CHANNEL ESTIMATION FOR LTE DOWNLINK

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CHANNEL ESTIMATION FOR LTE DOWNLINK

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To My Parents

For they brought me up, encouraged and supported me throughout my life, and for their sacrifices that made me obtain the best education possible.

AND

My Wife

The source of my aspiration

My Brothers and Sisters

Who always wished all the best for me

The love of my parents, the aspiration of my wife and encouragement of my brothers, sisters, friends have really been a tonic to me.

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Ahmed Mohammed Mohamed , Johor Bahru, Malaysia

ABSTRACT

In LTE system, supporting high mobile user speed is one of the key of requirements. However, the channel variation in different mobility scenarios is a significant challenge to achieving this goal. The channel estimation is required at the receiver part to satisfy the good performance with channel variation. In this master thesis, I use the different estimators to estimate the channel at the LTE Downlink system with different scenarios. The LS block fading estimator use at low mobility where the channel is statistic during one subframe. When the user speed more than 20 km/h the LS block estimation degrade in MSE and throughput performance. The LS fast fading outperforms the LS block fading at the velocity more than 25 km/h. LS estimation can be simply implemented with low computational complexity, however the MSE performance is not satisfactory at the high mobility. The LMMSE method is optimum in minimizing the MSE of the channel estimates and in throughput performance.However, the algorithm contains matrix inverse operation and other complex operations which causes high computational complexity. To compatible between these different estimators with good performance and low complexity, the proposed method is used. This method combines three different type channel estimations which is termed Hybrid Linear Mean Square Error (HLMSE). This proposed estimator is a hybrid of the Least Square (LS) estimator block for low mobility , LS fast fading estimator for moderate mobility and Linear Minimum Mean Square Error (LMMSE) estimator for high mobility. The performance of the HLMSE estimator compared with LS in terms of throughput and Mean Square Error(MSE) outperforms the LS in both throughput and MSE. The complexity of the HLMSE can be controlled by channel variation, which depends on mobility.

ABSTRAK

Di dalam sistem LTE, keperluan untuk menyokong kelajuan data bagi pengguna mudah alih yang laju adalah salah satu kunci. Walau bagaimanapun, perubahan saluran dalam senario ubah alih yang berbeza adalah satu cabaran besar untuk mencapai matlamat ini. Anggaran saluran yang diperlukan di bahagian penerima untuk memenuhi kebutuhan yang baik dengan perubahan saluran. Dalam tesis sarjana ini, saya memakai penganggar yang berbeza untuk menganggarkan saluran pada sistem LTE pautan turun dengan senario yang berbeza. Penggunaan penganggar pudar Blok LS pada mobiliti yang rendah di mana saluran adalah statistik dalam satu subframe. Apabila kelajuan pengguna lebih daripada 20 km/j anggaran LS blok merendahkan prestasi MSE dan pemprosesan. Performa cepat pudar LS melebihi blok pudar LS pada kelajuan lebih daripada 25 km/j. Anggaran LS hanya boleh dilaksanakan dengan kerumitan pengiraan yang rendah, namun prestasi MSE tidak memuaskan pada mudah alih tinggi. LMMSE adalah kaedah optimum dalam mengurangkan anggaran saluran MSE dan prestasi pemprosesan. Walau bagaimanapun, algoritma mengandungi operasi matriks songsang dan lain-lain operasi yang kompleks yang menyebabkan kerumitan pengiraan yang tinggi. Kaedah ini menggabungkan tiga jenis saluran anggaran yang berbeza yang dipanggil Ralat Min Hibrid Linear Square (HLMSE). Penganggar yang dicadangkan adalah hibrid daripada Least Square (LS) dan penganggar blok untuk mudah alih yang rendah, penganggar LS cepat pudar untuk mudah alih sederhana dan minimum dan Linear Min Ralat Square (LMMSE) penganggar bagi mudah alih yang tinggi. Prestasi penganggar HLMSE berbanding LS dari segi kendalian dan Mean Square Error (MSE) melebihi performa LS dalam kedua-dua throughput dan MSE. Kerumitan HLMSE yang boleh dikawal oleh perubahan saluran, yang bergantung kepada pergerakan.

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LIST OF ABBREVIATIONS

3GPP	–	3rd Generation Partnership Project
ALMMSE	–	Approximate Linear Minimum Mean Square Error
BER	–	Bit Error Rate
CQI	–	Channel Quality Indicator
CSI	–	Channel State Information
CDD	–	Cyclic Delay Diversity
CP	–	Cyclic Prefix
DwPTS	–	Downlink Pilot Timeslot
E-UTRAN	–	Evolved Universal Terrestrial Radio Access Network
FFT	–	Fast Fourier Transform
FDD	–	Frequency-Division Duplexing
GDD	–	Generalized Delay Diversity
GP	–	Guard Period
HSPA	–	High Speed Packet Access
HSDPA	–	High Speed Downlink Packet Access
H-ARR	–	Hybrid Automated Repeat Request
HLMSE	–	Hybrid Linear Mean Square Error
ICI	–	Inter Carrier Interference
IP	–	Internet Protocol
ISI	–	Inter Symbol Interference
ITU	–	International Telecommunication Union
ITUVehA	–	International Telecommunication Union Vehicular A
LS	–	Least Square
LMMSE	–	Linear Minimum Mean Square Error

