

# Estimations of Indoor Propagation Characteristic at 5 GHz Band for IEEE802.11n Wireless LAN

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**Abstract** - Recently, a high-power wireless LAN access point (AP) based on IEEE802.11n/ac standard with a high-speed data transmission rate of more than 300 Mbps has been developed. Using this AP makes it possible to build easily wireless networks including a few floors in the adjacent as well as many rooms in the same floor. This paper discusses indoor propagation characteristics including received signal strength indicators (RSSI) and channel modeling in the office environment based on a large-scale numerical electromagnetic simulations. A precise numerical model is developed for the simulation at 5 GHz frequency band. As a result, we confirm the validity of numerical simulation and propose an estimation method of RSSI and indoor channel model. The manner is useful to design number of access points as well as their locations for building wireless networks.

**Index Terms** — Indoor propagation, Wireless LAN, Channel modeling, Numerical electromagnetic simulation.

## I. INTRODUCTION

Low cost wireless LAN systems based on IEEE802.11n/ac standard are available recently [1]. Using them as an access point (AP) contributes to realize a wide coverage area on one or several floors in an office building and a residential house [2],[3]. However, losses, reflections and diffractions due to the walls, floors, ceilings and many kinds of furniture should be taken into account in the indoor environment [4]. Our research group have been studying to estimate indoor radio wave propagation characteristics of WLAN system in the 2.4 and 5 GHz bands by measurements and numerical electromagnetic simulations [5]-[10].

The paper discusses indoor propagation characteristics of a WLAN system based on the IEEE802.11n standard operating in the 5 GHz band in a typical office environment. We conduct a large-scale numerical electromagnetic simulation using the FDTD technique to estimate indoor propagation characteristics such as RSSIs and channel models. For the purpose, we will develop a precise numerical model of an office environment with the space resolution of 5 mm. Especially, metallic obstacles are modeled in detail to obtain results corresponding to the measurements since they affect radio wave propagation severely.

## II. NUMERICAL MODEL OF AN OFFICE ENVIRONMENT

Finite difference time domain (FDTD) method [10] is employed in an numerical electromagnetic simulation. A

problem space is discretized by cubical cells. Since we will calculate RSSI and Poynting vector in the office environment, the computer simulation needs many running time and a large amount of computer resources such as CPU cores and main memories. For these reasons, we have developed the large-scale FDTD software running on the supercomputer.

Figure 1(a) depicts a numerical model of office environment which corresponds to the third floor in Information Initiative Center, Hokkaido University. There are an elevator, pipe spaces, a rest room and so on at the center of floor surrounded by the public space such as passages. Also, laboratories and officer's rooms enclose them. The area of the floor is about 645 m<sup>2</sup>. The numerical model includes a wireless LAN access point placed in the passage and furniture such as chairs, desks, partition screens, metallic shoe boxes and so on. Iron rods are employed in the inside of concrete walls to make a four-layered grid structure. A dimension of the unit cell is  $\Delta x = \Delta y = \Delta z = 5$  mm. In addition, the AP is modeled by a conductive box with two dipole elements of 25 mm long shown in Fig. 1(b). They are excited by a co-phased sinusoidal signal at the frequency of 5200 MHz corresponding to the carrier frequency. Considering the computational stability, a time step size is chosen as  $8.6 \times 10^{-12}$  sec. The problem space is terminated by a ten-layered CPML absorbing boundary condition with the twenty guard cells from the surfaces of concrete wall.

## III. NUMERICAL RESULTS

Figure 2(a) depicts the visualized distribution of vertical electric field components in the office environment. It is seen that the radio wave propagates mainly along the corridor from AP and the electric field components are observed in the rooms adjacent to it.

Figure 2(b) visualizes Poynting vector corresponding to the propagation channel. Since AP is placed on the corridor ceiling, the Poynting vector is forced to go downward and radiationally from AP. It can be seen from the figure that several unique propagation channels are observed. The radio wave propagates towards the window while being repeatedly reflected by the reinforced concrete wall in the left hand side room. In addition, the wave reflected at the hallway corner passes through the stairs to the downstairs. The waves reflected by the metal door and the shoe lockers go into the rooms in the opposite side of AP.

