 and "bounces" off the simulation border on reachind the grid boundary with an angle determined by incoming direction and further the mobile node continues to move in the new path found.

Random Waypoint Mobility Model –It was first proposed by Johnson and Maltz [13]. [6] and [7] have included pause times between changes in direction and/or speed. In the beginning , a mobile node stays in one location for a certain period of time(pause time) and once the pause time expires , the mobile node preferably chooses a random destination and speed that is uniformly distributed between [0,maximum_speed]. This is the speed at which the mobile node travels towards the newly chosen destination. Movement pattern of a mobile node using Random Way point mobility model is similar to the Random Walk Mobility Model if pause time is zero. Radom Way point is simplest model whose node trace is generated by setdest tool by CMU Monarch group, included in NS2.

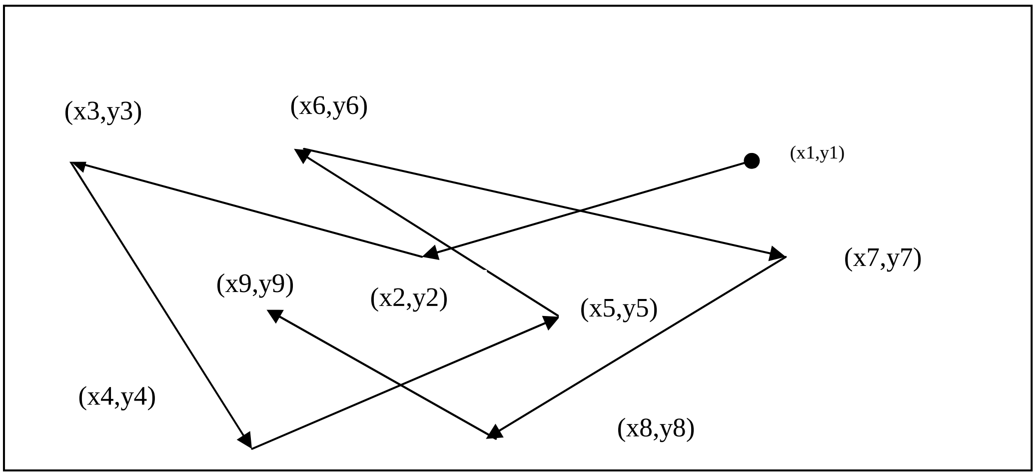


Fig2. Fig. Random Waypoint Model showing node movement.

Random Direction Mobility Model - In Random Waypoint model, mobile nodes appear to converge and disperse. To alleviate this type of behavior and to promote semi-constant number of neighbors, the Random Direction Mobility Model was created. Here random direction forms the basis instead of random destination, and on reaching the boundary, the mobile node stops for certain period of time and on choosing another angular direction(between 0 and 180) continues further. In modified Random Direction mobility Model, a mobile node is no longer forced to travel the boundary of simulation area before stopping to change direction, Instead it selects destination anywhere along the direction of travel.

Boundless Simulation Area Mobility Model by [8] showed that there exists a relationship between the previous direction of travel and velocity of a mobile node, with its current direction of travel and velocity.

Probabilistic version of the Random Mobility Model -With the help of three different states; State 0 for current location of a given mobile node, state 1 for mobile node in previous location and State2 for mobile node's next location when mobile nodes move forward, Chiang's mobility model makes use of probability matrix for determining the position of a particular mobile node in the next time step.

City Area, Area Zone and Street Unit Mobility Models: In [9], characteristics of mobility models have been explained in detail including required inputs/outputs and issues that should be considered when designing specific mobility model. Input parameters include population of mobile nodes, geographic area organized into regions and a time period. In output parameters we have a collection of functions that determine the location of a mobile node over the geographical area at a particular time. On combining these input/output parameters with the Transportation Theory, these authors have created three Models-The City Area Model, Area Zone and Street Unit Models.

A brief introduction to Transportation Theory is presented here before going to these three models. To determine the load a system should carry in a given geographical area of service, many different important variables are considered- i) The purpose of trip. ii) Exact route taken including starting and ending points. iii) Population groups such as working people. iv) Periods of high mobile node activity. v) Transportation system's capacity and usage costs. vi) Popular Areas attracting many mobile nodes.

City Area Model-represents user mobility and traffic behavior for large-scale geographical area. In the center of city, there is a high concentration of workplaces and businesses which is surrounded by fairly dense distribution of dwelling areas for people (urban areas) and the population density gradually decrease on moving away from center of city representing sub urban and rural areas. Thus the main concentration is given on how to represent large-scale flows of traffic within city limits.

The *Area Zone Model* takes a more in depth look at mobility within a city by dividing it into regions by using square-shaped building blocks and an orthogonal grid representing a street network. Hence, this model is quite useful for modeling large scale interactions.

Street Unit Model beautifully models the movements of individual mobile nodes to simulate realistic traffic conditions by minimizing the traveling time for all mobile nodes and implementing safe driving characteristics (speed limit and minimum distance allowed between any two mobile nodes). But these three theoretic models create realistic simulation environments that are full of obstacles and strictly defined travel paths.

