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Effect of Configuration of SDMA Base Station Antenna for Space Division Characteristic in Urban Area

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1. Introduction

Multiple Access technology such as TDMA, CDMA is used for increasing the frequency utilization efficiency. SDMA system is also researched for further frequency utilization efficiency improvement [1]. A radiation pattern such that emphasize the signal from desired user and suppress the signal from the other user is formed in SDMA system by applying smart antennas at the base station. In the SDMA system signal from each user is separated spatially by forming orthogonal pattern. As the result, plural user can communicate simultaneously using the same time and the same frequency. The frequency utilization efficiency become twice if space division for two users is any time possible. However, frequency utilization efficiency in SDMA system deteriorates when users are close to each other because of interfering between each user.

In the past, authors studied the characteristics of SINR when one desired user and one interfering user exist in urban area [2][3]. In this paper, in order to examine realization possibility of space division, simultaneous communication in the case of two desired users is considered. In Section 2, an urban propagation model is presented. In Section 3, evaluation method of SDMA is explained. In Section 4, effect of configuration of BS antenna on space division characteristics is shown. Effect of distribution of height of building is discussed in Section 5.

2. Urban Propagation Model

The urban propagation model used in this paper is illustrated in Fig.1. The size of the urban model is 630x630m and the model comprises 64 blocks where one block comprises four buildings. The heights of the buildings are distributed at random in the range between 9 to 51m. The widths of buildings are distributed in the range of between 10 to 30m. The construction of the building is concrete and the dielectric constant and conductivity of the buildings and the ground are set to 5 and 0.01[S/m], respectively. Number of the user terminals is two. It is assumed that the height of the user terminals are 1.5m, radiation patterns of the user terminals are omni pattern, and the terminals move on road inside the thick line in Fig.1. We calculated propagation characteristics (arrival direction, intensity, and delay time) between the base station and the respective terminals.

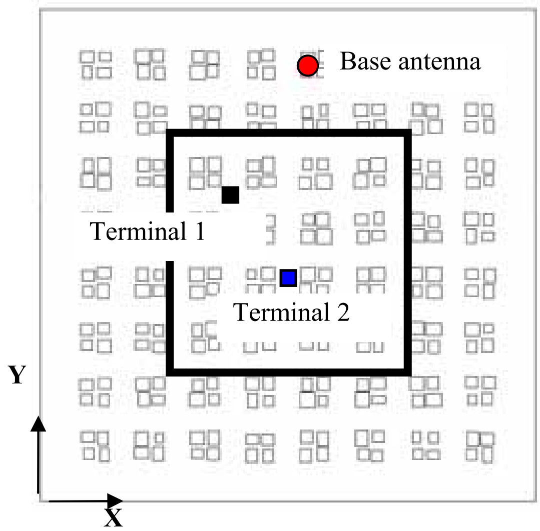

Figure 1: Urban Propagation Model

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3. Evaluation Method of SDMA

We assumed in analysis that base station antenna is composed of linear array arranged in parallel with x axis. Frequency is 3.0 GHz. The BS antenna adaptively controlled with Minimum Mean Square Error. We considered following two type of SINR.

$$SINR_1 = \frac{S_1}{S_2 + N}[dB]$$

$$SINR_2 = \frac{S_2}{S_1 + N}[dB]$$

Here, S_1 is signal power from terminal 1, S_2 is signal power from terminal 2, and N is noise power. Namely, $SINR_1$ is the value of SINR when terminal 1 is desired terminal and terminal 2 is interfering terminal. In opposite, $SINR_2$ is the value of SINR when terminal 2 is desired user terminal and terminal 1 is interfering user terminal. We examined SINR characteristics for ten kinds of urban propagation model.

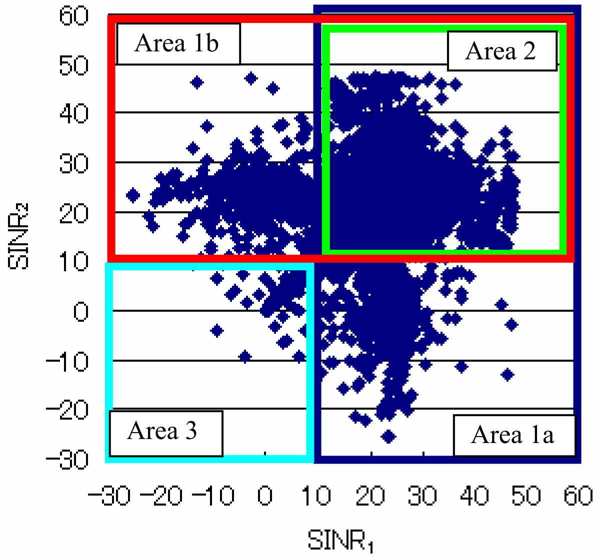

Figure 2: Characteristics of SINR in Urban Area (60m)

Figure 2 shows SINR distribution when the BS antenna height is 60m. The horizontal axis shows $SINR_1$, the vertical axis shows $SINR_2$. Here, we assume that the communication can be realized when SINR is more than 10dB. Namely, terminal 1 can communicate with the BS in area 1a of Fig.2, terminal 2 can communicate in area 1b of Fig.2. Thus two users can communicate simultaneously and space division is possible when both of $SINR_1$ and $SINR_2$ is more than 10dB which is indicated in Fig.2 as area2. On the other hand, both users can not communicate when both of $SINR_1$ and $SINR_2$ is less than 10dB in area 3. To make the possibility of SDMA clear, we pay attention to lower SINR among the $SINR_1$ and the $SINR_2$.

