Mobility Metrics Estimation and Categorization for SNET Protocols

Anita Sethi[1], Prof. J. P. Saini[2], Dr. Shailendra Mishra[3],

[1] Uttrakhand Technical University,
Dehradun, India

[2] M.M.M. Engineering College
Gorakhpur, India

[3] Professor & Head, BCTKEC
Dwarahat

Abstract

In the performance assessment of an ad-hoc protocol, the protocol should be verified under genuine circumstances including, but not restricted to, an effective transmission range, inadequate buffer space for the storage of messages, illustrative data traffic models, and a mobility model. Deterioration of average speed as the simulation growths, a variance between the extensive duration distribution of nodes and the initial one, and sometimes the unpredictability of the model are the problems caused by simulation of mobility models. A mobility model emulates the actual world movement of mobile nodes and is essential component to simulation based analysis. So, satisfactory analytical and real demonstration of mobility is a very significant subject in simulation of mobile ad hoc networks. Our domino effects point out that the ad hoc protocols are certainly inclined by these mobility models. Extensive simulations have been conducted for different conditions of network density and node mobility for each of the four mobility models and also for different values of the degree of randomness parameter for the Gauss-Markov mobility model.

Keywords: *Random Waypoint Mobility Model, City Section mobility model, Manhattan mobility model, Gauss-Markov mobility model.*

Introduction

Traces and syntactic are the two tactics for modeling of the mobility pattern. In trace-based models provide mobility patterns that are perceived in real-life systems and in it everything is deterministic whereas syntactic models represent the movements of mobile nodes accurately. Further Individual mobile movements and Group mobile movements are two categories of syntactic models. Random models based on statistical properties, models with temporal dependency influenced by their movement histories, models with spatial dependency, and models with geographical restrictions are four prime categories. The mobility pattern of the distinct mobile node is measured in case of Individual Mobility Models. In group mobility model, the supportive group movement of the mobile nodes performances in synchrony as a group, and reference random point group mobility model is a model of this classification. The autoregressive mobility model contemplates mobility patterns of distinct nodes associating the mobility grades that may involve position, velocity, and acceleration at consecutive time instants. A synchronized movement job is performed by dynamic mobile nodes over (visually invisible) self-organized networks in nature in flocking and swarm mobility model. The virtual game-driven mobility model agreements with a distinct node or a cluster of mobile nodes based on user/player policies that are mapped from the real world to virtual agents interacting with each other or with groups of mobile users. In non-recurrent mobility model, the moving objects move in a totally unknown way without repeating the previous patterns, and these moving objects can be mobile nodes of the ad hoc network that constantly changes its topology or the continuously moving data arises in a broad variety of applications, including weather forecast, geographic information systems, air-traffic control, and telecommunications applications.

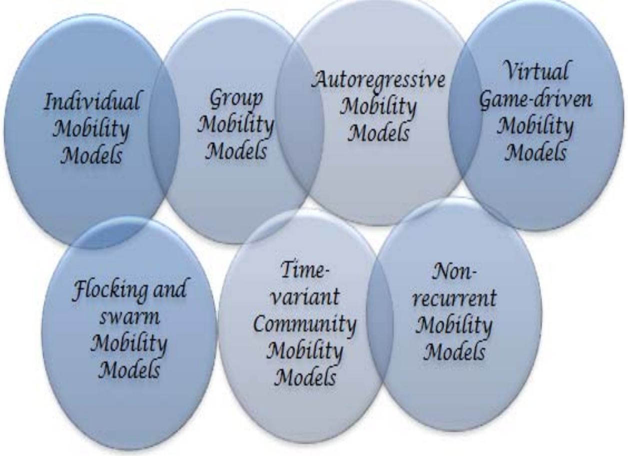


Figure 1 Classification of Mobility Models

The time-variant community mobility model captures the non-homogeneous behaviors in both space and time with inter-node dependency of the community of interest (COI)-based mobile network structure. The framework estimates the performance of spontaneous network routing protocols over diverse mobility patterns that capture specific characteristics. The mobility models used in our analysis include the Random Waypoint, City Section mobility model, Gauss-Markov mobility model and Manhattan mobility model. Mobility metrics objective is to capture some of the aforesaid mobility characteristics and Connectivity graph metrics aim to study the effect of different mobility patterns on the connectivity graph of the mobile nodes. It has also been observed in previous works that under a given mobility pattern, routing protocols perform differently because each protocol differs in the basic mechanisms or “building blocks” it uses.