A hierarchy of mobility models by Lam : Lam [10] developed a hierarchy of mobily models like metropolitan, National and International Mobility Models each focusing on different range of movement.The Metropolitan mobility model (METMOD) focuses on mobile node movements in metropolitan area. The entire geographical region is divided into smaller regions or subnets. The probability of a mobile node moving into an adjacent area is described with help of movement connectivity matrix. Each element (x,y), within the matrix represents the probability of a mobile node in a particular area, moving to another area. The National Mobility Model (NATMOD) models behavior of mobile nodes moving between metropolitan area by dividing entire simulation region into smaller geographic areas which form entire metropolitan area. Assumption is made about flights from each airport to drive a traffic volume for the Mobility Model. In International Mobility Model (INTMOD), the data is compiled from few countries in an attempt to create an accurate traffic volume . Hence, objects are countries and traffic flows to and from objects representing individual countries.

IV. GROUP MOBILITY MODELS

Entity mobility models represent multiple mobile nodes whose actions are not dependent on each other. Whereas group mobility models exist to model the behavior of mobile nodes moving together.

A. Simple Group Mobility Model

Sanchez [11], had observed that random walk/random movement model may not be sufficient to describe many "real-life" situations and thus Column, Pursue and Nomadic Community Mobility Models were thus created [11], [12].

1) Column Mobility Model can be used for scanning or searching. This model sounds good for representing a set of mobile nodes that form a line and uniformly move forward in a particular direction. Eg. A row of atheletes marching together towards goal. In slight modification of Column Mobility Model,individual mobile nodes follow one another like children moving from prayer ground to their classrooms respectively.

2) Pursue Mobility Model: According to Sanchez[11] the model efforts to represent mobile nodes tracking a particular target . eg . Athletes trying to reach their final destination running in the same direction.

3) Nomadic Community Model: is useful for representing groups of mobile nodes that collectively move from one position to another.Within each group, individual nodes maintain their own personal "spaces" where nodes may prefer to move in random ways.

B. Reference Point Group Mobility Model

Reference point Group Mobility Model is used for representing a random motion of a group of mobile nodes as well as random motion of each individual Mobile node within the group. .

1) In-Place Mobility Model partitions a given geographical area in such a way that each subset of the original area is assigned to a specific group, which operates only within that geographic subset. Each mobile node within a single group may participate in an activity different from every other mobile ndoe in the group.

2) Overlap Mobility Model: It is one of the variation of Reference Point Group Mobility model. Here simulation is done on several different groups each of which meant for a different purpose,working in same geographic region and within the same geographical boundary, each group may have different characteristics than other groups.

3) Convention Mobility Model: [3] divides a given area into smaller subsets and allows the groups to move in a similar pattern throughout each subset.

V. USER MOBILITY MODEL

User Mobility Model [14] attempts to represent human movement behavior (in form of operator) in form of two level hierarchy consisting of Global Mobility Model or GMM at the top and Local Mobility Model or LMM at the bottom. GMM is a deterministic model used to create intercell movements whereas LMM is a stochastic model with dynamically changing state variables to model intracell movement. The figure 4.. shows that mostly the mobile users exhibit some regularity in their daily movement, which is governed by a number of user mobility patterns (UMP's) , recorded in a profile for each user and indexed by the occurrence time.

