

Capacity Analysis of OAM-MIMO based on Transmitter and Receiver Distance

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ABSTRACT

The channel capacity plays an important role in the estimation of the maximum data that can be transferred through a given channel. Orbital angular momentum (OAM) is gaining importance in the research community because of the multiple orthogonal modes. Higher OAM modes diverge with the transmission distance. In this paper, the channel capacity of the OAM-MIMO system is analyzed by varying the distance between the OAM transmitter and receiver.

I. INTRODUCTION

The demand for high data rate is increasing day by day and to fulfil these demands, traditional schemes such as FDMA, TDMA and CDMA cannot be implemented as they have already utilized up to their maximum limits. Orbital angular momentum (OAM) is based on the angular momentum of the electromagnetic waves, characterized by helical phase front, an unexploited area in wireless communication and combining OAM with MIMO can result in the enhanced spectrum efficiency [1]. In orbital angular momentum-based wireless communication different OAM modes can be used simultaneously as all the generated modes are orthogonal to each other [2, 3]. Uniform circular arrays (UCA) can be used for the generation of the OAM beams because multiple OAM beams with different modes can be generated simultaneously. Uniform circular arrays (UCA) has low profile, less weight and ease of manufacturing and can be employed for the enhancement of multiplexing gain of the line of sight (LOS) OAM communication [4]. For OAM communication based on uniform circular arrays (UCA), the receiver and transmitter must be aligned as the OAM generated beams are divergent in nature and hollow in the center. To mitigate this issue the cheapest and readily available solution is to optimize the distance between receiver and transmitter so that the maximum

number of OAM modes can be utilized without compromising on the capacity of the channel. In this paper, the capacity of the channel is analyzed by changing the transmitter and receiver UCAs distance and analyze its effect on the channel capacity.

II. SYSTEM MODEL

The system model is illustrated in Figure 1. The distance between the centers of transmitter UCA and receiver UCA is d . The radius of Transmitter UCA is R and that of the receiver UCA is r . The number of antennas in the transmitter UCA is N and the receiver UCA has M number of antennas. For OAM wireless communication, generally, the M and N are the same. The transmitter and receiver UCAs are coaxial to each other and the Line of sight (LOS) scenario is considered. H_x is the channel between transmitter and receiver UCAs for different OAM modes.

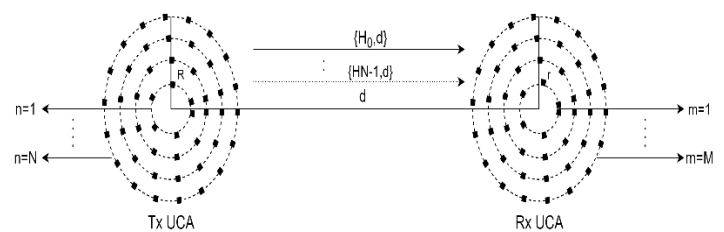


Fig. 1: OAM transmitter and receiver based wireless communication system

III. CHANNEL CAPACITY ANALYSIS

The achievable channel capacity of OAM-MIMO transmission can be derived as below by equation 1 [5].

$$C = \sum_{q=1}^Q \log_2(1 + \beta \phi^2) \dots \dots \dots (1)$$

where

$$\phi = \sum_{m=1}^M \sum_{n=1}^N \alpha |h_{s,(m,n)}|^2 P$$

where α is the Tx signal to noise ratio (SNR) for each OAM modes. Moreover, h is the channel between transmitter and receiver UCAs, and P is the total power.

IV. RESULT ANALYSIS

This section analyzes and compares the channel capacities by varying the transmitter and receiver antenna distance. The parameter values are set as $d=5\lambda$ (Case 1), 10λ (Case 2), 15λ (Case 3), 20λ (Case 4), $\lambda = 0.1$, $M=4$, $N=4$. Figure 2 illustrates that the capacity of the OAM-MIMO decreases as the distance between the transmitter and receiver increases. As it can be seen from figure 2 that the capacity greatly reduces when the distance is increased from 5λ (case 1) to 10λ (Case 2). After that in case 3 and case 4, the reduction is a bit small.

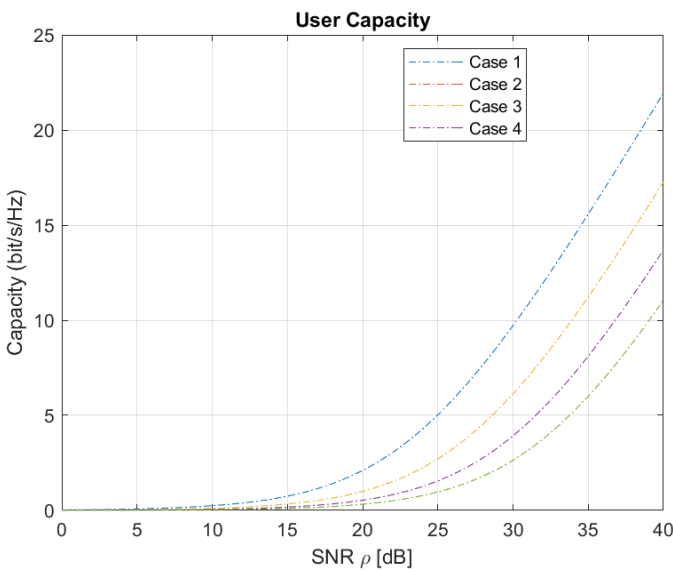


Fig. 2: Sum capacity vs. transmit SNR for different transmitter and receiver distance

As the higher OAM modes converge with the distance so when the transmitter and receiver distance is increased, the intensity of the beam is reduced, and these modes

cannot be detected correctly by the receiver which causes a reduction in the overall capacity of the channel.

So, this is clearly visible that, the distance between transmission and receiver greatly reduced the channel overall capacity.

V. CONCLUSION

The effect of distance between the transmitter and receiver UCAs on the channel capacity is analyzed for orbital angular momentum wireless communication and it has been observed that the channel capacity decreases as the distance between the transmitter and receiver UCA increases.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

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