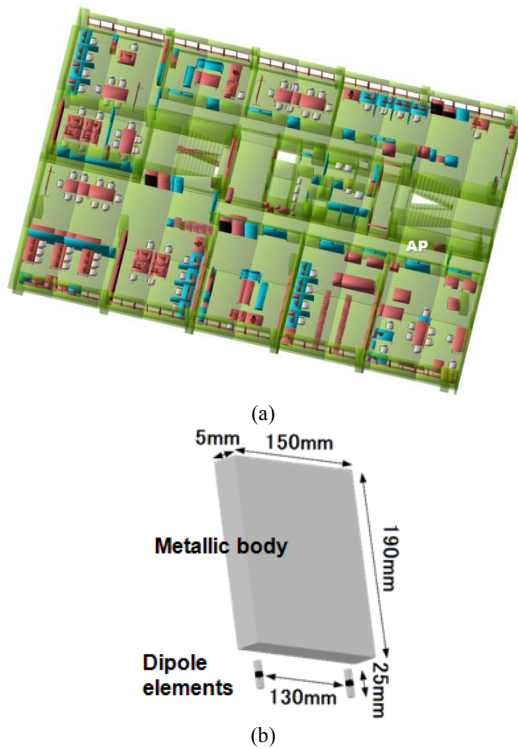


Fig. 1. Numerical models of the floor in the office environment (a) and an access point geometry (b).

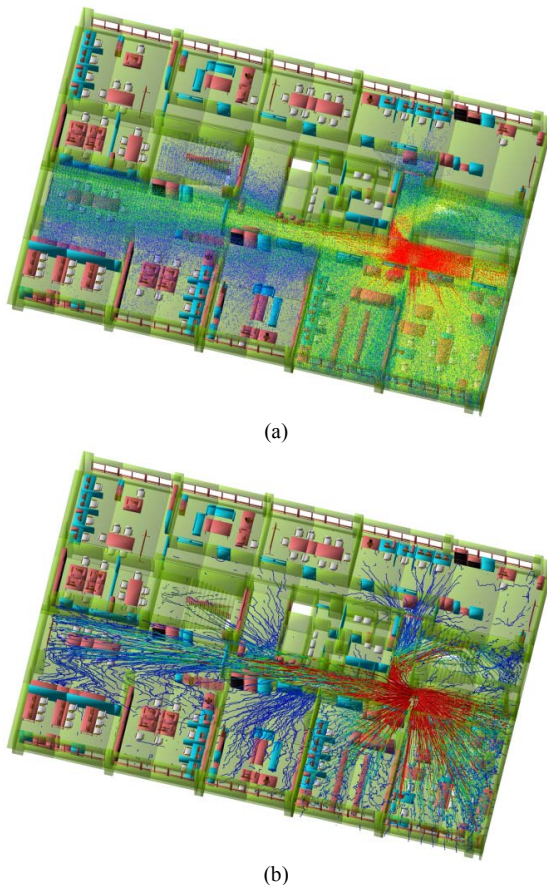


Fig. 2. Results of numerical electromagnetic simulation, RSSI (a) and Poynting vector (b).

#### IV. CONCLUSION

The WLAN system based on the IEEE802.11n/ac standard achieves high output power by occupying a wide frequency bandwidth and high data throughput in the indoor multipath communication environment by adopting the MIMO-OFDM. This paper discussed the indoor propagation characteristics in the office environment by the numerical electromagnetic simulations in order to estimate RSSIs and channel models of a high-speed WLAN system operating in the 5 GHz band. The numerical electromagnetic simulations using the FDTD technique and the precise numerical model of the office environment were carried out. The results are expected to contribute to the indoor radio wave propagation research and they are thought to be one of the effective design approaches so that the installation position and the number of APs can be estimated numerically.

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