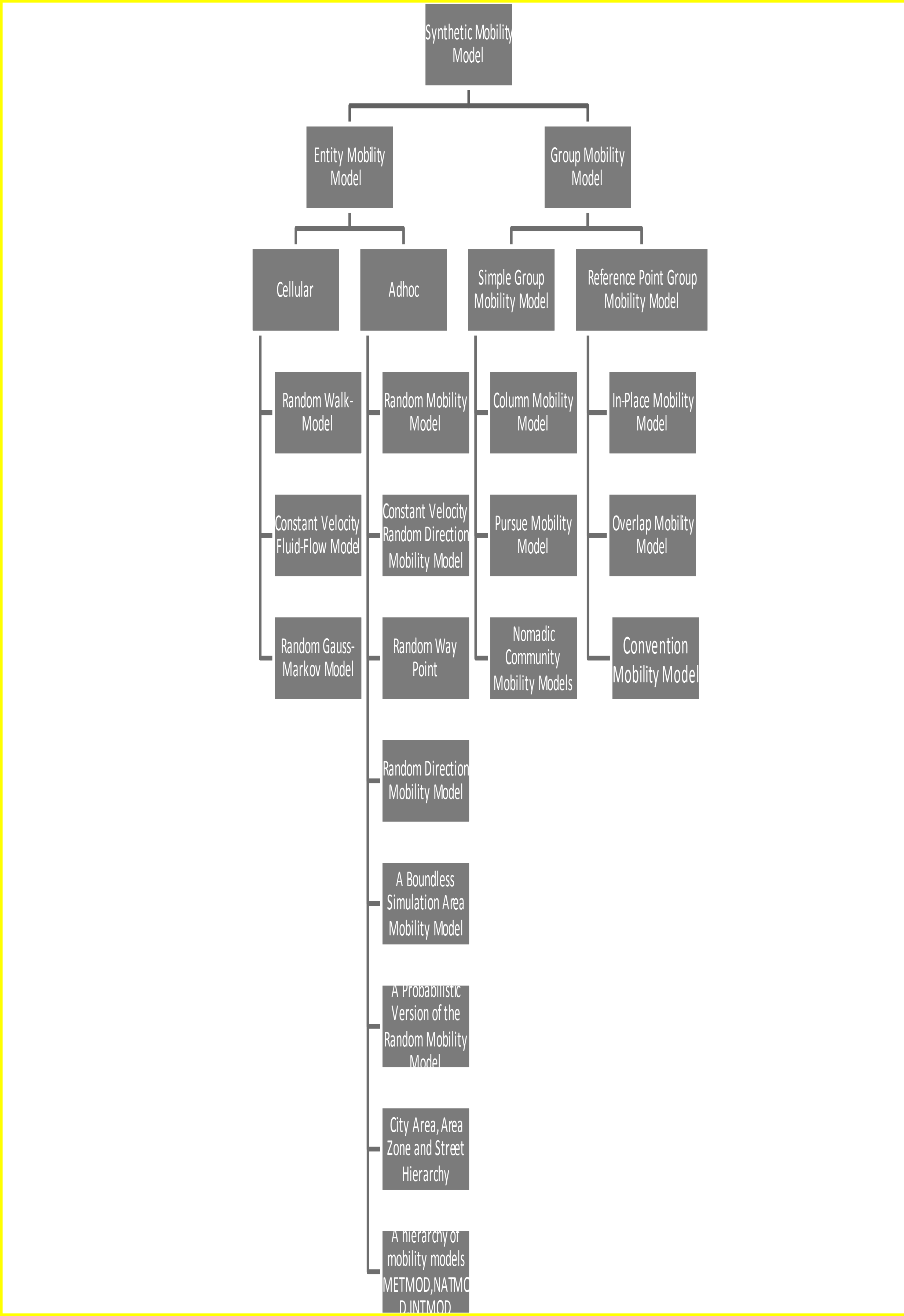
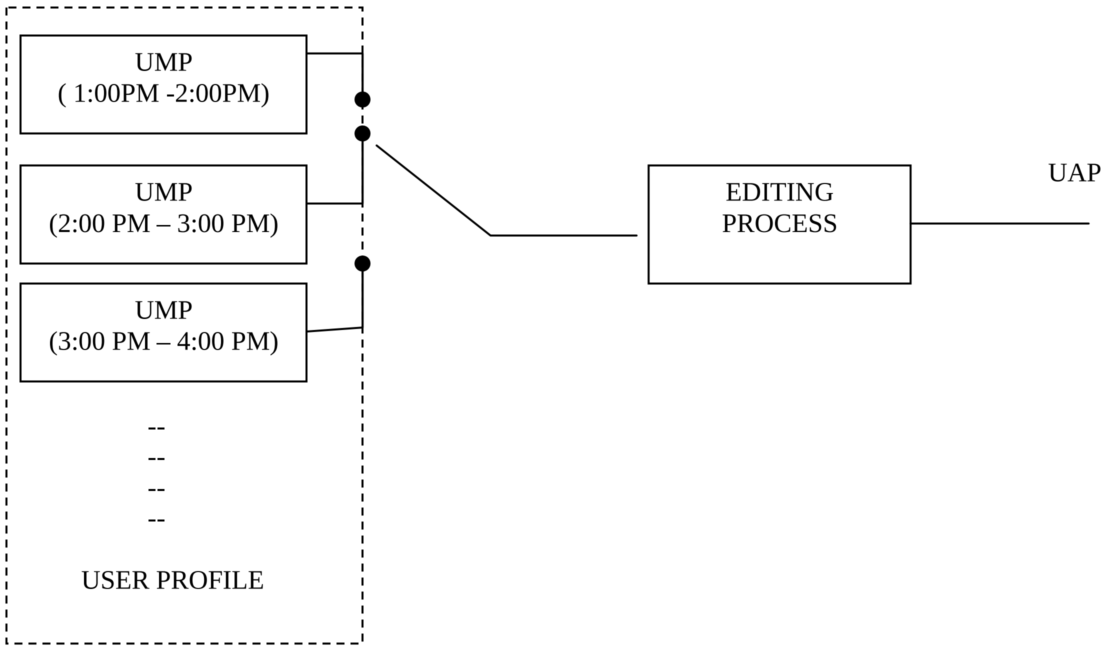
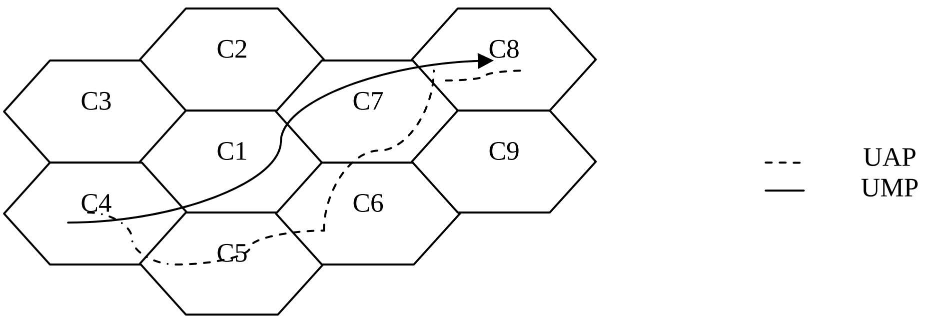


Fig5. Classification of Mobility Models



(a)



(b)

Fig.6 Global Mobility Model

Local Mobility Model is based on the observation that random choice of intercell movement is actually a logical function of the user's position, speed, direction and cell geometry. In real life applications, node's movement largely depends on its environments like motion of vehicles are bounded by the freeway or local streets, buildings and other obstacles

