

Enhancement of 5G/6G Simulator using Point Cloud Data

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Abstract—We have developed the 5G/6G simulator (Point Cloud 5G/6G Simulator) which evaluates the performance of 5G/6G based on raytrace simulation using real environment model generated from point cloud data acquired in specific evaluation environment such as indoor and factory. This paper describes the evaluation results of the system performance of the 5G/6G in indoor environment by applying the method of Map-based hybrid channel model (MHCM) specified in 3GPP to the existing simulator to enhance the simulator. As the result of the evaluation at 4.7 GHz, 28 GHz and 100 GHz, it was confirmed that the throughput of the case applying the MHCM method was higher than that of existing method without MHCM.

I. INTRODUCTION

We have developed the 5G/6G simulator (Point Cloud 5G/6G Simulator) using point cloud data, which enables us to visually recognize the system performance such as received level of radio waves and throughput in order to evaluate the deployment of the 5G/6G to specific environments such as indoor and factory environments [1, 2]. The simulator evaluates the performance of the 5G/6G using the result of raytrace simulation based on real environment model generated from point cloud data acquired in the evaluation environment, which has recently attracted attention as method to estimate the propagation characteristics with high accuracy. This paper describes the results of the evaluation of the system performance of the 5G/6G in indoor environments by applying the method of Map-based hybrid channel model (MHCM) specified by 3GPP to the simulator [3]. The paper is organized as follows. Section 2 describes the outline of the existing point cloud 5G/6G simulator and the enhancement of the simulator by applying the MHCM. Section 3 describes the evaluation results of the 5G/6G transmission characteristics in indoor environment using the enhanced simulator. Section 4 describes summarizes the paper.

II. OUTLINE OF THE EXISTING POINT CLOUD 5G/6G SIMULATOR AND ENHANCEMENT OF THE SIMULATOR

The simulator is based on the 6G simulator described in [4]. The outline of the existing 6G simulator and the point cloud 5G/6G simulator will be described below.

The existing 6G simulator was developed to quantitatively verify the 6G requirements and technical concepts described in the DOCOMO 6G white paper, and possibility of utilizing the sub-terahertz band for the system [5]. Since the existing 6G simulator can be used to evaluate the performance of the 5G, it is referred to as the 5G/6G simulator in this paper. In the existing 5G/6G simulator, the channel model between the base

TABLE I. RAYTRACE SIMULATION PARAMETERS

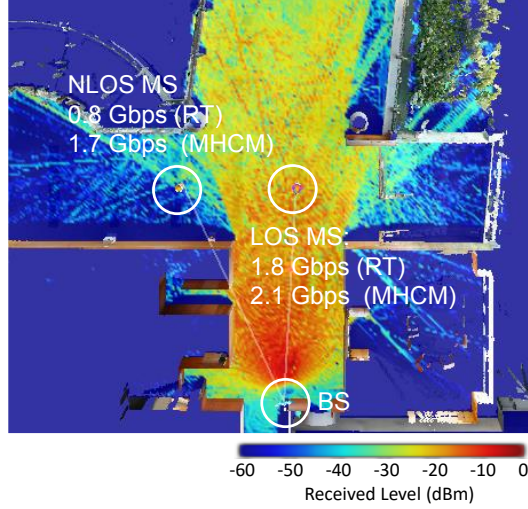
Parameters	Specifications
Center Frequency	4.7, 28, 100 GHz
BS and MS antenna height	2.0, 1.5 m
BS and MS antennas	Omni directional antenna (0 dBi)
Calculation algorithm	Ray launching
Ray launching interval	0.1 deg.
Number of reflections	10
Material	Concrete

station (BS) and the mobile station (MS) used for system level simulation is the model standardized by 3GPP [3], on the other hands, the point cloud 5G/6G simulator developed for the system evaluation of a specific environment utilizes the channel information obtained based on raytrace simulation using a indoor real environment model generated from point cloud data. Specifically, the path loss, the delay and the departure/arrival angle of each path, calculated by raytrace are used. In the newly enhanced simulator, the channel is generated by applying MHCM method in addition to the above existing point cloud 5G/6G simulator [4]. Specifically, the center angle of the cluster is the departure/arrival angle obtained by raytrace simulation, and the channel is generated by adding rays constituting the cluster, and the system level simulation is performed.

