Cairo University

SCATTERED SEARCH SPACE DESIGN FOR CONTROL CHANNELS IN LTE AND LTE-ADVANCED

By

Fady Nabil Alfonse

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

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Key Words:
LTE; LTE-Advanced; PDCCH; EPDCCH; Search Space; Blind Decoding; CCE index.

Summary:

As the world grows in technology, demand of higher data rates increases. LTE and LTE-Advanced systems offer high data rates with low latencies. Some technologies used in LTE and LTE-Advanced systems depend on the performance of the control channels PDCCH and enhanced PDCCH. One of the main operations in the control channels is the search space allocation scheme, in which the UE performs blind decoding to search for control information intended for it. The work and study done in this thesis targets the development of the standard search space allocation scheme into a more scattered design to decrease the blocking probability of all UEs in the cell; and hence allows for more enhancement and developments in the data rates.
The proposed scattered search space design of the allocation scheme offered better performance than the standard search space design and other schemes proposed in various research papers.

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I would like to thank all employees in Axxcelera Egypt for their cooperation which helped to build up my experience enabling me to choose and develop my research point.

Finally, I would like to thank the committee of the 7th International Congress on Ultra Modern Telecommunications and Control (ICUMT) for giving me the opportunity to present and publish a conference paper containing the main idea of this thesis.

Dedication

I would like to dedicate this thesis to the communication society in Egypt. And I encourage anyone who is interested to contact me for any further information if needed related to this topic; and I will help as far as I can.

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Nomenclature

AL	Aggregation Level
CA	Carrier Aggregation
CAPEX	Capital Expenditure
CCE	Control Channel Element
CFI	Control Format Indicator
CoMP	Coordinated Multipoint
CP	Cyclic Prefix
CSI-RS	Channel State Information Reference Signals
CSRS	Cell Specific Reference Signals
DCI	Downlink Control Information
DL	Downlink
DMRS	Demodulation Reference Signals
DPS	Dynamic transmission Point Selection
ECCE	Enhanced Control Channel Element
eNB	evolved Node B
EREG	Enhanced Resource Element Group
EPDCCH	Enhanced Physical Downlink Control Channel
FDD	Frequency Division Duplexing
GERAN	GSM/EDGE Radio Access Network
GW	Gateway
HARQ	Hybrid Automatic Repeat Request
ICIC	Inter-cell Interference Coordination
LTE	Long Term Evolution
LTE-A	Long Term Evolution Advanced
MAC	Medium Access Control
MIMO	Multiple Input Multiple Output
MME	Mobility Management Entity
MU-MIMO	Multi-User Multiple Input Multiple Output
OFDMA	Orthogonal Frequency Division Multiple Access
OPEX	Operating Expenses
PCFICH	Physical Control Format Indicator Channel
PCI	Physical Cell ID
PDCCH	Physical Downlink Control Channel
PDCP	Packet Data Convergence Protocol
PDSCH	Physical Downlink Shared Channel
PHICH	Physical HARQ Indicator Channel
PHY	Physical Layer
PRACH	Physical Random Access Channel
PSS	Primary Synchronization Signals
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
RAN	Radio Access Network
RE	Resource Element
REG	Resource Element Group
RF	Radio Frequency
RLC	Radio Link Control

RNTI	Radio Network Temporary Identifier
RRC	Radio Resource Control
RRH	Remote Radio Head
SC-FDMA	Single Carrier Frequency Division Multiple Access
SSS	Secondary Synchronization Signals
TDD	Time Division Duplexing
TP	Transmission Point
UERS	UE-Specific Reference Signals
UL	Uplink
UTRAN	UMTS/HSPA Terrestrial Radio Access Network
3G	3rd Generation
3GPP	3rd Generation Partnership Project
4G	4th Generation

Abstract

As the world grows in technology, demand of higher data rates increases. LTE and LTE-Advanced systems offer high data rates with low latencies. Some technologies used in LTE and LTE-Advanced systems depend on the performance of the control channels PDCCH and enhanced PDCCH. One of the main operations in the control channels is the search space allocation scheme, in which the UE performs blind decoding to search for control information intended for it. The work and study done in this thesis targets the development of the standard search space allocation scheme into a more scattered design to decrease the blocking probability of all UEs in the cell; and hence allows for more enhancement and developments in the data rates.

The proposed scattered search space design of the allocation scheme offered better performance than the standard search space design and other schemes proposed in various research papers.

Chapter 1 : Introduction

There have been great improvements in the industry of wireless communication systems. The need started with voice communication, followed by text messages, and then focus started to shift to data services. Data and Internet services in wireless communication systems started with the 3rd generation (3G) networks, then the demand for higher bitrates and mobility support led to the 4th generation (4G) networks known as Long Term Evolution (LTE). LTE offered many features such as higher bitrates, higher capacities, wide coverage, mobility support and many other services. LTE is used nowadays in many countries all around the world. Then as the need for more services and functionalities increased, more updates were added to LTE standards to come up with LTE-Advanced. LTE-Advanced is not just an upgrade to LTE; it also supports many other important features that emerged during its development. The implementation of the new services and features required higher system performance across the layers of LTE-Advanced system.

1.1. LTE and LTE-Advanced Physical Layer

In order to support the features offered by LTE-Advanced, the functions of the physical layer (PHY) are required to support higher capacities, users and bitrates. PHY is responsible for the reliable transfer of data and information between the base station named evolved Node-B (eNB) and the User Equipment (UE) through the air interface, Downlink (DL) from eNB to UE and Uplink (UL) from UE to eNB. It relies on many channels that carry different types of information to be exchanged between eNB and UE. The channel carrying the data, called the Physical Downlink Shared Channel (PDSCH), and the channel carrying the essential control information, called Physical Downlink Control Channel (PDCCH) are the main DL channels. The LTE standard used PDSCH and PDCCH, but due to the need for more services enhanced PDCCH (EPDCCH) was introduced in LTE-Advanced standard.

1.2. The Thesis Proposal

This thesis proposes a new scattered design for the search space allocation scheme that can be used in LTE and LTE-Advanced to improve the performance of the control channels PDDCH and EPDCCH. Simulations were conducted to measure the performance of the proposed scattered design with respect to the performance of the standard search space scheme design using some metrics such as the blocking probability of UEs in various conditions.

The proposed scattered design is proved to have better performance than the standard search space allocation scheme.