ENERGY DETECTION METHOD IN COGNITIVE RADIO

NORAIRIN BTE MAHMAT SANI

This Report Is Submitted In Partial Fulfillment Of Requirements For The Bachelor Degree Of Electronic Engineering (Wireless Communication)

Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka

June 2013

© Universiti Teknikal Malaysia Melaka

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Energy Detection Method In Cognitive Radio

Sesi Pengajian : 1 2 / 1 3

Saya NORAIRIN BTE MAHMAT SANI

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD****	**(*Mengandungi maklumat terhad yang telah ditentukan oleh* organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)
MAS HASLINDA BT MOHAMAD
Pensyarah
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya, 76100 Durian Tunggal,
Melaka

Tarikh: 11/6/2013

Tarikh: 11/06/2013

© Universiti Teknikal Malaysia Melaka

"I hereby declare that this report is the result of my own work except for quote as cited in the references."

Signature : .....

Author : Norairin bte Mahmat Sani

Date : 11/6/2013

© Universiti Teknikal Malaysia Melaka

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Wireless Communication) With Honours."

Signature :.....

Supervisor's Name : Pn Mas Haslinda binti Mohamad

Date :11 JUN 2013

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

Foremost, all praise to ALLAH for entire incredible gift endowed upon me and for giving me the health and strength to complete this 'Projek Sarjana Muda'.

First of all, I would like to give a million thanks and appreciation to my supervisor, Pn Mas Haslinda binti Mohamad for her advice, criticism and also her guidance in order to complete my project. Besides, she also provided good ideas and opinions on my project. The final project year has given me some experience that I can use for the future.

Thus, I would like to dedicate my appreciation and special thanks to my parents and my friends, that give me full support and encouraged for me throughout to complete my final project year. Without them, I would not be able to complete my final project year.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

Currently, the internet is widely used among users to communicate with each other. Mobile lifestyle and a variety of devices now require multi-band and multi-platform technology be it through wired or wireless. Due to the enhancement system, the use of the internet to become a priority for users from communicating wherever they are, because of the increasing number of users from time to time. This situation has resulted in increasing demand for spectrum and frequency bands become much more crowded. Therefore, the available spectrum is unable to meet the growing needs of consumers. One way to overcome this problem is cognitive radio, which includes several techniques of cognitive radio spectrum detector. Energy detector is one of the spectrum detector techniques that were used. The objective of this project is to produce a BPSK modulation as input to the energy detector to detect the empty spectrum. Through energy detector, the probability of detection (P_d), the probability of missed detection (P_m), and the thresholds were obtained. The results shown that the detection probability (P_d), and the number of channels present that are available were obtained. Besides, the BPSK signal can be generated by using MATLAB software. Through BPSK signal as input signal, the detector energy spectrum can be generated to detect the present channel that are available, where P_d and P_m were obtained. The analysis shown that when the number of samples, N = 8, nearly 44.5% of the channels were fully occupied by primary users. However, this percentage was decreased when the number of samples, N equal to 16 and 32. As the conclusions, the objectives of this project were achieved, where the energy detection capable to detect the present channel with random binary of BPSK modulation.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Pada masa ini, internet digunakan secara meluas di kalangan pengguna untuk berkomunikasi dengan satu sama lain. Gaya hidup mudah alih dan pelbagai peranti kini memerlukan pelbagai jalur dan teknologi pelbagai platform sama ada melalui wayar atau tanpa wayar. Oleh kerana sistem peningkatan, penggunaan internet untuk menjadi keutamaan bagi pengguna untuk berkomunikasi di mana mereka berada, kerana peningkatan jumlah pengguna dari semasa ke semasa. Keadaan ini telah menyebabkan peningkatan permintaan bagi spektrum dan jalur frekuensi menjadi lebih sesak. Oleh itu, spektrum yang sedia ada tidak dapat memenuhi keperluan yang semakin meningkat pengguna. Salah satu cara untuk mengatasi masalah ini adalah radio kognitif, yang merangkumi beberapa teknik kognitif radio pengesan spektrum. Pengesan Tenaga adalah salah satu teknik pengesan spektrum yang digunakan. Objektif projek ini adalah untuk menghasilkan modulasi BPSK sebagai input kepada pengesan tenaga untuk mengesan spektrum kosong. Melalui pengesan tenaga, kebarangkalian pengesanan (P_d), kebarangkalian pengesanan terlepas (P_m), dan ambang diperolehi. Keputusan menunjukkan bahawa kebarangkalian pengesanan (P_d), dan bilangan saluran sekarang yang terdapat diperolehi. Selain itu, isyarat BPSK boleh dijana dengan menggunakan perisian MATLAB. Melalui BPSK isyarat sebagai isyarat input, spektrum tenaga pengesan boleh dihasilkan untuk mengesan saluran ini yang boleh didapati, di mana P_d dan P_d diperolehi. Analisis ini menunjukkan bahawa apabila bilangan sampel, N = 8, hampir 44.5% daripada saluran diduduki sepenuhnya oleh pengguna utama. Walau bagaimanapun, peratusan ini telah berkurangan apabila bilangan sampel, N bersamaan dengan 16 dan 32. Sebagai kesimpulan, objektif projek ini telah dicapai, di mana pengesanan tenaga mampu untuk mengesan saluran ini dengan binari rawak BPSK modulasi.

