

Link analysis on Indoor and Outdoor environment for Mobile Ad hoc NETwork Supported with base stations

Dr.Ibrahim khider¹ ,Amna Saad¹ ,Prof.WangFurong²

¹Department of electronics, Sudan University of Science and Technology,
P.O.Box 72,Eastern Deims Khartoum, Sudan

²Communication Switch Research Center ,Dept of Electronic and Information Engineering
Huazhong University of Science and Technology
,P.R.China-Wuhan-430074

Abstract

Mobility and connectivity metrics in Mobile Ad hoc NETwork (MANET) is one of the most important topics in Indoor and Outdoor environment. Each MANET mobility and connectivity metrics has its own strengths and weaknesses. It turns out the impact of mobility model has become a critical issue in the research of performance comparison. In this paper, we provide a study of the link analysis in indoor and outdoor environment supported with base stations in which mobile nodes move according to random waypoint mobility model (RWP) and Manhattan mobility model (MH) respectively. The analysis includes the mobility and connectivity metrics in environment model. We provide in-depth investigation such as the impact of speed, number of nodes and simulation time on link, and how parameters of combined mobility model influence link dynamics. Our study about the link analysis gives an insight into the network topology dynamics of MANET, and it provides the basis of further analysis of MANET such as network connectivity. Simulation results verify our analysis of the link of MANET in indoor and outdoor environment.

Key words: mobility model, mobility metrics, connectivity metrics, environment, Mobile Adhoc Networks, base stations, Simulation.

1. INTRODUCTION

A Mobile Ad hoc NETwork (MANET) is considered to be an autonomous system of self-organized mobile nodes without relying on any infrastructure. However cellular network, where at least one access point (base station) regulates the access of the nodes. Therefore, ad-hoc networks offer immense flexibility. These properties of ad-hoc networks have increased the interest in them in recent years, also for real world scenarios. The confluence of these two wireless models and technology presents opportunity for new type of wireless network paradigm; we call it a hybrid wireless network [Karthik , 2004][Mesut ,2006]. Node mobility is one of the key characteristics of MANET, and it is also one of the critical factors that have significant influence on the performance of MANET protocols, mainly the routing protocols. Conventional mobility models proposed for MANET can be classified into two categories: Entity model and Group model. Entity models are used to represent the movement of an individual mobile node. Among Entity models, the Random Waypoint model (RWP) [T. Camp, 2002] is the most popular model used in this field. However, the interaction among the mobile nodes cannot be reflected by Entity models. Group models are therefore proposed. A typical model is the Reference Point Group Mobility (RPGM) model [X. Hong, 1999]. A major drawback of conventional models is that

some environment factors such as spatial constraints, speed limits, etc are ignored. Street traffic system could be an example environment. Cars are moving along the roads and choose one way out if a junction is met. The people follow the routes to building, spend some time there then go out from one of the room exits. Moreover, in some certain environment such as arts exhibition, the destinations of visitors are not random, but more or less deterministic in that they always visit some places more attractive to them. These mobility scenarios cannot be handled properly by most of existing models. In this paper, two particular environments in the realistic world are studied. Accordingly, two environment-aware mobility models are introduced and simulated. The Random Waypoint model is used to model the movement in buildings in the simulation area and mobile adhoc networks supported with base stations to discuss their impact on the overall performance of the wireless network in urban area we have used a scenario generated with NS-2 [Jae Chung]. The Manhattan model can be used to construct streets such as in a city area. The remainder of the paper is organized as follows. Sections 2 briefly review related research in the area of mobility modeling; the two mobility models (RWP and Manhattan) are overviewed. Section3 depicts a combine mobility model in urban area. Description of the intensive simulations and results are given in sections 4 and 5respectively. The last section presents the conclusion.

The remainder of the paper is organized as follows. RWP and Manhattan are overviewed in section2 and 3 respectively. Section4 depicts a combine mobility model in indoor and outdoor environment. Section 5 describes mobility and connectivity metrics Description of the intensive simulations and results are given in section 6 and 7 respectively .The last section presents the conclusion.

