DESIGN AND IMPLEMENTATION OF MIMO-LONG TERM EVOLUTION-ADVANCED TO SUPPORT LARGER BANDWIDTH

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ABSTRACT

The migration of mobile communication technologies are divided into four generations. Long Term Evolution (LTE) is called LTE rel-8, the evolution of LTE led to new technology referred to as LTE-Advanced, is the true fourth generation (4G) evolution step, with the first release of LTE (rel-8) which was labeled as “3.9G”. LTE-Advanced is a mobile broadband access technology founded as a response to the need for the improvement to support the increasing demand for high data rates. The standard for LTE-A is a milestone in the development of Third Generation Partnership Project (3GPP) technologies. Carrier Aggregation is one of the most distinct features of LTE-Advanced that makes the bandwidth extension of up to 100 MHz thus the theoretical peak data rate of LTE-A may be even up to 1 Gbps. This proposed system presents new LTE-Advanced depending on carrier aggregation to obtain better performance of the system. The new design of LTE-Advanced offers higher peak data rates than even the initial LTE-A; while the spectrum efficiency has been amended; As a result, the aggregated LTE-A will support 120 MHz instead of 100 MHz in order to obtain higher peak data rate access up to 4 Gbps. The system was applied with 8x8 Multiple Input Multiple Output (MIMO) using different modulation techniques: QPSK, 16 QAM, and 64 QAM. From the simulation results, it is clear that proposed LTE-Advanced with 64 QAM has high values of throughput in case of depending code rate equals to 5/6 with 8x8 MIMO.

ABSTRAK

Penghijrahan teknologi komunikasi mudah alih dibahagikan kepada empat generasi. Long Term Evolution (LTE) dipanggil LTE rel-8, evolusi LTE yang membawa kepada teknologi baru yang dikenali sebagai LTE-Lanjutan, adalah generasi yang benar-benar evolusi generasi keempat (4G), dengan keluaran pertama LTE (rel-8) yang dilabelkan sebagai "3.9G". LTE-Lanjutan adalah teknologi akses komunikasi mudah alih jalur lebar yang ditubuhkan untuk menjawab kepada keperluan permintaan yang semakin meningkat bagi kadar data yang tinggi. Standard untuk LTE-A adalah peristiwa penting dalam pembangunan teknologi generasi ketiga Partnership Project (3GPP). Penggabungan Carrier merupakan salah satu ciri yang paling ketara dalam LTE-Advanced yang membenarkan sambungan jalur lebar sehingga 100 MHz, oleh itu secara theoretical puncak kadar data LTE-A mungkin melebihi 1 Gbps. Sistem yang dicadangkan membuka lebaran baru LTE-Advanced namun demikian ia bergantung kepada penggabungan carrier untuk menghasilkan prestasi yang lebih baik daripada sistem. Reka bentuk baru LTE-Advanced menawarkan kadar data puncak yang lebih tinggi daripada permulaan LTE-A, manakala kecekapan spektrum telah dipinda; Secara kesimpulan, penggabungan LTE-A akan menyokong 120 MHz dan bukannya 100 MHz untuk mendapatkan kadar data puncak yang boleh mengakses sehingga 4 Gbps. Sistem ini telah diaplikasikan dengan 8x8 Pelbagai Input Pelbagai Output (MIMO) dengan menggunakan pelbagai teknik modulasi yang berbeza: QPSK, 16 QAM, dan 64 QAM. Daripada keputusan simulasi, ia jelas menunjukkan bahawa cadangan LTE-Advanced dengan 64 QAM mempunyai nilai-nilai yang tinggi pemprosesan dalam kes bergantung kadar kod sama dengan 5/6 dengan 8x8 MIMO.

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LIST OF ABBREVIATIONS

1G	-	First Generation
2G	-	Second Generation
3G	-	Third Generation
3GPP	-	Third Generation Partnership Project
4G	-	Fourth Generation
ACLR	-	Adjacent Channel Leakage Ratio
AIM	-	Advanced Interference Management
B.W	-	Bandwidth
BER	-	Block Error Rate
BS	-	Base Station
BTS	-	Base Transceiver Station
BW_{GB}	-	Bandwidth Guard Band
CA	-	Carrier Aggregation
CB	-	Coding Blocks
CCs	-	Component Carriers
CDF	-	Cumulative distribution function
CDMA	-	Code Division Multiple Access
CM	-	Cubic Metric
CoMP	-	Coordinated Multi Point
CP	-	Cyclic Prefix
C-Plane	-	Control-Plane

