Sudan University of Science and Technology

College of Engineering

School of Electronics Engineering

COORDINATED MULTIPOINT TRANSMISSION AND RECEPTION OF LTE-ADVANCED

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

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الإستهلال

قال تعالى:

[وَمَا أُوتِيتُمْ مِنْ الْعِلْمِ إلاَّ 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، الأولي 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 بنسبة4.5% الي22.5% اما الكفاءة الطيفية تحسنت بنسبة 22%الي 65% والانتاجية تحسنت ايضا بنسبة.60% و قل زمن تاخير الاشارة بنسبة 50%الي 66.7% وكذالك تحسن كفاءة عرض النطاق بنسبة .30%

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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

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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.