Effect of LOS on SINR Characteristics of SDMA System in Urban Area

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Abstract The Space Division Multiple Access (SDMA) system was proposed to improve the frequency utilization efficiency. In this paper, to grasp the effect of SDMA in a multi-path environment such as an urban area, Signal to Interference plus Noise power Ratio (SINR) characteristics in a city propagation environment are evaluated. Computer simulation results show that the fluctuation of the SINR depends on the height of the base station antenna and the location of the desired terminal. The results also show that the SINR value varies with the height of the BS antenna, and the SINR value becomes highest when the BS antenna is set to approximately 75 m. The SINR value in the case of Line Of Sight (LOS) is larger than that for Non-Line Of Sight (NLOS) when the BS antenna is set at a low location such as 50 m. However, the NLOS SINR value becomes larger than that for LOS when the BS antenna is set at a high location.

1. INTRODUCTION

Establishing technology that achieves high quality and high-speed wireless access is inevitable considering the popularity of multimedia and wireless communications. Since frequency is a limited resource, multi-access technologies such as Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), and Code Division Multiple Access (CDMA) were introduced into mobile communication systems. Furthermore, Space Division Multiple Access (SDMA) systems have attracted much attention as a technique that increases the frequency utilization efficiency [1]. In SDMA systems, smart antennas are applied to base stations (BSs) and orthogonal radiation patterns are formed toward the individual user terminals. The terminals can establish access using the same frequency, the same time, and the same code because the signals from individual users are separated based on the radiation pattern [2][3].

In SDMA systems, however, when the desired and interfering terminals are close to each other the frequency utilization efficiency cannot be significantly increased because the signals cannot be separated using the radiation pattern of the smart antennas. Establishing SDMA is very complicated in urban areas due to multi-path propagation.

This paper evaluates the effect of the BS antenna height on the Signal to Interference plus Noise power Ratio (SINR) characteristics and the difference in the SINR characteristics between Line Of Sight (LOS) and Non-Line Of Sight (NLOS) NLOS propagations. In Section 2, an urban propagation model is presented and the simulation process is described. In Section 3, the effects of the height of the BS antenna on the SINR characteristics are discussed. In Section 4, the difference in the SINR characteristics between the LOS and NLOS cases for the desired user terminal is discussed.

ISBN: 89-86522-78-0 94460

2. URBAN PROPAGATION MODEL

The urban propagation model used in this paper is illustrated in Fig. 1. The size of the urban model is 630x630 m and buildings are located in a grid pattern. The urban propagation model comprises 64 blocks where one block comprises four buildings. The road width is set to 20 m. We assume that the heights of the buildings are distributed at random in the range of 30 ±0.7x30 (between 9 to 51 m) and the widths of the buildings are distributed in the range of 20 ±0.5x20 (between 10 to 30 m). The dielectric constant and conductivity of the buildings and the ground are set to 5 and 0.01 [S/m], respectively.

We assume that the BS antenna is a linear array that comprises four elements, the element spacing is 0.5 wavelengths, and the array is adaptively controlled using the Minimum Mean Square Error (MMSE) algorithm. The frequency is 3.0 GHz. We also assume that there are two user terminals. One of these is the desired terminal and the other is the interfering terminal, which moves in the gray area in Fig. 1. The height of the user terminals is 1.5 m. Vertical polarization is used. We calculate the propagation characteristics (the arrival direction, intensity, and delay time) for each user terminal using the propagation model.

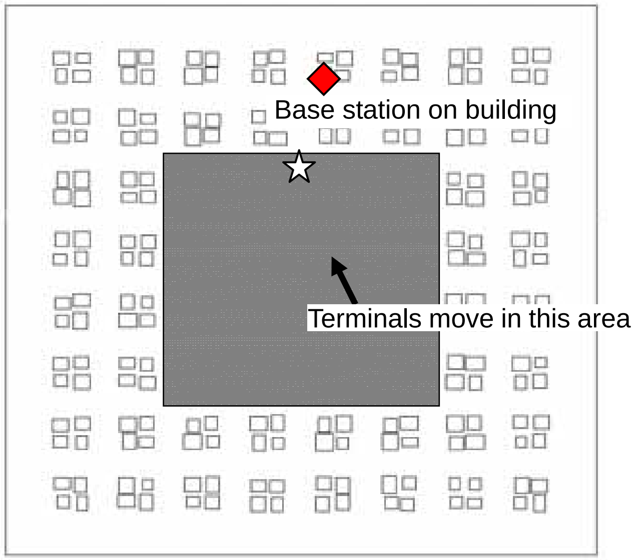

Fig.1 Urban propagation model

In the urban propagation model described above, we calculate the propagation characteristics (arrival direction, intensity, and delay time) for the desired and interfering terminals. The SINR is expressed as

$$SINR = \frac{Desired\ user\ \ power}{Interference\ user\ \ power + Noise\ \ power}[dB]\ .$$

