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Elimination of Wireless Service Blind Spot by Co-operation between Mobile Terminals

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Abstract

In recent years, wireless communication technology becomes popular. To accommodate thousands of users, frequency bands utilized in the system tends to become high. When the high frequency band is utilized in wireless communication system, blind spots are occurred in downtown due to shadowing by buildings. In this paper, two co-operation schemes between the mobile terminals are proposed for eliminating the blind spots. One is "high power selection scheme" and another is "combine scheme". Effectiveness of proposed co-operation schemes is shown by numerical results. It is shown that the percentage of blind spots can be reduced less than 5% if the height of base station is over 80m and more than 16 relay terminals are in the downtown area.

1. Introduction

In recent years, radio waves in a high frequency is used in high speed mobile communication systems[1]. If the radio frequency is higher, the propagation loss in space is larger and the radio waves tend to propagate straightly. Therefore, the radio waves are shadowed in the downtown area, and blind spots are occurred[2]. In order to solve this problem, the mobile terminal that is possible to communicate with the base station is behaved as a relay terminal and radio waves are re-transmitted by the relay terminal to the receiving terminal. It is expected that the blind spots. can be eliminated by the co-operation schemes between the mobile terminals[3].

In this paper, two co-operation schemes are proposed for eliminating the blind spot. Effectiveness of the co-operation schemes is clarified, and the effect of the number of relay terminals on the elimination of blind spots are examined.

2. Co-operation Scheme between Mobile Terminals

When the co-operation between the terminals is applied, a mobile terminal in the service area re-transmits radio waves to another mobile terminal which is in the blind spot. Namely, the mobile terminals in the service area acts as relay terminals. Therefore, the receiving terminal can communicate even if the receiving terminal is in the blind spot itself. Thus, the blind spots occurred in the usual communication system can be eliminated. Figure 1 shows the concept of co-operation scheme between mobile terminals.

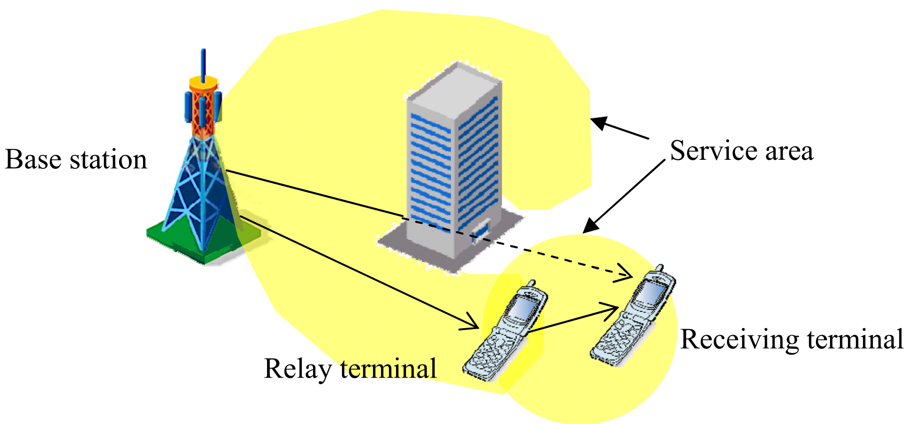

Figure 1: Co-operation Scheme between Mobile Terminals

When the relay terminal is in the blind spot, the relay terminal cannot communicate with the base station. Then the radio waves are not re-transmitted by the relay terminal. On the other hand, when both of the relay terminal and the receiving terminal can communicate with the base station, then one of the following two schemes is applied to the receiving terminal.

(1) High power selection scheme: High power signal between a direct signal from the base station or the relayed signal is selected.
(2) Combine scheme: Direct signal from the base station and the relayed signal are combined.

3. Analysis Condition and Evaluation Method

3.1 Analysis Model and Condition

Figure 2 shows a bird's-eye view of a city model in the analysis[4]. Figure 3 indicates the details of the analysis model. A block is composed of four buildings. A block size is 50m×50m. 64 blocks is arranged in the space of 640m×640m. Distance between the blocks is 20m. The base station is located at (x,y)=(340m,560m). The relay terminals and the receiving terminal are moved on the observation area of the city center. The observation area size is 280m×280m. Analysis condition is shown in Table 1.

