The effect of two realistic Radio Propagation Models for Mobile Ad hoc NETworks in Urban Area Environment Supported with stations

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Abstract—In the field of Mobile Ad Hoc Networking, most current results have been achieved using simulators. Network simulation tools are frequently used to analyze performance of MANET protocols and applications. The need for reproducible results and easy to observe environments limits the use of real world measurements for those kind of networks. They commonly offer only simple radio propagation models that neglect obstacles of a propagation environment .The radio wave propagation model has a strong impact on the results of the simulation run. It is stated here that the two more realistic radio propagation models has a strong impact on the results of the simulation run. The model is based on data of the simulation area in urban area. Consequently, we obtain different performance evaluation results. This paper gives insights on the effect of these propagation models for MANETs in indoor and outdoor environments and presents the parameters and the results of simulating

Index Terms— Mobile Adhoc Network, Propagation models, Mobility Models, base stations, Simulation.

1 INTRODUCTION

Mobile ad-hoc networks (MANETs) are created spontaneously by wireless communication peers, without relying on a fixed infrastructure. The devices communicate directly with each other when they are in transmission range. Network simulation tools [1], [2] are frequently used to analyze the performance of MANET protocols and applications. These tools model the applications running on mobile devices, the wireless network protocol stack, radio signal propagation, and the mobility of the network users. The radio propagation models used in common MANET simulators assume an obstacle-free area and a free line-of sight between all communicating partners. As a consequence, the communication range is modeled by a simple circle around the mobile device. However, this poorly reflects radio wave propagation in a typical outdoor scenario, like a city center, in which buildings significantly affect the communication between nodes. Nevertheless, the vast majority of publications that investigate MANET protocol and application behavior still rely on such simple models. Due to the nature of self-organization, the dynamic topology caused by mobility and transmission power control, and the multiple-hop routing in MANETs, it is difficult to build a complete analytical model to study the network performance. On the other hand, a real testbed is expensive. Therefore, the simulation study of MANETs is important. In this paper, we study different radio propagation models using ns-2 [2] because it is open source and is widely used in both academia and industry. In ns-2 the radio propagation models have the following features: the Friss-space model is used for short distances and the approximated two-ray-ground model is used for long distances. The shadowing model is employed to characterize the probabilistic multiple path fading during radio propagation. These models are considers data of the simulation area, which are available from urban environment. Radio propagation waves are necessary propagation characteristics for any configuration. The environments systems are intended to be installed are ranging from indoor up to outdoor environment .Hence wave propagation models are required covering whole range including indoor and outdoor environment scenarios. The phenomena which effect radio wave propagation can generally be described by five mechanisms as following; Reflection: is the abrupt change in direction of a wave front at an interface between two dissimilar media so that the wave front returns into the medium from which it originated. Reflecting object is large compared to

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wavelength. Scattering: is a phenomenon in which the direction (or polarization) of the wave is changed when the wave encounters propagation medium discontinuities smaller than the wavelength results in a disordered or random change in the energy distribution. Diffraction: is the mechanism that the waves spread as they pass barriers in obstructed radio path (through openings or around barriers).Diffraction is an important when evaluating potential interference between terrestrial and stations sharing the same frequency. Absorption is the conversion of the transmitted EM energy into another form, usually thermal. The conversion takes place as a result of interaction between the incident energy and the material medium, at the molecular or atomic level. One cause of signal attenuation due to walls, precipitations and atmospheric gases. Refraction: is redirection of a wave front passing through a medium having a refractive index that is a continuous function of position or through a boundary between two dissimilar media. For two media of different refractive indices, the angle of refraction is approximated by Snell's Law known from optics penetration. Figure.1 shows these mechanisms. We use an existing implementation of the propagation model from a specialized tool. We prove that the usage of radio propagation models change simulation results considerably. The remainder of this paper is structured as follows. In Section II, we present mobility models. Section III gives an overview of shadowing and ricean models. Section IV describes the scenarios in urban area. Section V illustrates the results .Section VIconcludes this paper.

