Sudan University of Science and Technology College of Engineering School of Electronics Engineering



COORDINATED MULTIPOINT TRANSMISSION AND RECEPTION OF LTEADVANCED

A Research Submitted In Partial fulfilment for the Requirements of the Degree of B.Sc. (Honors) in Telecommunications Engineering

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الإستهلال

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[وَمَا أُوتِيثُمْ مِنْ الْعِلْمِ إِلاَّ قَلِيلا]

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DEDICATION

To our mothers, fathers and teachers.

ACKNOWLDGEMENT

"We would like to thank our supervisor, Dr. Fath Elrahman Ismael Khalifa for the valuable advice and support he has given us in the writing of the project. We would also like to thank all our teachers, in the school of electronics engineering, for their encouragement and guidance. Our deepest thanks go to our mothers and fathers for their Encourages, efforts, understanding and support."

ABSTRACT

Coordinated multi-point (CoMP) transmission and reception is a network multiple-input multiple-output (MIMO) technology considered in 3GPP LTE-Advanced systems. In order to improve reliability and capacity of the services for the user equipments (UEs) at the cell edges, CoMP utilizes cooperation among neighbouring enhanced node Bs (eNBs). When a mobile station is at the cell edge, it may be able to receive signals from multiple cell sites, and the mobile station's transmission may also be received at multiple cell sites. If the data transmission and signalling from multiple cell sites can be coordinated, the downlink performance can be significantly improved. This coordination can be similar to the interference avoidance techniques or the case where the same data is transmitted from multiple cell sites. In the uplink, since the signal can be received by multiple cell sites, the system can take advantage of coordinated multipoint reception to significantly improve the link performance. In the project, presented two scenario of networks, first is when coordination(CoMP) performed and other, is when there is no coordination to network(No-CoMP), By using Matlab Program the results are show that data rate, throughput especially cell-edge throughput, spectral efficiency and Bandwidth Utilization is improved after coordination have been formed.

The results shows that data rate increased by 4.5 % to 22.5 % while spectral efficiency improved by 22 % to 65 % and also throughput increased by 60 %, delay time improved by 50 % to 66.7%, and also improves bandwidth efficiency by 30%.

المستخلص

يعتبر تنسيق الشبكات متعددة النقاط للإرسال والإستقبال من التكنولوجيا متعددة المدخلات والمخرجات وهي من الانظمة المتقدمة للجيل الرابع لأجل تحسين الموثوقية و الخدمات لمعدات المستخدم على حواف الخلية، الشبكة المنسقة تستخدم لتعزيز التعاون بين العقد المتجاورة، وفي حالة ان المستخدم موجود في حافة الخلية قد يكون قادرا على تلقي إشارات من عدة خلايا في مواقع متعددة ويمكن أيضا أن يرسل المستخدم الي عدة مواقع ، إذا كان نقل البيانات والإشارات من خلية المواقع متعددة يمكن تنسيقها، وأداء الإستقبال يمكن أن يحسن بشكل كبير. هذا التنسيق يمكن أن يكون مماثل لتقنيات تجنب التداخل أو في حالة يتم نقل نفس البيانات من مواقع متعددة الخلايا، لأن الإشارة يمكن الحصول عليها من مواقع متعددة الخلايا، يمكن للنظام الاستفادة من الإستقبال المتعدد المنسق للتحسين في أداء الارتباط.

في المشروع، عرض اثنين سيناريو من الشبكات، الأولى عند تنسيق الشبكة المتعددة الارسال والاستقبال، والأخر هي عندما لا يكون هناك تنسيق للشبكة ، باستخدام برنامج الماتلاب كانت النتائج تظهر أن معدل البيانات ، والكفاءة الطيفية ، الانتاجية خصوصا الانتاجية عندما يكون المستخدم في حافة الخلية، تاخير زمن الاشارة ، وزيادة كفاءة عرض النطاق الترددي كان هو الافضل بالنسب الأتية:

معدل البيانات زادت بنسبة %4.5 الي %22.5 اما الكفاءة الطيفية تحسنت بنسبة %22الي 66.7 و الانتاجية تحسنت ايضا بنسبة. %60 و قل زمن تاخير الاشارة بنسبة 50 %الي 66.7 وكذالك تحسن كفاءة عرض النطاق بنسبة . 30%

TABLE OF CONTENTS

الإستهلال	I
DEDICATION	II
ACKNOWLDGEMENT	III
ABSTRACT	IV
المستخلص	V
TABLE OF CONTENTS	VI
LIST OF TABLES	IX
LIST OF FIGURE	X
LIST OF SYMBOLS	XXI
LIST OF ABBROVATIONS	XII
CHAPTER ONE INTRODUCTION	17
1.1 Preface	17
1.1 Problem Statement	18
1.2 Proposed Solutions	18
1.3 Aims and Objectives	
1.4 Methodology	19
1.5 Thesis Outlines	19
CHAPTER TWO LITRETURE RE	VIEW Error! Bookmark not
defined.	
	Error! Bookmark not defined.
LITRETURE REVIEW	Error! Bookmark not defined.
2.1 Background	Error! Bookmark not defined.
2.2 LTE Standardization	Error! Bookmark not defined.
2.3 LTE System Architecture	Error! Bookmark not defined.
2.4 LTE Key Features	Error! Bookmark not defined.