2. RANDOM WAYPOINT MOBILITY MODEL

Random Way Point mobility model (RWP) [J. Yoon,2003] [F. Bai, 2003][F. Bai ,2004][W. Navidi,2004] is simple and widely used in many simulation studies of ad hoc routing protocols. In this model each node is assigned an initial position uniformly distributed within a region (rectangular region). Then, each node chooses a destination uniformly inside the region, and selects a speed uniformly from [minspeed, maxspeed] independently of the chosen destination. That means the distributions of nodes' speeds and locations are stationary. To avoid the transient period from the beginning, one solution is to choose the nodes' initial locations and speeds according to the stationary distribution; another one is to discard the initial time period of simulation to reduce the effect of such transient period on simulation results. The node then moves toward the chosen destination with the selected speed along a straight line starting from current waypoint. After reaching the destination, the node stops for duration called "pause time", and then repeats the procedure. All nodes move independently of each other at all time.

3. MANHATTAN MOBILITY MODEL

The MH model is used to emulate the nodes movement on streets defined by maps [F. Bai, 2003][F. Bai ,2004]. The map is composed of a number of horizontal and vertical streets. Each street has two lanes, one in each direction (North/ South for vertical streets, and East/West for horizontal ones). Each node is only allowed to move along the grid of horizontal and vertical streets. At an intersection of horizontal and vertical streets, a mobile node can turn left, or right, or go straight with probabilities 0.25, 0.25, and 0.5, respectively. The speed of a mobile node is temporarily dependent on its previous speed 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 Mobility models capture the geographic restrictions. The

speed of a node $s(t)$ is updated according to: $s(t+1) = \min(S_{max}, \max(0, s(t) + a(t) * X))$ where X Uniform $[-1, 1]$, and $a(t)$ is Acceleration Speed.

4. DESCRIPTION OF COMBINED MOBILITY MODEL IN URBAN AREA ENVIRONMENT

This section introduces a combined model of Manhattan and Random Waypoint, the movements of a node switch from one mobility model (Manhattan or Random Waypoint) to another based on its location in the network. When the nodes are on the street, they move as Manhattan mobility model movement pattern, when they are located in the building, they will move as Random Waypoint model. The movement nodes are divided in two groups depending on their speed a “pedestrian” group with a low speed and a “vehicular” group with a higher speed. The pedestrian group of users is moving with a normal distributed speed with a mean of 3 km/h and a standard deviation of 0.3 km/h [F. Bai, 2003]. The vehicular group of users has also a normal distributed speed but with a mean of 50 km/h and a standard deviation of 2.5 km/h. At each cross-road, users of both groups can either continue straight with the probability $Pr(\text{straight}) = 0.5$ or turn left/right with the probability $Pr(\text{left}) = Pr(\text{right}) = 0.25$. To represent the movement of mobile nodes in outdoor environment (streets) and indoor environment (buildings) we have used Finite State Machine (FSM) to explain the movement of mobile nodes by using state diagram and state transition table as shown in fig.1 and TABLE.1, .

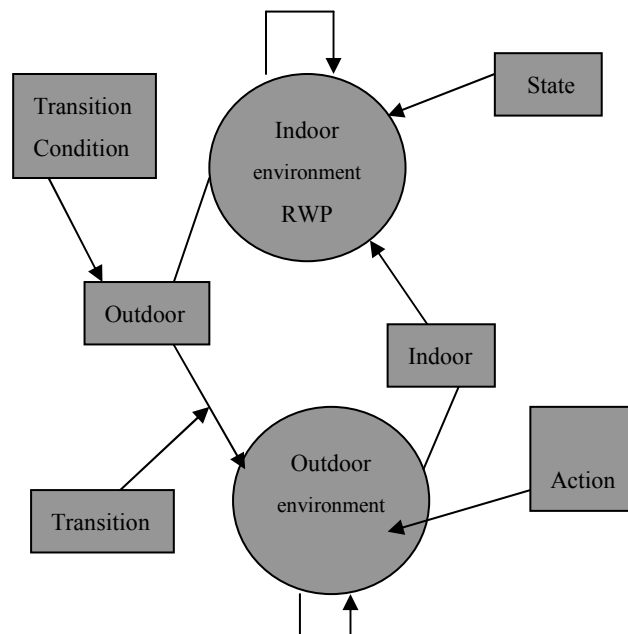


Fig.1, State Transition Diagram of Random Waypoint and Manhattan Mobility Model

In the paper, we limit the study to an urban area supported with base stations modeled by a RWP and Manhattan mobility model. The area is wrapped around North-South and West-East and the grid is composed of 4 by4 buildings. The buildings are 240X240m and the streets have two opposite lane, the distance between lanes is 1 m and the width of lane is 6 meter. Fig.2 shows the layout of indoor and

outdoor environments in urban area and the movement of nodes. Fig.3 shows the movement of nodes in simulation area using manhattan and Random Waypoint mobility models.

