Abstract—For multi-gigabit wireless transmission, this work models and analyzes millimeter/sub-millimeter wave indoor communications. By using the blocking probability to describe the interruption of transmitted signals, this paper evaluates system-level performance and the correlation coefficient between propagation signals. Numerical results reveal that the proposed channel model for multi-gigabit wireless transmission, which uses the blocking probability, is suitable for describing the effect of obstacle blocking in the indoor environment.

I. INTRODUCTION AND BACKGROUND

Demand for high data rate transmission is increasing rapidly in recent years. One of good examples is the wireless transmission of uncompressed high-quality video signals in indoor communication systems. Millimeter and sub-millimeter wave, which ranges from 100 GHz to 10 THz, has sufficient spectrum bandwidth for future 10-100 Gbps wireless transmission. The interest of millimeter/sub-millimeter wave has fueled intense efforts for the realization of multi-gigabit wireless transmission [1]-[2]. The frequencies around 300 GHz are especially interesting because semiconductor technology progress will soon allow relatively cost-efficient components [3]. The use of millimeter/sub-millimeter wave relies on line-of-sight (LOS) conditions with narrow-beam antennas. This property causes the millimeter/sub-millimeter wave systems to require high-gain directive antennas [4]. Therefore, the operation modes will differ from conventional wireless local area networks that use omni-directional antennas. The desired mode of operation will be line-of-sight (LOS) transmission. In case the direct link is interrupted, directed non-line-of-sight (NLOS) transmission could be used to enhance the reflections in the specular direction [5].

In order to analyze the performance of millimeter/sub-millimeter wave indoor communications in system-level, a proper channel model that describes the characteristics adequately is important. Priebe et al. [6] investigates the characteristics of scattered multi-path clusters like angle and time of arrival for sub-millimeter wave indoor channel modeling. The numerical form of the specular reflections in sub-millimeter wave channel propagation, which should be determined from ray tracing or a statistic model for proceeding the channel modeling in [6], is provided in [7]. This work uses a modified channel model by bringing the obstacle rate to the channel modeling in [6], is provided in [7]. This work uses a modified channel model by bringing the obstacle rate to the channel modeling in [6], is provided in [7]. This work uses a modified channel model by bringing the obstacle rate to the channel modeling in [6], is provided in [7]. This work uses a modified channel model by bringing the obstacle rate to the channel modeling in [6], is provided in [7].

Simulation environment considers the indoor room, where different blocking probability is used for evaluating the achievable data rates. The LOS and single-reflected signals (i.e., NLOS paths) on the walls of the square room deliver significantly more power to receivers than twice-reflected paths [5]. The influence of double-reflected paths might not be negligible as interference. However, this work does not consider their influence with a high signal-to-interference-plus-noise ratio (SINR) assumption. It is assumed that carrier frequency is 300 GHz, bandwidth is 1 GHz, and transmit power is 0 dBm. Other parameters used in the simulation is based on [7].

II. SYSTEM MODEL

System model considers millimeter/sub-millimeter wave indoor communications as shown in Fig. 1, where access point is located in the central ceiling and user equipment (UE) is distributed uniformly within square indoor room. Each NLOS path is a single-reflected signal from each wall, which is denoted as $r_x^+$ from $x^+$-direction wall, $r_x^-$ from $x^-$-direction wall, and so on. Hence, an UE has one LOS path and six NLOS paths (i.e., $r_x^+, r_x^-, r_y^+, r_y^-, r_z^+, r_z^-$). When LOS or NLOS signal propagates the indoor environment, some paths can be blocked by the obstacles with a blocking probability (i.e., $p_{\text{block}}$). For example, in Fig. 1, UE 1 has both LOS and NLOS paths while UE 2 has NLOS paths without LOS path because of an obstacle.

![Fig. 1. System model for millimeter/sub-millimeter wave indoor communications.](image-url)
the $r_{\text{LOS}}$ path is blocked generally if $r_z^+$ path is blocked, which can be a good guideline when the antenna finds the strongest signal from access point.

Fig. 3 describes the effect of blocking probability caused by obstacles. Each curve visualizes the decrease of the achievable data rate as $p_{\text{block}}$ increases. The decrease rate is 3 up to 7% when $p_{\text{block}}$ is 20%. In addition, the decrease of date rate is 18% when $p_{\text{block}}$ is 40%. This result show that the achievable data rate of indoor cell-edge user is from 1 to 3 Gbps, which is suitable for multi-gigabit wireless transmission, even though any UE is located at the indoor edge region.

Fig. 2. Correlation in the azimuth plane. (a) $\theta_{\text{los}}$ vs. $\theta_{r^+}$, (b) $\theta_{\text{los}}$ vs. $\theta_{r}$, (c) $\theta_{\text{los}}$ vs. $\theta_{r^+}$.

Fig. 3. Achievable date rates with respect to the blocking probability.

IV. SUMMARY

This paper provided the obstacle rate to describe the blocking of the signals in millimeter/sub-millimeter wave channel model and evaluated the correlation coefficient between propagation signals.

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