

Novel Configuration for Indoor Wireless LAN Base Station Applied to SDMA System

Sokthai CHAN, Mitoshi FUJIMOTO, and Toshikazu HORI

Faculty of Engineering, University of Fukui, 3-9-1, Bunkyo, Fukui, 910-8507 Japan

E-mail: sokthai@wireless.fuis.fukui-u.ac.jp, {hori, fujimoto}@fuis.fuis.fukui-u.ac.jp

Abstract The application of indoor wireless LANs to the Space Division Multiple Access (SDMA) system was proposed; however, in this proposed scheme it is difficult to separate signals from individual mobile terminals using the directional beam of a base station (BS) when the mobile terminals approach each other. In order to address this problem, a novel configuration for a BS in the SDMA system is proposed in this paper. The optimal arrangement of array antennas in the BS is considered. The configuration establishes orthogonal channels between mobile terminals and the BS enabling the signals from the mobile terminals to be separated. The simulation results show that the optimal BS configuration depends on the wall materials that comprise the room. Moreover, the results show that the optimal element spacing is slightly narrower than half the size of the room for both concrete and metallic walls.

1. INTRODUCTION

In recent years, since the demands of land mobile communications and wireless personal communications have rapidly increased with the popularization of cellular phone subscribers and Internet access, a wireless system with a high data rate and high channel capacity must be established. An indoor wireless LAN (IEEE802.11a), which has been developed and put into commercial use, employs Orthogonal Frequency Division Multiplexing (OFDM) transmission [1]. Moreover, in order to achieve higher spectrum efficiency and higher communications quality, Space Division Multiple Access (SDMA) [2][3], which is applied to indoor wireless LANs, was proposed. However, it is difficult to separate individual signals from respective mobile terminals by using a directional beam of a base station (BS) when the mobile terminals approach each other. Namely, when the directions of the mobile terminals approach each other from the viewpoint of the BS, the BS is not able to separate them spatially, and simultaneous communications becomes unavailable. In this paper, a novel BS configuration for the SDMA system used in indoor wireless LANs is proposed in order to address the above problem. In addition, the optimal arrangement of the array antenna of the BS is considered based on an evaluation of the Cumulative Probability (CP) of the SINR (Signal to Interference plus Noise power Ratio). In Section 2, the proposed BS configuration is described. In Section 3, an analysis model and an evaluation method are explained, and the optimal BS configuration is discussed based on the simulation results in Section 4.

2. PROPOSED BS CONFIGURATION

The conventional adaptive array antenna, where the distance between the transmission and reception stations is long enough compared to the aperture length of the array, forms a directional beam using the entire antenna array. In order to overcome the problem when mobile terminals approach each other in the SDMA system, the element spacing of the BS is maintained at a sufficient distance, which is greater than the conventional spacing, as shown in Fig. 1. In this case, the directional beam pattern of the array antenna cannot be considered because the distance between the transmission and reception stations is too short compared to the length of the array aperture.

The proposed BS configuration is shown in Fig. 2. A Guard Interval (GI) is used to receive separately the signals from two mobile terminals at the BS. Two sets of weight coefficients are utilized to receive the

individual signal from the two mobile terminals. One set of weight coefficients form a directional beam that receive the signal from Terminal 1 and suppress the signal from Terminal 2. The other set forms a directional beam that receives the signal from Terminal 2 and suppresses the signal from Terminal 1. In order to form such a directional beam, the GI is utilized. CHOP1A in Fig. 2 extracts the GI from the signal of Terminal 1 and CHOP1B extracts the tail of the effective symbol corresponding to the signal from CHOP1A. The signal from CHOP1A and CHOP1B are the same if there is no interference signal. Thus, the signal from CHOP1B is treated as the reference signal in the MMSE algorithm [4], and the difference between signals from CHOP1A and CHOP1B is minimized by the the MMSE algorithm [5][6]. In the case of Terminal 2, the signal from CHOP2A and that from CHOP2B are used to form the directional beam that receives the signal from Terminal 2 and suppresses the signal from Terminal 1 in the same way as described above. Therefore, OFDM signals from two mobile terminals can be received individually by the proposed BS configuration.