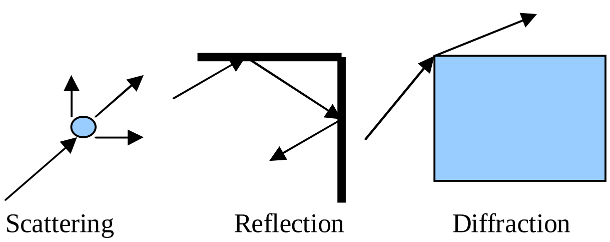

Fig. 1, the phenomena effect radio wave propagation

2 MOBILITY MODELS

A mobility model is a representation of a certain real or abstract world that contains moving entities. A mobility model is usually used to describe the mobility of an individual subscriber. Sometimes it is used to describe the aggregate pattern of all subscribers. The following discussion attempts a brief overview of the two commonly used mobility models to analyze design systems in wireless ad hoc networks , each with a specific goal and suitable for a specific scenario. Random Way Point mobility model (RWP) [3] [4] [5] [6] is a simple, widely used, model in the 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 times. Manhattan model is used to emulate the nodes movement on streets defined by maps [4] [5]. The map is composed of a number of horizontal and vertical streets. Each street has two lanes, one in each direction (North and South for vertical streets, and East and 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.

3 RADIO PROPAGATION MODELS

Radio channels are much more complicated to analyze than wired channels. Their characteristics may change rapidly and randomly. There are large differences between simple paths with line of sight (LOS) and those which have obstacles like buildings or elevations between the sender and the receiver (Non Line of Sight (NLOS)). To implement a channel model generally two cases are considered: large-scale and small-scale propagation models. Large scale propagation models account for the fact that a radio wave has to cover a growing area when the distance to the sender is increasing. Small scale models (fading models) calculate the signal strength depending on small movements or small time frames. Due to multipath propagation of radio waves, small movements of the receiver can have large effects on the received signal strength. In the following, frequently used propagation radio models are described in more detail.

-Shadowing model: The shadowing model realizes the log-normal shadowing model. It is assumed that the average received signal power decreases logarithmically with distance. A Gaussian random variable is added to this path loss to account for environmental influences at the sender and the receiver. The shadowing model consists of two parts.

The first one is known as path loss model, which also predicts the mean received power at distance d, denoted by $\overrightarrow{P_r(d)}$ It uses a close-in distance d0 as a reference. $\overline{P_r(d)}$ is computed relative to $P_r(d_0)$ as follows.

$$\left[\frac{P_r(d_0)}{\overline{P_r(d)}}\right]=\left(\frac{d}{d_0}\right)^{\beta} \quad (1)$$

β is called the path loss exponent, and is usually empirically determined by field measurement. From Eq. (1) we know that β = 2 for free space propagation. Table.1 gives some typical values of β larger values correspond to more obstructions and hence faster decrease in average received power as distance becomes larger. $P_r(d_0)$ can be computed from Eq. (1). The path loss is usually measured in dB. So from Eq. (1) we have

$$\left[\frac{\overline{P_r(d)}}{P_r(d_0)}\right]_{dB}=-10\beta\log\left(\frac{d}{d_0}\right) \quad (2)$$

The second part of the shadowing model reflects the variation of the received power at certain distance. It is a log-normal random variable that is; it is of Gaussian distribution if measured in dB. The overall shadowing model is represented by

$$\left[\frac{P_r(d)}{P_r(d_0)}\right]_{dB}=-10\beta\log\left(\frac{d}{d_0}\right)+X_{dB} \quad \text{.......... (3)}$$

Where XdB is a Gaussian random variable with zero mean and standard deviation σ_{dB}. σ_{dB} is called the shadowing deviation, and is also obtained by measurement. Table.2 shows some typical values of σ_{dB} (dB). Eq. (3) is also known as a log-normal shadowing model. The shadowing model extends the ideal circle model to a richer statistic model: nodes can only probabilistically communicate when near the edge of the communication range [7] [8] [9] [10].

