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Optimum Directivity of Base Station Antenna in Street Microcell

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***Abstract* – This paper describes the optimum directivity of a low base station antenna for street microcell. In order to simulate the propagation characteristics, the ray tracing technique is applied for street microcell. And, the channel capacity is evaluated for optimizing the antenna directivity. It is clarified by the simulation results that the optimum beam tilt angle and the beam width in the vertical plane are 10 degrees and 9 degrees, respectively.**

***Index terms* — street microcell, optimum directivity, beam tilt angle, beam width.**

1. Introduction

Recently, data traffic is increasing rapidly by the spread of a smart phone and various applications. Therefore, the fifth generation mobile communication system uses higher frequency band to use wide bandwidth than conventional that and is aims to improve mobile communication service [1]. If high frequency band is used, a base station antenna is arranged on the street from its characteristic and street microcell is formed. A multi beam antenna is considered that it is used in high frequency [2]. However, the optimum directivity of antenna is not clarified for street microcell.

This paper clarifies the effects of a directivity of a low base station antenna for street microcell on channel capacity and indicates the optimum directivity of a low base station antenna for street microcell.

2. Analytic Model and Evaluation Method

(1). Analytic Model

In real urban district environment, objects to exist as obstacle (e.g., a human and a car) and shape of building impact transmission characteristics. In this paper, street microcell model which is expressed as a simply urban district is analyzed to confirm outline.

Fig. 1 shows street microcell analysis model. The high building is arranged on both sides of the street of road width W. Relative permittivity of the building and the street ε_r is 5.31 and conductivity σ is 0.368[S/m]. The distance between a transmitter and a receiver is L. The height of the transmitter is h_t and the height of the receiver h_r is 1.5 meter. The vertical polarized wave is used and the frequency is 20 GHz.

The directivity of the receiver antenna is omnidirectional, and the transmitter antenna has a directional pattern. Fig. 2 shows the directivity of the transmitter antenna. The beam width in horizontal plane is φ_h and the beam width in vertical plane is θ_v and the beam tilt angle is δ that a horizontal direction is 0°. Suppose the center direction of beam is (θ_0,φ_0). If θ and φ is $|\theta-\theta_0| \leqq \theta_v$, and $|\varphi-\varphi_0| \leqq \varphi_h$, the directivity of the transmitter antenna is determined by Eq.(1).

$$E(\theta,\phi) = K\cos\left\{\frac{\pi}{2}\frac{\theta-\theta_0}{\theta_v}\right\}\cos\left\{\frac{\pi}{2}\frac{\phi-\phi_0}{\phi_h}\right\} \quad (1)$$

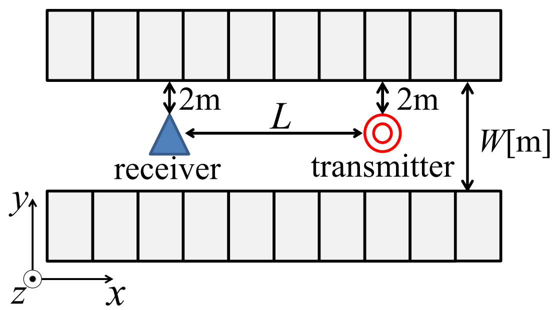

Fig. 1. Street microcell analysis model

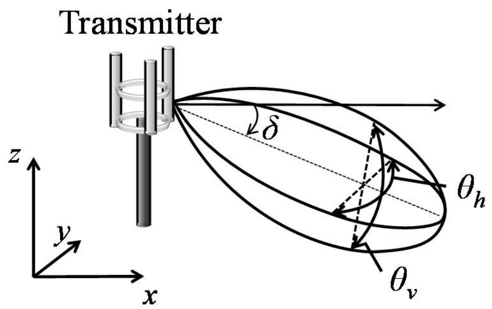

Fig. 2. Directivity of transmitter antenna

(2). Evaluation Method

The evaluation method of this paper used the channel capacity C. C is determined by Eq. (2).

$$C = \log_2(1+\frac{S}{N}) \quad \text{[bit/s/Hz]} \quad (2)$$

Here, S is received power and N is noise power. N is -110dBm.

3. Effect of Beam Width in Horizontal Plane on Channel Capacity

Fig. 3 shows the effect of the beam width in horizontal plane on the channel capacity. Here, W = 30m, h_t = 3.0m, θ_v = 10° and δ = 0°.The solid line is the channel capacity of the receiver that the distance from the transmitter is L meter.

When the beam width in horizontal plane is narrower, the channel capacity is larger as shown in Fig. 3. As the distance is longer, the channel capacity is smaller.

