Considerations on Indoor Propagation Concerning to Wideband Wireless LAN System

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1. Introduction

Currently the high-speed wireless LAN system, IEEE802.11n, is widely used [1],[2]. Its advantages are a high output power and a high transmission rate such as 300 Mbps with the bandwidth of 40 MHz. So they make it possible to communicate with clients over the wider area including the line-of-sight and non-line-of-sight as well as plural floors in a building. In this paper, we will focus on an indoor propagation in a large office building. First, the received signal strength indication (RSSI) is measured for a wireless LAN system based on an IEEE802.11n standard. Furthermore, they are estimated by using the large-scale electromagnetic field analysis in order to show the validity of the experiment results and the effectiveness of computer simulations.

This paper consists of four chapters. Our experimental environments and measurement methods are explained and then measured results are shown in Section 2. Computer simulations based on the FDTD technique are carried out and numerical results are compared with measured ones in Section 3. Finally, conclusive remarks are presented in Section 4.

2. Measurements of Propagation Loss

The study of the indoor propagation was experimentally carried out in one floor of a relatively large office building depicted in Fig. 1. It is a map of the 9th floor in the building of Electronics and Information Engineering, School of Engineering, Hokkaido University. We use the area of the corridor for the measurement on the orbital track shown by the dashed line in Fig. 1. Its each corner portions are marked by A, B, C and D. The distances of AB and CD and of BC and DA are 8.8 m and 47.9 m, respectively. The shaded part is corresponding to the research lounge which is a continuous open space from the ninth floor to the tenth floor.

A wireless LAN access point (AP) is located on the ceiling of the ninth floor at the corner B in Fig. 1. We use the Buffalo WZR-HP-G300NH as an AP [3]. The equipment supports the IEEE802.11n standard for the frequency band of 2.4 GHz and achieves a communication speed of 300Mbps with the bandwidth of 40 MHz. The transmission speed is automatically changed from 300 Mbps to 6 Mbps depending on the communication environment. In the experiment, we choose the channel 7 whose frequency corresponds to 2,442 MHz and use the channel 11 as an additional channel for the 40 MHz bandwidth. Figure 2 (b) shows a setup of experimental equipments and how to measure received signal strength indication (RSSI) by using a mobile PC as a terminal. The PC in the wagon moves to the specified direction at a constant speed of 0.1 m/s and measures RSSI automatically per one second. We used USB2.0 wireless terminal, WLI-UC-G300HP, for the PC supporting IEEE802.11n.

Figure 3 shows the measured results. In experiments, RSSI is measured at the height of 0.82 mm above the floor and at the centre of hallway in the order of A-B-C-D-A. The vertical axis in Fig. 3 denotes RSSI. It can be seen from the figure that the communication can be able in the NLOS of the same floor. Additionally, we can see that the communication is also possible around corner B in both the eighth and the tenth floors. There are larger RSSI distributions observed in the middle of section B-to-C and D-to-A in the tenth floor because of the open space structure around the research lounge.