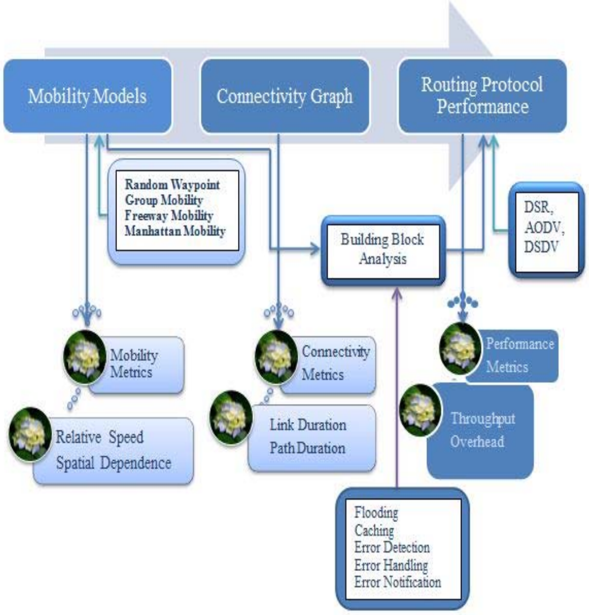


Figure 2 Framework of the Impact of Mobility on the Performance of Routing Protocols.

Formulation of Mobility Models

The random characteristics of mobile nodes in a Spontaneous Network may comprise of a stochastic process, and every single node’s movement may involve a number of sequences of random length intervals called mobility epoch during which a node moves in a constant direction at a constant speed. The direction and speed of a mobile node may show a discrepancy in accordance to mobility benchmarks depending on the varieties of mobility models from epoch to epoch. In group mobility, the similar may be the case for a group of mobile nodes. *Figure 3a* illustrates the movement of a node over convinced epochs by an arbitrary node n from its position n to another position n' over an interval of length t. If we take responsibility that node n moves with a velocity $\mathcal{V}_{in}$ and direction θ_{in} at epoch i and the duration of epoch i of node n is $\mathcal{T}_{in}$, node n moves a distance of $\mathcal{V}_{in}\,\mathcal{T}_{in}$ at an angle θ_{in} . Let us define the distance traversed during time interval $\mathcal{T}_{in}$ by a mobile node at epoch i as an epoch mobility vector $R_i^n = V_i^n\, T_i^n$.

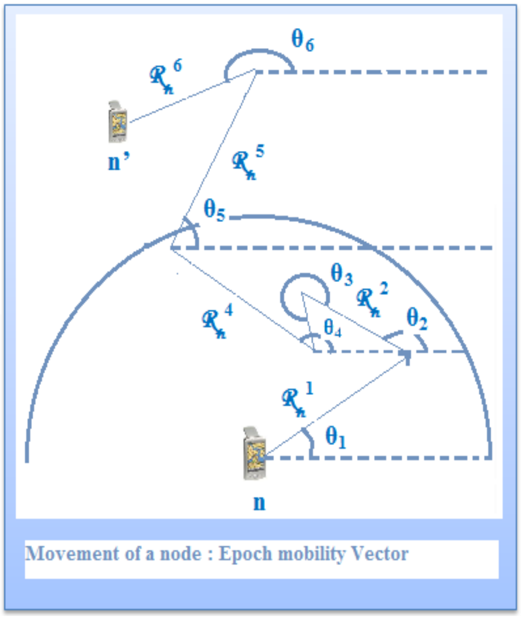


Figure 3a

In fact, *Figure 3b* shows the resulting epoch mobility vector R_i^n and it can be seen that this R_i^n is the vector sum of the individual epoch vectors. However, we need to examine the numerous parameters in order to articulate a mobility model.