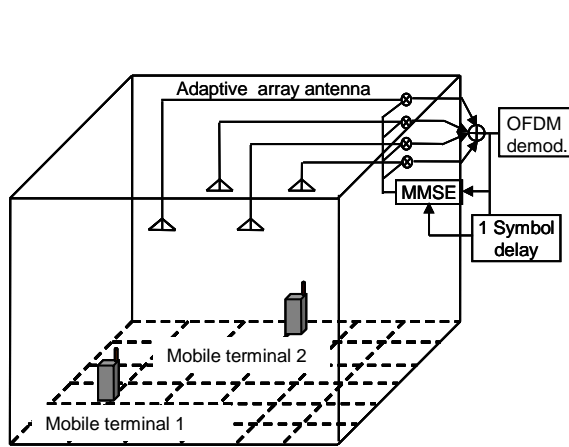
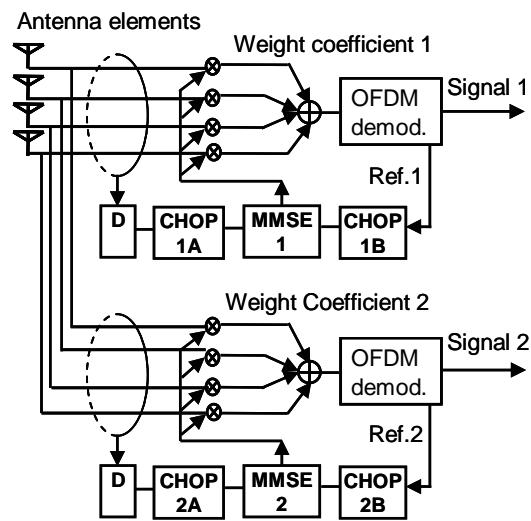


Fig. 1 Concept of BS configuration.



D: One symbol delay

Fig. 2 BS configuration.

3. ANALYSIS CONDITIONS AND EVALUATION METHODS

3.1 Simulation Model

Figure 3 shows the locations of the BS antenna and mobile terminal in the computer simulation. The array antenna layout of the BS is a square arrangement and there are two mobile terminals in the room. The directional patterns of the BS and mobile terminals are omni-directional. The height of BS antenna and that of the mobile terminal antennas are 3 m and 1 m, respectively. The carrier frequency is 5.2 GHz, the modulation scheme is QPSK-OFDM, the number of carriers is 64, and the GI length is 1/8 symbol of an effective symbol.

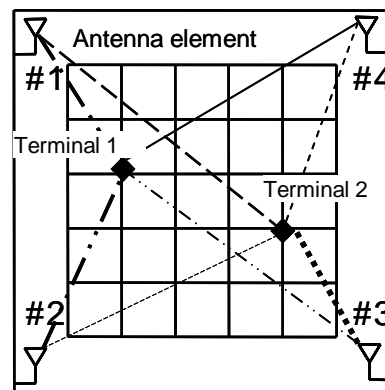


Fig. 3 Simulation model.

3.2 Evaluation Methods

Each terminal position is moved in the room in 1-m intervals. Regarding all arrangement combinations Terminal 1 (desired terminal) and Terminal 2 (interference terminal) in the room, the MMSE adaptive antenna at the BS is optimized and the SINRs of all the combinations are calculated. We evaluated the validity of the system using the value of 1% of Cumulative Probability (CP) of the SINR. This value means that the SINR value can be obtained in 99% of the area in the room. The simulation based on the Ray

Launching Method (RLM) is carried out as a propagation analysis and the Recursive Least Squares (RLS) algorithm is adopted to optimize the weight coefficients. The walls of the room are non-reflective, concrete, and metallic walls. The element locations are changed from the center of the room to the four corners in 1-m intervals, and the CP of the SINR is calculated for each case.

