WINNER channel model with geometric optics and probability for indoor environment

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***Abstract* – WINNER channel model applied novel path loss is proposed. This path loss uses geometric optics and probability. It is proposed for predicting an indoor radio propagation to achieve more computational simple over ray-tracing method and better accuracy than a statistical model[1]. As a result, more accurate interference analysis and channel characteristics analysis for a wireless communication system are possible based on this modified channel model.**

***Index Terms* — WINNER Channel model, path loss, probability and geometric optics**

I. INTRODUCTION

Recently, since the demand for wireless communication services in indoor environments is increased, interference between wireless devices is serious. As multiple wireless devices operate simultaneously, the interference between wireless devices occurs and the value of SINR is reduced. Due to depletion of the frequency resource, interest in frequency sharing technique is increased. For the application of its technique, a quantitative evaluation of the frequency interference is necessarily required, thus research are conducted actively. At this time, the consideration to the PHY layer for this interference analysis is necessary and channel characteristics derived the channel model are required. To consider the interference analysis of the wireless devices, the channel attributes based on the WINNER channel model can be used. This WINNER channel model is an effective model among the channel model which is used to indicate the channel characteristics of the indoor and outdoor environments. However, the log-distance model in WINNER channel model existing has a limit that does not take into the complex environment[2]. In this paper, the path loss using geometric optics and probability can consider a complex indoor environment.

The paper is organized as follows. Section II states the content on the path loss that was applied to the modified WINNER channel model. It is a theory behind the new model and presents a key equation for estimating path power. Section III shows the channel characteristics of the WINNER channel model employing the path loss which is proposed.

II. PATH LOSS USING GEOMETRIC OPTICS AND PROBABILITY

In general, radio waves in the indoor environment reach the receiver suffering many disorders like reflection and transmission by a number of obstacles. The purpose of this section is to relate the path power to the key site-specific propagation parameter such as reflection coefficient, transmission coefficient and mean-free distance.

A. *Path Power Corresponding to The Number of Reflection and Transmission* [3]

The distance l is between the transmitter and the receiver in a free-space environment. The received path power of radio wave undergoing n intersections (reflections times m, transmissions times (n-m)) is as (1).

$$P(l,n,m) = P_0 l^{-2} R^{2m} T^{2(n-m)} \qquad (1)$$

R is the reflection coefficient, T is the transmission coefficient, and P_0 is a reference path loss value from 1m. The reference path loss value P_0 is expressed by

$$P_0 = G_t G_r (c/4\pi f)^2.$$

Applying the probability distribution function of occurring the reflection and transmission, the average power that reaches the receiver is the same as (2).

$$P(l) = P_0 l^{-2} \sum_{n=0}^{\infty} \sum_{m=0}^{n} f(n,m|l) R^{2m} T^{2(n-m)} \qquad (2)$$

B. *Calculation of $f(n,m|l)$ and General Formula for Path Power*

Probability distribution function has Poisson distribution in the indoor environment. After considering the path and quantifying the probability of transmission and reflection, the formula (2) can be expressed as (3).

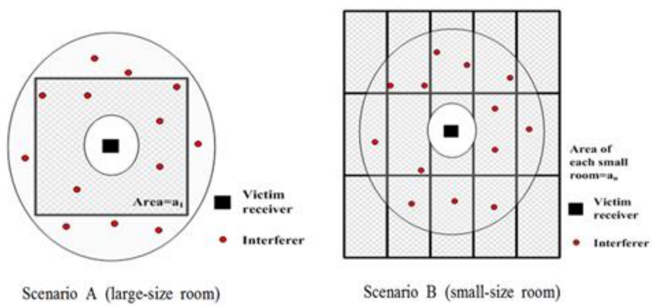

Fig. 1. Indoor Environment Scenario

$$P(l) = P_0 l^{-2} e^{-\gamma l} e^{\frac{\gamma l (T^2+R^2)}{2}} e^{\frac{\gamma l (T^2-R^2) e^{-\Delta\gamma}}{2}} \qquad (3)$$

In the formula (3), $1/\gamma$ means the mean-free distance of the radio wave before passing on the obstacle. Its value is determined in accordance with the indoor environment[4-5].

III. WINNER Channel Characteristics of Applying the Proposed Path Loss

Scenario A and B is a dominant indoor environment which is LOS(Line-of-Sight) and NLOS(None-LOS) respectively [6]. It is used for both scenarios verifying the path loss proposed. Scenario A is a large room in which many interferers are located in the LOS region. On the other hands, scenario B is a small room in which almost all interferers are located in NLOS region. Each room's parameter is calculated by geometrical probability and total mean-free distance can be obtained by averaging over the interference zone area. These are showed as follow TABLE I.

TABLE I. Indoor environmental parameters

	Width [m]	Length [m]	Height [m]	$1/\gamma$
Scenario A	8.4	8.5	2.62	3.23
Scenario B	4	6	2.62	2.5

Using the interior parameters of each scenario, the path loss based on geometric probability is applied to the WINNER channel model. After setting reflection coefficient to 0.7 and transmission coefficient to 0.5 for convenience, simulation was performed[7-8]. To perform interference analysis in PHY layer, it is necessary to extract channel characteristics like channel matrix. Proposed channel model uses parameters obtained from measured CIRs (channel impulse response).

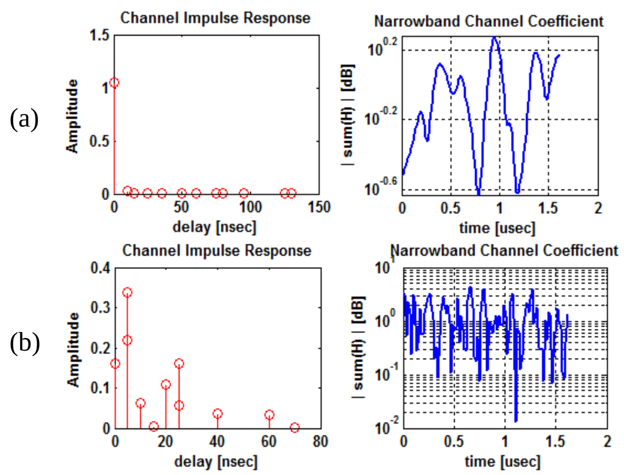

Fig. 2. Channel characteristics of the indoor environment (a) scenario A (b) secnario B

It uses positions of MS (Mobile Station) to introduce scenario-specific correlation of link. So, this model may indicate a number of scenarios. Fig. 2 indicates the channel characteristics of the WINNER channel model applied to the proposed path loss. Looking the CIR in (a), it can be known that direct wave is dominant in the LOS environment. As the waves are undergoing slow fading due to the dominant direct wave, it is manifested in the channel coefficient. Opposite to the (a), it can be known by channel impulse response in (b) that channel characteristics of NLOS environment without the direct wave. It also shows that narrowband channel coefficient has the condition which fast fading is dominant.

IV. Conclusion

For the application of frequency sharing technique, a quantitative evaluation of the frequency interference is necessarily required. The consideration to the PHY layer is required because of this. Thus channel characteristics derived the channel model are required for the consideration to the PHY layer because of this interference analysis. The existing path loss, which is applied to the WINNER channel model, has a limit that does not take into the complex environment. Path loss based on geometric optics and probability, however, it is possible to consider in complex indoor environment as shown in Fig. 1. Being taken as a two indoor environment scenarios which LOS and NLOS is dominated, channel characteristic is derived by them. It has an improved accuracy compared to the Log-distance model used to analyze the path loss in the indoor environment existing. It is possible to perform the interference analysis with more accurate channel characteristics.

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