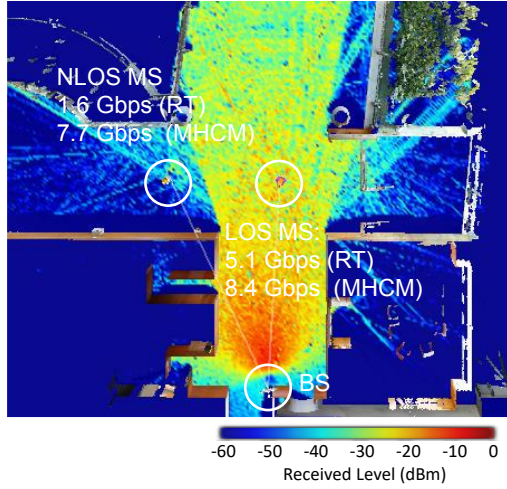
III. EVALUATION OF TRANSMISSION CHARACTERISTICS

Raytrace simulation was performed based on the point cloud data acquired in the NTT DOCOMO office, and the transmission characteristics were evaluated using the enhanced point cloud 5G/6G simulator described in the previous section. The raytrace parameters are shown in Table 1. Polygon data generated from the acquired point cloud data was used for the raytrace simulation. The center frequencies were set at 4.7 GHz, 28 GHz and 100 GHz, assuming the 5G/6G. The BS and MS antennas were omni antennas, and the BS antenna height was 2.0 m and the MS antenna height was 1.5 m. The numbers of the reflections of the ray search is 10. The wall material was all concrete.

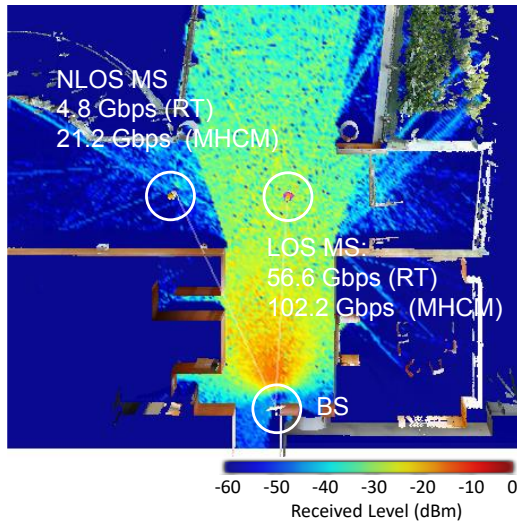
Figure 1 shows the color map of the received level of each frequency. The figure shows that the received level of each frequency is high in the line-of-sight (LOS) environment and decreases in the non-line-of-sight (NLOS) environment.



(a) 4.7 GHz



(b) 28 GHz



(c) 100 GHz

Fig. 1. Received level and DL throughput

TABLE II. TRANSMISSION SIMULATION PARAMETERS

Center Frequency	4.7 GHz	28 GHz	100 GHz
Bandwidth	100 MHz	400 MHz	8.0 GHz
BS transmission power	30 dBm		
MS transmission power	23 dBm		
Number of BS antenna elements	144	2304	9216
(V x H x subarray)	(4 x 4 x 9)	(16 x 16 x 9)	(32 x 32 x 9)
Sub - array spacing	0.5 λ	4 λ	30 λ
Number of MS antenna elements	144		
(V x H x subarray)	(4 x 4 x 9)		
MS antenna element spacing	0.5 λ		
Number of BS	1		
Number of MS	2		
Number of MIMO layers	1, 2, 3, 4, 8		

Next, the evaluation results of the transmission characteristics are shown. Table 2 shows the parameters of the system level simulation. We calculated the throughput based on fading channel is generated from the channel described in the previous section and beamforming (BF) and MIMO spatial multiplexing by Massive MIMO. The parameters of rays in a cluster of the MHCM were that of the Indoor-Office LOS environment described in [4]. Figure 1 shows the throughput of downlink (DL) at 4.7 GHz, 28 GHz and 100 GHz with 1 BS and 2 MSs. RT is the throughput calculated by the existing method without MHCM. For each frequency, the throughput is higher in the LOS environment, and the throughput is higher when MHCM is applied. The increase in the throughput simulated using MHCM method is due to the increase in the effect of MIMO by adding rays in the cluster.

IV. CONCLUSION

In the paper, we evaluated the transmission characteristics of 4.7 GHz, 28 GHz and 100 GHz in indoor environment using channel generated based on MHCM method for the enhancement of the point cloud 5G/6G simulator developed for system evaluation in a specific environment. In this evaluation, it was confirmed that the throughput in the LOS environment was higher than that in the NLOS environment at each frequency, and that the throughput was higher when the MHCM method was applied than the existing method without MHCM.

In the future, the estimation accuracy of the simulator will be evaluated by comparing the throughput measured using the experimental equipment in the real environment with the simulation results. In addition, the validity of the parameters such as the angular spread of rays added in the cluster specified in the MHCM of the 3GPP will be evaluated.

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