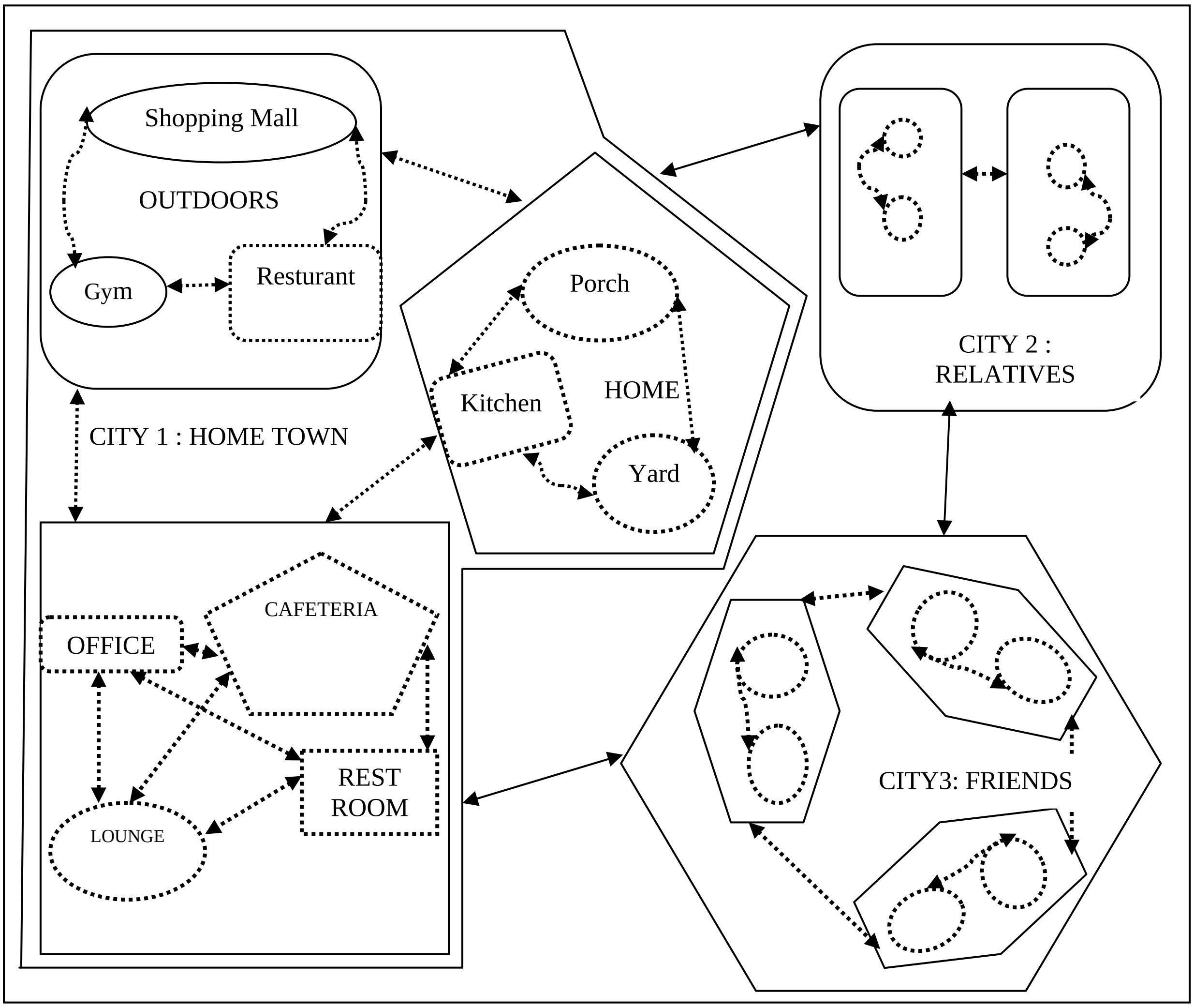


Fig7. The Sociological Orbit

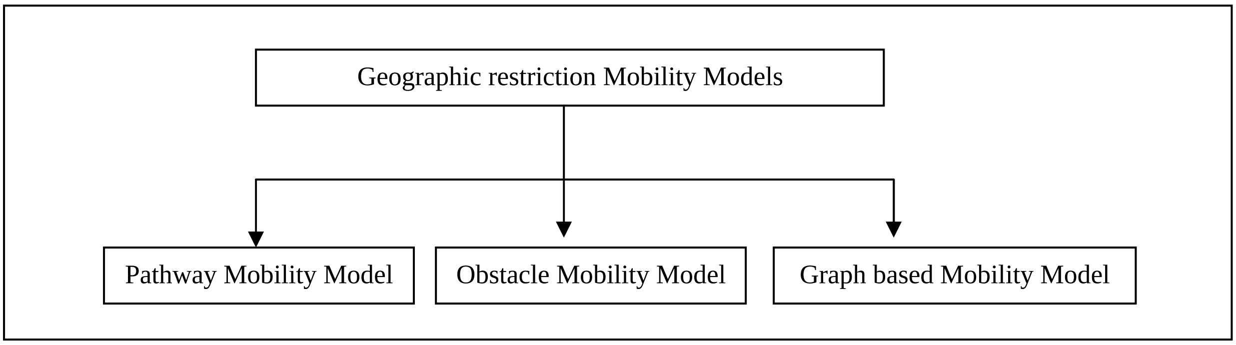


Fig8. Geographical Restriction mobility Models

VI GEOGRAPHICAL RESTRICTION MOBILITY MODEL

A. Pathway Mobility Model:

Pathway mobility model integrates geographic constraints into the mobility model to restrict the node movement to the pathways in the map. In city section mobility model, a street network is modeled which represents a section of a city. The streets and speed limits on those streets completely depend on the type of city being simulated. In city map model , the vertices of the graph represent the buildings of the city and the edges model the streets and freeways between those buildings. Nodes move towards their destination through the shortest path along the edges. Upon reaching the destination, 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 the simulation.