Table.1

Some Typical values of path loss β

Environment		β
Outdoor	Free space	2
	Shadowed urban area	2.7 to 5
In building	Line-of-sight	1.6 to 1.8
	Obstructed	4 to 6

Table.2

Some Typical values of shadowing deviation σ_{dB}

Environment	σ_{dB} (dB)
Outdoor	4 to 12
Office, hard partition	7
Office, soft partition	9.6
Factory, line-of-sight	3 to 6
Factory, obstructed	6.8

-Ricean fading model: This model is fading model, meaning that it describes the time-correlation of the received signal power. Fading is mostly caused by multipath propagation of the radio waves that means fading is the result of variation (with time) of the amplitude or relative phase, or both, of one or more of the frequency components of the signal because of changes in the characteristics of the propagation path with time.The factors that affect fading include motion, transmission bandwidth of signal compare to bandwidth of channel and multipath propagation.. If there is one dominant (line of sight) path and multiple indirect signals, Ricean fading occurs [10]. The PDF of the Ricean distribution is given by:

$$p(r)=\begin{cases}\dfrac{r}{\sigma^2}\exp\left(\dfrac{r^2+A^2}{2\sigma^2}\,I_0\left(\dfrac{Ar}{\sigma^2}\right)\right) & A\geq 0,\ r\geq 0\\ 0 & r<0\end{cases} \quad (4)$$

Where A is peak amplitude of the dominant signal ,I0() represents a modified Bessel function of the first kind and r is the mean value of the ricean distribution.

DESCRPTION OF URBAN area SCENARIOS

To evaluate the impact of the radio wave propagation model on the performance of a Mobile Ad Hoc Network the throughput and delay of multiple constant bit rate (CBR) streams is taken as an indicator. Measurements conducted by several researchers show that most simulators give too good values for these metrics. So any prediction derived from this simulation that concerns real networks is based on false assumptions. In this work, two scenarios are simulated in detail. They represent very different working environments. One is an indoor scenario with low mobility. The second one is an outdoor scenario simulating pedestrian walking through a city. This scenario is characterized by hostile environment for radio waves. Both scenarios share some similarities: Network traffic is created by starting CBR connections between randomly selected nodes. The simulation duration is 900 sec. We have implemented a shadowing model as radio propagation model with values of the path loss exponent 5 and the shadowing deviation 4 dB .For ricean fading model we used k factor 6dB and value of maximum speed 2.5 m/sec. We ran our simulations with movement patterns generated for 6 different maximum speeds, 10, 20, 30, 40, 50, 60 m/s with

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constant pause time 2.0 sec and 7 different pause times, 0, 5, 10, 20,30,40,50 seconds with constant speed 50m/sec. This part introduces scenarios of urban area environment which is divided in two parts as following:

-Indoor scenario:The indoor scenario is conducted on a simulation area whose layout shown in fig.1. For this layout a map with 2D and some measurements of the radio signal strength exists on an area of 1000m × 1000m. The movement for the nodes is created using random waypoint model. Nodes moving inside building have a very low mobility. Their pause time is equally distributed. The movement speed is distributed uniformly. The number of nodes in a scenario is ten. The maximum number of CBR connections is set to ten; the offered load per connection is 512Byte/s.

Outdoor scenario:The outdoor scenario is based on the street map of city, when the nodes are on the street, they move as Manhattan mobility model movement pattern. The Buildings act as obstacles for the radio waves and narrow streets may act as wave guides. Buildings have high attenuation but do not completely block the signal. 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 [4]. 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 have can either continue straight with the probability Pr (straight) = 0.5 or turn left/right with the probability Pr (right) = Pr (right) = 0.25. In this paper the area is wrapped around North-South and West-East and the grid is composed of 3 by 3 buildings. The buildings are 300x300 m and the street has two opposite lane, the distance between lane 1 m and the width of lane 6 meter. The movements of a node switch from one mobility model to another based on its location in urban environment.Fig.2 shows the movement of nodes in simulation area.