4. Effects of Configuration of Antenna on Space Division Characteristics

4.1 Effects of Base Station Height

Figure 3 shows the cumulative density function of SINR as a parameter of BS antenna height. The solid lines show cumulative density function in case of two users, and the broken lines show that of one user. As a matter of course, SINR characteristics for one user are better than the case of two users in any BS antenna height. As BS antenna height rises, SINR characteristics of two users and one user close to each other. For example, SINR characteristics are almost the same when BS antenna height is 80m and 100m. Thus, it is said that space division is possible with the same communication quality as the case of one user when BS antenna is more than 80m.

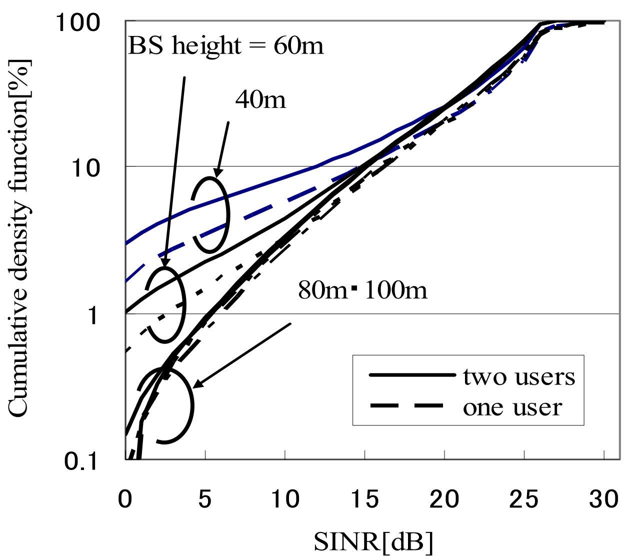

Figure 3: Effects of Height of BS Antenna on SINR

4.2 Effects of Number of Elements

Figure 4 shows the SINR of cumulative density function 10% (CDF 10%). The horizontal axis shows BS antenna height, the vertical axis shows value of SINR when cumulative density function 10%. The solid lines show characteristics of two users, the broken lines show characteristics of one user. The SINR characteristics don't depend on BS height when BS antenna height is more than 60m. Moreover SINR of two users decreases greatly when BS antenna height is less than 50m and it is lower between 1 to 5dB than that of one user. From the figure, it can be said that SDMA of two users can be achieved when the height of the BS height is more than 60m and number of elements is more than three.

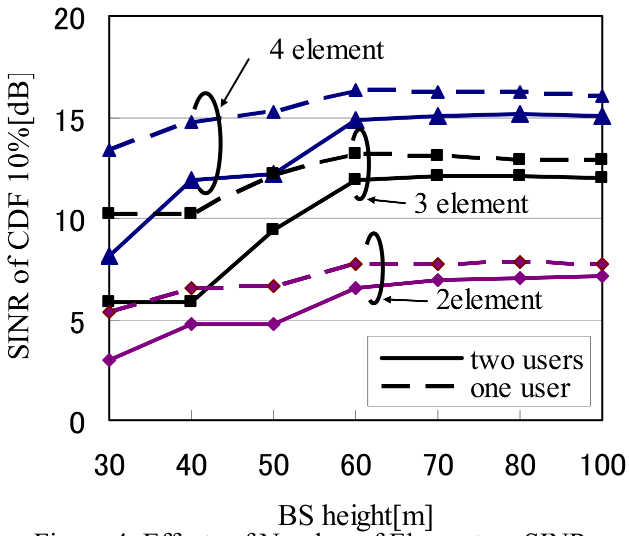

Figure 4: Effects of Number of Element on SINR

4.3 Effects of Element Spacing

Figure 5 shows the CDF 10% when the element spacing is changed. The horizontal axis shows BS antenna height, and the vertical axis shows value of SINR when cumulative density function 10%. The solid lines show characteristics in case of two users, the broken lines show characteristics of one user. When height of BS antenna is less than 60m, the SINR characteristics are improved as the element spacing extended. But, SINR characteristics don't depend on the element spacing when height of BS antenna is more than 80m.

