بسم الله الرحمن الرحيم

SAFAA MAHMOUD

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

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قسم

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SAFAA MAHMOUD

AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

ENGINEERING PHYSICS AND MATHEMATICS DEPARTMENT

Mathematical Optimization for Precoding in MIMO Systems

A Thesis submitted in partial fulfillment of the requirements of the degree of Doctor of Philosophy in Engineering Mathematics

Submitted by

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in Engineering Mathematics (Engineering Physics and Mathematics Department).

The work included in this thesis was carried out by the author at the Engineering Physics and Mathematics Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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Thesis Summary

This thesis proposes new precoding techniques through the usage of mathematical optimization algorithms to enhance the precoding stage of the wireless transmission and apply it to the emerging fifth generation (5G) wireless communications networks. The precoding stage in the 5G networks is challenging because recent technologies like massive multi-input-multi-output antenna arrays (M-MIMO) and small cells (SCs) need optimized precoders' designs that can best use these technologies.

The objectives of this thesis are finding optimized precoders' designs for 5G technologies. The first objective is to propose an optimized precoder for a transmitter equipped with M-MIMO antenna array in a single-tier network. This is done by modelling the precoder problem, solving it analytically and testing through simulations the validity of this model.

The second objective is to propose an optimized precoder for a group of transmitters in a double-tier network where one transmitter is equipped with M-MIMO and the other transmitters are SCs. This is done by modelling the precoder problem by two different models: a centralized model and a distributed model. Then, the two models are solved and the optimal precoders are compared through numerical simulations. A robust precoder model is proposed in the case of distributed processing to consider the practical case of the inability of the SCs to know information about users not served by them. Numerical simulations that prove the validity of the proposed models are presented. The thesis is organized into five chapters as listed below:

Chapter 1: Brief introduction of the objective, contributions and thesis outline are introduced.

Chapter 2: This chapter consists of two main parts. The first part defines the mathematical optimization solving techniques. The second part explains matrix inversion techniques.

Chapter 3: This chapter contains an overview on 5G, the latest technology of wireless networks. Then two technologies will be focused on which are M-MIMO and SCs.

Chapter 4: A precoder design that tackles the problem of slow convergence of linear precoding in a single-tier M-MIMO networks is proposed. Mathematical formulation of the problem is proposed, analytical solution of the optimization problem is driven. Numerical simulations that evaluate and prove the validity of the proposed design are presented.

Chapter 5: In this chapter, a precoder that aims at maximization of the total sum rate of all served users in a network that contains M-MIMO and SCs is proposed. Mathematical formulation of the problem is proposed, a reformulation of the optimization problem into centralized and distributed problems is done. A robust precoder model is proposed in the case of distributed processing to consider the practical case of the inability of the SCs to know information about users not served by them. Numerical simulations that prove the validity of the proposed models are presented.

Chapter 6: This chapter focuses on presenting the conclusions of this thesis work. In addition, future research directions are proposed.

Key words: Mathematical optimization, Matrix inversion, Neumann series expansion, Sum rate maximization, M-MIMO, Precoding, Small cells.

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