# Change in SINR Characteristics in Urban Area Environment

Hajime KUWAHARA*, Toshikazu HORI*, Mitoshi FUJIMOTO*, and Kentaro NISHIMORI**

*Faculty of Engineering, University of Fukui, **NTT Network Innovation Labs,
*3-9-1 Bunkyo, Fukui, 910-8507 Japan **1-1 Hikari-no-oka, Yokosuka, 239-0847 Japan
E-mail:kuwahara@wireless.fuis.fukui-u.ac.jp

**Abstract** Space Division Multiple Access (SDMA) has been proposed to improve the utilization efficiency of a channel. This paper evaluates the effect of the base station (BS) height and the height dispersion of the surrounding buildings to clarify the frequency utilization efficiency of SDMA in a multi-path wave environment such as in an urban area. The simulation results show that there is little fluctuation in an area in which the SINR value is less than 10 dB when the height of the BS antenna exceeds 100 m. Moreover, the results show that variance of the SINR decreases as the height of the BS antenna increases.

**Keywords:** SDMA, SINR, Urban Area, Propagation

## 1. INTRODUCTION

Establishing technology that achieves high quality and high-speed wireless access was 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.

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 by the radiation pattern.

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 by using the radiation pattern of the smart antennas. Establishing SDMA is very complicated in urban areas due to multi-path propagation. Therefore, we evaluated the Signal to Interfere plus Noise power Ratio (SINR) characteristics of the SDMA system in urban areas through computer simulations.

This paper evaluates the effects of the BS height and the height dispersion of the surrounding buildings in order to clarify the frequency utilization efficiency of the SDMA system in a multi-path wave environment such as an urban area. In Section 2, an urban propagation model is presented and the simulation process is described in Section 3. In Section 4, the effects of the height of BSs and the height dispersion of the surrounding buildings are discussed.

## 2. URBAN PROPAGATION MODEL

The urban propagation model used in this paper is illustrated in Fig. 1. We assume that the BS antenna comprises four elements, and the desired user terminal is located in line of sight (LOS). We also assume that the interfering user terminal moves in the direction of the X-axis (transverse direction), and the heights of the desired and the interfering user terminals are 1.5 m. The small squares in Fig. 1 indicate buildings. The urban

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propagation model comprises 64 blocks where a block of buildings comprises four buildings. We assume that the heights of the buildings are distributed at random in the range of 30 ±hx30 (0< h <1) and the widths of the buildings are distributed in the range of 20 ±0.5x20. Here, the value of h determines the height dispersion of the surrounding buildings. We set the value of h to 0.7 when we vary the BS antenna height. Namely, the heights of the buildings are distributed from 9 to 51 m.

When evaluating the changes in the SINR characteristics due to the height dispersion of the surrounding buildings, the height of the BS antenna is set to 50 m.

Moreover, the road width is set to 20 m in each model. The dielectric constant and conductivity of the buildings and the ground are set to 5 and 0.01[S/m], respectively.

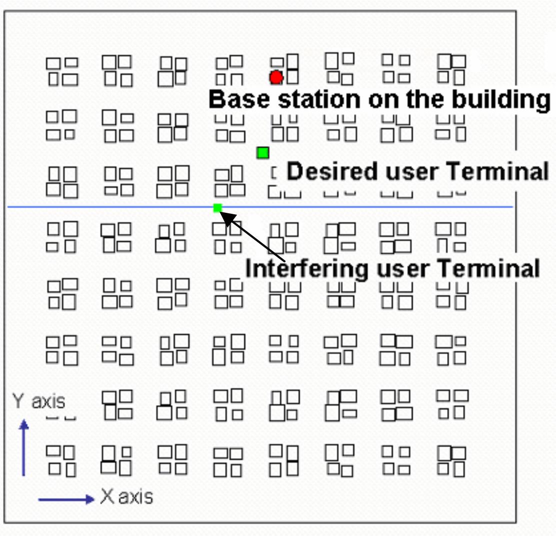


Fig.1 Urban propagation model

## 3. CALCULATION OF PROPAGATION CHARACTERISTICS IN URBAN AREA

In the urban propagation model described previously, we calculate the propagation characteristics (the arrival direction, intensity, and delay time) of each desired terminal and interfering terminal. The SINR is expressed as

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

We evaluated the SINR value for 10 urban propagation models. In these models, the building parameters, such as the height and width of the building, differ from building to building. It is assumed that the BS antenna comprises a four-element linear array based on the MMSE (Minimum Mean Square Error) algorithm, and the element spacing is 0.5 wavelengths.