2.	4.1	Enhanced Air Interface	Error! Bookmark not defined.
	2.4.2	Spectral Efficiency	Error! Bookmark not defined.
	2.4.3	Latency	Error! Bookmark not defined.
	2.4.4	Mobility	Error! Bookmark not defined.
2.	.5 L	TE Transmission Schemes	Error! Bookmark not defined.
	2.5.1	Downlink Transmission Scheme	Error! Bookmark not defined.
	2.5.2	Uplink Transmission Scheme	Error! Bookmark not defined.
2.	.6 L	TE-Advanced	Error! Bookmark not defined.
	2.6.1	Requirements of LTE-Advanced	Error! Bookmark not defined.
	2.6.2	LTE Advanced Enabling Technolog	iesError! Bookmark not defined.
	2.6.2	2.1 Heterogeneous Networks	Error! Bookmark not defined.
	2.6.2	2.2 Relays Nodes	Error! Bookmark not defined.
	2.6.2	2.3 Carrier Aggregation	Error! Bookmark not defined.
	2.6.2	-	sion or Reception Error! Bookmark not
	defi		
	.7 R	Related Works	Error! Bookmark not defined.
C	.7 R HAP	Related Works TER THREE COORDINATEI	O MULTIPOINT
C	.7 R HAP RAN	Related Works FER THREE COORDINATEI SMISSION AND RECEPTION	O MULTIPOINT J Error! Bookmark not defined.
C T	.7 R HAP RAN	Related Works FER THREE COORDINATEI SMISSION AND RECEPTION	O MULTIPOINT
C T.	.7 R HAP RAN	Related Works TER THREE COORDINATEI SMISSION AND RECEPTION The CoMP Architecture	O MULTIPOINT J Error! Bookmark not defined.
C T.	7 R HAP RAN 1 T	Related Works TER THREE COORDINATEI SMISSION AND RECEPTION The CoMP Architecture Centralized Architecture	O MULTIPOINT Error! Bookmark not defined. Error! Bookmark not defined.
C T.	7 R HAP RANS 1 T 3.1.1 3.1.2	Celated Works FER THREE COORDINATEI SMISSION AND RECEPTION The COMP Architecture Centralized Architecture Distributed Architecture	O MULTIPOINT Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T. 3.	7 R HAP RANS 1 T 3.1.1 3.1.2	Celated Works TER THREE COORDINATEI SMISSION AND RECEPTION The CoMP Architecture Centralized Architecture Distributed Architecture CoMP Schemes	O MULTIPOINT SError! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T. 3.	7 R HAP RAN 1 T 3.1.1 3.1.2 2 C 3.2.1	Celated Works TER THREE COORDINATEI SMISSION AND RECEPTION The CoMP Architecture Centralized Architecture Distributed Architecture CoMP Schemes CoMP Schemes in the Downlink	D MULTIPOINT SError! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T. 3.	7 R HAP RAN 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C	Celated Works	D MULTIPOINT SError! Bookmark not defined. Error! Bookmark not defined.
C T 3.	7 R HAP RAN 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C	Celated Works TER THREE COORDINATEI SMISSION AND RECEPTION The CoMP Architecture Centralized Architecture Distributed Architecture CoMP Schemes CoMP Schemes in the Downlink CoMP Schemes in the Uplink Mathematical Representation	D MULTIPOINT SError! Bookmark not defined. Error! Bookmark not defined.
C T 3.	7 R HAPT RANS 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C 4 N	Celated Works	D MULTIPOINT IError! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T. 3. 3.	7 R HAP RANS 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C 4 M 3.4.1	Celated Works	D MULTIPOINT Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T 3.	7 R HAP RANS 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C 4 M 3.4.1 3.4.2	Celated Works	D MULTIPOINT Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T 3.	7 R HAP RANS 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C 4 M 3.4.1 3.4.2 3.4.3	Celated Works	D MULTIPOINT SError! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined. Error! Bookmark not defined.
C T. 3. 3.	7 R HAPT RANS 1 T 3.1.1 3.1.2 2 C 3.2.1 3 C 4 N 3.4.1 3.4.2 3.4.3 3.4.4	Celated Works	D MULTIPOINT Serror! Bookmark not defined. Error! Bookmark not defined.

