Abstract

The research reported in this thesis pertains to the large-MIMO systems, which employs tens of antennas in their terminals. The main motivation behind considering large-MIMO systems is its potential to practically realize very high spectral efficiencies and diversity orders. The large-MIMO systems exploit huge spatial dimensions and improve the multiplexing and diversity capability. Apparently, detection is a major challenge due to the increased complexity. While the detection techniques in literature assume the large-MIMO channels to be independent and identically distributed (i.i.d), factually the channel is likely to be spatially correlated. Spatial correlation at transmit/receive antennas and the structure of scattering and propagation environment can affect the MIMO channel resulting in degraded BER performance. Currently, lattice reduction aided detection is understood to be the best approach for detection in spatially correlated channels due to the fact that it transforms the problem into a domain with near orthogonal lattice, thereby reducing the effect of spatial correlation.

This thesis focuses on the design of large-MIMO detection techniques that can achieve improved BER performance compared to the lattice reduction aided detectors with affordable computational complexity. Large-MIMO systems of $8 \times 8$, $16 \times 16$ and $32 \times 32$ configurations with various correlation scenarios including uncorrelated, low, medium and high correlation channels are considered. The work is focused on developing the techniques that are tailored to various symbol constellations. In addition, this thesis explores the metaheuristics and machine learning domains to seek algorithms to solve the large scale detection problems. The work reported in this thesis is comprised of the following parts.

1. The feasibility of semidefinite relaxation detector (SDR) for detection in large-
MIMO systems employing 4-QAM constellations is investigated. Since, the problem formulation is convex; it has an additional leverage of finding the global optima solution. While the BER performance of SDR detectors is encouraging in uncorrelated and correlated channels, the complexity characteristics and performance in high correlation channels needs improvement.

2. A sparse semidefinite relaxation (S-SDR) detector is proposed to address the complexity issue of SDR detector, in which the system model is reformulated using a sparse approach and a regularization term inducing sparsity is introduced into the semidefinite programming model. This reduces the computational complexity approximately by 50% and requires relatively fewer computations.

3. We explore the metaheuristic approach to address the detection problem in high correlated channels. Cuckoo search (CS), a popular metaheuristic technique is proposed and modified to suit discrete space search and is employed for detection in large-MIMO systems. The combination of local search and global search inherent in the cuckoo search enables the CS detector to obtain the global optima thereby improving the diversity order.

4. As the promising large-MIMO detection approaches do not offer a significant complexity-performance tradeoff for BPSK constellations, we explore the machine learning algorithms, support vector regression in particular to solve the problem of detection in large-MIMO systems employing BPSK constellations.

5. Lattice reduction aided detectors are unmatched for their performance - complexity tradeoff in large-MIMO systems employing higher order QAM constellations. Hence, we propose a hybrid approach by combining QRZ-LLL reduction and depth first search with multiple output selection strategy to improve the performance of LR detectors.

In a nutshell, the studies in this thesis provide a couple of alternatives for large-MIMO detectors and viable solution for spatially correlated channels. The proper detector can be chosen based on the constellation adopted and correlation depth.