PhD Thesis – Thèse de doctorat

Title : Fast performance evaluation of massive precoded MIMO Multi-users systems

Keywords and skills : Massive MIMO, green radio, probability density function, mutual information, precoding

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Nowadays, Multiple Input Multiple Output (MIMO) systems are used by the modern norms like 4G or, in a near future, 5G where the energy consumption is a key-point. A promising solution for cellular topology is the massive MIMO with multiple users (MU) where the base station may have more than one hundred transmit antennas. The theoretical study of such a system is a real challenge, especially when advanced techniques are used like precoders. The main idea of precoding is to use the channel state information (CSI) at the transmitter in order to optimize a pertinent criterion. There are existing various solutions such as waterfilling, beamforming, max-dmin [Collin04], mercury waterfilling [Lozano06], Lattice [Kapetanovic12]…

However, it is difficult to choose the best solution according to performance criteria, like energy consumption, capacity or complexity. Moreover, the choice is more difficult if we consider open-loop techniques such as OSTBC or turbo-code. That is why the aim of this study is to provide a fast evaluation of performance of precoded massive MIMO-MU system with respect to several parameters: MIMO size, precoder, fading channel, modulation length, number of users… The probability density function (pdf) of the square minimum distance can be obtained for the max-dmin precoder to estimate the ergodic capacity and the bit error rate (BER) [Oyedapo14]. Even though it is available only for two transmit symbols, uncorrelated Rayleigh fading, and the max-dmin criterion, the method can be extended to other precoders or channel statistics.

Thus, a first step of the thesis will be to calculate the pdf for Rice and correlated Rayleigh fading of other precoders and to increase the number of transmit symbols with the E-dmin [Vrigneau08]. Then, two main paths may be followed. The E-dmin can be adapted to a MU scheme where the power allocation must minimize the inter-user interference and the theoretical study has to be done. The second path will be to express the mutual information, then log-likelihood ratio as a function of dmin in order to obtain their pdf. Then, the EXIT chart will be expressed if possible, or approximated, and the study of the association precoder-error correcting code would be possible. We can also imagine proposing new precoders helping the performance or the convergence speed. The final step will be the evaluation and comparison of the energy consumption and complexity in the aim of energy efficient and reconfigurable architectures.

The applicant should have a Master Degree in Computer Engineering or Telecommunications and must have strong background in signal processing and digital communications. He/she should also have good programming skills in Matlab and C. Good knowledge in mathematics and probabilities could be a plus.

References

[Collin04] L. Collin, O. Berder, P. Rostaing, and G. Burel, "Optimal minimum distance-based precoder for MIMO spatial multiplexing systems," *IEEE Trans. Signal Process.*, vol. 52, no. 3, 2004.

[Vrigneau08] B. Vrigneau, J. Letessier, P. Rostaing, L. Collin, and G. Burel, "Extension of the MIMO precoder based on the minimum euclidean distance: A cross-form matrix," *IEEE J. Sel. Areas Signal Process.*, vol. 2, pp. 135–146, Apr. 2008.

[Oyedapo15]: J. O. Oyedapo, B. Vrigneau, R. Vauzelle, and H. Boeglen, "Performance analysis of closed-loop MIMO preco- der based on the probability of minimum distance," *IEEE Trans. Wireless Commun.*, April 2015.

[Kapetanovic12] D. Kapetanovic, F. Rusek, T. Abrudan, and V. Koivunen, "Construction of minimum euclidean distance MIMO precoders and their lattice classifications," *IEEE Trans. Signal Process.*, vol. 60, no. 8, pp. 4470–4474, 2012.

[Lozano06] A. Lozano, A.M.Tulino, and S.Verdu´,"Optimum power allocation for parallel Gaussian channels with arbitrary input distributions," *IEEE Trans. Inf. Theory*, vol. 52, Jul. 2006.