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Conclusion and Future Scope

The technology in the field of wireless communications is changing faster recently. A significant research work on next generation technology is carried out well before the current technology is deployed across the world. Massive MIMO is one of the such technologies. A significant research on this technology already has been carried out. In this thesis, the open issues regarding the channel modeling, channel estimation, and power-allocation in massive MIMO systems have been identified and some solutions have been proposed to a few of them so that this technology can be brought a step closer to deployment. However, there is a further possibility of research to make the system even better. The following sections conclude the different research works presented in this thesis and explore the future scopes of the same.

6.1 CHANNEL MODELING

For channel modeling, a new block fading channel model for massive MIMO systems is proposed in this thesis. The proposed channel model is shown to simulate the spatial variations along with temporal or spectral variations in the channel simultaneously. The details of the underlying propagation are embedded in the channel model while having an analytically tractable expression. A few properties of measured channel from literature have been explained using the proposed channel model that are otherwise not addressed by existing analytically tractable channel models. A qualitative validation has been provided for the channel model by using the existing data from measured channel for massive MIMO systems.

The new channel model is promising. Still, there is a scope for future work on it. A quantitative validation of channel can be done using a measured channel with known geometry of clusters. The characterization of channel model with practical measurements in different scenarios is also needed before this channel model can be used for design of a cellular system. The calculation of parameters for this channel model for arbitrary geometry of antenna array needs a slight variation from the proposed one which has to be altered based on the practical design.

6.2 CHANNEL ESTIMATION AND TRACKING

For channel estimation and tracking in massive MIMO systems, the temporal correlation of channel has been exploited in the current work. The scheme is designed to work in a correlated block fading channel in such a way that the base station requires a pilot based channel estimation only once at the start of communication, the base station then keeps estimating and tracking the channel using the uplink user data of current resource block and the estimated channel matrix of previous resource block. An analysis of estimation error and computational complexity of the proposed algorithm has been provided. The performance of the proposed algorithm is evaluated using simulation where a detailed comparison with pilot based estimation methods has been provided. The practical usability of the scheme has been brought out by variation of different system parameters in performance evaluation.

The proposed algorithm performs better than the existing methods. Still, there is a room for more work on it. An initial estimate of the channel in proposed algorithm can be obtained from the channel estimate of the previous RB in a better way as suggested in chapter 4. The current scheme exploits only the temporal correlation of channel while the exploitation of spectral correlation along with temporal correlation will make the scheme even better. The proposed scheme uses turbo codes in the error correction part of the algorithm. Other error correction codes and techniques can be used in different scenarios for identifying possible improvements in the performance. The assumption of a constant channel within the resource block can be replaced with practical variations of channel under different scenarios of varying mobility.

6.3 POWER-ALLOCATION AND SUM-RATE

The work on sum-rate in chapter 5 reveals an average power-allocation optimization scheme for improved sum-rate and energy consumption in the uplink of a non-cooperative multi-cell multi-user massive MIMO system by using average transmit power control at MTs. Compared to the case of full power assignment at each MT, the improvements in sum-rate vary from 1% to 100% as the inter-cell interference increases with increasing number of users, decreasing size of the cell, or decreasing path-loss coefficients. This maximum sum-rate is obtained at a smaller power which leads to a simultaneous reduction of around 40% to 60% in total transmit power for different scenarios. Further, sacrifice of a small fraction of the sum-rate can result into a huge saving in total transmit power. The scheme also enables a control on the fairness among MTs by switching among several permutations of transmit power providing sum-rates close to the maximum. Finally, the proposed low complexity optimization algorithm for the scheme has 3 to 6 orders lower complexity compared to exhaustive search algorithm for typical values of the parameters. The simulation results of algorithm's performance show an improvement in sum-rate as well as in transmit power.

The work on analysis of the sum-rate can be extended for downlink. The current work is targeted on sum-rate maximization where a few numerical examples and proposed low complexity algorithm are used in the absence of a power allocation scheduler. A scheduler can be embedded with the scheme to use the power-allocation strategy in a practical system where the algorithm can be optimized for desired sum-rate, total transmit power, inter-cell interference statistics, and fairness among MTs. The inter-cell interference power is computed using an existing path loss model. The scheme can be tested by using a measurement of inter-cell interference statistics in a practical multi-cell massive MIMO system. The impact of total transmit power in each cell under different relative power distributions among MTs can be further investigated to find out how it affects the inter-cell interference depending on the locations of MTs.

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