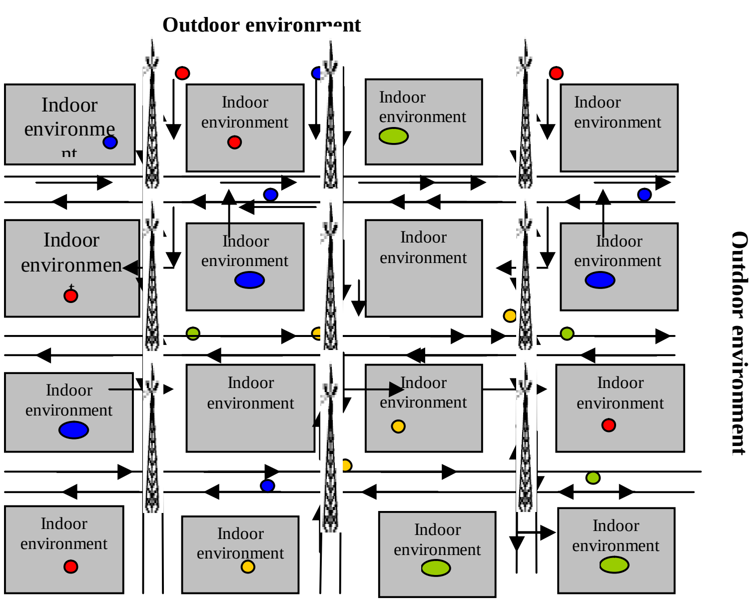


fig. 2, Layout of MANET 3X3 urban environment

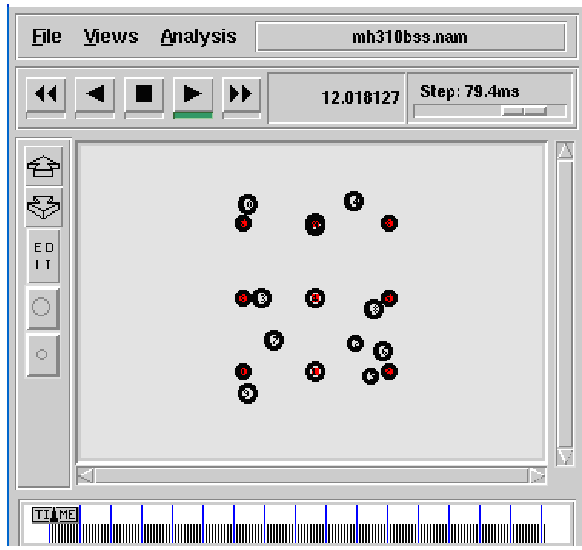
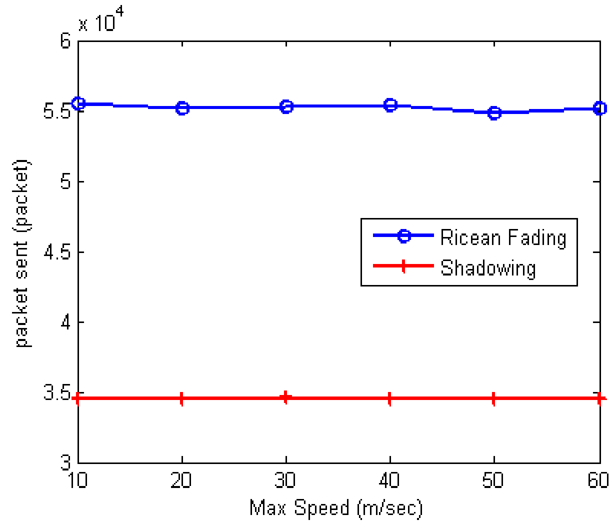


Fig. 3, movement of nodes in simulation field
With 9 base stations

4 SIMULATION RESULTS

The analysis of simulation results is performed based on the standard metrics of number of sent packets, throughput, number of dropped packets, packet delivery ratio and packet routing overhead between different radio propagation models. We conducted our simulations on changing the parameters for mobile nodes' movement scenarios and their connection pattern files. We supposed different speed and pause time for movement scenarios files.Figure.4 indicates that shadowing model sends very few packets; ricean fading send high packets. Figure.5; shows that ricean is better performance than shadowing model when throughput is considered as metric .In contrast, shadowing radio propagation model drops few packets as shown in figure.6, although the results indicate that its throughput is lower than ricean fading model. Figure.7 evaluates the reliability of packet delivery ratio. In comparison to ricean fading model, the results in Figure.7 indicate that shadowing radio propagation model is low with respect to the measured delivery rate. Our results in Figure.8 show that ricean fading and shadowing propagation models perform consistently well with respect to routing overhead (routing overhead equal zero).