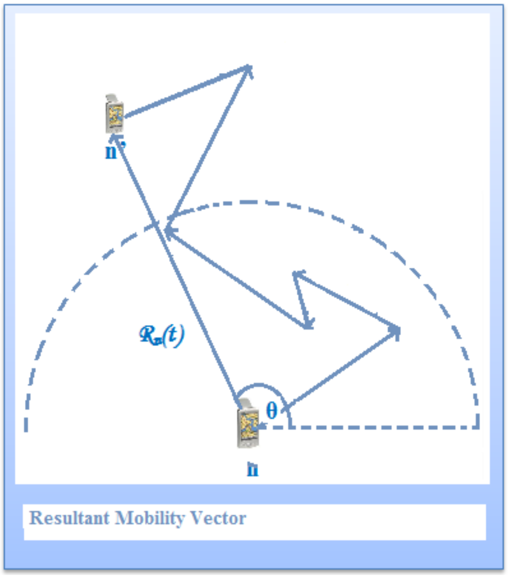


Figure 3b

Link availability is an appropriate metric in becoming died out links are the standards in spontaneous networks. Contrasting cellular systems where mobility is measured relative to a stationary base station, the mobility problem in ad hoc networks is more complex because both ends of each link are mobile. In a spontaneous network, every single communication path consists absolutely of wireless links, which frequently alteration independently of one another. The mobility of the nodes causes frequent link failures, triggering route recovery. Subsequently, Routing delay and the number of control packets are increased.

Mobility Matrices are used to represent the link and path stability, making it significant to investigate mobility metrics in random mobility models.

An energetic path with h hops between any two nodes at time t_0, the path availability $\mathcal{A}(t, h)$ at time t is defined as the probability that the path exists at time t, given that it existed at time t_0.

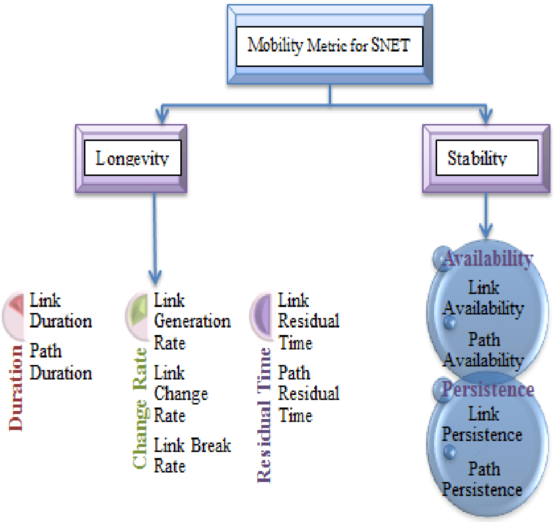


Figure 4 Mobility Metrics

An energetic path with h hops between any two nodes at time t_0, the path persistence $\mathcal{P}(t,h)$, as a function of time, is defined as the probability that the path will continuously last until at least time t, given that it existed at time t_0. An energetic path with h hops between any two nodes at time t_0,, the path residual time, $\mathcal{R}(h)$, is the length of time for which the path will continue to exist until it is broken. The link residual time is denoted $\mathcal{R} \triangleq \mathcal{R}(1)$.

Random Waypoint Mobility Model

Originally, the nodes are presumed to be positioned at random positions in the spontaneous network. The movement of every single node is self-governing of the other nodes in the network. The mobility of a specific node is defined as follows:

The node elects a random target position to travel with the velocity using which the node passages to this chosen position is uniform-randomly nominated from the interval $[v_{min}, \ldots, v_{max}]$. The node travels in a straight line in a specific direction to the preferred position with the elected velocity. After accomplishment the objective setting, the node may rest there for a definite time called the pause time. The node then carry on to choose another objective position and moves to that position with a new velocity chosen again from the interval $[v_{min}, \ldots, v_{max}]$. The selection of each target location and a velocity to move to that location is independent of the current node location and the velocity with which the node reached that location.

