Study on Subarray Beam Allocation for Sub-Terahertz-Band MIMO Spatial Multiplexing in Indoor Office Environments

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1. Introduction

The use of a sub-Terahertz band (100–300 GHz) is being considered for 6G to achieve extremely high data-rate communication exceeding 100 Gbps. A hybrid MIMO architecture with subarrays and a precoder is realistic and effective for sub-Terahertz-band MIMO spatial multiplexing [1]. The performance depends on the number of multipaths. It has been, however, reported that we only have few sub-Terahertz-band multipaths in indoor office environments [2]. This paper describes a subarray beam control method for efficient downlink MIMO spatial multiplexing.

2. Configuration of Hybrid MIMO System

A base station (BS) has V planar subarrays, and each subarray has $Q \times Q$ antenna elements. A phase shifter is connected to each antenna element, and each subarray works as a phased array with DFT-based beamforming weights. The subarrays are connected to a digital precoder, and an optimal precoding process is conducted. User equipment (UE) has a U-element linear array.

3. Beam Allocation Method

First, we obtain candidate beams to be possibly allocated to the subarrays as follows. The UE transmits pilot signals at all the subcarrier frequencies, and the BS measures the received power changing the DFT-based beam. The beams that have received power exceeding a preset threshold are candidates. In this paper, the threshold was set to a level 3 dB higher than noise power. Next, we select a pre-specified maximum number of DFT-based beams from the candidates in order of received power, and allocate them to the subarrays. Finally, we determine the optimum maximum beam number for a given channel environment.

4. Simulations

The simulation parameters are listed in Table 1. In this paper, we examined the transmission performance of beam allocations using 1000 LOS channels generated based on [2]. Figure 1 shows the average channel capacity versus BS–UE distance for several scenarios. “Single layer” in the figure indicates the result without spatial multiplexing. We see that higher channel capacity is obtained when we employ spatial multiplexing. Moreover, it is seen that “Maximum beam number: 3” achieves the highest channel capacity in the pre-specified maximum beam cases. However, the optimum number of selected beams depends on each multipath propagation environment. “Optimum beam selection,” which selects the optimum number of beams from one to eight for each channel, achieves even higher channel capacity.

Table 1 Simulation parameters

Transmission power BS / UE	30 dBm / 10 dBm
Noise power	−76 dBm（Ambient temp. 290 °K, NF 5 dB）
BS–UE distance	5, 10, 15, 20, 25, 30 m
No. of BS subarrays V	8
No. of UE antenna elements U	4
Subarray composition $Q \times Q$	64 × 64 planar array
Center frequency	141 GHz
Bandwidth	2 GHz
Subcarrier spacing	500 kHz
Frequency at evaluation	141.00025 GHz

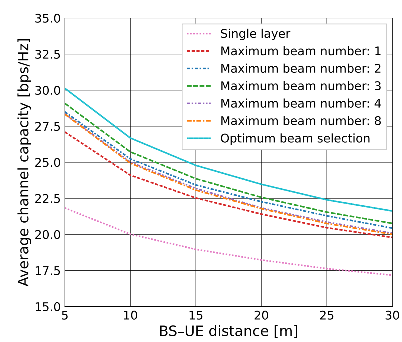

Fig. 1 Average channel capacity versus BS–UE distance

5. Conclusions

We have investigated subarray beam allocation for sub-Terahertz-band communication in indoor office environments. Simulation results show that efficient MIMO spatial multiplexing is achieved when we select the optimum number of DFT-based beams for a given channel environment.

References

[1] C. Lin et al., IEEE Commun. Mag., 54(12), 124–131, 2016.
[2] S. Ju et al., IEEE J. Sel. Areas Commun., 39(6), 1561–1575, 2021.

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