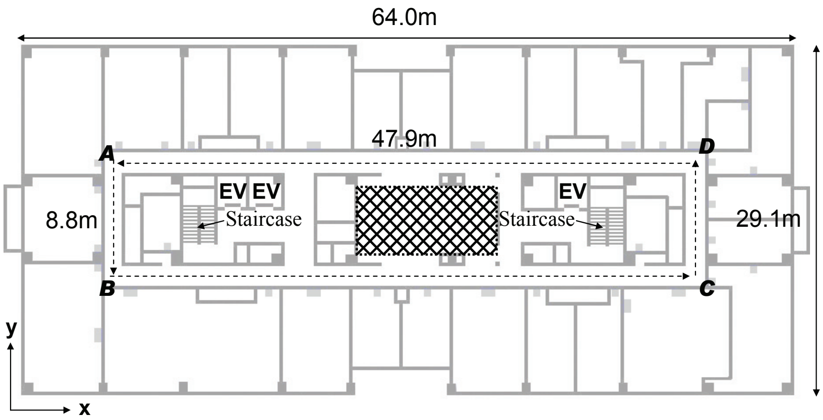
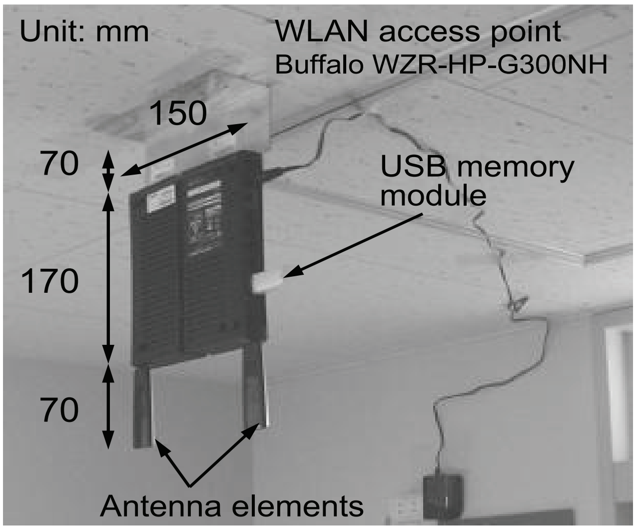
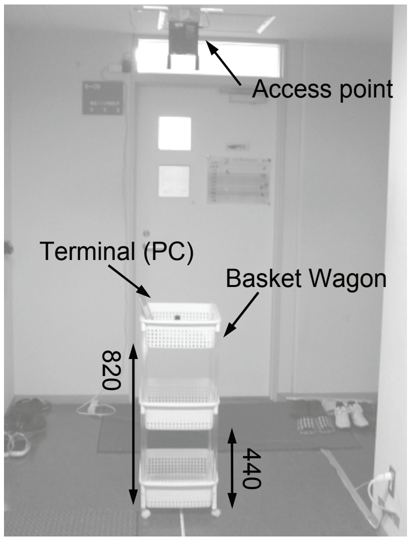


Figure 1: A floor map



(a) Access point



(b) Measurement equipments

Figure 2: Setup of experiment equipments

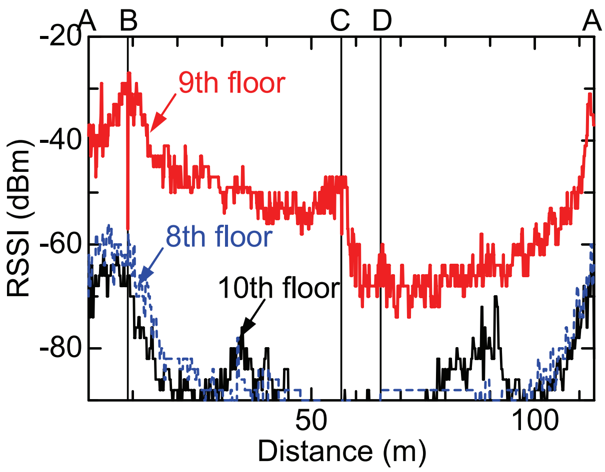
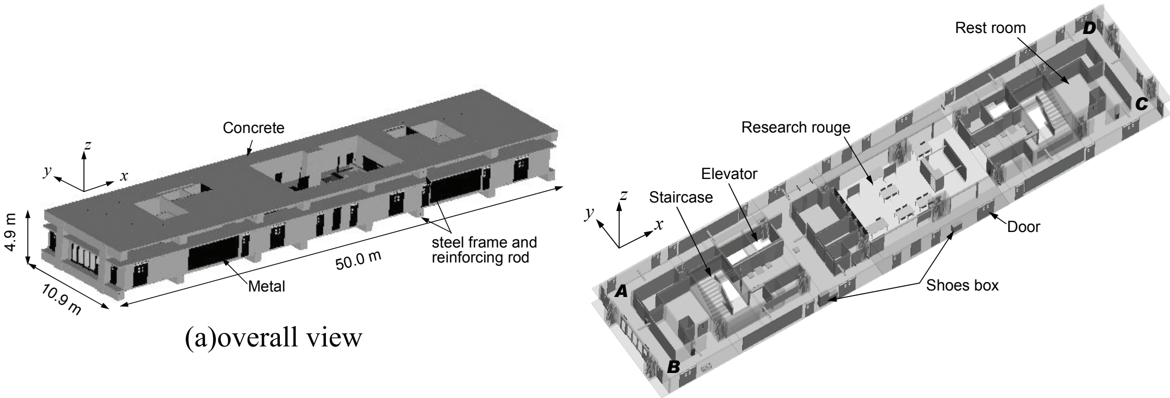