TABLE.1, State Transition Table of Random Waypoint and Manhattan Mobility Model

Conditions	Current State	
	MH State	RWP State
Condition Indoor	RWP	RWP
Condition Outdoor	MH	RWP

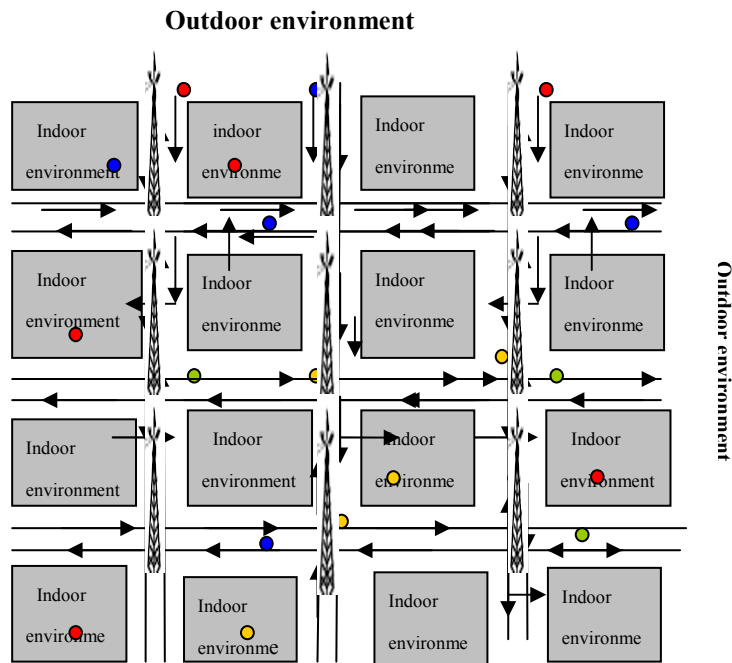


Fig.2, Layout of 3X3Urban environment

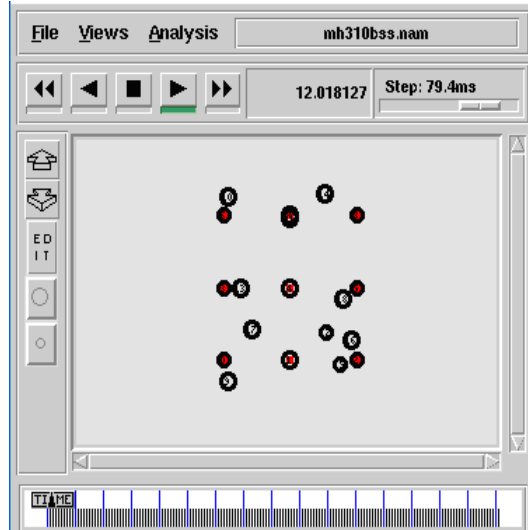


Fig.3, Movement of Nodes in Simulation Field
With 9 base stations

5. OVERVIEW OF MOBILITY AND CONECTIVITY METRICS

Many metrics have been used with the aim to adapt routing protocols to the possible changes in the network topology due to node mobility [F. Bai, 2003]. In this section a variety of metrics have been used to measuring link analysis and the performance in the environment model. Figs.2, 3 shows a typical movement scenario in indoor and outdoor environment that we will principally use in our simulation tests. Before defining the metrics, we introduce basic terminologies used in the paper:

$\vec{V}_i(t)$: Velocity vector of node i at time t.

$\vec{V}_j(t)$: Velocity vector of node j at time t.

$\vec{V}_i(t')$: Velocity vector of node i at time t' .

$X(i, j, t)$: Indicator variable.

$N(i, t)$: the number of neighbor nodes for node i at time t.

$C(i, j, t)$: Link connectivity between nodes i and j at time t.

T : Simulation time

N : Number of mobile node.

