In this dissertation, the efficient design of multi-input and multi-output (MIMO) receiver technique is investigated. The MIMO transmission provides the significant increase of channel capacity without sacrificing transmission bandwidth. As the high performance MIMO receivers demand complex joint detection and decoding operations, the development of computationally efficient MIMO decoding techniques has been a challenging problem tackled by a number of communication and signal processing researchers. The application of the celebrated turbo principle to the MIMO detection problem enables us to achieve the near-optimal performance promised by the MIMO channel capacity. Hence, devising a low-complexity iterative MIMO receiver is becoming important to implement the high-performance communication receiver with present hardware technology. The primary contributions, which are claimed in this dissertation, are fold in two-phase: 1) the performance enhancement of the Vertical-Bell Lab Layered Space Time (V-BLAST) detection via soft interference cancellation, and 2) the development of a low-complexity near-ML detection technique, that improves the computational complexity of sphere decoding (SD) algorithm.

Firstly, an improved V-BLAST detection technique, referred to as the soft input, soft output, and soft feedback (SIOF) V-BLAST detector is proposed. Its application to TURBO-MIMO systems is investigated. Based on the observation that the effect of error propagations (EP) limits the performance of V-BLAST detector, the soft feedback interference cancellation is devised to minimize the effect of EP. More specifically, a symbol estimator is derived by minimizing the power of interference plus noise, given a priori probabilities of undetected symbols and a posteriori probabilities for already detected symbols. As a result, soft feedback interference canceller based on a posteriori information is derived, which leads to a symbol detector robust to error propagation effects. This formulation leads to the successive soft feedback detector consisting of the interference canceller, which subtracts soft feedback (a posteriori) estimates of the past symbols, and the MMSE interference nuller. For its low-complexity implementation, an approximated SIOF V-BLAST detection algorithm is presented, which allows for time-invariant realization of symbol ordering and linear filtering process. Furthermore, the sub-optimal symbol detection algorithm is introduced, which sacrifices the negligible performance with significantly reduced complexity. As a result, such iterative receiver that uses soft feedback yields the better BER performance and faster convergence to the minimum BER than existing detection algorithms. Next, another low-complexity implementation, called iterative SIOF algorithm, is proposed, which employs the iterative group cancelling method. We repeatedly apply the symbol detection algorithm while feeding back the a posteriori symbol estimates for which its detection is considered to be reliable. The simulations performed on quasi-static fading channels demonstrate that the SIOF V-BLAST detector provides the performance gains over the previous TURBO-BLAST technique, most notably when more transmit antennas are used. Iterative algorithm of hybrid detection make the optimal ordering unnecessary gaining the significant complexity savings.

Secondly, a near-ML detection technique, called reduced stage sphere decoding (RS-SD) algorithm is proposed. The key principle behind the RS-SD algorithm is the successive search space reduction via dimension reduction, i.e., a vast number of points in search space reduce to a few promising points, which results in significant reduction of complexity when finding a closest point. A new extension of sphere decoding is introduced, which can facilitate the performance-complexity trade-off. The preprocessing and postprocessing steps are included in our framework along with the probabilistic tree search algorithm which tightens the original sphere constraint for complexity reduction. The simulations performed for V-BLAST transmission demonstrate that the significant complexity reduction can be achieved compared to the full stage SD algorithm while keeping the performance loss below an acceptable level.
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