PERFORMANCE EVALUATION OF OFDM AND MC-CDMA BASED COGNITIVE RADIO SYSTEM

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To

To my beloved mother and father,

To

To my brothers and sisters.

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In The Name Of ALLAH, The Most Beneficent, The Most Merciful

All praise is due only to ALLAH, the lord of the worlds. Ultimately, Only ALLAH has given us the strength and courage to proceed with our entire life. His works are truly splendid and wholesome, and his knowledge is truly complete with due perfection.

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ABSTRACT

The present development of high data rate wireless applications has lead to extra bandwidth demand. However, finding a new spectrum bandwidth to accommodate these applications and services is a challenging task due to lack of spectrum resources. In fact, recent studies have shown that the spectrum are utilized inefficiently especially for conventional spectrum allocation. Therefore, in order to enhance spectrum efficiency, Federal Communications Commission (FCC) has proposed dynamic spectrum access (DSA) mechanism, where unlicensed users can opportunistically borrow unused spectrum from licensed owners. The radio that enables this concept is called Cognitive Radio (CR). Nevertheless, it is difficult for single transmission to get a large contiguous frequency spectrum block in DSA and this have significant impact on broadband and multi-carrier transmission systems such as Orthogonal Frequency Division Multiplexing (OFDM) and Multi-carrier Code Division Multiple Access (MC-CDMA). This thesis investigates on non-contiguous OFDM (NC-OFDM) and non-contiguous MC-CDMA (NC-MC-CDMA) system. The implementation of NC-OFDM and NC-MC-CDMA systems provide high data rate via large number of non-contiguous sub-carriers without interfering to the existing transmissions by turning off the sub-carriers corresponding to these spectrum bands. This thesis evaluates Bit Error Rate (BER) performance of NC-OFDM and NC-MC-CDMA on mobile scenario where each propagation path will experience an apparent shift in frequency due to the relative motion between the transmitter and receiver while the number null sub-carriers is constant for all.

ABSTRAK

Pembangunan aplikasi tanpa wayar untuk data berkelajuan tinggi telah membawa kepada permintaan kepada tambahan jalur lebar. Walau bagaimanapun, untuk mendapat jalur spektrum bagi untuk menampung aplikasi dan perkhidmatan ini adalah satu tugas yang mencabar kerana kekurangan sumber spektrum. Malah, kajian terkini telah menunjukkan penggunaan spektrum yang tidak cekap terutama pada peruntukan spektrum konvensional. Oleh itu, untuk meningkatkan kecekapan penggunaan spektrum, FCC telah mencadangkan satu mekanisma untuk mengakses spektrum secara dinamik (DSA), di mana pengguna yang tidak berlesen boleh meminjam spektrum yang tidak digunakan oleh pemilik spektrum berlesen tersebut secara oportunistik. Sistem radio yang memperkenalkan konsep ini dikenali sebagai Radio Kognitif (CR). Walau bagaimanapun, ia adalah sukar untuk sistem penghantaran tunggal untuk mendapatkan blok spektrum frekuensi yang besar melalui DSA dan ini mempunyai kesan yang ketara ke atas sistem jalur lebar serta penghantaran berbilang pembawa seperti pemultipleksan pembahagian frekuensi ortogon (OFDM) dan berbilang pembawa pembahagian kod pelbagai masukan (MC-CDMA). Tesis ini mengkaji OFDM tidak rapat (NC-OFDM) dan MC-CDMA tidak rapat (NC-MC-CDMA). Pelaksanaan NC-OFDM dan sistem NC-MC-CDMA menyediakan kadar data yang tinggi melalui sebilangan besar sub-pembawa tidak rapat tanpa mengganggu kepada penghantaran sedia ada dengan mematikan sub-pembawa yang sama dengan jalur spektrum ini. Tesis ini menilai prestasi kadar bit ralat (BER) NC-OFDM dan NC-MC-CDMA dalam senario bergerak bebas di mana setiap laluan perambatan mengalami perubahan ketara dalam frekuensi disebabkan oleh gerakan relatif antara penghantar dan penerima, serta jumlah subpembawa batal adalah malar.