Speed-based Metrics: -

- Average Relative Speed between all nodes (RS) is the average magnitude of relative speed of two nodes over all neighborhood pairs and all time. RS is given by:

$$RS(i, j, t) = \left| \vec{V}_i(t) - \vec{V}_j(t) \right| \dots \dots \dots (1)$$

-Spatial Dependence: the average function value of angle of

Relative velocity of two nodes over all neighborhood pairs and all times, the following equation shows Degree of spatial dependence

$$D_{spatial}(i, j, t) = RD(\vec{v}_i(t), \vec{v}_j(t)) * SR(\vec{v}_i(t), \vec{v}_j(t)) \dots \dots \dots (2)$$

RD is relative direction and SR is speed ratio

-Degree of temporal dependence: shows the similarity of node's velocities at different times [3], and it is given by:

$$D_{temporal}(i, t, t') = RD(\vec{v}_i(t), \vec{v}_i(t')) * SR(\vec{v}_i(t), \vec{v}_i(t')) \dots \dots \dots (3)$$

Link-based Metrics:

The idea is based on using link information's experienced by every node. There exists a link between two nodes, if they are in each other transmission range. The most used for link-based Metrics are:

- Link Duration (LD): the duration of one link is calculated as the time that two nodes are within transmission rang of one other .LD is given by:

$$LD = \begin{cases} \sum_{t=1}^T \frac{X(i, j, t)}{LC(i, j)} & \text{if } LC \neq 0 \\ \sum_{t=1}^T X(i, j, t) & \text{otherwise} \end{cases} \dots \dots \dots (4)$$

-Number of link change LC (i, j): Number of link changes for a pairs of nodes i and j is a number of times the link between them down to up. Average number of link changes LC (i, j) averaged over all node pairs is given by:

$$LC(i, j) = \sum_{t=1}^T c(i, j, t) \dots \dots \dots (5)$$

Density-based Metrics

Node Density (ND) is the number of neighbors seen by the considered node. Average number of nodes that stay within a node radio range at a time t is given by the following equation:

$$ND = \frac{\sum_{T=1}^T \sum_{i=1}^N N(i, t)}{TN} \dots \dots \dots (6)$$

6. SIMULATION DESCRIPTION

A variety of matrices have been used for the MANET environment. In this paper, we study the most popular mobility and connectivity metrics in urban area environment. Our evaluations are based on the simulation using Network Simulator (NS-2) environment with CMU wireless adhoc networking extension [T. Camp, 2002] and we extract the useful data from trace file using mobility trace analyzer tool (version 1.0 beta) [F.Bai, 2004] then the graphs are generated using Matlab. Simulation environment consists of 10 wireless nodes forming an ad hoc network, moving over a 1000 X 1000 space, DSR routing protocol for 900 seconds of simulated time. We implemented a shadowing model as radio propagation model with values of the path loss exponent ($\beta= 5$) and the shadowing deviation ($\sigma_{dB}=4$ dB). Each run of the simulator accepts as input a scenario file that describes the exact motion of each node and the exact sequence of packets originated by each node, together with the exact time at which each change in motion or packet origination is to occur. We have generated different scenario files with

varying movement patterns and traffic loads (CBR), the traffic consist of cbr type with 9 connections, data rate 1 packet/sec, packet size 512 byte and the transmission range 250m. And then ran against each of these scenario files. When Nodes in street move according to manhattan model otherwise they move according to Random Waypoint model .The movement scenario files used for each simulation are characterized by a number of nodes and simulation times. Each simulation ran for 900 seconds. We ran our simulations with movement patterns generated for 10 nodes with different maximum speed. In simulation, we chose to make evaluation according to the following metrics: Relative Speed, Spatial Dependence, Temporal Dependence, Link Duration, Link Change and Node Degree.

7. SIMULATION RESULTS

Figures below demonstrate the simulation results by applying different maximum speed for urban area supported with base stations as shown in figures2, 3.

Figure.4 shows that the relative speeds is increase linearly when maximum speed increases before and after 30m/sec the drop happen in 30m/sec due to using RWP as movement pattern . The values of spatial dependence are decrease when maximum speed increases as shown in figure.5. Figure.6 shows that the values of temporal dependence approximately zero before maximum speed reach 40m/sec then it become high.Figure.7 shows that the link duration decreases linearly when maximum speed increase. Node degree has fluctuation values as shown in figure.8 due to random behavior in our model.figure.9 shows the effect of speed in changing link, when maximum speed increases link change increases accordingly. We can conclude that fluctuation values for our results occurred because of using random waypoint as apart of our urban model.