4. OPTIMAL BS CONFIGURATION

4.1 Dependency on Wall Material

(1) Relationship between wall material and SINR characteristics

Let us assume that the room is 20*20*3 m and the BS antenna elements are arranged at the four corners of the room. Figure 4 shows the cumulative probabilities of the SINR when the wall materials are non-reflective, concrete, and metal. The vertical axis of Fig. 4 represents the CP of the SINR, where the SINR value represented on the horizontal axis corresponds to the CP for the entire room. From Fig. 4, the CP of the SINR of a non-reflective wall, concrete wall, and metallic wall are 21.3 dB, 24.2 dB and 36.5 dB, respectively. Hence, we find that an excellent SINR value can be obtained when the wall material is metal.

(2) Optimal BS antenna arrangement

For comparison, we changed the element positions from the center of the room to the four corners in 1-m intervals and calculated the SINR CP value for each case. Figure 5 shows the simulation results. The horizontal axis of Fig. 5 represents the antenna element spacing, which is changed from 1 to 20 m in 1-m intervals away from the BS, while the vertical axis shows the CP 1% of the SINR. From Fig. 5, we find that the optimal element spacing of the BS is different according to the wall material of the room. In addition, the figure shows that the optimal element spacing is slightly narrower than half of the size of the room for both concrete and metallic walls, whereas the optimal element spacing is half of the size of the room for a non-reflective wall. Moreover, we obtained excellent SINR values for any element space of metallic wall.

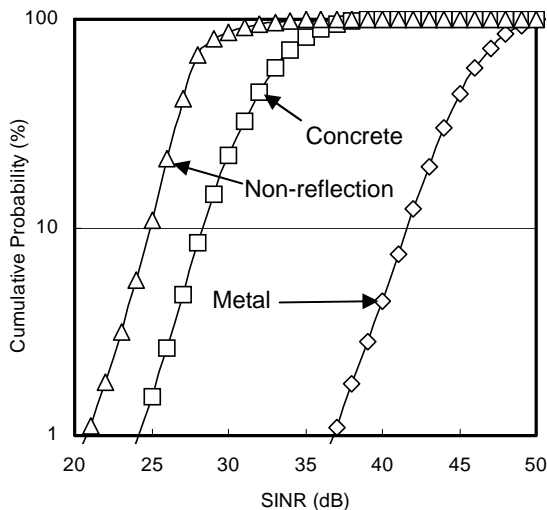


Fig. 4 Relationship between SINR characteristics and wall materials.

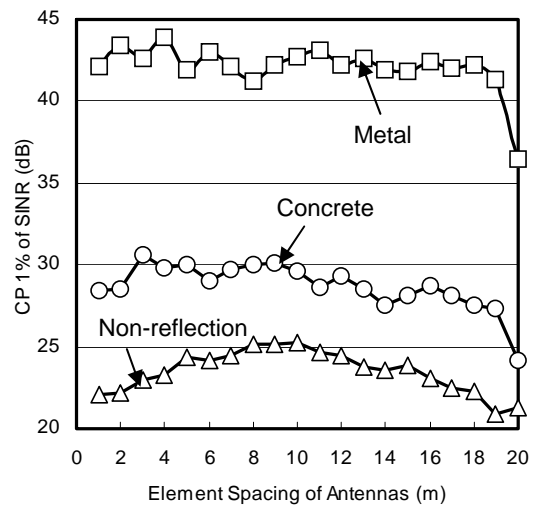


Fig. 5 Relationship between element spacing of antenna and CP 1% of SINR

4.2 Optimal BS Configuration for Concrete Wall

(1) SINR characteristics of concrete wall

In this simulation, we assumed concrete wall material for the room. We changed the element positions from the center of the room to the four corners in 1-m intervals and compared their SINR CP values in each

case. As shown in Fig. 6, the CP of the SINR value has a peak around 3 m and it drastically decreases with wider antenna element spacing.

