Empirical Model Indoor Corridor Path Loss at 5 GHz

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Abstract – **In this paper, an empirical propagation model for indoor corridor at 5 GHz based on ray tracing dataset has been proposed. The model can predict the line-of-sight (LOS) and non-line-of-sight (NLOS) path loss characteristics for indoor corridor with T-junction using distances from the junction to the transmitter and receiver, while taking into account the width of the corridor.**

Index Terms — **Path-loss model; corridor; Non Line-of-sight (NLOS); WLAN.**

1. Introduction

Indoor radio planning is very important nowadays because of the mobile devices. In a lot of buildings, pico base stations are installed to carter the need for mobile coverage. Effective planning ensures the proper coverage of and the quality of coverage by preventing interferences. The path loss is one of the most important parameter to determine the coverage and is heavily used for signal evaluation because it can be measured easily compared to other parameters. There are different path loss models exist to satisfy needs for indoor environments. These includes empirical, theoretical, and deterministic models. Empirical model such as ITU-R [1] provides estimation but may not be accurate enough for localized prediction. Deterministic models employing geometric optics [2] or full wave method [3] provides improved accuracy but requires geometric data of the sites and dedicated software. For engineering applications though, it appears that empirical models are preferred as they are simple to use. In [4], an empirical model was developed that allows prediction of corridor for 5.3 GHz with just the width of the corridor and the distance. Line-of-sight (LOS) and non-line-of-sight (NLOS) and the transition region. When the receiver is in the LOS region (i.e. same corridor as the transmitter), the path loss can be presented by free space path loss. On the other hand, when the receiver is in the NLOS region (i.e. a perpendicular corridor), the path loss can be expressed in a simple empirical formula. While this model provides good prediction for the condition specified, it does not consider the effect of corridor width on the propagation characteristics.

In this work, an empirical path loss corridor for 5 GHz Wi-Fi frequency band is proposed that takes into consideration the width of the corridor on the loss behavior. Ray tracing is employed to generate data for the model as it allows the prediction of path loss in more variety of environment that will otherwise be different to obtain using measurement.

2. Empirical Path Loss Model

The corridor that is being considered in this paper is shown in the Fig. 1. It can consist of 2 corridors that meet at a T-junction. The corridor has a height of h and width of w. The location of the transmitter is marked as TX and the receiver is marked RX and the distance is measured from the center of the junction o. The length d_1 and d_2 from the origin o and represent the distance to TX along the LOS path and NLOS path respectively. All the lengths above are measured in meters. The path loss for the LOS region can be expressed by free space path loss model (1).

$$PL(d_1,d_2)=\begin{cases}32.4+20\log(f_c)+20\log(d_1), & \text{for LOS}\\ PL_{NLOS}(d_1,d_2), & \text{for NLOS}\end{cases} \quad (1)$$

where f_c is frequency in GHz and d is the LOS distance in meters from TX. Note that the equation is valid when the receiver is within the near region [5].

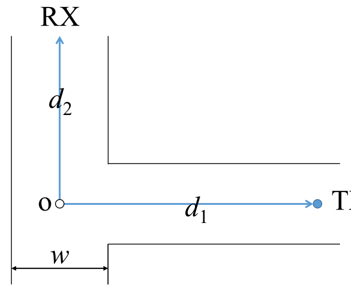

Fig. 1. The corridor and the reference system.

In the LOS region the path loss is independent of the cross-sectional dimensions up to a distance that is dependent on the frequency. When the distance exceeds the break point into the far region, there is a change in characteristics in the path loss, a dual-slop model such as can be employed to estimate the change of path loss characteristics [5].

(1) Ray Tracing Simulation Setup

The empirical model built based upon the data generated with ray tracing using Wireless InSite [6]. In the simulation the corridor is assumed have a cross sectional dimension of width w and height h = 3 m. Three different corridor width are considered from 2 m to 4 m. The walls are made up of brick with permittivity ϵ_r = 4.4, and conductivity σ = 0.001 S/m. The ceiling and floor are made of concrete with

ϵ_r = 15, and σ = 0.015 S/m. The walls are assumed to be perfectly flat without obstacle along the path.

