AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics Engineering and Electrical Communications

Performance Evaluation of Massive MIMO Systems

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

by

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Bachelor of Science in Electrical Engineering

(Electronics Engineering and Electrical Communications)

Faculty of Engineering, Ain Shams University, 2013

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STATEMENT

This thesis is submitted as a partial fulfilment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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THESIS SUMMARY

Two timeless truths are evident: first, demand for wireless communications will always grow; second, the quantity of available electromagnetic spectrum will never increase. The fundamental wireless problem is a physical layer problem: how to provide ever-increasing total wireless throughput reliably and uniformly throughout a designated area. Massive MIMO (Multiple-Input-Multiple-Output) makes a clean break with current practice through the use of a very large number of service antennas (i.e., hundreds or thousands) that are operated fully coherently and adaptively. Extra antennas help by focusing the transmission and reception of signal energy into ever-smaller regions of space. This brings huge improvements in throughput, energy efficiency, and spectral efficiency. This thesis presents the analysis and simulation of multi-layer precoding framework, to enable efficient and low complexity massive MIMO operation. A massive MIMO system, operating in Frequency Division Duplexing (FDD) mode of operation, suffers from prohibitively high overhead associated with downlink channel state information (CSI) acquisition and downlink precoding, due to the lack of uplink/downlink channel reciprocity. A heuristic edge-weighted vertex-coloring based pattern division (EWVC-PD) scheme is proposed to reduce the overhead of a two-layer precoding approach, in a practical scenario where the user clusters undergo serious angular-spreading-range (ASR) overlapping, under a constraint of limited number of subchannels. Mathematical analysis as well as numerical simulations reveal the potential solutions for FDD massive MIMO systems to achieve high throughput gains with simplified signal processing.

The thesis is divided into five chapters including lists of contents, tables and figures as well as list of references.

Chapter 1

This chapter is an introduction including the motivation for this work, followed by the thesis outline and contributions.

Chapter 2

This chapter includes a literature review on MIMO systems with focus on the evaluation of massive MIMO systems.

Chapter 3

This chapter presents the system and channel models of Massive MIMO networks, with focus on two-layer precoding.

Chapter 4

This chapter proposes a new solution of low overhead weighted-graph-coloring-based two-layer precoding for FDD massive MIMO systems. Simulation results are shown at the end of this chapter

Chapter 5

Conclusions of this thesis work are given in this chapter. Suggested future work is presented, including possible extensions and promising integrations with other modules.

Keywords: ASR overlapping, graph coloring problem, massive MIMO, pattern division, two-layer precoding.

Dedicated to my family

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