LTE	–	Long Term Evolution
LTE-A	–	Long Term Evolution-Advanced
MATLAB	–	Matrix Laboratory
MLE	–	Maximum Likelihood Estimator
MSE	–	Mean Square Error
MIMO	–	Multiple Input Multiple Output
MISO	–	Multiple-Input Signal-Output
OFDM	–	Orthogonal Frequency Division Multiplexing
OFDMA	–	Orthogonal Frequency Division Multiple Access
PHY	–	Physical
QAM	–	Quadrature Amplitude Modulation
QOS	–	Quality Of Service
RAN	–	Radio Access Network
RB	–	Resource Block
RE	–	Resource Element
SNR	–	Signal to Noise Ratio
SC-FDMA	–	Single Carrie Frequency Division Multiple Access
SIMO	–	Single Input Multiple Output
SISO	–	Single Input Single Output
SDMA	–	Space-Division Multiple Access
SFBC	–	Space Frequency Block Coding
STC	–	Space Time Coding
STBC	–	Space Time Block Coding
SSD	–	Soft Sphere Decoder
SU-MIMO	–	Single-User Multiple Input Multiple Output
TTI	–	Transmission Time Interval
TDD	–	Time-Division Duplexing
TD-SCDMA	–	Time Division Synchronous Code Division Multiple Access
UE	–	User Equipment
UMPCs	–	Ultra-Mobile PCs
UMTS	–	Universal Mobile Telecommunication System
UpPTS	–	Uplink Pilot Timeslot

UTRAN	–	UMTS Terrestrial Radio Access Network
WCDMA	–	Wideband Code Division Multiple Access
WLAN	–	Wireless Local Area Network

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CHAPTER 1

INTRODUCTION

1.1 Background

Long Term Evolution (LTE) was standardized by 3GPP to improve the UMTS mobile phone standard to cope with future requirements. The LTE project is not a standard, but it will result in the new evolved release 8 of the UMTS standard, including wholly extensions and modifications of the UMTS system. LTE can provide up to 300 Mbps peak data rate for downlink(4 x 4MIMO) and 75 Mbps for uplink, the latency for radio-network is less than 10 ms [1]. The spectrum efficiency is a significant compared to 3rd generation (3G) systems. LTE provides extensive supports both frequency-division duplex (FDD) and time-division duplex (TDD) , support for spectrum flexibility and targets a smooth evolution from earlier 3GPP system such as Time Division Synchronous Code Division Multiple Access (TD-SCDMA) and High Speed Packet Access (HSPA) as well as 3rd Generation Partnership Project 2 systems such as cdma2000 [1]. The LTE downlink transmission scheme is based on Orthogonal Frequency Division Multiple Access (OFDMA) which converts the wide-band frequency selective channel into a set of many flat fading subchannels. The significant benefits for users and operators in LTE , including the following [2]:

- Performance and capacity With LTE built to provide downlink peak rates of at least 100Mbps and allowance for speeds of more than 300 Mbps as well as Radio access network (RAN) round-trip times of less than 10 ms, LTE meets key 4G requirements compared to other comparable technologies.
- Simplicity Flexible carrier bandwidths ranging from 1.4 MHz up to 20 MHz as well as LTE support time division duplexing (TDD) and frequency division duplexing (FDD). 3GPP has already identified fifteen paired and eight unpaired

spectrum bands for LTE and with many more to come, operators will be able to introduce LTE in new bands where it is easiest to deploy 10 MHz or 20 MHz carriers and eventually deploy LTE in all bands. Features such as self-configuration and self-optimization will simplify and reduce the cost of network roll-out and management, hence simplifying the building and management of next generation LTE radio networks in the future. These will be deployed in parallel with simplified, IP-based core and transport networks that are easier to build, maintain and incorporate new services.

- Terminals Wide range LTE modules can be embedded into devices like mobile phones, computers and other consumer electronic devices, such as ultra-portables, notebooks, gaming devices and cameras. These devices can have universal coverage from the onset as a result of LTE supporting handover and roaming to existing mobile networks.

1.2 Problem Statement

The channel estimation in OFDM systems is generally based on the use of pilot subcarriers in given positions of the frequency-time grid. The estimators are compared in terms of the throughput, that allows to observe influence of an estimator on the complete system. Although the Mean Square Error (MSE) shows directly the performance of an estimator, it is not clear if the decrease of MSE, will also increase the throughput. The problem here is that the subcarriers are not perfectly orthogonal to each other so we need the channel estimators for rapidly changing channels.

1.3 Objectives and Scope

The objectives of this research are:

1. To estimate the channel for LTE system downlink .
2. To minimize the mean squared error (MSE) using different channel estimation algorithms.

3. To investigate the LS and LMMSE estimation effect for the specific model on the Throghput and MSE performance.
4. To get the optimal estimator with low complexity and good performance.

The main objective of this study is to provide very good estimation and compare the performance with LS and LMMSE estimators.
The scope of this research includes:

- Literature review for LTE .
- Architecture of LTE,system model and current progress on channel estimation for LTE downlink.
- Study link level simulation for LTE from channel estimation view.
- The simulation tool which will be used is Matrix Laboratory(MATLAB) based on the Vienna LTE simulators.

1.4 Structure of the Report

The rest of this report is organized as follows. Chapter 2 offers a detailed background about LTE Air Interface features describing LTE down link frame structure ,overview for OFDM,the transmission techniques used in LTE and the related work for LTE downlink channel estimation Research methodology is explained in Chapter 3 which illustrates the map used to carry out this study from beginning untill end. The physical model of the system and system model are discussed, a description of channel estimation used is provided, At the end, the methodology to extract results is also described. Chapter 4 presents results and discussion ,it presents the results from simulation of each of the following algorithms: Least Squares Channel Estimation(LS) for block and fast fading, LMMSE Channel Estimation , Approximate LMMSE Channel Estimation and Proposed estimator. A thorough discussion on these results is also presented to analyze and evaluate the performance in each algorithms. Chapter 5 concludes the the study and points out potential future directions for this work.

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