CRC	-	Cyclic Redundancy Check
CRS	-	Cell-specific Reference Symbol
CSI	-	Channel State Information
CSI-RS	-	Channel State Information -Reference Signal
CSIT	-	Channel State Information at the Transmitter
DC	-	Direct Current
DFT	-	Discrete Fourier Transform
DFT-S-OFDM	-	Discrete Fourier Transform–Spread–OFDM
DL	-	Downlink
DRX	-	Discontinuous Reception
EDGE	-	Enhanced Data Rates for GSM Evolution
eNB	-	enhanced Node B
EPC	-	Evolved Packet Core
E-UTRA	-	Evolved Universal Terrestrial Radio Access
E-UTRAN	-	Evolved UMTS Terrestrial Radio Access Networ
EVM	-	Error Vector Magnitude
FDD	-	Frequency Division Duplex
FDMA	-	Frequency Division Multiple Access
FEC	-	Forward Error Correction
FFS	-	For Further Studies
FFT	-	Fast Fourier Transform
GPRS	-	General Packet Radio Service
GPS	-	Global Positioning System
GSM	-	Global System for Mobile
HARQ	-	Hybrid Automatic Repeat Request
HeNB	-	Home eNodeB
HSDPA	-	High Speed Downlink Packet Access

HSPA	-	High Speed Packet Access
HSUPA	-	High-Speed Uplink Packet Access
IDFT	-	Inverse Discrete Fourier Transform
IFFT	-	Inverse Fast Fourier Transform
IM3	-	Third-order Inter Modulation
IMD	-	Inter Modulation Distortion
IMT-Advanced	-	International Mobile Telecommunications - Advanced
IP	-	Internet Protocol
ISI	-	Inter Symbol Interference
ITU	-	International Telecommunications Union
ITU-R	-	ITU-Radiocommunication
JP	-	Joint Processing
LTE	-	Long Term Evolution
LTE-A	-	Long Term Evolution-Advanced
MA	-	Multiple Access
MAC	-	Medium Access Control
MBRs	-	Maximum Bit Rates
MIMO	-	Multi Input Multi Output
MISO	-	Multiple Input Single Output
MU-MIMO	-	Multi User- Multi Input Multi Output
OCC	-	Orthogonal Cover Codes
OFDM	-	Orthogonal Frequency Division Multiplexing
OFDMA	-	Orthogonal Frequency Division Multiple Access
P	-	Power
P/S	-	Parallel to Serial
PA	-	Power Amplifiers
PAPR	-	Peak to Average Power Ratio

P_{CC}	-	Primary component carrier
Pe	-	Error Probability
PHY layer	-	Physical layer
PRB	-	Physical Resource Block
PS	-	packet-switching
PUCCH	-	Physical Uplink Control Channel
QAM	-	Quadrature Amplitude Modulation
QoS	-	Quality of Service
QPSK	-	Quadrature Phase Shift Keyed
RBs	-	Resource Blocks
Rel-10	-	Release-10
Rel-11	-	Release-11
Rel-12	-	Release-12
Rel-8	-	Release-8
Rel-9	-	Release-9
RF	-	Radio Frequency
RRC	-	Radio Resource Control
RS	-	Reference Signal
S/P	-	Serial to Parallel
SAE	-	System Architecture Evolution
SC-FDMA	-	Single Carrier Frequency Division Multiple Access
SDM	-	Spatial Division Multiplexing
SEM	-	Spectrum Emission Mask
SIMO	-	Single Input Multiple Output
SISO	-	Single Input Single Output
SNR	-	Signal to Noise Ratio
SU-MIMO	-	Single User- Multi Input Multi Output

TBs	-	Transport Blocks
TDD	-	Time Division Duplexing
TD-LTE	-	Time Division -Long Term Evolution
TDMA	-	Time Division Multiple Access
TD-SCDMA	-	Time Division-Synchronous Code Division Multiple Access
TSG RAN	-	TSG Radio Access Network
UE	-	User equipment
UL	-	Uplink
UMTS	-	Universal Mobile Telecommunications System
U-Plane	-	User-Plane
WCDMA	-	Wideband Code Division Multiple Access
WiMAX	-	Worldwide interoperability for Microwave Access
βi	-	Fraction of Bandwidth Allocated to user i

CHAPTER 1

INTRODUCTION

The specifications of Long Term Evolution (LTE) in 3rd Generation Partnership Project (3GPP) (Release-8) has recently been completed when work began on the new Long Term Evolution- Advanced (LTE-A) standard (Release-9 and beyond). LTE-A meets or exceeds the requirements imposed by International Telecommunication Union (ITU) to Fourth Generation (4G) mobile systems. These requirements were unthinkable a few years ago, but are now a reality. Peak data rates of 1 Gbps with bandwidths of 100 MHz for the downlink, very low latency, more efficient interference management and operational cost reduction are clear examples of why LTE-A is so appealing for operators. Moreover, the quality breakthrough affects not only operators but also end users, who are going to experience standards of quality similar to optical fiber.