B. Obstacle Mobility Model:

In Obstacle Mobility Model a user can freely define the positions of obstacles . For eg. Buildings. The Movement graph is defined by the Voronoi Diagram of the obstacles corners and Voronoi graph with obstacle. The Shortest path routing policy is used to move the nodes between two locations in the movement graph.

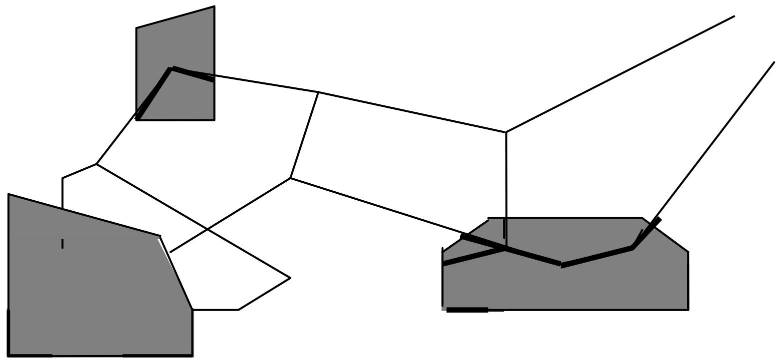


Fig 9. Voronoi diagram of the obstacle corners

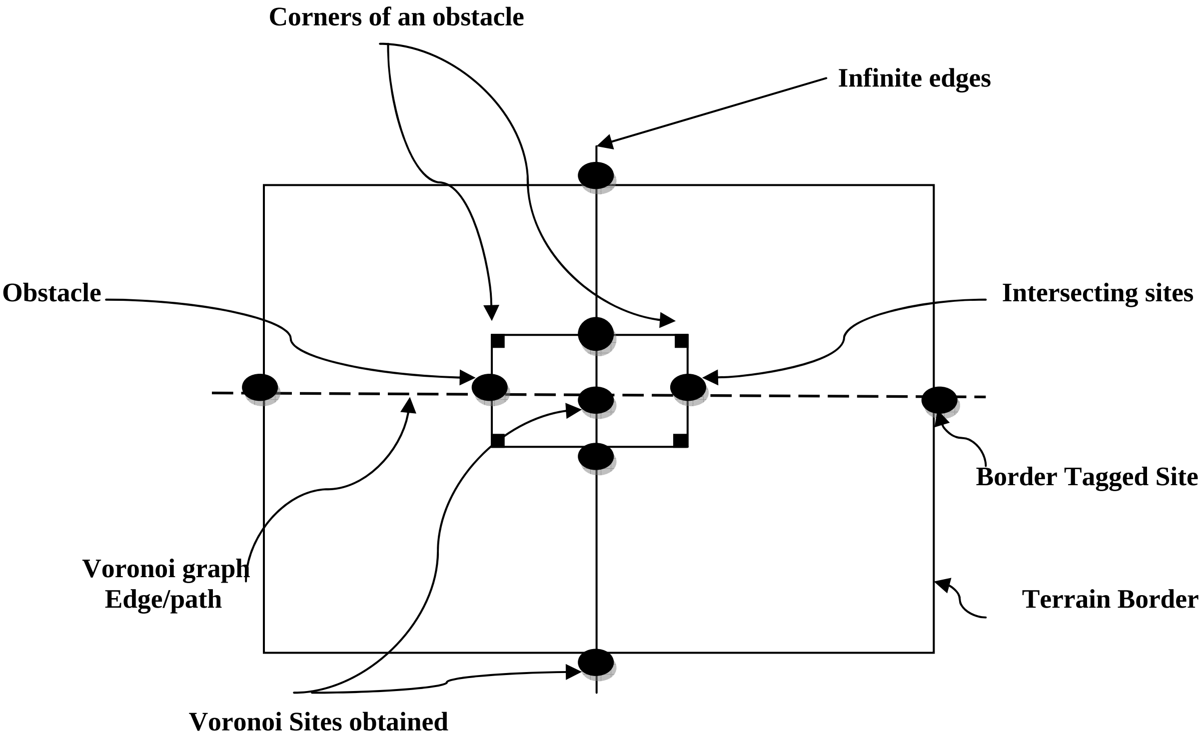


Fig10 . Voronoi path and obstacles

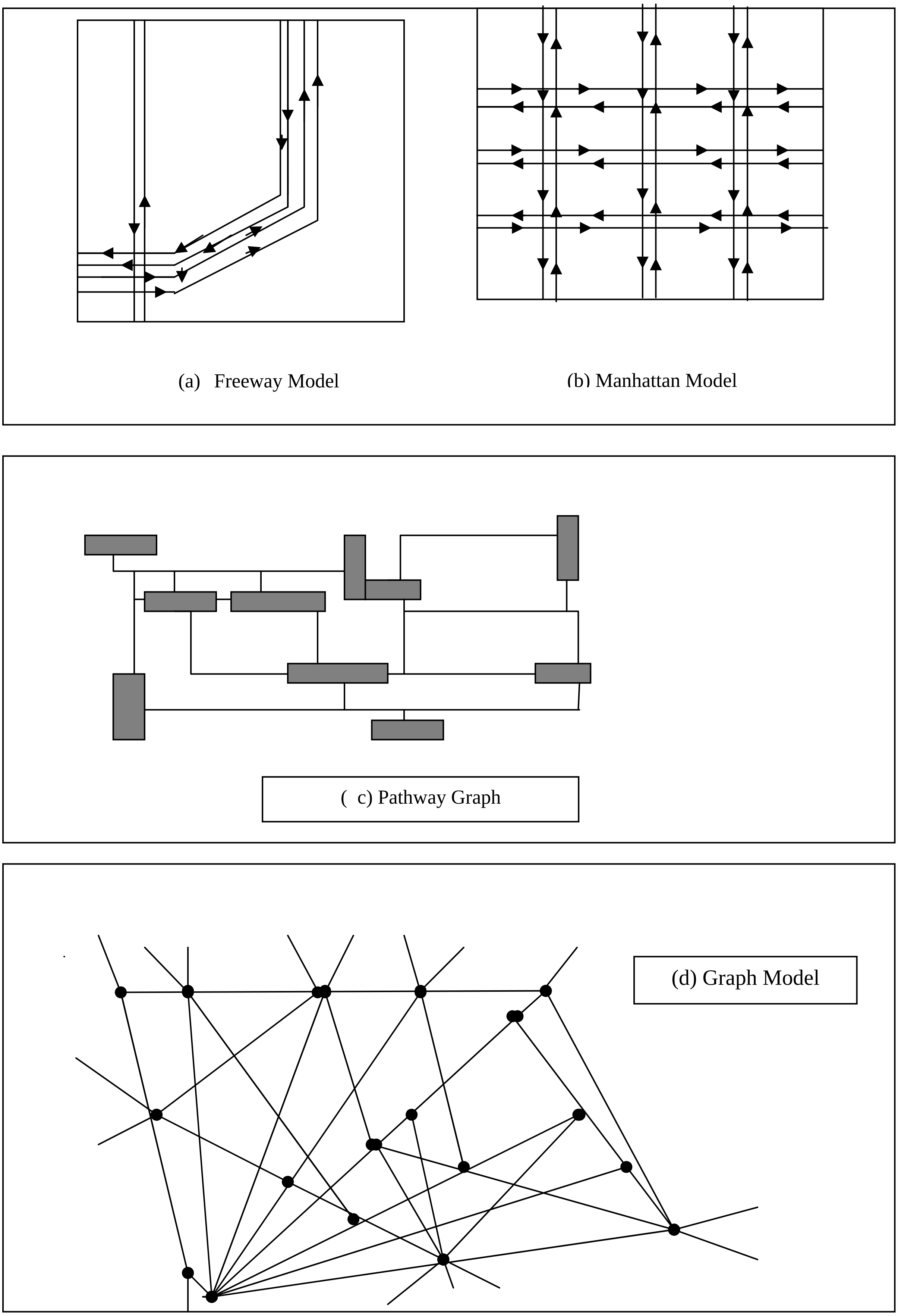


Fig11. Representation of Mobility models

C. Graph based Mobility Model:

The connected graph shows the locations that the users might visit with the edges to connect those locations eg streets. Firstly each mobile node is initialized at a random vertex in graph and moves towards another vertex, which is selected randomly as its destination by moving through shortest possible path. After making a short pause for a randomly selected period at the destination, the node picks out another destination from other vertices randomly for the next movement.

VII. OTHER CLASSIFICATION

Mobility models [16] are classified four classes : Random Models , Models with Temporal Dependency, Models with Geographic Dependency and Models with Spatial Dependency. Random models are pure randomized whereas Models with Temporal Dependency implicate a coherence. The movement of a node depends on the movement pattern of the history. All kinds of mobility that are restricted by any geographic restrictions like lanes are grouped into Models with Geographic Dependency. Models with Spatial Dependency cover all mobility models that tends to move in a correlated manner. A group specific structure within the group is observed as a coherence between different groups moving towards a common goal.