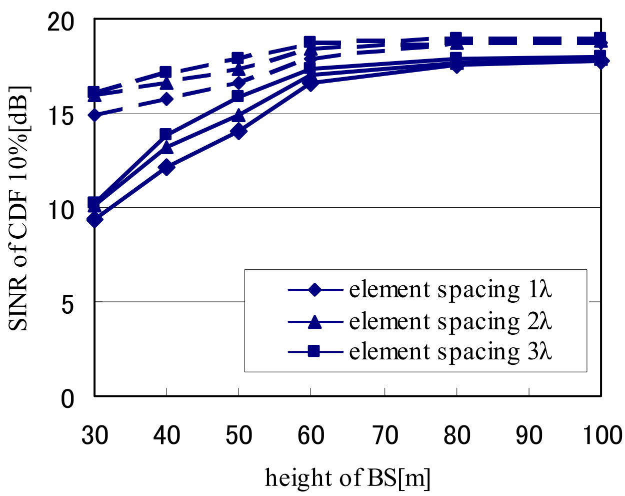

Figure 5: Effects of Elements Spacing on SINR

5. Effects of Building Height Distribution

In order to clarify the effect of the height dispersion of the buildings, the range of dispersion was changed. Here, the heights of the buildings are distributed in the range of between 3 to 17m and between 15 to 85m besides the range of between 9 to 51m. Other conditions are the same as that of chapter 2.

Figure 6 shows the result of the simulation. The horizontal axis shows SINR, the vertical axis shows cumulative density function of the SINR, the solid lines show value in case of two user, the broken lines show value in case of one user. Height of BS antenna is 60 m, the number of elements is four. As we can see, the SINR characteristics are affected by height dispersion of buildings, because SINR characteristics are different even if height of BS antenna is the same. If height of BS antenna is high enough compared with surrounding buildings, space division for two users is possible in the same communication quality as the case of one user.

Figure 7 shows SINR of cumulative density function of 10% when BS height is varied. The solid lines show the value of two users, the broken lines show the value of one user. If BS antenna is mounted at the lower point than maximum height of the buildings, SINR for two users is greatly lower that that of one user.

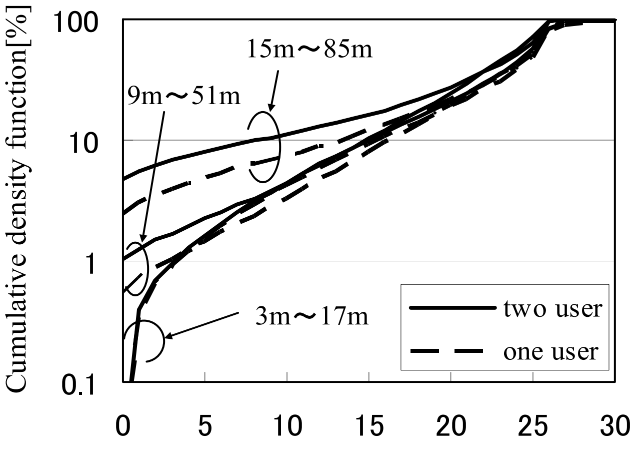

Figure 6: Effect of Building Distribution on SINR

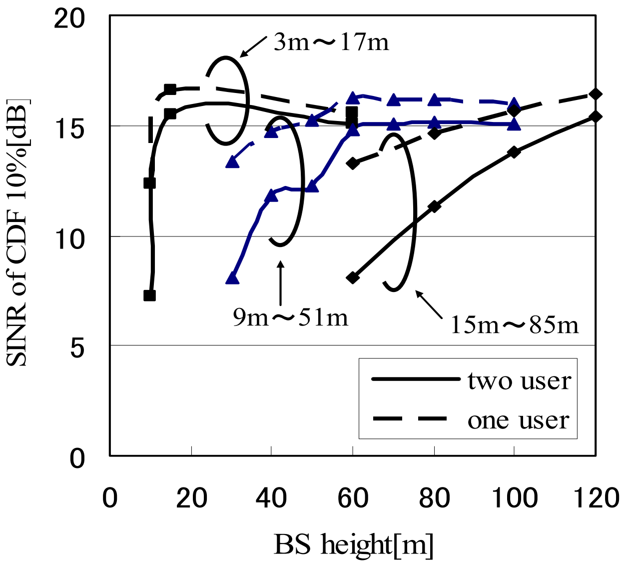

Figure 7: SINR of Cumulative Density Function 10% in Each Town

6. Conclusion

Effect of configuration of BS antenna on space division characteristics of SDMA system in urban area was evaluated. Moreover, effect of distribution of building height on SINR characteristics was evaluated.

At first, effect of height of BS antenna was evaluated. As the result, it was clarified that space division for two users was possible in the same communication quality as one user when BS antenna was mounted at high position. Next, effects of number of elements were evaluated. It was found that obtained SINR in case of two users at the same time was lower 1 to 5 dB than one user when number of elements was few. Moreover, effects of element spacing were evaluated. It was shown that SINR characteristics did not depend on the element spacing when BS antenna was very higher than surrounding building. At the last, effect of building height distribution was evaluated. It was clarified that space division of two users was possible if BS antenna was set up higher than maximum height of building.

And it was explained that SINR for two users was greatly lower than that for one user when BS antenna was mounted at the lower point than maximum height of the buildings. Considering the circumstances mentioned above, it was indicated that BS antenna should be located higher position that the height of surrounding building, and the number of element should be more than three.

References

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