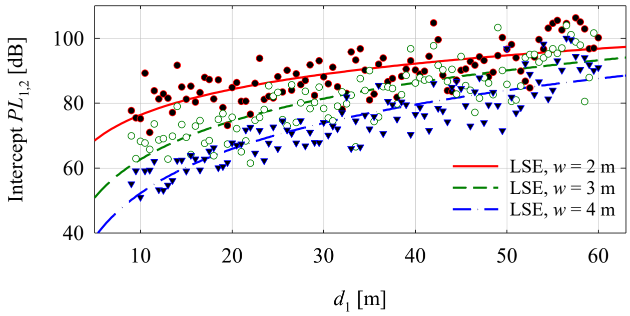

Fig. 2. NLOS path loss intercept vs d_1, for w = 2 to 4 m

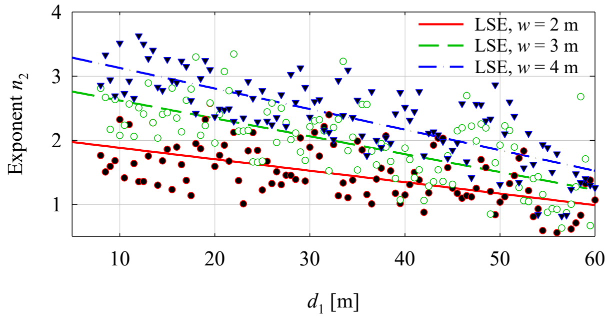

Fig. 3. NLOS path loss exponent vs d_1, for w = 2 to 4 m

(2) A 5.3 GHz path loss model for corridor that consider width of corridor

The NLOS path loss can be modelled using the 2 parameter log exponent, with the intercept point $PL_{1,2}$ and loss exponent n_2, as represented by equation (2). The value for $PL_{1,2}$ and n_2 are obtained by using least square estimate on the ray tracing dataset for w from 2 to 4 m. The $PL_{1,2}$ intercepts can be estimated with another 2 parameters log exponent and the result is compared with the simulated results as shown in Fig. 2. On the other hand, the exponent n_2 can be estimated with a 2 parameter linear regression and the result of the regression is shown in Fig. 3.

$$\begin{aligned} PL_{NLOS} &= PL_{1,2} + 10 n_2 \log(d_2) \\ PL_{1,2} &= (91.7 - 21.6w) + (8.3 + 9.6w)\log(d_1) \\ n_2 &= (0.72 + 0.69w) - (0.0047 + 0.0071w)d_1 \end{aligned} \qquad (2)$$

To construct an empirical that consider that effects of corridor width while maintaining a simple formulation, the range of d_1 is limited to obtain a good fit for all widths. This is because of the change in the mechanism of propagation with different range of d_1. For instance, when the transmitter is close to the junction, the received power on the receiving end along d_2 is dominated by reflected wave. As the transmitter is moving further away from the junction, i.e., as d_1 increases, the corner diffraction becomes more important mechanism. Also, the path loss characteristics at is markedly different as the width of the corridor changes, especially when d_1 is small. Therefore, resulting fit is limited to 8 m ≤ d_1 ≤ 60 m. For comparison, the result of the ray tracing and the model in equation (2) is compared for w = 2 m and 4 m as shown in Fig. 4.

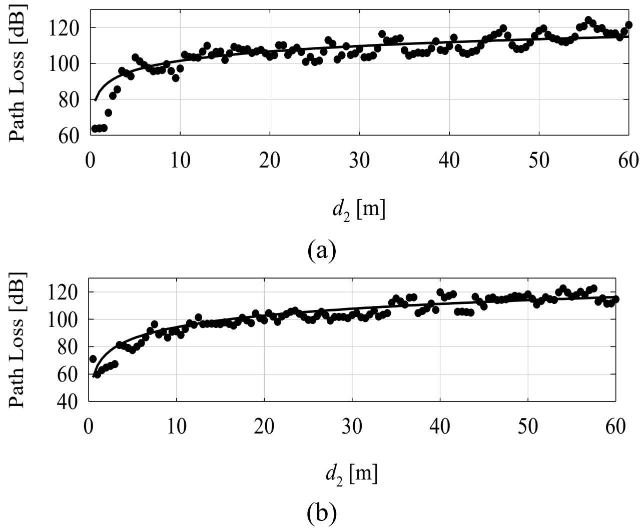

Fig. 4. Comparisons of the path loss of equation (5) with ray tracing for d_1 = 20 m and (a) w = 2 m, (b) w = 4 m.

3. Conclusion

In this paper, an empirical path loss model for indoor corridor with T-junction for 5 GHz is proposed. The model allows prediction d_1 and d_2 and consider the effect of width of the corridor. The model was compared with ray tracing and show good agreements.

Acknowledgment

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