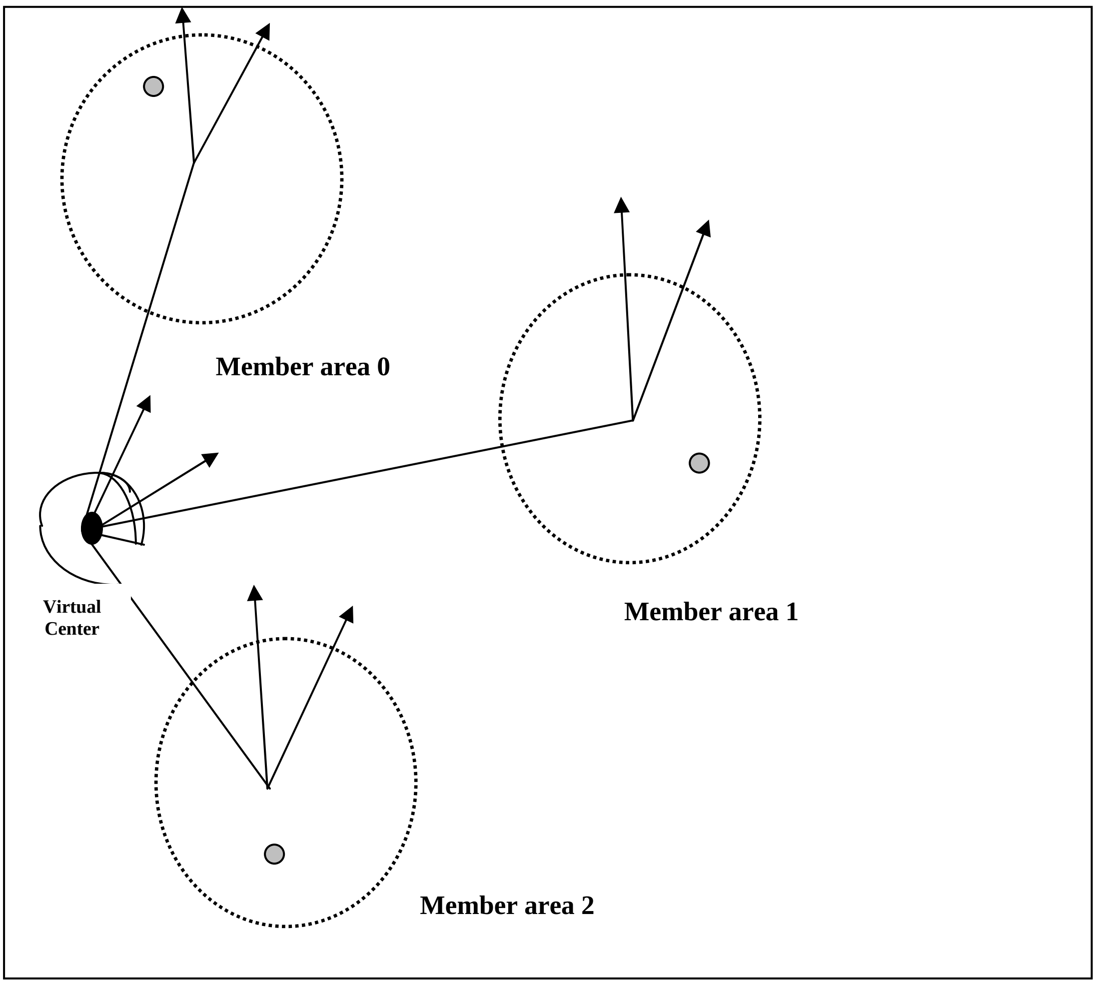


Fig12. Group Member Structure.

VIII. MOBILITY MODELING OF OUTDOOR SCENARIOS FOR MANETS

The User –Oriented mobility model [15] takes into account three key factors that influence user movement in a given area: Outdoor environments (movement constraints and points of interest), user travel decisions and user movement dynamics which is diagrammatically shown here.

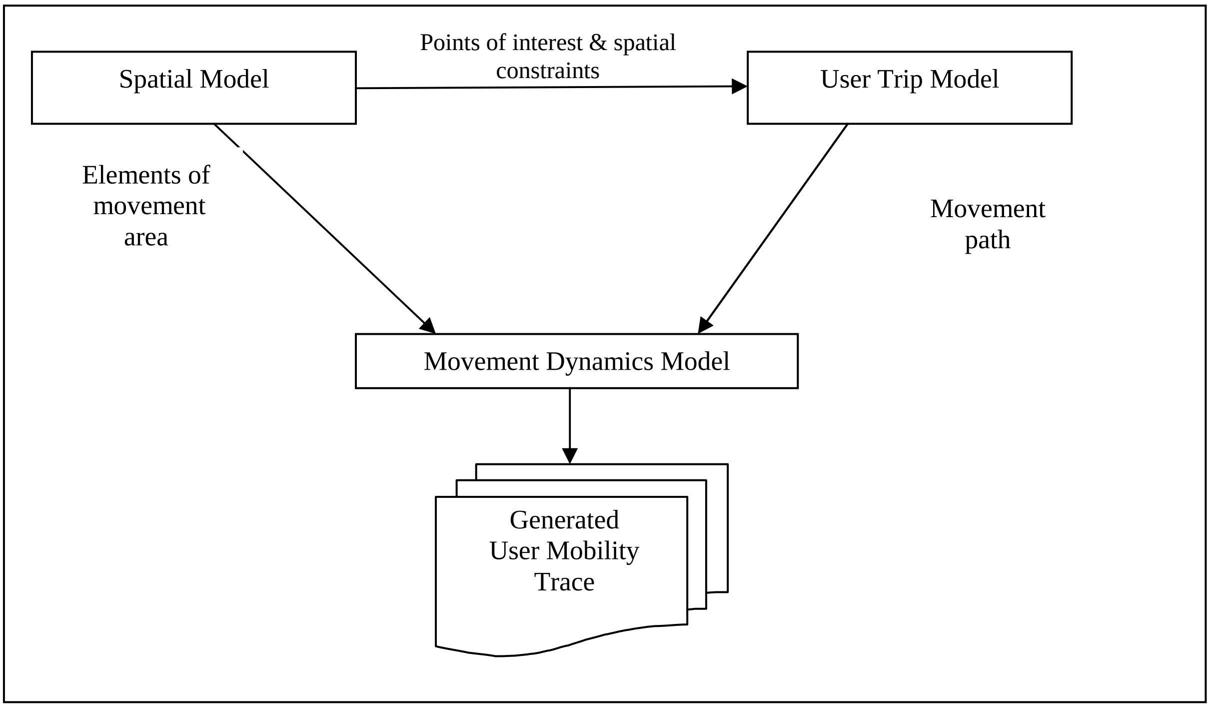


Fig.13. Mobility Modeling for outdoor scenarios

An outdoor environment may contain so-called points of interest" eg. Markets which normally serve as destination points of movement. The modeling of user travel decisions includes the modeling of user trip sequences and the modeling of movement path selection. Two major groups of mobile clients are pedestrians and vehicles. Consequently, the resulting mobility model integrates three sub-models : spatial model, user trip model and the movement dynamics model. The spatial model contains the description of outdoor environment including area constraints and is initialized from a digital map taken from a geographic information system. The user trip model performs mobility at the level of user trips (paths) . The movement dynamics model shows dynamics of user movement (position changes) along their movement paths. Mobility traces are obtained from changing user positions which serve as an input for MANET simulation.