(2) Optimal BS configuration depending on the size of the room

Let us assume that the wall material of the room is concrete, and the room sizes are 15*15*3 m, 20*20*3 m, and 25*25*3 m. We simulated the variations in the CP SINR by changing the element spacing of the BS in the above kinds of rooms and the results are shown in Fig. 7. From the graph, we found that the optimal element spacing is slightly narrower than half of the size of the room. Moreover, the SINR decreases when the size of the room becomes larger.

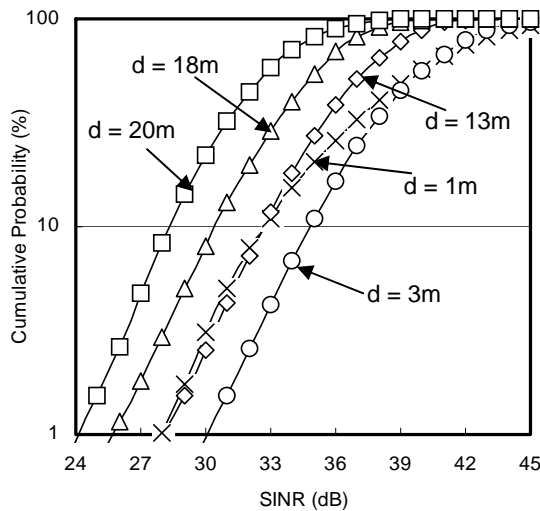


Fig. 6 Optimal array arrangement for concrete walls and employing various element Spacings

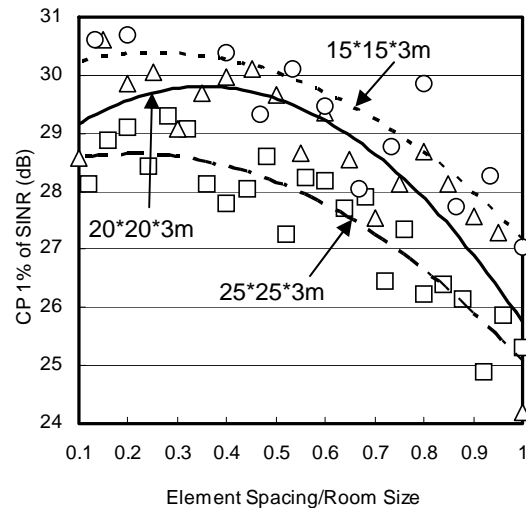


Fig.7 Optimal array arrangement of concrete wall and various room sizes

5. CONCLUSIONS

In this paper, we considered the optimal BS configuration for the SDMA system. Through the results of our simulations, the optimal element spacing for the BS was found to be different depending on the wall material. It was also clarified that the optimal element spacing is slightly narrower than half of the size of the room for both concrete and metallic walls.

REFERENCES

- [1] Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: High-Speed Physical Layer in the 5 GHz Band, IEEE802.11a/D5.0, April 1999.
- [2] K. Cho and T. Hori, "Smart Antenna System Actualizing SDMA for Future Wireless Communications," Proc. of ISAP2000, Fukuoka, Japan, pp. 1485-1488, Aug. 2000.
- [3] H. Jin and H. Lui, "Performance of Space-Division Multiple-Access (SDMA) with Scheduling," IEEE Commun. Mag., vol. 1, no. 4, pp. 611-618, Oct. 2002.
- [4] S. Hori, N. Kikuma, and N. Inagaki, "MMSE Adaptive Array Utilizing Guard Interval in the OFDM Systems," IEICE Trans. Commun., vol. J85-B, no. 9, pp. 1608-1615, Sept. 2002 (In Japanese).
- [5] N. Kikuma and M. Fujimoto, "Adaptive Antennas," IEICE Trans. Commun. vol. E86-B, no. 3, pp. 968-979, March 2003.
- [6] Y. Ogawa, M. Ohmiya, and K. Itoh, "An LMS Adaptive Array for Multipath Fading Reduction," IEEE Trans. Aerosp. and Electron. Syst., vol. AES-23, no. 1, pp. 17-23, Jan. 1987.