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# Routing Performance of Mobile Ad Hoc Network in Urban Street-grid Environment by Using Peer-to-Peer Propagation Model

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**Abstract**— In this paper, effect of non-line of sight propagation in an urban-street environment on routing performance in mobile ad hoc network is investigated. We implement a reliable propagation model in network simulator (NS2) named peer to peer propagation model which has been shown to be suitable for our street-grid environment by taking into account non-line of sight paths. Our simulation result shows that multiple reflected signals in an urban street grid environment have significant impacts on routing performance.

## 1. INTRODUCTION

Mobile ad hoc network (MANET) is a self-organizing and self-creating network which requires no fixed infrastructure [1]. Nodes are able to directly communicate with each other if they are in communication range. Multi-hops transmission is required to deliver packet from sources to destinations. Hence, routing protocol and realistic propagation model are imperative and challenging in MANET. Many network simulation tools [2–4] have been used to analyze the routing performance of MANET by assuming that the link between two nodes is in line-of-sight (LOS). However, this LOS assumption is not valid especially in an urban environment where the received signals in non-line-of-sight (NLOS) region are dominated by reflections along the streets-referred to as NLOS propagation [5–7]. However, most of the MANET papers reported in the literature review ignore such propagation paths [8–10]. Also it is assumed that there will be no communication link among nodes if direct LOS path is blocked [11, 12]. In this paper, we integrate into NS2 a reliable propagation model which takes into account reflected signals along street in an urban street environment [13]. To investigate the effects of NLOS propagation on MANET routing performance, AODV routing metrics including packet delivery ratio, normalized routing load, and average end to end delay are examined. The remainder of article is organized as following. Section 2 elaborates on related work. Section 3 describes our implemented peer to peer propagation model. Section 4 depicts simulation setting and result. Section 5 concludes the paper and suggests future works.

## 2. RELATED WORKS

Effect of non-line of sight propagation on routing performance has been studied and shown to have a significant impact on routing performance in MANET [14, 15]. [14] gave insights on the effect of different propagation models for MANET in indoor and outdoor environments by using three available propagation models in NS2, namely free space, two ray ground and shadowing propagation models. However, the three propagation models did not address the effects of reflected, refracted and diffracted signals from obstacles in free space and two ray ground. Furthermore, the parameter of shadowing propagation model was chosen arbitrarily. [15] proposed an algorithm to take into account the non LOS propagation paths and shadowing effect by modifying the available propagation model in NS2 namely modified free space, modified two ray ground and modified shadowing propagation models. In modified free space and two ray ground models, there would be no received power in NLOS region as the existence of reflected, diffracted and scattered signals are neglected. In the modified shadowing propagation model, the power received was calculated by choosing arbitrarily the value of path loss exponent  $\beta$  and the standard deviation  $\alpha_{dB}$  of a Gaussian random variable.

## 3. PEER-TO-PEER PROPAGATION MODEL FOR MANET

In this paper, a peer-to-peer propagation model [13] is propose to be integrated in NS2 for MANET simulation in a street grid environment. The theoretical path loss formula has been shown to have good agreement with experimental data collected in Tokyo and New York Cities. The following is the list of assumption for our proposed propagation model.

- Width of the streets is assumed to be known.

- Reflection loss is assumed known and constant at all building surfaces. In other words, propagation path with the minimum number of reflection is considered as the dominant signal path.

For the urban street-grid environment as shown in Figure 1, the minimum number of reflections  $N$  between two nodes, e.g., A and B for signal path undergoes reflections along the main street  $W_m$  and side street  $W_s$  can be derived [13]:

$$N_{\min} = \left\lfloor 2\sqrt{\frac{r_m r_s}{W_m W_s}} \right\rfloor$$

The total path loss for reflection is given by:

$$\left[ \frac{P_r}{P_t} \right]_{\text{dB}} = 10 \log \left( \frac{\lambda}{4\pi(r_m + r_s)} \right)^2 + L_w N_{\min} + X'_{\text{dB}} \quad (1)$$

where  $L_w = 20 \log R_0$  in dB.  $R_0$  is loss per reflection and  $\lambda$  is the wavelength of the operating signal,  $X'_{\text{dB}}$  is Gaussian random variable with zero mean and standard deviation  $\alpha'_{\text{dB}}$ .

Likewise, the minimum number of reflections  $N$  between two nodes, e.g., A and C for signal path undergoes reflections along the main street  $W_m$  and parallel street  $W_p$  can be derived as [17]:

$$N_{\min} = \left\lfloor \frac{r_m}{W_m} \sqrt{\frac{r_s W_m W_p}{W_s(r_m W_p + r_p W_m)}} + \frac{r_s}{W_s} \sqrt{\frac{W_s(r_m W_p + r_p W_m)}{r_s W_m W_p}} + \frac{r_p}{W_p} \sqrt{\frac{r_s W_m W_p}{W_s(r_m W_p + r_p W_m)}} \right\rfloor \quad (2)$$

The total power loss is given by:

$$\left[ \frac{P_r}{P_t} \right]_{\text{dB}} = 10 \log \left( \frac{\lambda}{4\pi(r_m + r_s + r_p)} \right)^2 + L_w N_{\min} + X'_{\text{dB}} \quad (3)$$

If two nodes are in line of sight with one another and their distance is less than cross-over distance, e.g., node A and B, (1) is used; if their distance is more than cross-over distance, e.g., node A and C, (2) is deployed. If they are in non-line of sight, e.g., node A and D, received power is determined by (6).