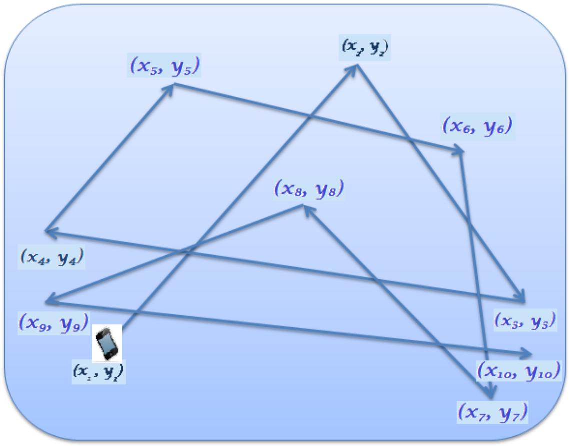


Figure 5 Random waypoint Mobility Model

City Section Mobility Model

Primarily, the nodes are presumed to be arbitrarily located in the path intersections. Each one path is assumed to have a specific speed limit. Based on this speed perimeter and the block length, one can conclude the time it would take to move in the path. Every node positioned at a specific path intersection elects an arbitrary objective path intersection to move will experience the least amount of travel time. In case of two or more paths incur the least amount of travel time, the tie is broken arbitrarily. After attainment of the objective path intersection, the node may stay there for a pause time and then again choose an arbitrary objective path intersection to move. This procedure is repeated independently by each node.

Manhattan Mobility Model

At first, the nodes are supposed to be haphazardly engaged in the path intersections. The movement of a node is decided one path at a time. Initially, every single node has equal probability of electing any of the paths leading from its primary position. After a node initiates to move in the elected direction and touches the successive path intersection, the subsequent path in which the node will move is chosen probabilistically. If a node can stay to move in the identical direction or can also change directions, then the node has 0.5 probability of staying in the identical direction, probability of 0.25 for fine-turning to the east/north and 0.25 probability of fine-turning to the west/south, depending on the direction of the prior movement. If a node has only two alternatives like situation when the node is in one of the four bounding paths of the network, then the node has an equal probability of discovering either of the dualistic options. If a node reaches any of four corners of network, then the node has no other choice except to explore that option..

Gauss-Markov Mobility Model

In the beginning, the nodes are arbitrarily positioned and the movement of a node is self-determining in the network. Every node i is assigned a mean speed, $\check{S}_i$, and mean direction θ_i, of movement. For every constant time period, a node calculates the speed and direction of movement based on the speed and direction during the previous time period, along with a certain degree of randomness incorporated in the calculation. The node is assumed to move with the calculated speed and in the calculated direction during every fixed time period. For a particular time instant, $\mathbf{t_i^{a+1}}$, the speed and direction of a node i is calculated as follows:

$$S_i^{a+1} = \alpha * S_i^a + (1-\alpha) * \overline{S_i} + \sqrt{1-\alpha^2} * S^G\left(t_i^a\right)$$

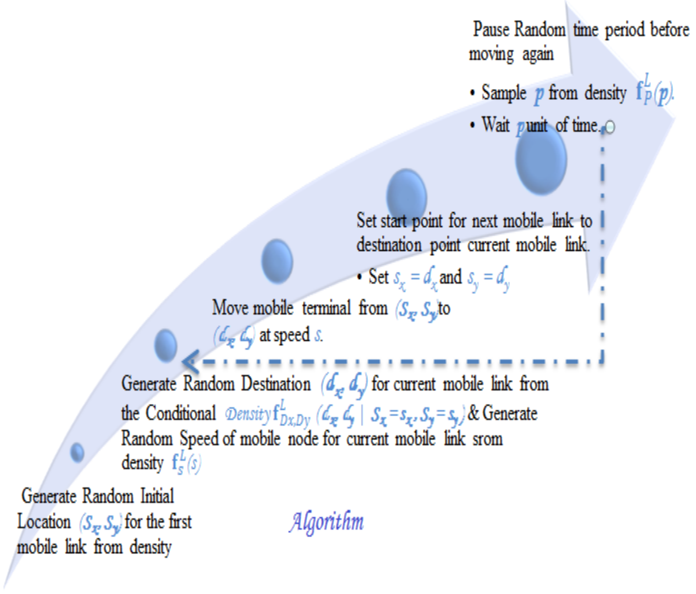
$$\Theta_i^{a+1} = \alpha * \Theta_i^a + (1-\alpha) * \overline{\Theta_i} + \sqrt{1-\alpha^2} * \Theta^G\left(t_i^a\right)$$