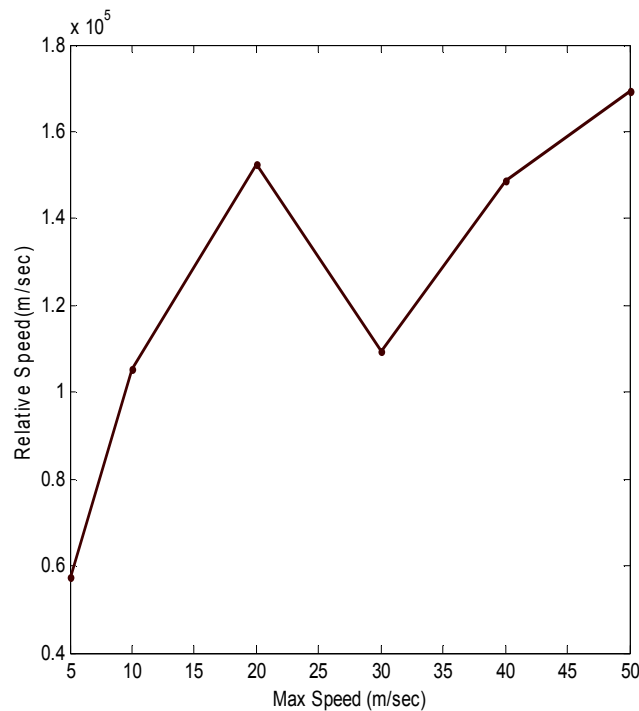


Fig.4, Relative Speed Vs Speed for 3x3urban area

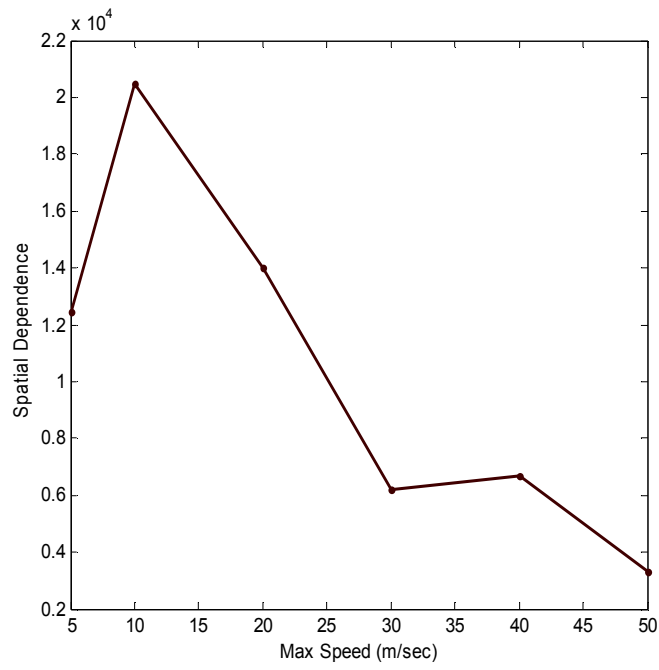


Fig.5, Spatial Dependence Vs Speed for 3x3urban area

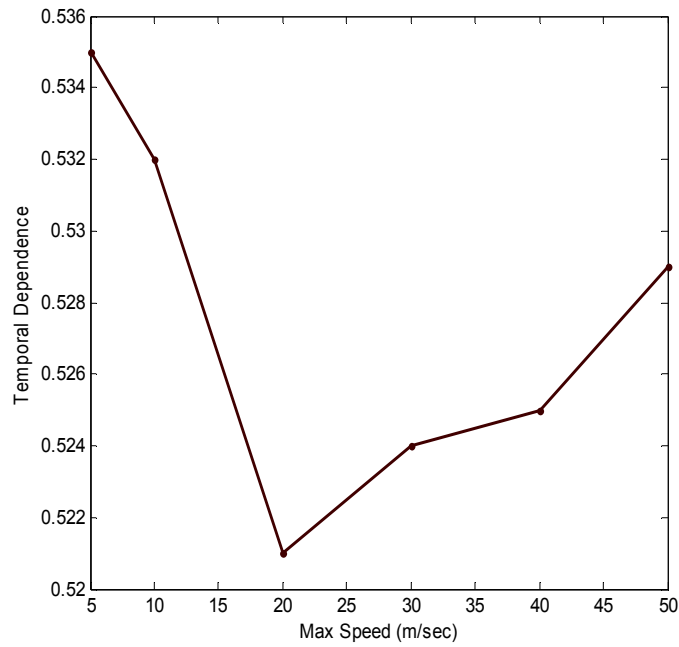


Fig.6, Temporal Dependence Vs Speed for 3x3urban area

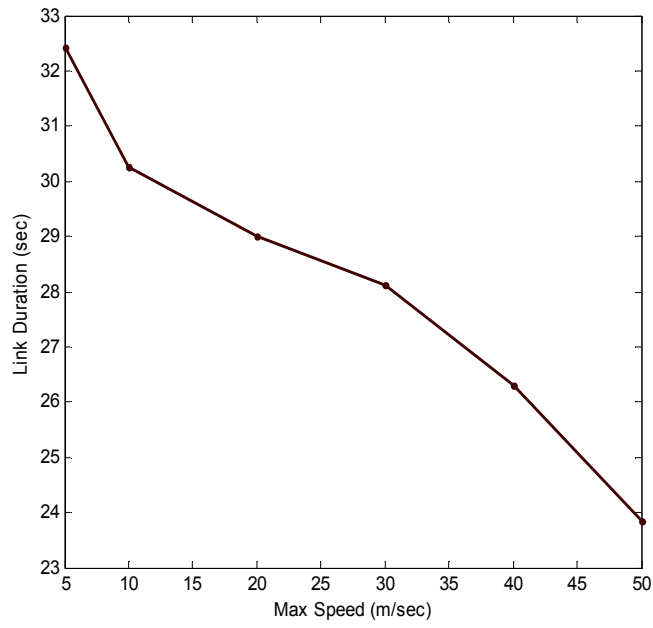


Fig.7, Link duration Vs Speed for 2x2urban area

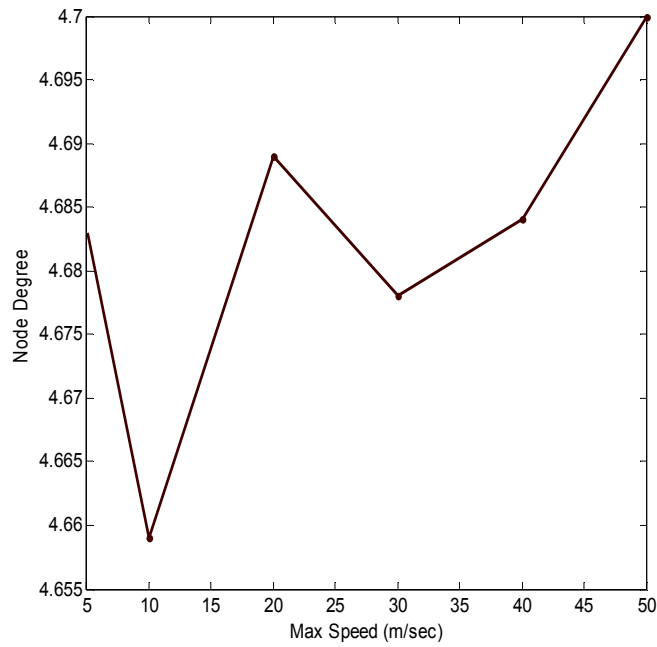


Fig.8, Node Degree Vs Speed for 3x3urban area

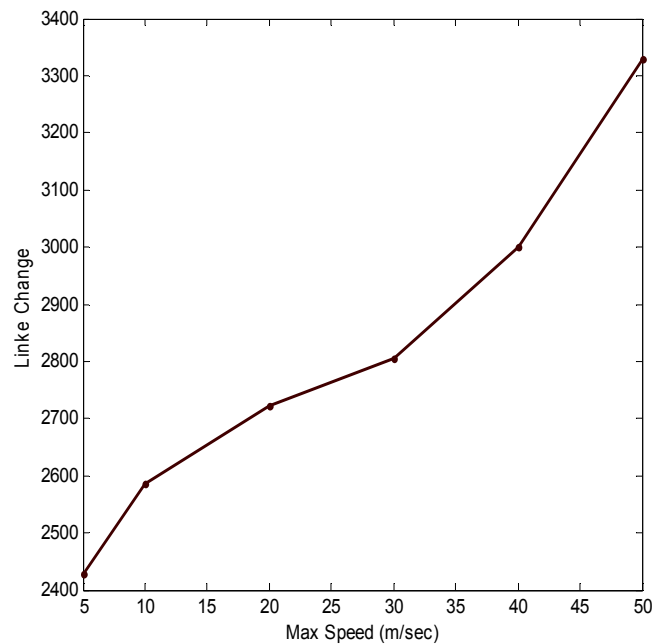


Fig.9, Link change Vs Speed for 3x3urban area

8. CONCLUSION

In this paper, we investigated some important issues related to the simulation and use of MANETs in urban environments. In particular, we introduced urban environment which include indoor and outdoor environment with combine mobility model (RWP and MH). We used our simulation model to study some general characteristics (set of metrics) of urban environments and their impact on MANET performance. We implemented a combined mobility model in the IMPORTANT framework in NS-2 and we used a framework to analyze the link. The impact of mobility and connectivity metrics on environment is presented. We have presented mobility metrics using mobility information. Our study indicates that the mobility and connectivity