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Study of Channel Capacity Improvement by Open Loop Active Propagation Control

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***Abstract* - By changing the propagation characteristics of the environment actively in some ways, we can obtain the better transmission performance of wireless communication channel. We call such method "Active Propagation Control" (APC). In this paper, we analyze the improvement effect of the transmission performance by APC in the case where the propagation characteristics are continually changed without any feedback from the receiver for the purpose of reducing the spatial dependency of the transmission characteristics caused by multipath fading. We change the indoor propagation characteristics by rotating a metal plate in a room and evaluate the changes of the characteristics by two-dimensional FDTD analysis. In the evaluation the improvement of SISO and MIMO channel capacity by APC is shown.**

***Index Terms* — Radio propagation, Active propagation control, Channel capacity, FDTD.**

I. Introduction

As increasing users of wireless communications in recent years, larger capacity wireless communication systems are required. As one of improvement methods to cover the requirement we showed that the improvement of the transmission performance is possible by actively changing the propagation characteristics of the environment [1, 2]. We call such method "Active Propagation Control" (APC). We showed the fundamental effectiveness of APC in the case where the propagation characteristics are optimized using feedback control from a receiver so that the transmission performance becomes the best. On the other hand, it is imagined that we can also improve the performance like average channel capacity by APC in the case where the propagation characteristics are continually changed without such optimization. It is expected that by using such control with appropriate signaling we can reduce the spatial dependency of the transmission characteristics. We call such method "Open Loop APC" (OLAPC) in particular. In this paper we evaluate indoor propagation characteristics by the two-dimensional Finite Difference Time Domain (FDTD) in order to present the fundamental effectiveness of OLAPC for Single-Input Single-Output (SISO) and Multiple-Input Multiple-Output (MIMO) transmissions. We assume an empty room environment where a metal plate is rotating with the purpose of changing the propagation characteristics for OLAPC.

II. Open Loop Active Propagation Control

Figure 1 shows the basic concept of OLAPC. The propagation environment is continually changed by a device which can change the propagation characteristics. In wireless communication environments there are some positions where the propagation characteristics are severely degraded by factors as represented by multipath fading. We can imagine that using OLAPC with appropriate modulation and demodulation system enables us to displace such positions temporally. Thus we can reduce the spatial dependency of the transmission characteristics so that the transmission performance at such positions is improved on average.

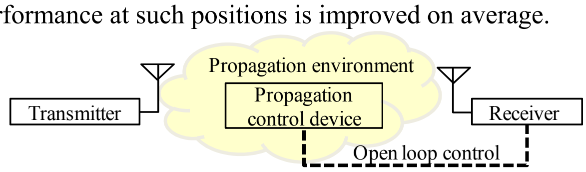

Fig. 1 Basic concept of OLAPC.

III. Evaluation of Improvement Effect by OLAPC

In order to evaluate the improvement by OLAPC, we analyze indoor propagation characteristics by two-dimensional FDTD. Figure 2 schematically shows the simulation model. In the model, we assume a concrete wall having 1 m thickness outside the room. Also we apply the first-order Mur boundary condition outside the wall. The cell of FDTD is a square 0.01 m on a side. In the room environment a rotating metal plate is placed. We assume slow rotating speed, so that the changes of the propagation characteristics are regarded as quasi-static. The width of the plate is 0.05 m and the center is fixed at (7.0, 4.0). We assume the transmitter is fixed at (1.0, 1.0) and the transmitting antenna radiates vertical polarization wave, which is perpendicular to the model plane. Also we assume the carrier frequency is 2.4GHz.

In order to show the improvement by OLAPC, we calculate SISO and MIMO channel capacities when the metal plate is rotating. We move one and two receiving antennas for the SISO and MIMO cases respectively every 0.01 m in the room while keeping the arrangement of the antennas as shown in Fig. 2. For the MIMO case the antenna spacing is 0.12 m, which is about a single wavelength of the carrier wave. We assume that we can obtain the ideal channel capacity calculated by using the method shown in [3] for each rotation angle of the metal plate (=instantaneous capacity). Also we assume we can obtain the ideally-averaged value of the instantaneous channel capacity over the rotation. At the later evaluation we express the average value as OLAPC. Also, we use the channel capacity when the metal plate is fixed at 90° for the reference and express it as "90°". We define Signal to Noise power Ratio (SNR) at a position 1 m away from the transmitter in a two-dimensional free space environment and the same noise power is assumed in the whole area of the room. It indicates SNR varies depending on the positions even in an identical simulation.

Figure 3 shows the channel capacity for SISO case when the receiver moves straightly from (9.0, 4.0) to (9.0, 8.0) as shown in Fig. 2. In this figure the metal plate length *W* is 2.0 m and SNR is 10dB. It can be seen from the figure that the variation width of the capacity becomes smaller in OLAPC compared with the fixed case and the transmission characteristics are averaged by OLAPC.

