Cairo University

RATE ANALYSIS IN MASSIVE MIMO UNDER COVARIANCE ESTIMATION

By

Amel Mohamed Mahmoud Mahmoud El-Sayed

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

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Under the Supervision of

Prof. Dr. Yasmine Aly Hassan Fahmy

………………………………

Professor of Communications
Electronics and Communications Department
Faculty of Engineering, Cairo University

Dr. Ahmed Mohamed Hesham Mohamed Riad

………………………………

Associate Professor of Communications
Electronics and Communications Department
Faculty of Engineering, Cairo University

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Approved by the
Examining Committee

____
Prof. Dr. Yasmine Aly Hassan Fahmy, Thesis Main Advisor

____
Dr. Ahmed Mohamed Hesham Mohamed Riad, Advisor

____
Prof. Dr. Magdy Saied El Soudani, Internal Examiner

____
Dr. Karim Gomaa Seddik Ibrahim, External Examiner

- Associate Professor at the Electronics and Communications Engineering Department, American University in Cairo (AUC).

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2019

Engineer's Name: Amel Mohamed Mahmoud Mahmoud
Date of Birth: 22/3/1992
Nationality: Egyptian
E-mail: amel.moh.academic@gmail.com
Phone: 01146390534
Address: 959 St.17, Third Quarter, 6 October city
Registration Date: 1/10/2014
Awarding Date: / /2019
Degree: Master of Science
Department: Electronics and Communications

Supervisors:

Prof. Yasmine Aly Hassan Fahmy
Dr. Ahmed Mohamed Hesham Mohamed Riad

Examiners:

Dr. Karim Gomaa Seddik Ibrahim (External examiner)
- Associate Professor at the Electronics and Communications Engineering Department, American University in Cairo (AUC).

Prof. Magdy Saied El Soudani (Internal examiner)
Prof. Yasmine Aly Hassan Fahmy (Thesis main advisor)
Dr. Ahmed Mohamed Hesham Mohamed Riad (Advisor)

Title of Thesis:

RATE ANALYSIS IN MASSIVE MIMO UNDER COVARIANCE ESTIMATION

Key Words:
Massive MIMO; Covariance Estimation; MMSE Channel Estimation; Pilot Contamination; Semi-blind Channel Estimation

Summary:

Massive MIMO is one of the enablers of the fifth generation. We study the performance of uplink massive MIMO system where the users suffer from the pilot contamination but possess linearly independent covariance matrices. Based on the latest results of the unlimited capacity of massive MIMO system with pilot contamination existence and assuming the covariance matrices are known, we show that this unlimited capacity result holds true for massive MIMO systems even when the covariance matrices are fully unknown (and not estimated) at the base station. However, covariance estimation improves the uplink capacity. We prove this result for both of static and time-varying channel models. We also consider both of single-cell and multi-cell massive MIMO systems with covariance estimation and semi-blind channel estimation for the two-antenna users. We show that the capacity is still unlimited by using MMSE channel estimation and data detection for all the scenarios mentioned above.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Amel Mohamed Mahmoud Mahmoud. Date:

Signature:

Dedication

I dedicate this thesis to my loving family and friends; father, mother, sister, brother, grandmother, and my lovely niece. I am nothing without them and I could not reach anything without their love, existence and guidance. Especially I want to thank my beautiful mother, Fatma, who is my greatest supporter for everything and I can’t imagine completing anything without her existence by my side.

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Nomenclature

1G	First Generation
1xRTT	Single-Carrier Radio Transmission Technology
2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project
4G	Fourth Generation
5G	Fifth Generation
8PSK	Eight Phase Shift Keying
ADC	Analog-to-Digital Converter
AMPS	Advanced Mobile Phone System
AR	Autoregressive Model
AWGN	Additive White Gaussian Noise
BS	Base Station
BW	Bandwidth
CDMA	Code-Division Multiple-Access
CG	Complex Gain
CPs	Cyclic Prefixes
CSI	Channel-State Information
DAC	Digital-to-Analog Converter
DAMPS	Digital Advanced Mobile Phone System
dB	Decibel
EDGE	Enhanced Data Rates for GSM Evolution
EV-DO	Evolution-Data Optimized
F.T.	Fourier Transform
FBMC	Filter Bank Multi-Carrier

FDD	Frequency Division Duplex
FDMA	Frequency-Division Multiple-Access Technique
FM	Frequency Modulation
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HSCSD	High Speed Circuit Switched Data
HSDPA	High Speed Downlink Packet Access
HSOPA	High Speed OFDM Packet Access
HSUPA	High Speed Uplink Packet Access
i.i.d.	Independent Identical Distributed
iDEN	Integrated Dispatch Enhanced Network
IEEE	Institute of Electrical and Electronics Engineers
IMT-MC	International Mobile Telecommunications Multicarrier
IP	Internet Protocol
IR	Infra-red
IS	Interim Standard
ISI	Inter-Symbol Interference
ITU	International Telecommunication Union
LD	Log-distance
LOS	Line-of-Sight
LS	Least Square
LTE	Long Term Evolution
MCS	Mobile Cellular System
MF	Matched Filter
MIMO	Multiple-Input Multiple-Output
MISO	Multiple-Input Single-Output
M-MMSE	Multi-cell Minimum Mean Square Error