The parameter α $(0 \le \alpha \le 1)$ is used to incorporate the degree of randomness while calculating the speed and direction of movement for a time period. The degree of randomness decreases as we increase the value of α from 0 to 1. When α is closer to 0, the degree of randomness is high, which may result in sharper turns. When α is closer to 1, the speed and direction during the previous time period are given more importance (i.e., the model is more temporally dependent) and the node prefers to move in a speed and direction closer to what it has been using so far. Thus, the movement of a node gets more linear as the value of α approaches unity. The terms $S\ G(t_i^a)$ and $G\ (\mathbf{t_i^a})$ are random variables chosen independently by each node from a Gaussian distribution with mean 0 and standard deviation 1. If (x_i^a, y_i^a) are the coordinates of node i at time instant $\mathbf{t_i^a}$, the co-ordinates $(\mathbf{x_i^{a+1}}, \mathbf{y_i^{a+1}})$ of the node at time instant t_i^{a+1} are given by:

$$X_i^{a+1} = X_i^a + [S_i^a * \cos(\Theta_i^a)]$$

$$Y_i^{a+1} = Y_i^a + [S_i^a * \sin(\Theta_i^a)]$$

ALGORITHM



Algorithm

Performance Metrics

The following performance metrics are evaluated:

Percentage Network Connectivity: Percentage network connectivity indicates the probability of finding an *s-d* path between any two nodes in the network for a given network density and level of node mobility. Measured over all the *s-d* sessions, this metric is the ratio of the number of static graphs in which there is an *s-d* path to the total number of static graphs in the mobile graph.

Average Route Lifetime: The average route lifetime is the average of the lifetime of all the static paths of an *s-d* session, averaged over all the *s-d* sessions.

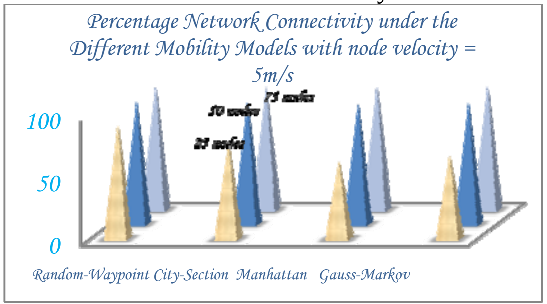
Average Hop Count: The average hop count is the time averaged hop count of a mobile path for an *s-d* session, averaged over all the *s-d* sessions. The time averaged hop count for an *s-d* session is measured as the sum of the products of the number of hops for the static *s-d* paths and the corresponding lifetime of the static *s-d* paths divided by the number of static graphs in which there existed a static *s-d* path. For example, if a mobile path comprises of a *2-hop* static path *p1*, a *3-hop* static path *p2*, and a *2-hop* static path *p3*, existing in static graphs *1-3*, *4-7* and *8-10* respectively, then the time-averaged hop count of the mobile path would be $(2*3 + 3*4 + 2*3) / 10 = 2.4$.