In order to reach these levels of capacity and quality, the international scientific community, in particular the 3GPP are developing different technological enhancements on LTE. The most important technological proposals for LTE-Advanced are support of wider bandwidth (carrier aggregation), advanced Multiple Input Multiple Output (MIMO) techniques, Coordinated Multipoint transmission or reception (CoMP), relaying and enhancements for Home eNodeB (HeNB) by Cardona, Monserrat and Cabrejas (2013).

The 3GPP is in the process of development of certain technological proposals to meet the demanding requirements of LTE-A. At this point, 3GPP has focused its attention on different points that required technological innovations and one of them is supporting of wider bandwidth (carrier aggregation) which is the main issue of this thesis. Carrier aggregation can be defined as one of the most important technologies that ensure the success of 4G technologies; this concept involves transmitting data in multiple contiguous or non-contiguous Component Carriers (CCs). Each Component Carrier (CC) takes a maximum bandwidth of 20 MHz to be compatible with LTE Release 8 (Dahlman, Parkvall, Sköld and Beming, 2008). In addition to the peak data rate, another motivation for carrier aggregation is to facilitate efficient use of fragmented spectrum. In LTE-Advanced carrier aggregation, each component carrier can take any of the channel bandwidths of 1.4, 3, 5, 10, 15, and 20 MHz that are supported by LTE. Component carriers do not have to be of the same frequency (Taha, Hassanein and Abu Ali, 2012). Operators with a fragmented spectrum can also provide high data rate services through carrier aggregation technology. Carrier aggregation also allows advanced features such as multi-carrier scheduling, interference coordination, quality of service (QoS) differentiation, carrier load balancing, and heterogeneous deployment to be used to further increase the spectral efficiency of the system. For instance, with QoS differentiation, different subscription classes can be created whereby users are assigned a bandwidth and a preferred carrier on the basis of their level of service agreement. Multi carrier scheduling can also be used to schedule users in a carrier that is experiencing less interference, thus improving throughput. Similarly, carrier aggregation can be used with inter-cell interference coordination techniques to ensure that users are scheduled in a manner that will generate less interference with surrounding cells.

1.1 Problem Statement

LTE-A has peak data rate limitations, its maximum reaches 1 Gbps due to number of component carriers which is five. Proposed LTE-Advanced offers considerably higher data rates than it in the current release of LTE-A. In addition, the spectrum usage efficiency also has been improved.

In order to achieve these very high data rates it is necessary to increase the transmission bandwidth over that has been used by the first releases of LTE. The technique being proposed is termed carrier aggregation or sometimes channels aggregation. Using LTE-Advanced carrier aggregation, it is possible to utilize several carriers and in this way increase the overall transmission bandwidth. Proposed LTE-Advanced bandwidth for both types: contiguous and non-contiguous needs a suitable band which covers the whole bandwidth depending on the standard bands from 3GPP organization.

1.2 Objectives of the Research

The main objectives of this research are:

1. To improve LTE-A disadvantages by increasing the bandwidth at both sides (transmitter and receiver), where the current bandwidth is 100 MHz.
2. To increase peak data rate of the proposed system more than 1 Gbps which represents the peak data rate of LTE-A.
3. To apply MIMO technology on the proposed LTE-A system with 8x8 antennas.
4. To increase the efficiency of the proposed system comparing to efficiency of LTE and LTE-A systems.

1.3 Scope of the Research

This research is to study high bandwidth internet access anytime anywhere which is continuously increasing. In order to deliver the main objectives of this research; initial study of LTE and LTE-A techniques for cellular systems has been done by identifying critical parameters for performance optimization in cellular systems and deriving the mathematical formulations. Design the proposed LTE-Advanced system by developing LTE and LTE-A algorithms so that the new system will have wider bandwidth and higher peak data rate through Matlab and SystemVue programs. The design of the new

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