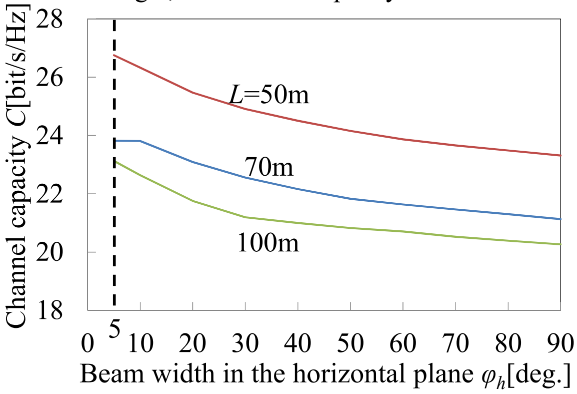

Fig. 3. Effect of beam width in horizontal plane on channel capacity

4. Effect of Beam tilt angle and Beam Width in Vertical Plane on Channel Capacity

(1). Effect of Beam Width in Vertical Plane and Beam Tilt Angle

The effect of the beam tilt angle and the beam width in vertical plane is discussed by using a multi beam antenna. We evaluated at the average channel capacity C_{ave} in the range of cell area that equals $L \times W$. Here, L=100m, W = 30m, φ_h = 90°, the number of beam is two and h_t=10m. The directivity of beam φ_0 is 180° and 270°.

Fig. 4 shows the effect of the beam tilt angle and the beam width in vertical plane on the average channel capacity. The maximum of the average channel capacity is 20.14 bit/s/Hz obtained when the δ and the θ_v is 10 degrees and 9 degrees, respectively.

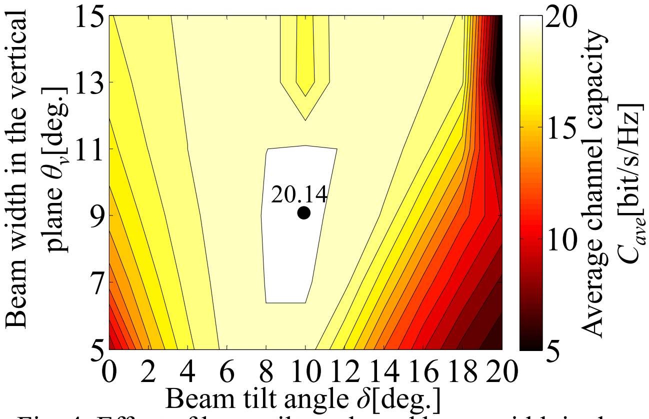

Fig. 4. Effect of beam tilt angle and beam width in the vertical plane on average channel capacity

(2). Optimum Beam Tilt Angle and Beam Width in Vertical Plane and for Street Microcell

The street microcell is composed of the cell area. The optimum beam tilt angle and the beam width in vertical plane is different depending on it.

Fig. 5 shows the relationship between the configuration of the street microcell and the optimum beam tilt angle and the beam width in vertical plane that the average channel capacity is maximized. The solid line is the beam tilt angle δ and the dotted line is the beam width in vertical plane. Here, ht , φ_h, and the number of beam is the same conditions as (1).

When the service area is wider, the beam tilt angle is smaller as shown in Fig. 5. As the road width is wider, the beam width in vertical plane is narrower.

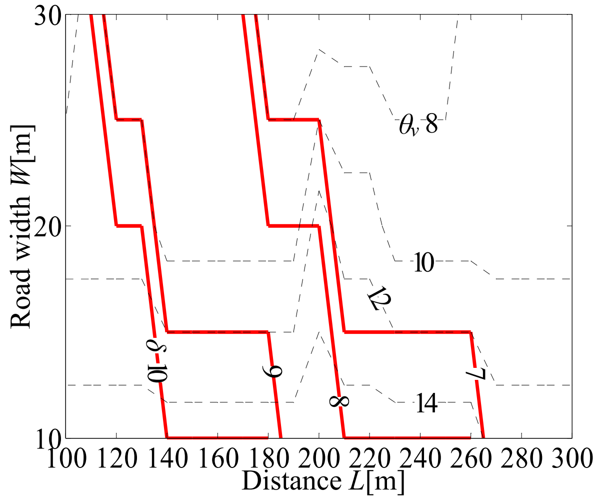

Fig. 5. Relationship between configuration of street microcell and beam tilt angle and beam width in vertical plane

5. Conclusion

The effect of the directivity of a low base station antenna for the street microcell on channel capacity was clarified. The result showed that the beam width in horizontal plane was narrower, the channel capacity was larger. Moreover, it was clarified by the simulation results that the optimum beam tilt angle and the beam width in the vertical plane are 10 degrees and 9 degrees, respectively. In addition, it was shown that the relationship between the configuration of the street cell and the beam width in vertical plane and the beam tilt angle that the average channel capacity was maximized.

Reference

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