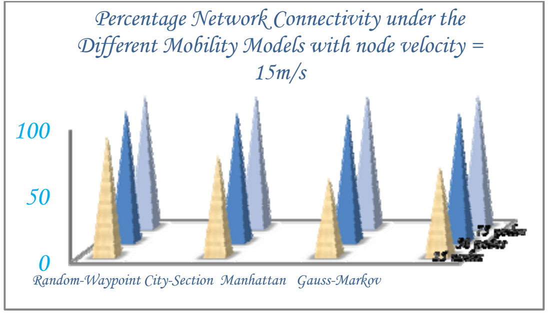
Network Connectivity: In case of minor-density networks, the inferior network connectivity achieved with the dual mobility models can be credited to the constrained motion of the nodes. In the instance of the Manhattan mobility model, the probabilistic behavior of direction selection after reaching each boarder is also a cause behind the lowest network connectivity detected for this mobility model among all the four mobility models. The amount of nodes dispersed in the area of the network may not be sufficient enough to connect any pair of source-destination nodes all the time. The direction of movement of the nodes is constrained close to the originally initialized mean direction of movement randomly chosen from $[0\ldots2\pi]$, in the case of the Gauss-Markov mobility model. When there are rare nodes in the network, the limited movement of the nodes close to the mean direction of movement is a restraining factor for network connectivity. Together the Random way mobility model and the Gauss-Markov mobility model exhibit a significant growth in network connectivity, for all levels of node mobility once we raise the number of nodes in the network. This demonstrates the fact that the randomness related with the mobility models guarantees that any combination of nodes will persist connected, provided we have at least a sensibly superior number of nodes, irrespective of the different levels of node mobility.

Simulation Results

Minimum hop mobile path

We now discuss the time averaged hop count per minimum hop path (refer Figure 8) and the average route lifetime (refer Figure 9) of the minimum hop paths determined as the constituent paths of the Minimum Hop Mobile Path under the four mobility models.





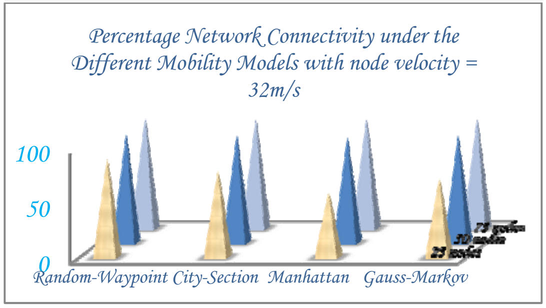
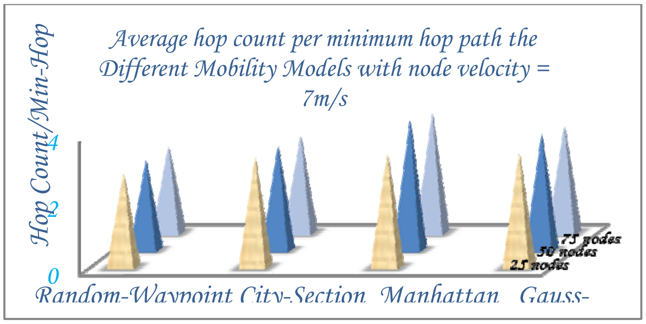
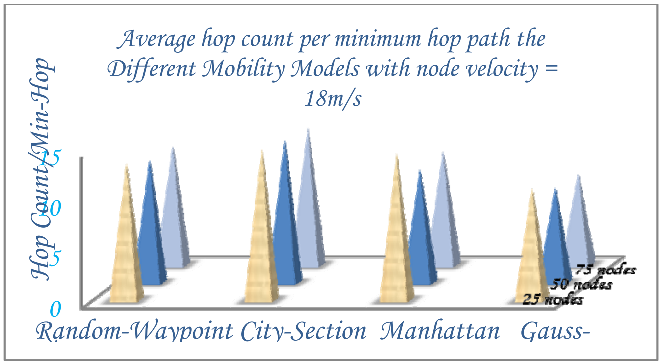


Figure 7 Percentage Network Connectivity

Average hop count per minimum hop path

The average hop count per minimum hop path determined for the two SNET mobility models and the Gauss-Markov model is considerably larger than the hop count per minimum hop path determined for the Random Waypoint mobility model. The relatively larger hop count can be attributed to the constrained mobility of the nodes under these three mobility models. The minimum hop paths in the street networks are most likely not to exist on or close to the straight line between source and destination nodes. Similarly, due to the temporal dependency associated with the Gauss-Markov mobility model, one cannot always find minimum hop paths lying on a straight line connecting the source and destination nodes. Based on our observations in Figures 8 we can arrive at the following ranking of the four mobility models in the increasing order of the magnitude of the hop count for the minimum hop paths: Random Waypoint model, City Section model, Gauss-Markov model and the Manhattan model.