## 4. SIMULATION RESULTS

### 4.1 Effect of BS Antenna Height

In the urban propagation models, the BS antenna height is changed from 50 m, 75 m, 100 m, 125 m, and 150 m. The simulation is performed based on the changes in the SINR characteristics considering the differences in antenna height. The beam width of the BS antenna element is set to 180 degrees.

Figure 2 shows variations in the SINR when the BS antenna height is set to 100 m. The horizontal axis in the figure denotes the position of the interfering user terminal, and the vertical axis denotes the SINR value. The desired user and the interfering user are in close proximity to each other at around 320 m in line

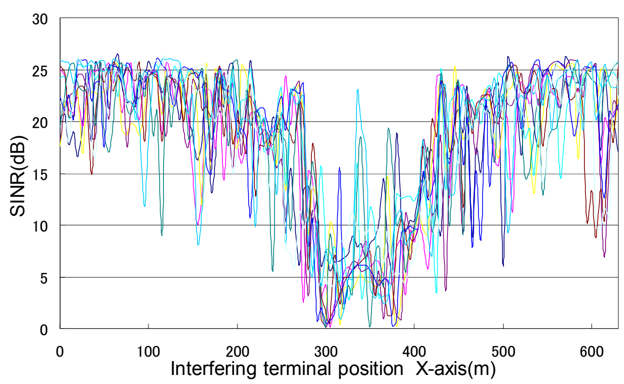


Fig.2 SINR characteristics (antenna height=100m)

on the Y-axis. Each line in Fig. 2 corresponds to one of the 10 urban models. Figure 2 verifies the degradation in the SINR is due to the proximity of the terminals to each other as is the case in the conventional SDMA.

Figure 3 shows the central value of the SINR for the 10 urban models. The horizontal axis in the figure is the interfering terminal position, and the vertical axis represents the central value of the SINR. We can see that even when the interfering terminal is close to the desired user terminal, there is a place with a high SINR value in case of the BS antenna is low.

Figure 4 shows the variance from the central value of the SINR. We can see that when the BS antenna height is low, there is a place where the variance becomes extremely large due to the influence of the buildings.

Figure 5 shows the range not exceeding the SINR of 10 dB and the average value for the variance for each antenna height. The horizontal axis in the figure is the BS antenna height, the left side vertical axis represents the range not exceeding the SINR of 10 dB, and the right side vertical axis represents the average of the variance from the central value. We can see that the range increases as the height of the BS antenna increases, and when the BS antenna height is 100 m or more, the range is almost constant. This is because, when the BS antenna height is high, there is no obstacle between BS antenna and the interfering terminal, and it becomes LOS in many cases. Furthermore, we find that the average value of the variance decreases as the height of the BS antenna increases because it is not affected by the surrounding buildings when the BS antenna height is high.

### 4.2 Effect of Dispersion of Building Heights

In order to clarify the effect of the height dispersion of the surrounding buildings, we changed the dispersion factor, h, when the average height of the building is fixed at 30 m. We set the value of h to 0.3 (building height is determined at random between 21-39 m), 0.5

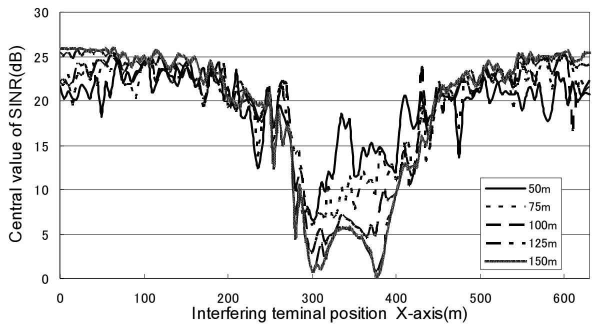


Fig.3 Central value of SINR (antenna height)