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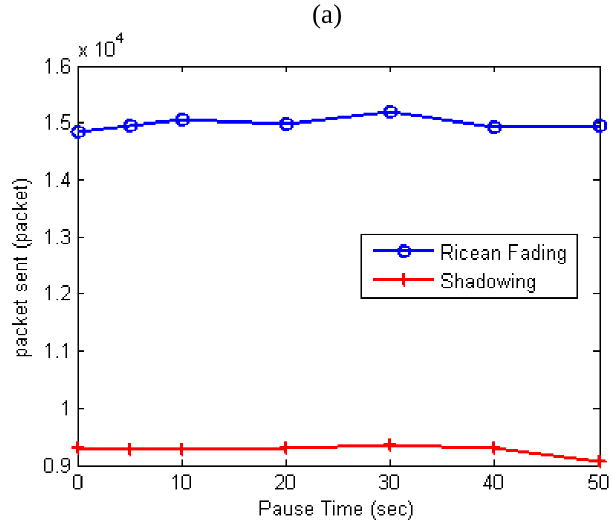
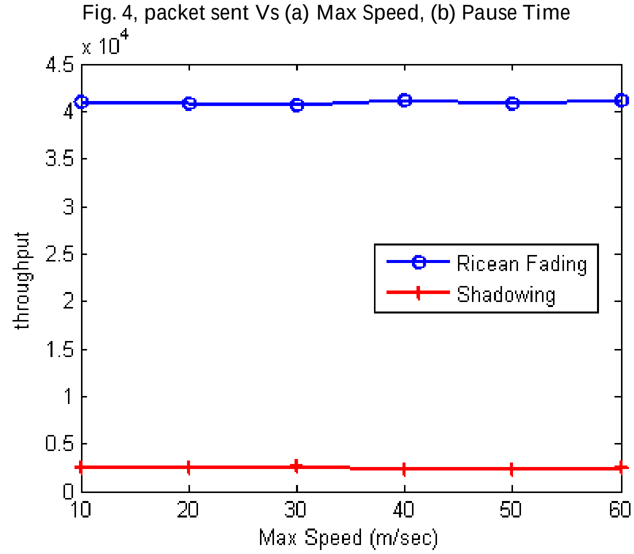


(b)

Fig. 4, packet sent Vs (a) Max Speed, (b) Pause Time



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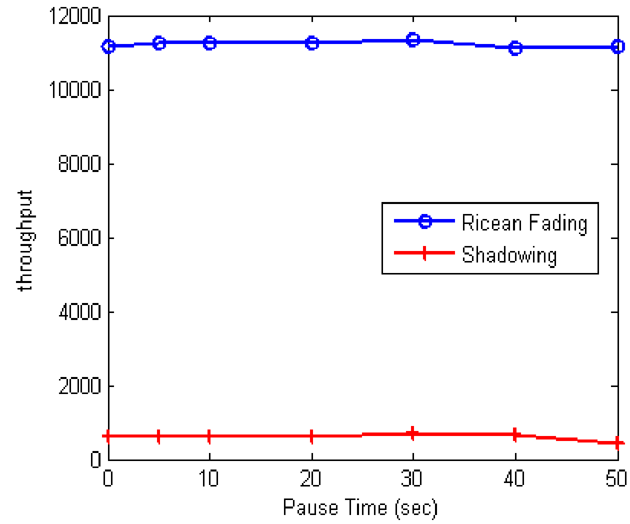
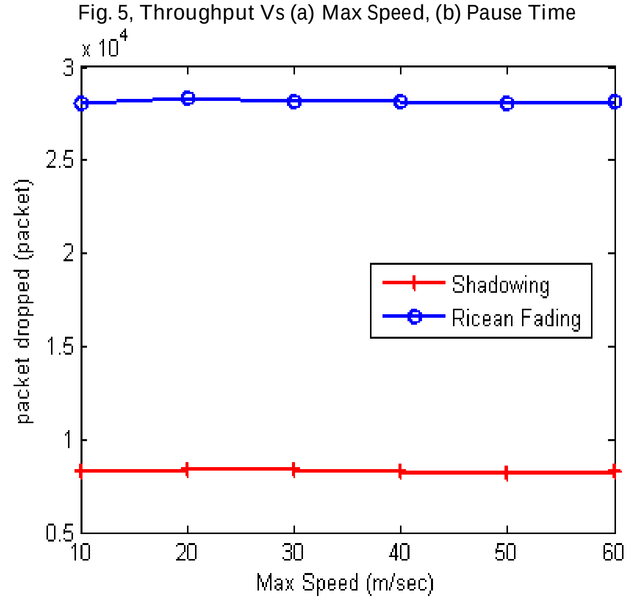