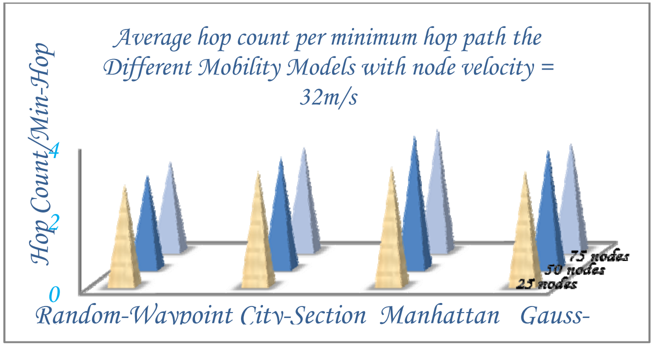


Figure 8 Average Hop count per min. hop Path

The average hop count per minimum hop path with a particular node velocity, under the Manhattan mobility model, Gauss-Markov mobility model and the City Section mobility model is respectively about 0.19, 0.17 and 0.14 more than that experienced for the Random Waypoint mobility model in minor-density networks. In moderate and high-density networks, the average hop count per minimum hop path under the City Section, Gauss-Markov and Manhattan mobility models is respectively about 18%, 25% and 40% more than that incurred for the Random Waypoint mobility model. We also observe that with increase in network density, the average hop count per minimum hop path for the Random Waypoint mobility model, City Section mobility model and the Gauss-Markov mobility model decreases (by a factor of 5%-10%).

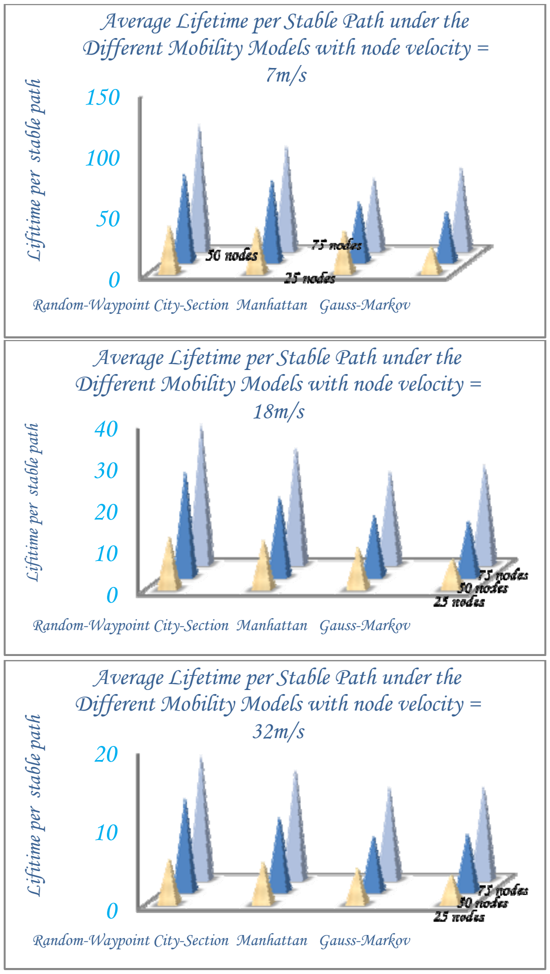


Figure 9 Average Lifetime per Stable Path

On the other hand, with increase in network density, the average hop count per minimum hop path for the Manhattan mobility model remained the same or even sometime increases up to 14%. This can be attributed to the significant increase in the network connectivity for the Manhattan mobility model with increase in network density, but at the cost of increase in hop count. Given the particular self-conscious constraints and random behavior of node movement under the Manhattan mobility model, with respect to source and destination, supplementary intermediary nodes have to be accommodated in the s-d paths.

