A Study on User Selection in Dual-Polarized Antenna Systems

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Abstract. Dual-polarized antenna (DPA) systems can provide two independent data transmissions in line-of-sight wireless channel environments. The capacity of each data stream can be affected by a rotation angle between transmitter and receiver DPAs and channel gains of vertical and horizontal receiver antennas. In this paper, we propose a user selection scheme for the DPA system. In the proposed scheme, the best DPA user is selected based on both the rotation angle and the channel gains. By using this scheme, the capacity of the DPA system increases two times when the selection order is three. The selected best user can even achieve 3 times of capacity when the selection order is six.

Keywords: Dual-Polarization Antenna. User Selection

1 Introduction

Dual-polarization antenna (DPA) consists of a vertical and a horizontal antenna. Two antennas are perpendicularly comprised. The vertical and horizontal antennas are physically orthogonal. Each antenna emits polarized electro-magnetic (EM) waves. EM waves transmitted from both antennas are also orthogonal [1]. Hence, a receiver can distinguish signals included in the EM waves if the receiver has also DPA. Different from the conventional multi-input and multi-output (MIMO), DPA is able to provide two independent data streams without multipath channels by using the antenna polarization. Accordingly, DPA system is called line-of-sight (LoS) MIMO system, which can be well applied to indoor small cell with small coverage and LoS dominant channel [2][3].

Although the DPA can implement the LoS MIMO, there are some technical difficulties not to degrade the capacity of DPA system. For example, a rotation angle between a transmitter and its corresponding receiver DPA severely degrades the capacity of the DPA system. Conventionally, there were researches about minimizing the rotation angle in DPA system [3][4]. Performance degradation due to the rotation angle is analyzed in [3]. Interference mitigation is proposed in order to minimize the effect of the rotation angle on the DPA system capacity [4]. However, those
researches cannot be applied to the LTE system because current LTE modem does not have functionalities to support the proposed schemes yet.

In this paper, we propose a user selection scheme for the DPA system. In the proposed scheme, the best DPA user is selected based on both the rotation angle and the channel gains. By using this scheme, the capacity of the DPA system increases 2 times when the selection order is three. The selected best user can even achieve 4 times of capacity when the selection order is six.

2 System Model

System model is illustrated in Fig. 1. In the system model, there are a transmitter and multiple receivers. Every receiver has a DPA. In Fig. 1, there are four receivers with different rotation angles. The DPA of the transmitter provides a reference angle for receivers to measure rotation angles. As illustrated, rotation angles are 0.1, 15, 60, and 100 degrees. Depending on the rotation angle $\theta$, signal-to-interference-and-noise ratio (SINR) which vertical antenna channel of the $i$-th receiver experiences can be expressed as [6]:

$$SINR_{v_i} = \frac{H_{v,v} \cos^2 (\theta_i)}{H_{v,h} \sin^2 (\theta_i) + N_o},$$  

(1)

where $H_{v,v}$ is the channel gain between the transmitter's vertical antenna and the $i$-th receiver's vertical antenna, and $H_{v,h}$ is the channel gain between the transmitter's
horizontal antenna and the $i$-th receiver's vertical antenna. $N_0$ is the background noise.

There are $N$ receivers. The transmitter selects the best user by using the following rule:

$$\max_{i} \arg \max_{i} SINR_{i}$$

As depicted in Fig. 1, each receiver has its own rotation angle. Hence, SINR values of receivers are different. Using the selection rule in (2), the best SINR receiver is selected, which will result in selection diversity gain.

### 3 Simulation and Results

![Graph](image)

**Fig. 2.** Spectral efficiency improvement v.s. selection orders

Fig. 2 depicts spectral efficiency improvement as the selection order increases. Selection order is the number of selectable receivers. Focusing on the rotation angle in (1), SINR value achieves the maximum value when the rotation angle is zero. Hence, it is more probable that the selected user has smaller rotation angle. Generally, it is known that the rotation angle is a random variable with the uniform distribution.
as a probability density function. Accordingly, the rotation angle decreases as the selection order increases.

When the selection order is one, the spectral efficiency is 1.578 bps/Hz. This is a performance of the random selection. However, as the selection order increases to three, the spectral efficiency reaches 3.3 bps/Hz. This value is more than two times of the random selection performance. Although DPA system implementation aims at indoor wireless communication, we can assume six receivers in an office without loss of generality. In this case, the proposed selection scheme achieves 4.6 bps/Hz. This spectral efficiency is almost three times capacity of that of the random selection.

4 Conclusion

In this paper, a selection diversity scheme was proposed for DPA system, and its performance was evaluated through computer simulation. Using the selection scheme, spectral efficiency of a DPA link improves because the selected receiver's rotation angle gets smaller as the selection order increases. When the selection order is three and six, the spectral efficiency improves two and three times.

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References