(b)

Fig. 5, Throughput Vs (a) Max Speed, (b) Pause Time



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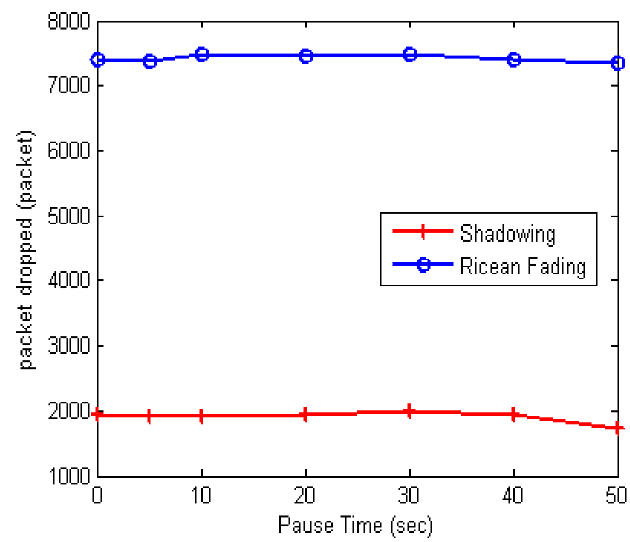
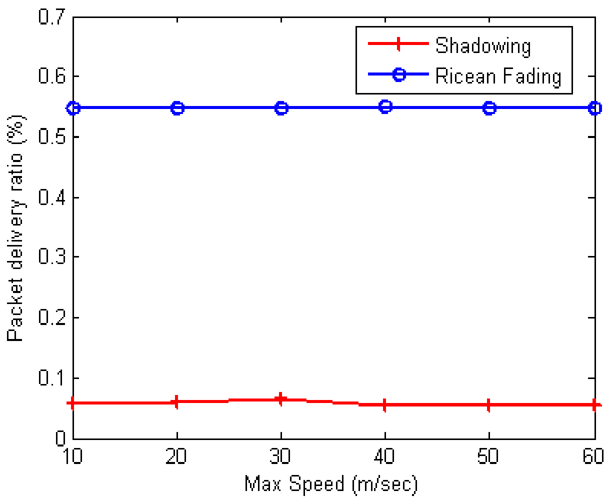


(b)

