TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Electrical and Computer Engineering Vodafone Chair Mobile Communications Systems

Studienarbeit/Project Work

Problem Statement

Millimeter wave (mmWave) communication is a key technology to accommodate gigabit data transmission in future mobile wireless systems as large chunks of unlicensed spectrum are available. Due to higher path loss at frequencies in mmWave range, highly directional antenna arrays are deployed at the transmitter (Tx) and the receiver (Rx). As a consequence, an additional beam probing phase needs to be introduced which finds suitable beam pairs between Rx and Tx. Time efficient beam probing is hereby key such that data communication can start as soon as possible [1,2]. In general, the beam probing is done either by, exhaustive search, where one probes each and every beam pair sequentially [2], hierarchical search, where one probes sectors and deduces favorable beam pairs based on a tree-search concept/algorithm [2], or sparsity-based channel estimation techniques, e.g. compressive sensing methods [3]. However, in this work frequency scanning arrays (FSA) [4] are used for beam probing, which were initially invented and used in the field of radar. FSAs are able to concurrently test all available beamformers or angle of departure at the Tx and an Rx in field is able to deduce its favorable beam pair by power spectrum analysis. The open question to answer is if such a method speeds-up the beam alignment phase.

Tasks

- literature review on beam alignment techniques and time synchronization techniques [5] for wireless communication
- understanding the more general concept of *frequency dependent array steering vectors* or the “so-called” wideband effect in mmWave communication [4,6]
- setting up a simulation framework in Matlab/Python for frequency scanning, exhaustive search, and hierarchical search including synchronization problem
- performance evaluation of time-efficiency of different schemes with/without time (or frame) synchronization at the receiver
- written documentation of the results in German or English

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Recommended References

[1] R. W. Heath, N. González-Prelcic, S. Rangan, W. Roh and A. M. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems,” https://arxiv.org/pdf/1512.03007.pdf

[2] A. Alkhateeb, Y. H. Nam et al., “Initial Beam Association in Millimeter Wave Cellular Systems: Analysis and Design Insights,” https://arxiv.org/pdf/1602.06598.pdf

[3] X. Song, S. Haghighatshoar and G. Caire, "Efficient Beam Alignment for Millimeter Wave Single-Carrier Systems With Hybrid MIMO Transceivers," https://ieeexplore.ieee.org/document/8625694

[4] C. Jans, X. Song, W. Rave and G. Fettweis, "Fast Beam Alignment through Simultaneous Beam Steering and Power Spectrum Estimation Using a Frequency Scanning Array," https://www.vodafonechair.com/media/publications/christoph-jans/Fast_Beam_Alignment_through_Simultaneous_Beam_Steering_and_Power_Spectrum_Estimation_Using_a_Frequency_Scanning_Array.pdf

[5] Timothy M. Schmidl and Donald C. Cox, “Robust Frequency and Timing Synchronization for OFDM,” http://home.mit.bme.hu/~kollar/papers/Schmidl2.pdf

[6] B. Wang, F. Gao, S. Jin, H. Lin and G. Y. Li, "Spatial- and Frequency-Wideband Effects in Millimeter-Wave Massive MIMO Systems," https://arxiv.org/pdf/1708.07605.pdf

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