#### 4. SIMULATION RESULTS AND SETTINGS

AODV is used as a routing protocol and Manhattan mobility model is employed to govern the node movement with 4 vertical and 4 horizontal streets. We compare our proposed peer to peer propagation model with the modified shadowing model propagation models proposed in [15]. Table 1 shows the parameters for simulation. From Figure 2 to Figure 4, the routing performance of AODV is higher when peer-to-peer to propagation model is used. In Figure 2, the packet delivery ratio

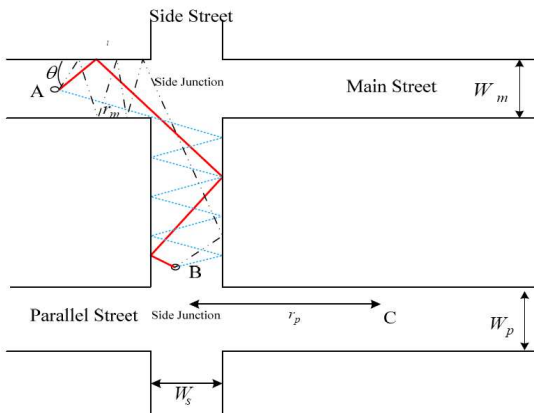


Figure 1: Illustration of side and parallel street scenario showing typical reflection paths.

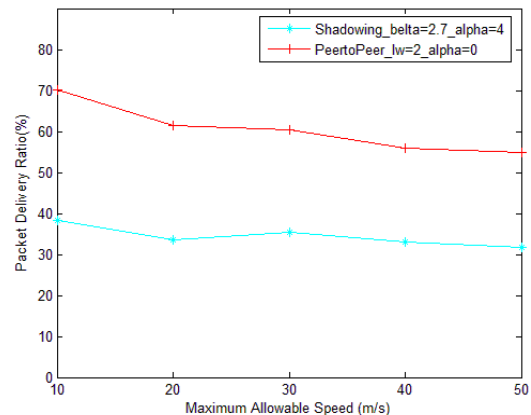


Figure 2: Comparison between peer-to-peer and shadowing models of packet delivery ratio.

Table 1: Simulation settings.

MAC Protocol	IEEE802.11DCF
Traffic model	4 CBR connections
Packet sending rate	1 packets/second
Power received threshold	$3.65262 \times 10^{10}$ W
Number of nodes	100
Simulation area	1500 m $\times$ 1500 m
Node maximum allowable speed	10 m/s to 50 m/s (in the step of 10 m)
$G_t, G_r, L, d_0$	1
$\lambda$	0.328 m
$\alpha_{dB}$	4 dB
$\beta$	2.7
$L_w$	2 dB (loss per reflection)
$W_s$	10 meters
$W_m$	35 meters

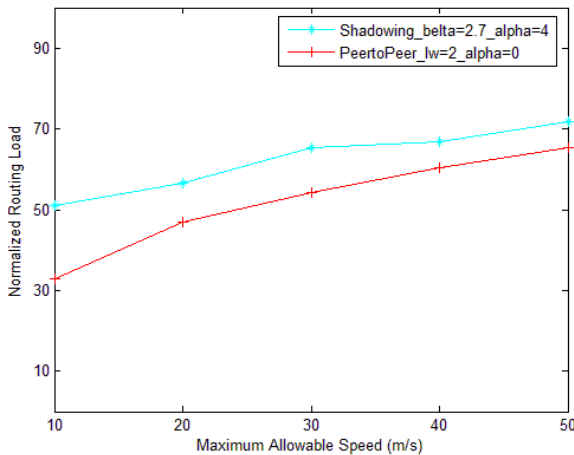


Figure 3: Comparison between peer-to-peer and shadowing models of normalized routing load.

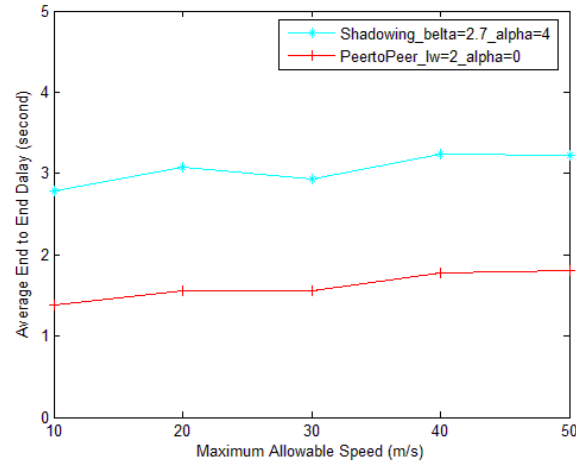


Figure 4: Comparison between peer-to-peer and shadowing models of average end to end delay.

increases from around 39% to 70% when modified shadowing and peer-to-peer propagation model are used respectively. It is because the received power of the peer to peer propagation model is higher than that of modified shadowing when distance between receiver and transmitter is more than cross in distance. Thus, it leads to more connectivity. In Figure 3, it is observed the normalized routing packet of peer to peer propagation model is less than that of modified shadowing model. This is as expected because the data received of peer-to-peer propagation model is higher than that of modified shadowing model. In Figure 4, it can be seen that the average end to end delay of the peer-to-peer propagation model is slightly less than that of modified shadowing propagation model. It is due the fact that the connectivity of peer-to-peer propagation model is more stable than that of shadowing model.

## 5. CONCLUSION

In this paper, we implemented a more realistic propagation model in an urban street environment. From simulation result, the effect of NLOS propagation model has a significant impact on routing performance in MANET. It can be observed that the received signal strength cannot be arbitrarily chosen or underestimate. Based on our implemented wireless propagation model, the authors are currently researching a new routing protocol in such urban street environment.

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