Conclusions

Like the model of quality of service is carry out by a set of constraints; the mobility model will be carry out by a set of metrics. The study signposts that the significant constraints for the precision of mobility metrics are the node density dissemination and the stability. The techniques of mobility metric calculation have straight emotional impact on the metric accuracy. The more genuine is a mobility model, the superior is the number of hops in the minimum hop routes and smaller is the lifetime of stable routes determined under the mobility model. The Random Waypoint model yielded the lowest hop count for minimum-hop routes and the largest lifetime for stable routes. On the other hand, more realistic mobility models such as the Gauss-Markov model and the Manhattan model yield a relatively larger number of hops for minimum-hop routes and a relatively smaller lifetime for stable routes. For a specified scenario of network density and node mobility, the average hop count of a Minimum Hop Mobile Path is less significant than the average hop count of a Stable Mobile Path; the average route lifetime of a Stable Mobile Path is more than the average route lifetime of a Minimum Hop Mobile Path.

References

[1] S. A. Kulkarni and G. R. Rao, “Mobility Model Perspectives for Scalability and Routing Protocol Performances in Wireless Ad hoc Networks,” Proceedings of the First International Conference on Emerging Trends in Engineering and Technology, pp. 176 – 181, July 2008.

[2] T. Camp, J. Boleng and V. Davies, “A Survey of Mobility Models for Ad Hoc Network Research,” Wireless Communication and Mobile Computing, Vol. 2, No. 5, pp. 483-502, September 2002.

[3] F. Bai, N. Sadagopan and A. Helmy, “IMPORTANT: A Framework to Systematically Analyze the Impact of Mobility on Performance of Routing Protocols for Ad hoc Networks,” Proceedings of the IEEE International Conference on Computer Communications, pp. 825-835, March-April, 2003.

[4] J. Ariyakhajorn, P. Wannawilai and C. Sathitwiriyawong, “A Comparative Study on Random Waypoint and Gauss-Markov Mobility Models in the Performance Evaluation of MANET,” Proceedings of the International Symposium on Communications and Information Technologies, pp. 894-899, September 2006.

[5] M. Abolhasan, T. Wysocki and E. Dutkiewicz, “A Review of Routing Protocols for Mobile Ad hoc Networks,” Elsevier Ad Hoc Networks, Vol. 2, No. 1, pp. 1-22, January 2004.

[6] S. P. Chaudhri, J. Y. L. Boudec, M. Vojnovic, “Perfect Simulations for Random Trip Mobility Models,” Proceedings of the 38th Annual Symposium on Simulation, pp. 72-79, San Diego, USA, April 2005.

[7] M. I. M. Saad and Z. A. Zukarnain, “Performance Analysis of Random-based Mobility Models in MANET Routing Protocol,” European Journal of Scientific Research, Vol. 32, No. 4, pp. 444-454, 2009.

[8] S. A. Kulkarni and G. R. Rao, “Mobility Model Perspectives for Scalability and Routing Protocol Performances in Wireless Ad hoc Networks,” Proceedings of the First International Conference on Emerging Trends in Engineering and Technology, pp. 176 – 181, July 2008.

[9] B. Divecha, A. Abraham, C. Grosan and S. Sanyal, “Impact of Node Mobility on MANET Routing Protocols Models,” Journal of Digital Information Management, Vol. 4, No. 1, pp. 19 – 23, February 2007.

[10] G. Ravikiran and S. Singh, “Impact of Mobility Models on the Performance of Routing Protocols in Ad hoc Wireless Networks,” Proceedings of the 59th IEEE Vehicular Technology Conference (VTC 2004-Spring), Vol. 4, pp. 2185 – 2189, May 2004.

[11] F. Bai, N. Sadagopan and A. Helmy, “The IMPORTANT Framework for Analyzing the Impact of Mobility on Performance of Routing Protocols for Ad hoc Networks,” Elsevier

Ad hoc Networks, Vol. 1, No. 4, pp. 383 ‐ 403, November 2003.