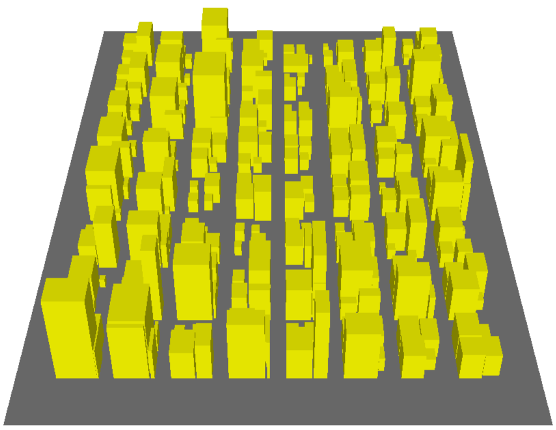

Figure 2: Analysis Model

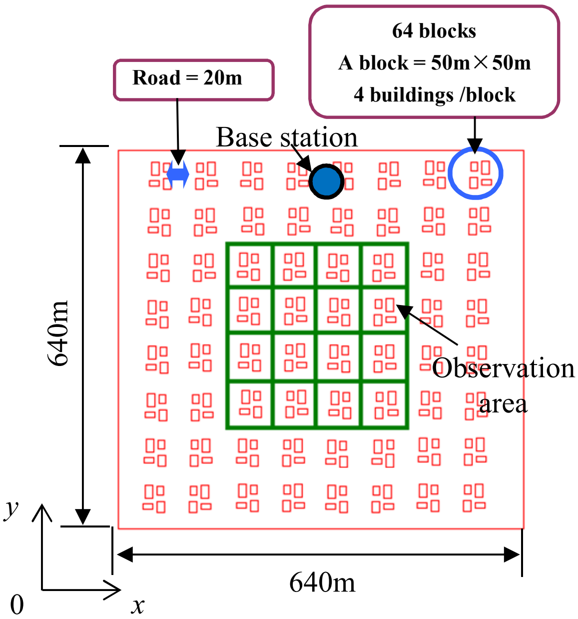

Figure 3: Details of Analysis Model

Table 1: Analysis Conditions

Transmission power of base station [dBm]	30	Height of base station[m]	80
Transmission power of relay terminal [dBm]	10	Height of mobile terminals[m]	1
Frequency[GHz]	5.0	Arrangement pattern of terminal	100
Average height of the building [m]	30	Minimum receiving power to ensure the link [dBm]	-80

3.2 Evaluation Method

In order to calculate the percentage of the blind spots, it is necessary to analyze the distribution of power in the observation area. Thus, a cumulative probability of power in the receiving area must be analysed. The blind spots in the observation area are calculated by setting the minimum received power to ensure the link of the communication.

4. Propagation Characteristics of Radio Waves in case of using Relay terminal

It is supposed that one relay terminal and one receiving terminal is located in the observation area, respectively. Both of terminals are moved on the observation area. The cumulative probability of power in the observation area is analyzed for the following three schemes.

(1) w/o Co-operation (Conventional communications)

(2) High power selection scheme

(3) Combine scheme

Figure 4 shows the analyzed result. It is shown in Fig.4 that the cumulative probability of power in case of "High power selection scheme" is higher than that of "w/o Co-operation". Namely, the receiving terminal can obtain high power signal via the relay. However, the distribution of power in case of proposed scheme is not greatly increased compared with the case of "w/o Co-operation". It is also said that both distribution of "High power selection scheme" and "Combine scheme" is almost the same. Since "High power selection scheme" is more simple than "Combine scheme", "High power selection scheme" is used, here after.

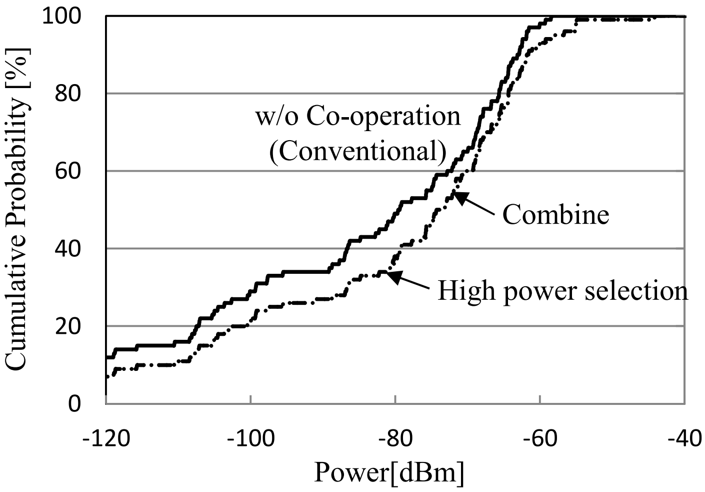

Figure 4: Cumulative Probability of Power

Next, it is considered that plural relay terminals are located in the observation area. Figure 5 shows the analyzed results when the number of relay terminals is 3, 5 and 10 units. The relay terminals are moved randomly in the observation area.