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LIST OF ABBREVIATIONS

AWGN	-	Additive White Gaussian Noise
BER	-	Bit Error Rate
CDMA	-	Code Division Multiple Access
CP	-	Cyclic Prefix
CR	-	Cognitive Radio
D/A	-	Digital-to-Analog
DSA	-	Dynamic Spectrum Access
DFT	-	Discrete Fourier Transform
FCC	-	Federal Communications Commission
FFT	-	Fast Fourier Transform
HPA	-	High Power Amplifier
ICI	-	Inter-Carrier Interference
IDFT	-	Inverse Discrete Fourier Transform
IFFT	-	Inverse Fast Fourier Transform
ISI	-	Inter-Symbol Interference
MC-CDMA	-	Multi-Carrier Code Division Multiplexing
MCM	-	Multi-Carrier Modulation
NC-MC-CDMA	-	Non-Contiguous Multi-Carrier Code Division Multiplexing
NC-OFDM	-	Non-Contiguous Orthogonal Frequency Division Multiplexing
OFDM	-	Orthogonal Frequency Division Multiplexing
P/S	-	Parallel-to-Serial
PA	-	Power Amplifier
PAPR	-	Peak-to-Average Power Ratio
PSK	-	Phase Shift Keying
QAM	-	Quadrature Amplitude Modulation

QPSK	-	Quadrature Phase Shift Keying
RCC	-	Radio Control Channel
RF	-	Radio Frequency
S/P	-	Serial-to-Parallel
SDR	-	Software Defined Radio
SNR	-	Signal-to-Noise Ratio
UWB	-	Ultra Wide Band

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Due to the advancement of new wireless applications, as well as development of existing wireless services, demand for extra bandwidth has been on rise [1,10]. As a result, the possibility of spectrum scarcity becomes more of a reality. In other words, emerging technologies and with the ever increasing number of wireless devices,the radio spectrum scarcity is increased every day [19].

There is a spectrum allocation called Command-and-Control came to prevent unlicensed access to access the spectrum, it is defined by government regulatory agencies. Measurements studies indicated that big part of the spectrum is in a rare use while some parts are in a heavy use most of the time and frequency [2,3].

Federal Communications Commission (FCC) is working on the unlicensed users to borrow spectrum from incumbent license users, this can be done by concept knows as Dynamic Spectrum Access (DSA). Wireless communication should be agile to perform dynamic spectrum access such that spectrum efficiency can be improved while no interference occurred with neighbored user

transmissions. To exploit frequency and time gaps which are not occupied by license holders, such a communication technique called Cognitive Radio. It can be defined as a smart wireless system that is aware of its surrounding environment through sensing and measurements [4, 5].

The common digital communication techniques of multi-carrier transmission such as Orthogonal Frequency Division Multiplexing (OFDM) and Code Division Multiplexing Access (MC-CDMA) are the most widely used technologies in current wireless communications systems. Theses techniques have the potential of fulfilling the requirements of cognitive radios inherently or with minor changes [15]. They provided an interest over other transmission technologies such as good spectrum efficiency, fading channel robustness, prevention of impulse interference, dealing with fading paths and frequency selective fading without channel equalization [20]. In addition, they have ability to turn off the sub-carriers which probably are close to the spectrum occupied by the incumbent users as to not allow any interference to current transmissions, enhance the spectrum efficiency by enabling second usage of the unused parts of the spectrum and addressing the issues of spectrum scarcity as well [19].

1.2 Statement of Problem

The problem behind this work is spectrum bandwidth shortage to send high data rate communication. It is very difficult to gain access to a large continuous block of frequency spectrum that is the limitation for high data rate transmission in mobile radio environment.

1.3 Objectives of the Study

The objectives of this study are:

1. To improve the spectrum efficiency in wireless communication.
2. To develop non-contiguous OFDM system and non-contiguous MC-CDMA system for supporting high data rate communication.
3. To evaluate the performance of NC-OFDM and NC-MC-CDMA in mobile radio environment.

1.4 Scope of the Study

The scope of the study in this project are:

- Conceptual Study
  Understand the concept of cognitive radio, OFDM and MC-CDMA. DSA model is shared using Overlay Spectrum sharing Approach with non-contiguous.
- Development and Analysis
  Develop OFDM and MC-CDMA based cognitive radio on dynamic spectrum access. Performance analysis of this project will consider performance evaluation such as Signal-Noise Ratio (SNR) and (BER) with doppler shift.
- Simulation
  The simulation tool used is Matlab.

1.5 Thesis Organization

This thesis is organized as follows:

In Chapter 2, a brief introduction to cognitive radio concept and basic principles of OFDM and MC-CDMA are presented. This chapter also overview of DSA techniques such as underlay and overlay approach to improve spectrum utilization efficiency and scarcity issue. Moreover, basic introduction to the non-contiguous transmission and channel models are also included.

In Chapter 3, methodology of OFDM and MC-CDMA implementation based on cognitive radio are discussed.

In Chapter 4, BER performance of NC-OFDM and NC-MC-CDMA is evaluated and viability of NC-OFDM and NC-MC-CDMA techniques for DSA with doppler shift.

In Chapter 5, the project final conclusions are outlined and future work directions are presented.

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