Fig. 6, Packet Dropped Vs (a) Max Speed, (b) Pause Time



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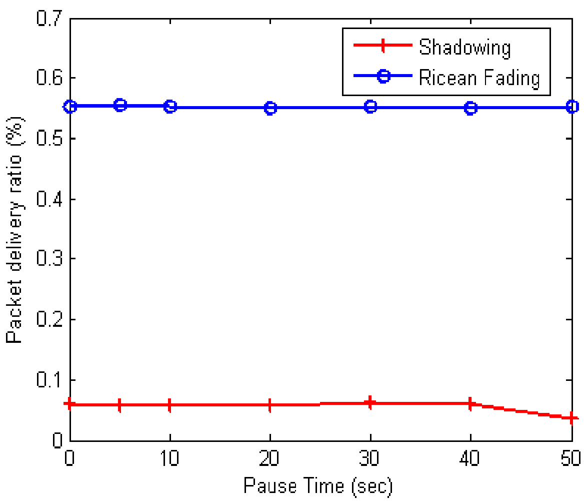
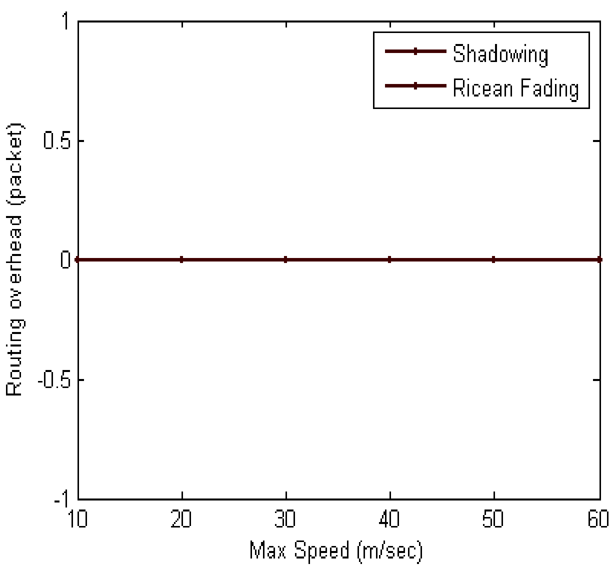
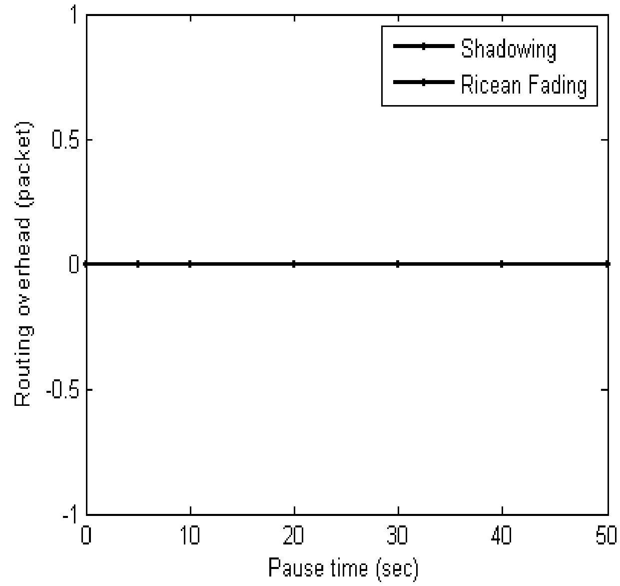


(b)

Fig. 7, Packet Delivery ratio Vs (a) Max Speed, (b) Pause Time



(a)



(b)

Fig. 8, Routing Overhead Vs (a) Max Speed, (b) Pause Time

5 CONCLUSION

The area of ad hoc networking has been receiving increasing attention among researchers in recent years, as the available wireless networking and mobile computing hardware bases are now capable of supporting the promise of this technology. In this paper, we have used pattern compound of more sophisticated mechanisms to model mobility that contribute to make the simulation realistic. We introduced urban environment which include indoor and outdoor environment using integrated mobility models. We used our simulation model to study some general characteristics of urban environments and their impact on MANET performance. We investigated some important issues related to the simulation and use of MANETs in urban environments supported with base stations. We have presented a radio wave propagation models showed how these models affect the performance of Mobile Ad Hoc Networks in urban area. We present the options available and provide the parameters used in the creation of scenarios for indoor and outdoor environments in an urban environment. We showed the effect of radio propagation models for wave propagation. We demonstrated that the usage of more accurate radio propagation models change simulated topologies considerably between commonly used propagation models. Consequently, we obtain different performance evaluation results. We compared radio propagation models performance variety of metrics, Packets sent, throughput, dropped packets, Packet Delivery Ratio, and packet routing overhead. For movement scenarios case, we supposed maximum speed and pause time. Researchers must be aware of significant difference between the real connection topologies and the topologies obtained with simple models offered by MANET simulation tools. For obtaining quantitative performance evaluation results in the

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target area, more accurate radio propagation models need to be used.

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