Figure 3: Measured results of propagation losses

3. Estimations of Propagation Loss

Finite difference time domain (FDTD) method [4],[5] is employed in an analysis. A problem space is discretized by cubical cells referred as a Yee cell. Since we will calculate RSSI in the large office building until the steady state in the time domain, the computer simulation needs much 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 which can obtain stable solutions within a reasonable calculation time [6].



(a)overall view

(b)Inside view

Figure 4: 3-dimensional model of the ninth floor

Table 1: Electrical constants of material

Items	Relative permittivity	Conductivity
Free space	1	0
Metal	-	∞
Concrete	5.5	0.023
Wooden material	2.5	0.001
Window glass	5.0	0.003
Plastics material	3.2	0.008
Rubber material	2.4	0.005

Figure 3 shows a numerical model consisting of only utility space in the ninth floor. Dimensions of the model are 50.0 m × 10.9 m × 4.9 m. Figure 3 (b) is the internal structure. Conductive walls are shown in the dark colour. The model includes furniture such as chairs, desks and partition screens in the research lounge as well as a metallic shoe box. Steel frames of 0.6 m wide in the concrete wall are placed each other apart from 6 m or 8 m long. Table 1 shows the electric constants of material, relative permittivity and conductivities, assumed in numerical simulations. Moreover, a spatial resolution is $\Delta x = \Delta y = \Delta z = 10$ mm. In addition, the AP is modelled by a conductive box with two monopole elements of 30 mm long. They are excited by a co-phased sinusoidal signal at the frequency of 2,442 MHz corresponding to the carrier frequency of the seventh channel. Considering the computational stability condition, a time step size is chosen as 1.73×10^{-11} sec. However, setting the 20 guard cells from the surface analytical models, the problem space is terminated by a CPML absorbing boundary condition with ten layers [6].

Figure 5 shows a calculated RSSI compared with measurements in the ninth floor. It is seen from the figure that the propagation loss is similar for both results. In the NLOS area of C-D-A, the measurement result is different from the analytical one in the value of about 10 dB. As this reason, the analytical model does not include the rooms around the corridor.

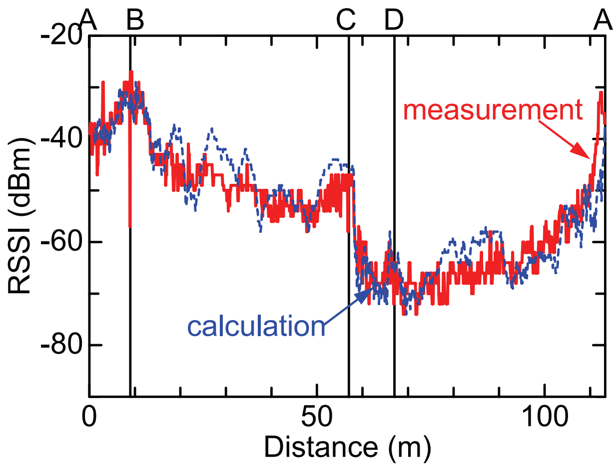


Figure 5: Comparison of measured and calculated propagation losses

4. Conclusions and Further Work

This paper discussed the indoor propagation characteristics in the large office building for the high-speed wireless LAN system based on the IEEE802.11n standard at the frequency band of 2.4 GHz. By measuring the received signal strength indication (RSSI), the signals were received in the line-of-sight and non-line-of-sight of the same floor, and in the part of the upstairs and downstairs environments. In addition, the FDTD calculations were carried out and compared with the measurements. There is good correlation between the two results. Therefore, it confirms the validity of the measurement results and the effectiveness of the large-scale FDTD analysis.
Future, we will consider relations between RSSI and averaged throughput for the IEEE802.11n wireless LAN system.

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