Throughput-Reliability Tradeoff Analysis of Multiplexing Oriented Transmission Schemes

ABSTRACT

The communication systems possessing multiple antennas at the transmitter and the receivers are termed as MIMO (multiple-input multiple-out) systems. MIMO is a RF technology or radio communications technology that is being used in many new technologies these days. Wi-Fi, Long Term Evolution (LTE) and many other wireless technologies are using the new MIMO wireless technology to provide increased link capacity and spectral efficiency combined with improved link reliability using what were previously seen as interference paths. The exploitation of several antennas at the transmitter and receiver ends are usually by two methodologies, viz., *Spatial Diversity* (SD) and *Spatial Multiplexing.* The first method exploits the diversity provided by transmitting several copies of same signal via multiple transmitting antennas and receiving the same signal multiple times at the multiple receiving antennas. The cardinality (i.e., number) of independent replication of same information at the receiver is known as *'diversity gain'* or *'diversity order'*.

For MIMO systems that operate at high SNR regime in Line of Sight (LOS) environment (i.e., no fading environment), the capacity augmented by several antennas in the system can be exploited by transmitting different information from every antenna, viz., spatial multiplexing, at the transmitter. The cardinality of different signals at the receiver at the same instance is known as *'multiplexing order'* or *'multiplexing gain'*. More recently, there has been a concerted effort to realize both the capacity and robustness gains simultaneously and it has been demonstrated that there is a fundamental tradeoff between these two types of gains, that is, *at what rate the error probability will decay and at what rate the data rate will increase with increase in Signal-to-Noise Ratio (SNR)* with analytically providing the correctness of Diversity-Multiplexing Tradeoff (DMT) for systems with any cardinality of transmit and receive antennas.

The DMT is considered to be the benchmark for comparing and evaluating the performance of existing and newly proposed transmission and reception schemes. Despite being proven to be a powerful tool of performance evaluation of MIMO systems, the DMT fails to answer - *how much reliability (or transmission rate) is increased in a system by increasing SNR by 3-dB*? This has led to the formulation of Throughput-Reliability Tradeoff (TRT) at high SNR regime due to its ability to reveal the reciprocity between outage probability (OP), SNR and transmission rate (R) more clearly unlike diversity-multiplexing tradeoff.

In this thesis,

1. The TRT analysis of 2-layer D-BLAST transmission scheme with two varieties of receiver considering Gaussian fading scenario has been proposed. First, TRT analysis of D-BLAST with group detection receiver is investigated where each contented diagonal of D-BLAST is detected at once. Then the TRT analysis of D-BLAST with successive interference cancellation receiver detecting a symbol at once has been investigated.
2. The TRT analysis of MIMO channels under broad class of fading distributions has been proposed. The broad class fading distribution includes different identical fading distributions, correlation between channels, non-identical fading distributions, and non-zero channel means. The analysis is carried out by characterizing the joint pdf of the eigenvalues of Gram matrix in high SNR regime. This work also investigates the relation between DMT and TRT of MIMO in broad class of fading distributions.
3. Finally, the asymptotic analysis of 2-layer D-BLAST transmission scheme with group detection receiver under broad class of fading channels has been proposed. The asymptotic analysis includes both DMT and TRT analysis. The D-BLAST considered here is a multi-layered space-time transmission scheme wherein each diagonal of code-word forms a group. On the other hand, group detection considered detects symbols by nulling out interference from other groups and performs maximum-likelihood (ML) decoding on the chosen group.
4. The validation of the proposed TRT analysis is done through Matlab simulations by obtaining outage versus SNR curves for the deduced expressions of TRT that overlap with the simulated system at large SNRs. Also, the DMT results have been illustrated through Matlab plots.

Keywords: Throughput-Reliability tradeoff, Diversity-Multiplexing Tradeoff, D-BLAST, Group decoding, Successive interference cancellation.