3. EFFECT OF BASE STATION HEIGHT

Figures 2 and 3 show the SINR characteristics when the BS antenna height is 150 m and 50 m, respectively. We assume that the desired user terminal is located at the star (☆) in Fig. 1, which is in LOS, and the interfering user terminal moves in intervals of 15 m. In the case that the BS antenna height is 150 m (Fig. 2), as the angular difference between the terminals becomes narrow, the SINR value is decreased, and as the angular difference becomes wide the SINR value is increased. In the case that the BS antenna height is 50 m (Fig. 3), however, there are some points that have a low SINR value, even though the angular difference between the terminals is wide. Figure 4 shows the effect of the BS antenna height on the SINR characteristics. The vertical axis represents the cumulative probability that is less than the SINR value on the horizontal axis. In the case that the BS antenna height is 75 m, the SINR reaches its highest value in a low range cumulative density. The S/N value is decreased and when the BS antenna is set at a location that is too low in urban area propagation, then the SINR value is decreased. On the other hand, when the BS antenna is set at a location that is too high, the desired wave and interfering wave cannot be received individually because the angular spread of the received signals becomes narrow. Thus, the SINR value is decreased.

4. EFFECT OF DESIRED TERMINAL LOCATION

Figure 5 shows the difference in the SINR characteristics between the two cases. One is the case that the desired terminal is located in LOS, and the other is the NLOS case. The parameter for the figure is the height of the BS.

The figure shows that the SINR value in the LOS case is greater than that for the NLOS case when the BS height is 50 m. When the BS is set at a high location such as 75 m or 150 m, however, the NLOS SINR value becomes larger than that for LOS. This is because the SINR value is decreased due to a low SNR value when the BS antenna is set at a low location and the desired terminal is in a NLOS area. On the other hand, a high SNR value can be obtained when the BS antenna is set at a high location. However, the SINR value is decreased when the two terminals are close to each other even if the desired terminal is in the LOS area. This is because the angular spread becomes narrow when the BS antenna is set at a location that is too high and the propagation is LOS.

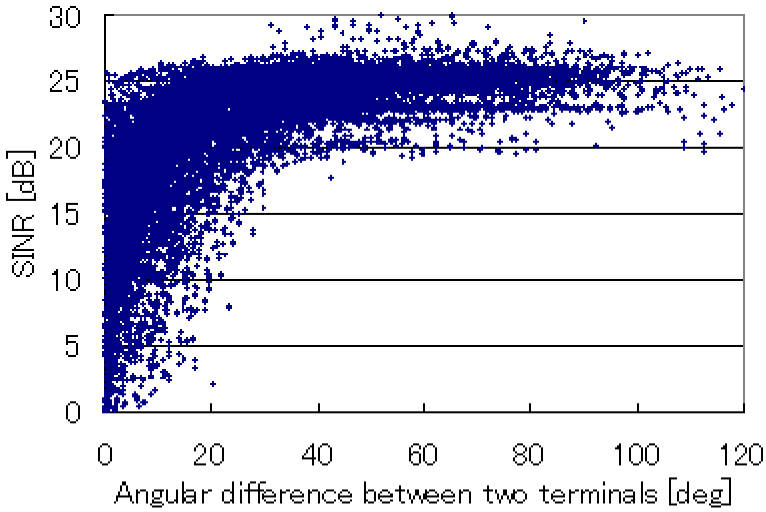

Fig. 3 SINR (BS antenna 50 m)

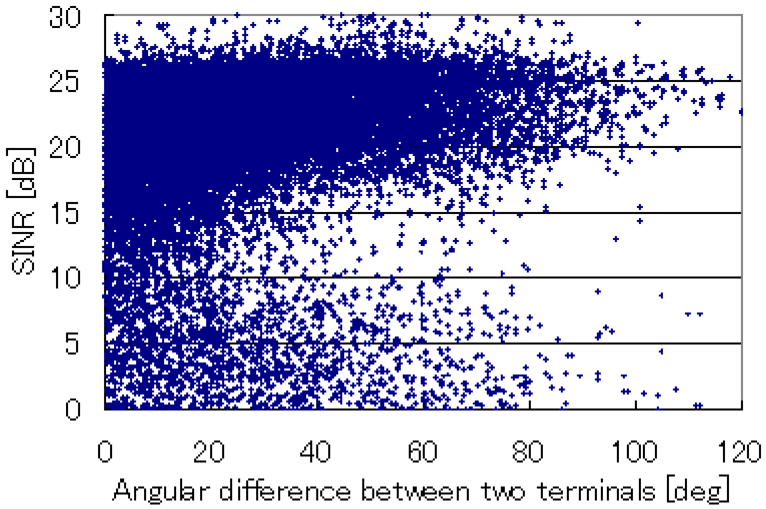

Fig. 2 SINR (BS antenna 150 m)