IX. MOBILITY METRICS CHARACTERISATION

The mobility models can be classified with different kind of mobility metrics classes[17] like randomness, dependencies and restrictions that are considered in table below:-

SINo.	Metrics	Charactersitics
1.	Random Based	Without any dependencies and restriction invoked in model
2	Spatial Dependencies	The movement of a node influenced by node around it
3	Temporal Dependencies	A node actual movement influenced by its past movement
4	Geographical Restriction	Node movement restricted in certain geographical area
5	Hybrid structure	All mobility metrics classes are integrated to attain the structure.

Table 1 . Categorization of Mobility Metrics and its characteristics

X. CONCLUSIONS AND FUTURE WORK

Without using a realistic mobility model, performance results obtained from simulations of mobile ad hoc networks may not correlate well with performance in a real deployment. A perfect mobility model should be based on correct topological maps, must include a traffic generation model, and must take into account preferential movements or destinations.Network heterogeneity will be an intrinsic property of next generation wireless networks due to the convergence of different access technologies to support versatile applications, which is going to impose design challenge requiring novel mobility models to accommodate the evolving complexities in an integrated wireless system for better performance analysis of routing protocols .

REFERENCES

[1] Z. Haas, and B. Liang. "Predictive Distance Based Mobility Management for PCS Networks." *IEEE Conference on Computer Communications (INFOCOM'99)*, March,1999.

[2] D. Lam, D. Cox, and J. Widom, "Teletraffic Modeling for Personal Communications Services." *IEEE Communications Magazine,* pages79-87, February, 1997.

[3] X.Hong, M. Gerla, G.Pei, and C. Chiang, "A Group Mobility Model for Ad Hoc Wireless Networks." *ACM International Workshop on Modeling and Simulation of Wireless and Mobile Systems (MSWiM'99),* August 1999.

[4] S. Basagni, I. Chlamtac, V. Syrotiuk, and B. Woodward. "A Distance Routing Effect Algorithm for

[5] Mobility (DREAM)." ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM'98), pages 76-84, 1998.

[6] M. Gerla , G.Pei, and S.Lee. "Wireless, Mobile Ad Hoc Network Routing." *IEEE/ACM WINLAB/BERKELEY Workshop (FOCUS'99),* May 1999.

[7] D. Johnson, and D. Maltz. Dynamic Source Routing in Ad Hoc Wireless Networks, pages 153-181, Kluwer

[8] Academic Publishers, 1996.

[9] S.Lee, M. Gerla, and C. Chiang, "On - Demand Multicast Routing Protocol." *IEEE Wireless* Communications and Networking

[10] Conference (WCNC'99), 1999.

[11] Z.Haas, "A New Routing Protocol for the Reconfigurable Wireless Networks." *IEEE 6th* International Conference on Universal Personal Communications (ICUPC '97), pages 562-566, 1997.

[12] J. Markoulidakis, G. Lyberopoulos, D. Tsirkas, and E. Sykas. "Mobility Modeling in Third-Generation Mobile Telecommunications

[13] Systems." *IEEE Personal Communications*, pages 41-50,1997.

[14] D. Lam, D. Cox, and J. Widom. "Teletraffic Modeling for Personal Communications Services." IEEE Communications Magazine,

[15] pages 79-87, February 1997.

[16] M. Sanchez. "Mobility Models." http://www.disca.upv.es/misan/mobmodel.htm

[17] M. Sanchez and P. Manzoni. "A Java-Based AdHoc Networks Simulator." *SCS Western* Multiconference Web-based Simulation Track. San Francisco, January 1999.

[18] J. Broch, D. A. Maltz, D. B. Johnson, Y.-C. H, and J. Jetcheva, A Performance comparison of multihop wireless ad hoc network routing protocols, in Proceedings of the Fourth Annual ACM/ IEEE International Conference on Mobile Computing and Networking (Mobicom 98), ACM , October 1998.

[19] Tong Liu, Paramvir Bahl, and Imrich Chlamtac, Mobility Modeling, Location Tracking, and Trajectory Prediction in Wireless ATM Networks, IEEE Journal on Selected Areas in Communications, Vol. 16, No. 6, August 1998.

[20] Illya Stepanov, Pedro Jose Marron, and Kurt Rothermel, Mobility Modeling of Outdoor Scenarios for MANETs, in Proceedings of the 38th Annual Simulation Symposium (ANSS'05) ,IEEE, 2005 .

[21] F.Bai and A. Helmy,A Survey of Mobility Models in Wireless Adhoc Networks,in Wireless Ad Hoc and Sensor Networks. Kluwer Academic Publishers, 2004.

[22] Santosh Kumar, S.C. Sharma, Bhupendra Suman, Mobility Metrics Based Classification & Analysis of Mobility Model for Tactical Network, International Journal of Next –Generation Networks (IJNGN) Vol.2, No. 3, September, 2010.

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