Figures 4 and 5 show Cumulative Distribution Function (CDF) of the channel capacity over the room for the SISO and MIMO cases, respectively. In Fig. 4, SNR is 10dB. The lines for *W* = 0.5 ~ 5.0 m correspond to OLAPC and "90°" is the fixed case when *W* = 2.0 m. In Fig. 5, *W* = 1.5 m. As shown in these two figures, the larger channel capacity in the fixed case decreases by using OLAPC. However, the smaller channel capacity in the fixed case is improved effectively by using OLAPC, that is to say, the spatial dependency of the transmission characteristics is reduced by OLAPC.

IV. Conclusion

In this paper, we evaluated the fundamental effectiveness of OLAPC on SISO and MIMO channel capacities. We assumed Open Loop Active Propagation Control (OLAPC) using a rotating metal plate in an indoor environment. The evaluation based on the two-dimensional FDTD method was carried out. It was found that we can improve the smaller channel capacity effectively by OLAPC. It was also found that OLAPC performs well so that the spatial dependency of the transmission characteristics is reduced.

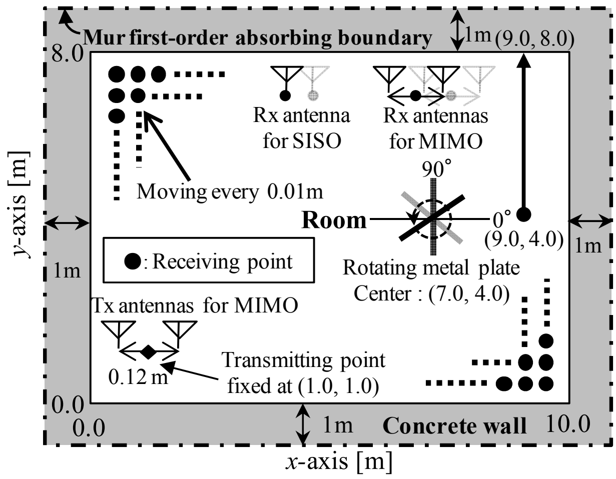

Fig. 2 Indoor environment model.

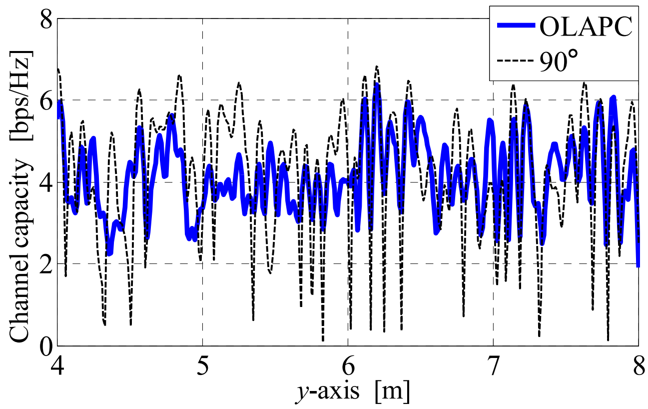

Fig. 3 Channel capacity for SISO.

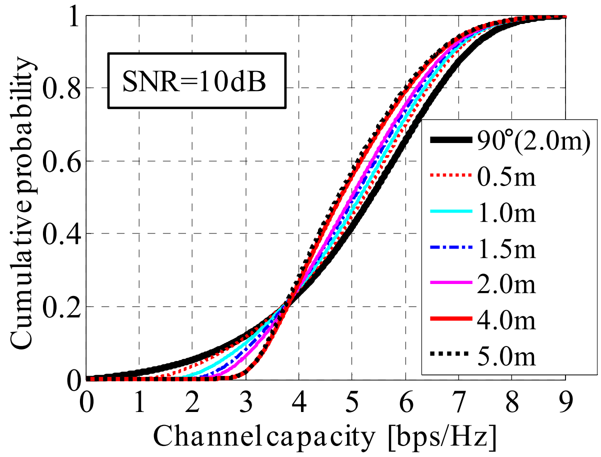

Fig. 4 CDF of SISO channel capacity.

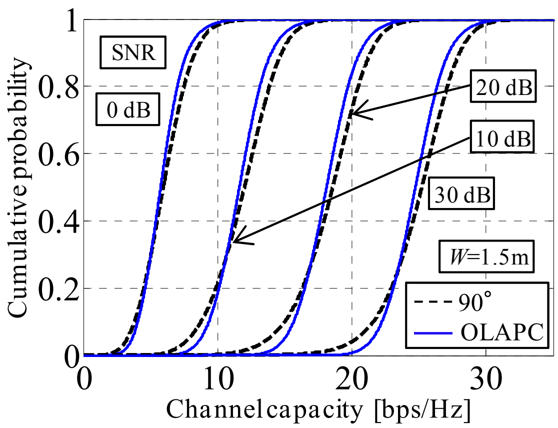

Fig. 5 CDF of MIMO channel capacity.

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