CHAPTER FOUR RESULTS AND DISCUSSION.. Error! Bookmark not defined.

4.1	Simulation Results Error! Bookmark n	ot defined.
4.1.1	.1 System capacity Error! Bookman	k not defined.
4.1.2	.2 Cell edge throughput Error! Bookman	k not defined.
4.1.3	Accumulated throughput Error! Bookman	k not defined.
4.1.4	.4 Spectral efficiency Error! Bookman	k not defined.
4.1.5	1.5 Resource block utilization Error! Bookman	k not defined.
4.1.6	1.6 Instantaneous data rate Error! Bookman	k not defined.
4.1.7	1.7 Queuing delay Error! Bookman	k not defined.
CHAI	APTER FIVE CONCLUSION AND RECOMMENDATI	ON Error!
Book	kmark not defined.	
5.1	Conclusion Error! Bookman	k not defined.
5.2	Recommendations	k not defined.
Refere	erences: Error! Bookmark n	ot defined.
Apper	endicesError! Bookmark n	ot defined.
APPENDIX A : System capacity and Instantaneous data rate Error! Bookmark not defined.		
	PPENDIX B : Cell edge Throughput, spectral efficiency, and Accumulated Error! Bookman	0 1
APP	PPENDIX C : Resource Block utilization Error! Bookman	k not defined.
APP	PPENDIX D :Queuing Delay Error! Bookman	k not defined.

LIST OF TABLES

Table	Description	Page no
2.1	LTE target and 3GPP requirements on LTE	17
	Advanced	

LIST OF FIGURES

Figure	Description	Page no
2-1	LTE Radio Access Network Architecture.	9
2-2	OFDM Subcarrier Spectrum	13
2-3	OFDMA Transmitter and Receiver Diagram	14
2-4	Transmitter and receiver structure for SC-FDMA	15
	and OFDM	
2-5	example of heterogeneous Networks.	18
2-6	Use of RN to improve indoor coverage	19
2-7	Carrier Aggregation	21
3-1	Concept of CoMP	29
3-2	Joint Processing CoMP.	32
3-3	Coordinated Scheduling / Beamforming Scheme	33
3-4	(a) interference rejection combining (b)	34
	coordinated scheduling	
4-1	Calculating System Capacity	42
4-2	Cell edge Throughput	43
4-3	Accumulated throughput	44
4-4	Spectral efficiency	45

4-5	Resource Block Utilization	46
4-6	Instantaneous data rate	47
4-7	Queuing delay	48

LIST OF SYMBOLS

Symbol	Description
Ts	Simulation Time
A,B,C	Number of eNBs
RB_{max}	Maximum Resource Block
U	Number of UEs
Nt	Number of Tx antennas
Nr	Number of Rx antennas
Hb	eNB antenna Hieght
hM	UE antenna height
λ	Rate of data