metrics are useful to capture and understand the mobility characteristics, we observe that some scenarios improve with add velocity. On the other hand, it is found that using mobility metric based on link and neighbors can be useful to study the performance with high mobility. Also we observe that the metrics influence the performance in environment model in urban area. Our study has shown that the simulation results are highly dependent on the movement behaviours of mobile node and simulation environment.

9. Acknowledgements

This work was supported by Sudan University of Science and Technology.

10. REFERENCES

- [1] Karthik Ramachandra, Hesham H. Ali, 2004, "Evaluating the Performance of Various Architectures for Wireless Ad Hoc Networks", Proceedings of the 37th Hawaii International Conference on System Sciences IEEE.
- [2] Mesut Güne, Jan Siekermann, 2006, "Are Ad-hoc Networks Able to Substitute Cellular Networks? A Performance Comparison of Ad-hoc Network Routing Protocols in Realistic Scenarios",

International Computer Science Institute (ICSI) Berkeley, CA, USA and Department of Computer Science, Informatik 4 RWTH Aachen University, Germany (Invited Paper).

[3] T. Camp, J. Boleng, and V. Davies, 2002, "A Survey of Mobility Models for Ad Hoc Network," Research in Wireless Communication and Mobile Computing (WCMC): Special issue on Mobile Ad Hoc Networking: Research, Trends and Applications, vol.2, no. 5, pp. 483-502.

[4] X. Hong, M. Gerla, G. Pei, and C. Chiang, 1999, "A group mobility model for ad hoc wireless networks," In Proceedings of the ACM International Workshop on Modeling and Simulation of Wireless and Mobile Systems (MSWiM).

[5] Jae Chung and Mark Claypool, Network Simulator, <http://nile.wpi.edu/NS/>

[6] J. Yoon, M. Liu, and B. Noble, 2003, "Sound Mobility Models," in Proc. ACM/IEEE Int'l Conf. Mobile Computing and Networking (MOBICOM '03), pp. 205-216.

[7] F. Bai, N. Sadagopan, and A. Helmy, 2003, "IMPORTANT: A framework to systematically analyze the Impact of Mobility on Performance of Routing protocols for Adhoc Networks," in IEEE INFOCOM'03.

[8] F. Bai and A. Helmy, 2004, "A Survey of Mobility Modeling and Analysis in Wireless Adhoc Networks", chapter, University of southern California, USA.

[9] W. Navidi and T. Camp, 2004, "Stationary Distributions for the Random Waypoint Mobility Model," IEEE Transactions on Mobile Computing ITMMC-3 pp. 99-108. Adhoc Networks," Book Chapter, Kluwer Academic Publishers.

[10] F. Bai and A. Helmy 2004, Mobility Trace Analyzer Tools, <http://nile.usc.edu/important/software.htm>