TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Electrical and Computer Engineering Vodafone Chair Mobile Communications Systems

Analysis of Synchronization Algorithms for Systems with 1-bit Quantization

Master/Diploma Thesis

Problem Statement

The design of communications systems to achieve data rates beyond 100 Gb/s necessitates the use of large bandwidths at high carrier frequencies, which in turn requires the receiver to be equipped with very fast analog-to-digital converters (ADCs). At these high sampling rates, high-resolution ADCs have been identified as a bottleneck regarding the power consumption of the system. Using ADCs with 1-bit of resolution for such systems is considered beneficial, as 1-bit ADCs can operate very energy-efficient and the loss in achievable rate due to the low resolution can be partially compensated by higher signaling and sampling rates, i.e., oversampling w.r.t. the Nyquist rate.

Most communications systems are based on the principle of synchronized detection, i.e., the receiver attempts to remove the influence of the propagation channel, which can cause several disturbances of the transmit signal, before it performs detection at symbol rate. In an ideal receiver, synchronization and detection are done jointly and splitting both is known to be suboptimal. Nevertheless, the split is usually necessary to derive algorithms with a feasible complexity.

Investigating suitable synchronization algorithms for systems with 1-bit quantization is a current research focus at the Vodafone Chair. The performance of synchronization algorithms can be measured by their influence on the mutual information between the transmitted symbol sequence and the log-likelihood-values for the symbols at the output of the synchronizer. This mutual information is either calculated or determined by simulation and allows for a comparison of the performance of different synchronization algorithms. The focus of this thesis is an assessment of the performance of different synchronization algorithms, as well as an investigation of the optimal approach of joint synchronization and detection. The latter can be achieved by measuring the mutual information between the transmitted symbols and the 1-bit quantized samples at the receiver – prior to synchronization and detection - which serves as a benchmark of what can be achieved by any practical algorithm. Moreover, it should be analyzed which part of the mutual information is discarded by separate synchronization and decoding to provide hints for the design of enhanced synchronization algorithms.

Expected Skills

- Experience with Matlab/Python
- Curiosity in information theory

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