It is found from Fig.5 that the distribution of power is improved as the number of relay terminal is increased.

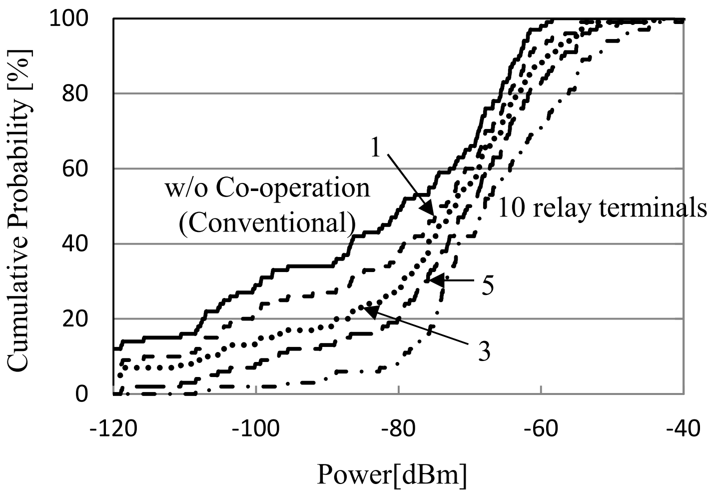

Figure 5: Effect of Number of Relay Terminal on Cumulative Probability

5. Effect of Relay Terminals on Elimination of Blind spot

In this paper, it is supposed that the minimum receiving power to ensure the link is -80dBm. It means that the point where the received power less than -80dBm is the blind spot. The relationship between the number of the relay terminals and a percentage of the blind spots is shown in Fig.6. The parameter in Fig.6 is a height of the base station. In Fig.6, 0 value on the horizontal axis means that the relay terminal does not exist. It is correspond to the conventional communications.

It is shown in Fig.6 that the percentage of the blind spot can be reduced less than 5% if the height of the base station is over 80m and more than 16 relay terminals are existed.

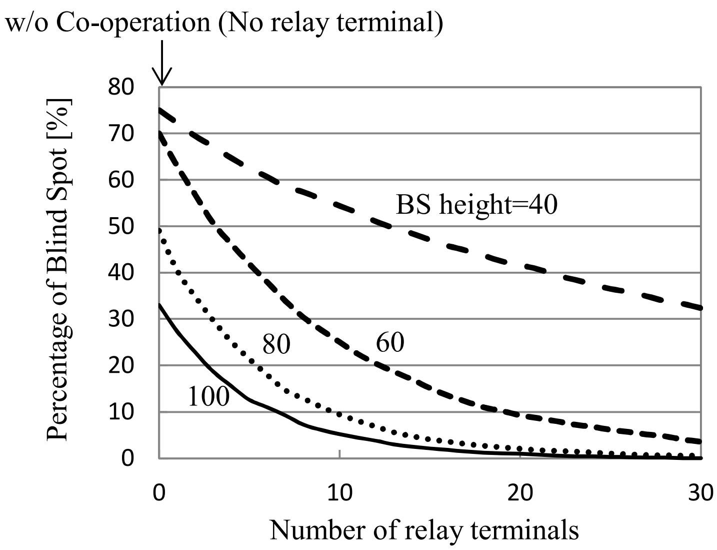

Figure 6: Effect of Elimination of Blind Spot

6. Conclusion

Two co-operation schemes between mobile terminals are proposed. It was shown that both of the proposed co-operation schemes were effective for eliminating the blind spot in the downtown area. It was shown that the distribution of power was improved as the number of relay terminal was increased. It was also shown that the percentage of the blind spots could be reduced less than 5% if the height of the base station was over 80m and more than 16 relay terminals were in the downtown area.

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