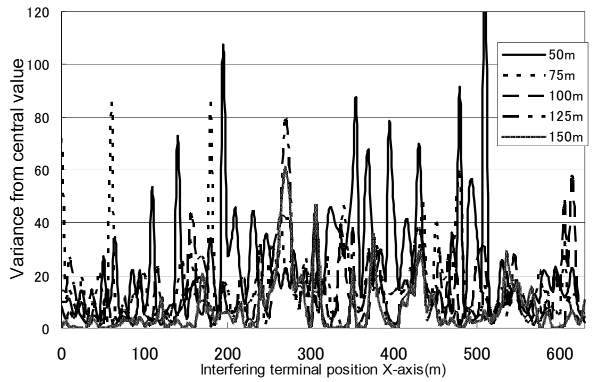


Fig.4 Variance from central value

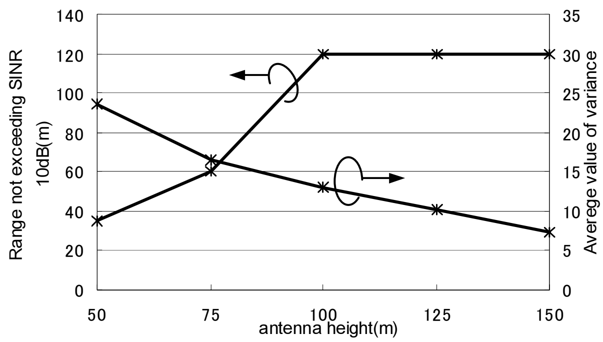


Fig.5 Range not exceeding SINR10dB average value of variance (antenna height)

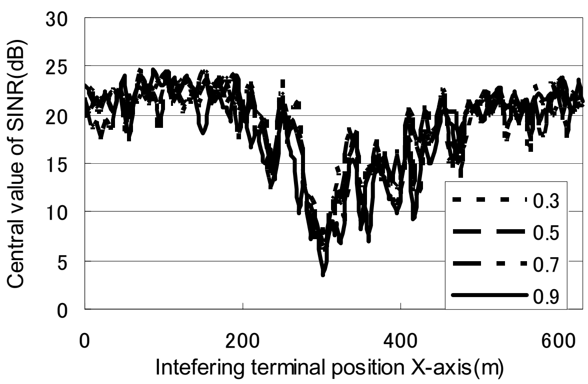


Fig.6 Central value of SINR (building height)

(between 15-45 m), 0.7 (between 9-51m), and 0.9 (between 3-57m). The beam width of the antenna element of the BS is set to 180 degrees in this simulation.

Figure 6 shows the central value of the SINR for each value of h. The horizontal axis in the figure is the interfering terminal position, and the vertical axis represents the central value of the SINR. Although a drop in the SINR for h = 0.9 is greater than for other case of h at around 350m and 415m in interfering terminal position, the tendency of SINR characteristics do not depend on the dispersion of the building heights.

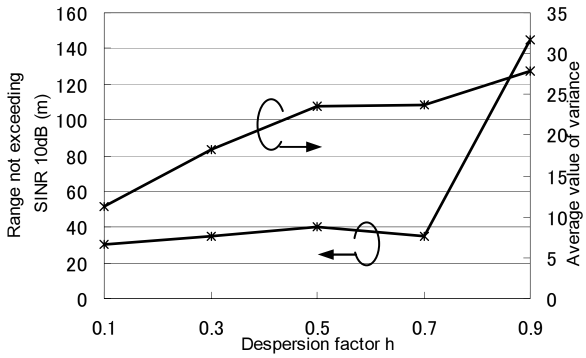


Fig.7 Range not exceeding SINR10dB average value of variance (building height)

Figure 7 shows the range not exceeding the SINR of 10 dB and the average value of the variance for each value of h. The horizontal axis in the figure is h, the left side vertical axis represents the range not exceeding the SINR of 10 dB, and the right side vertical axis represents the average of the variance from the central value. We can see that the range not exceeding the SINR of 10 dB is almost the same between h = 0.1 to 0.7. When h is 0.9, the range is 145 m. This is because there are several places where the SINR value is less than 10 dB.

Furthermore, we find that the average value of the variance increases as the value of h increases. This is because, when h becomes large, the influence of the building dispersion also becomes large.

**5. CONCLUSION**

We evaluated the effects of the height of the BS antenna and the effects of height dispersion of the surrounding buildings on the SINR characteristics through computer simulations. It was verified from the simulation results that the degradation in the SINR value due to the proximity of the terminals to each other follows the case of the conventional SDMA system. We found that the range where the SINR is less than 10 dB increases as the height of the BS antenna increases.

We also evaluated the effect of the height dispersion of the surrounding buildings. The results showed that the SINR variance decreases when the BS antenna is located high.

Finally, we showed the relationship between dispersion factor h and the range where the SINR value is less than 10 dB. The central value of the SINR was almost the same for each dispersion factor h except for h = 0.9. When h was 0.9, the range was 145 m. This means that we cannot maintain an SINR of 10 dB if the interfering terminal is closer than 145 m to the desired terminal when h is 0.9.

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