LIST OF ABBROVATIONS

Abbreviation Description

3GPP 3G Project Partnership Project

3G 3rd Generation

4G 4th Generation

LTE Long Term Evolution

LTE-A Long Term Evolution Advanced

CoMP Coordinated Multipoint

ITU International Telecommunication Union

SINR Signal to Interference and Noise Ratio

BS Base Station

eNBS Evolved Node BS

MS Mobile Station

UE User Equipment

RB Resource Block

1G 1st Generation

2G 2nd Generation

WCDMA Wideband Code Division Multiple Access

HSPA High Speed Packet Access

RAN Radio Access Network

RNC Radio Network Controller

OFDM Orthogonal Frequency Division Multiplexing

OFDMA Orthogonal Frequency Division Multiple Access

GPRS General Packet Radio Service

SGSN Serving GPRS Support Node

GGSN Gateway GPRS Support Node

SAE System Architecture Evolution

S-GW SAE Gateway

A-GW Access Gateway

MME Mobility Management Entity

UPE User Plane Entity

MIMO Multiple Input Multiple Output

QAM Quadrature Amplitude Modulation

FEC Forward Error Correction

E-UTRAN Evolved UMTS Terrestrial Radio Access Network

SC-FDMA Single Carrier- Frequency Multiple Access

WiMAX Worldwide Interoperability Microwave Access

WLAN Wireless Local Area Network

DVB Digital Video Broadcasting

ICI Inter-Cell Interference

ISI Inter Symbol Interference

CP Cyclic Prefix

FFT Fast Fourier Transform

IFFT Inverse Fast Fourier Transform

DFT Discrete Fourier Transform

IDFT Inverse Discrete Fourier Transform

GSM Global system for Mobile communication

TDMA Time Division Multiple Access

CDMA Code Division Multiple Access

PAPR Peak Average Power Ratio

RF Radio Frequency

DAC Digital to Analog Conversion

IMT International Mobile Telecommunication

HeNBS Heterogeneous eNBS

RN Relay Node

CA Carrier Aggregation

PF Proportional Fair

FR Fair Resource

CS/CB Coordinated Scheduling/ Coordinated Beamforming

CSI Channel State Information

SISO Single Input Single Output

CCS CoMP Coordinating Set

CTP CoMP Transmission Points

RSRP Reference Signal Received Power

JP Joint Processing

PDSCH Physical Downlink Share Channel

DCS Dynamic Cell Selection

JT Joint Transmission

PUSCH Physical Uplink Share Channel

IRC Interference Rejection Combining

ZF Zero Forcing

MMSE Minimum mean Square Error

BLER Block Error Rate

UMTS Universal Mobile Telecommunication Services

CHAPTER ONE

INTRODUCTION

CHAPTER ONE

INTRODUCTION

1.1 Preface

Cellular systems were initially designed to provide voice service for mobile terminals within vehicles, which requires small data rates. Today, they are developed so that they can provide users with many high data rate services such as video, audio, Internet, and other multimedia applications With advancement to 4G cellular networks, cellular operators are looking for low cost network solution to support increasing demand for high data rate mobile applications, mainly targeted for indoor users. base station is certainly a contending solution to achieve this target mobile communication technologies are often divided into generations, with 1G being the analog mobile radio systems of the 1980s, 2G the first digital mobile systems, and 3G the first mobile systems handling broadband data. The *Long-Term* Evolution (LTE) is often called "4G", but many also claim that LTE release 10 [1]. LTE-Advanced is new version of LTE in order to complete the requirements defined by the International Telecommunications Union (ITU) for next generation mobile communication systems. Requirements for LTE-Advanced are similar to LTE standards, excepting peak data rates and spectral efficiency which should be increased. In these days mobile communications with multimedia application are became popular which should reliably support high data rate transmissions.

In LTE Release 11, Third Generation Partnership Project(3GPP) introduced some simpler Coordinated multipoint transmission and reception(CoMP) concepts, but it is generally expected that advanced CoMP concepts will take longer to be mature enough for commercial use. The fundamental principle of CoMP is to coordinate

multiple Base Station(eNB) or antennas located within a certain geographical range in order to increase data rate at the UEs [2].

1.1 Problem Statement

In the a conventional cellular system, the BS is located in the cell center and it only serves the users in its coverage area. The signals transmitted from, serving BS decreases as the user moves towards cell edge this will lead to poor SINR and hence the throughputs, spectral efficiency, worsen for cell edge users.

In addition, as the number users in one eNBS increased, only small amount of resources is allocated to each one, while there may be unused resources in neighbouring cells.

1.2 Proposed Solutions

Cell coordination has been proposed as an efficient way which allows several base stations to transmit data simultaneously to the same user. The major challenge of cell coordination is to control the strong coupling of scheduling decisions in the three cells.

1.3 Aims and Objectives

The general aims of this research is to evaluate the effectiveness of CoMP system to improve overall quality for the user as well as improving the utilisation of the network resources.

The detailed objectives include:

- 1. To provide the necessary specification support to efficiently realize the benefits of cooperative transmission in the downlink and cooperative reception in the uplink.
- 2. Simulation model of the two networks by Matlab.
- 3. To coordinate the network to improve data rate, throughput, and delay of data which receives user in cell edge.
- 4. Compare the performance of two approaches: One is No-CoMP Network and other on is CoMP Network.

1.4 Methodology

This project is divided into two parts:

- 1. **Theoretical part:** include the study of the specification of LTE-Advanced and heterogeneous network scenario.
- 2. **Practical part:** include the simulation over a MATLAB platform. A MATLAB code has been written to simulate the system performance with and without coordination.

There are many parameters that can measure the system performance like (signal to interference ratio, throughput, spectral efficiency and bandwidth utilization) due to their huge effect on the system performance and their relation with each other, they have been selected in this project to verify the enhance of the system.

The output of the simulation is in graphs form, it shows the amount of improvement in each parameter.

1.5 Thesis Outlines

This Project composed of five chapters, thus outlines are as follows:

Chapter Two represented a literature review which talks in more details about LTE and some of its features and LTE-Advanced, its different Technologies, and also presents some of related works.

Chapter Three is Coordinated multipoint Transmission and Reception implementation scenarios, and also defines CoMP Architecture, explains to CoMP Schemes also explains its mathematical representation.

Chapter Four includes the performance metrics and dedicated for the results, obtained from matlab simulation, and their discussions.

The study is concluded with

Chapter Five, conclusion & Future Works, which summarizes the work done and recommendations.