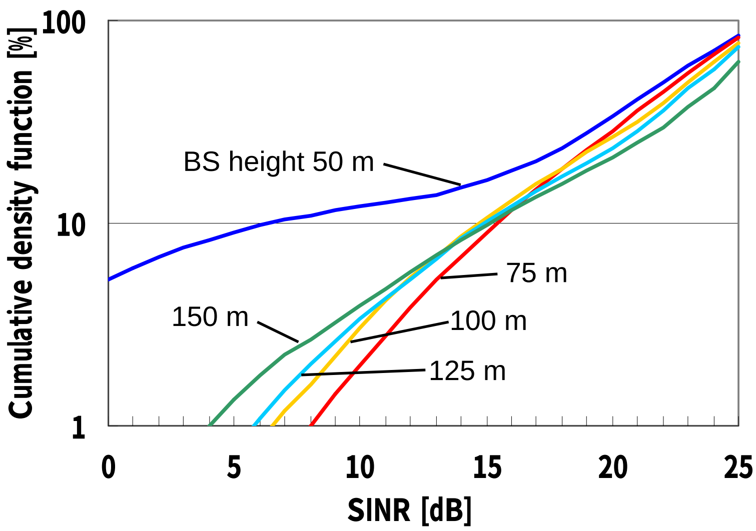

Fig. 4 Effect of BS antenna height on SINR

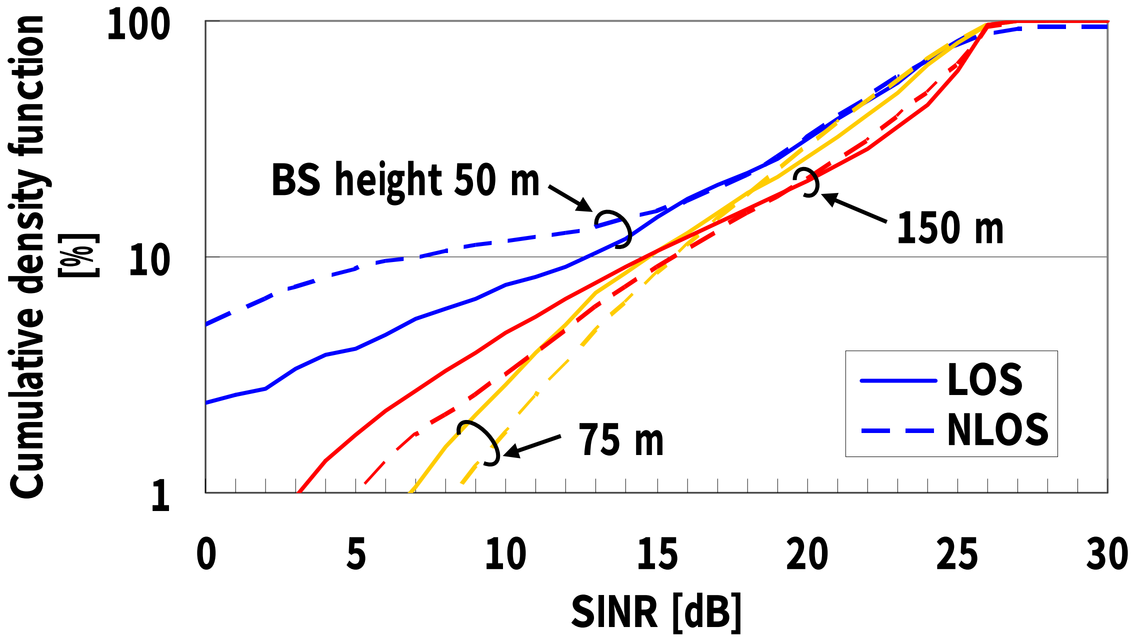

Fig. 5 Effect of LOS on SINR

5. CONCLUSION

The effects of the BS antenna height and desired terminal location on the SINR characteristics of the SDMA system in an urban area were evaluated. The results showed that the SINR value varied with the location of the BS antenna, and the SINR value reached its highest level when the BS antenna was set to 75 m. We showed that the SINR value in the LOS case is greater than that for the NLOS case when the BS antenna is set at a low location such as 50 m. However, the SINR value of the NLOS case becomes greater than that of the LOS case when the BS antenna is set at a high location.

ACKNOWLEDMENTS

The authors would like to express our appreciation to Dr. Kouich Tunekawa of Nippon Telegraph and Telephone Corp. (NTT) for his helpful suggestions and total support.

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