© Universiti Teknikal Malaysia Melaka

CONTENTS

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

This chapter covers about the project background mainly to synopsis of the project, objective and scope project, and problem statement.

1.1 Project Background

At present, the internet is widely used among users to communicate with each other. Moreover to the first communication system is limited by wire have now changed by introducing the wireless communication systems. Mobile and multi-device lifestyle currently requires multi-band and multi-platform wireless technology, which should be simplified or future-enhanced with software-defined wireless technology. Due to the enhancement system, the use of the internet to be the priority for users to communicate wherever they are, because of the increasing number of users from time to time.

© Universiti Teknikal Malaysia Melaka

This situation has resulted in increasing demand for spectrum and frequency bands become much more crowded, especially in densely populated urban centers. Various solutions have been made to overcome this situation. Among these is the sharing of spectrum, spectrum licensing for large companies and so on. Although a variety of possible solutions but still not able to overcome this problem. This situation has led to other solutions of cognitive radio technology. Cognitive radio are not the best solutions, but this is the other way to solved the situation.

What is cognitive radio? Cognitive radio is a network technology that automatically able to find and detected a vacant radio frequency. The cognitive radio has a capability using real time sensing of the radio environment, spectrum holes or white spaces that were unused at a specific time or location can be determined. By allowing secondary networks to share the spectrum with the primary networks, cognitive radio is expected to greatly improve the spectrum utilization.

One of the main functions of cognitive radio is spectrum sensing, where used transmitter detection to detect the unused spectrum. Transmitter detection consists of spectrum sensing. Spectrum sensing required by detecting unused spectrum and sharing it without harmful interference to other users. There are three spectrums sensing techniques that can be used in transmitter detection, such as energy detector, matched filter, and cyclostationary.

This project will introduce one of cognitive radio technology, which is an energy detector to solve spectrum scarcity. The energy detector will detect the unlicensed spectrum that can be used for the user with low SNR and high accuracy. For this project, BPSK signal was used to represent the spectrum sensing that should be able to detect the spectrum holes.

© Universiti Teknikal Malaysia Melaka

1.2 Problem Statement

Nowadays, the demand for wireless spectrum increased as the number of users who use wireless devices in communication systems increased. The current policies of spectrum block result in inefficiency of spectrum usage. In some block, the spectra are saturated, whereas other bands are underused. The improvement will need a flexible yet regulated use of spectrum band.

The spectrum becomes limited because of the lack of frequency resource in the VHF and UHF spectrum bands, where many users use the spectrum at the same time. Due to the increasing demand, therefore the existing spectrum is unable to meet the needs of users. To overcome this problem, one techniques are required, so that it can be used to sense or identify the unlicensed spectrum. Cognitive radio is a better ways to overcome this problem.

1.3 Project Objectives

The objectives of this project are:

(i) To study spectrum sensing techniques in cognitive radio.
(ii) To generate a BPSK signal by using MATLAB software.
(iii) To develop spectrum sensing algorithm using energy detector techniques by using MATLAB software.
(iv) To analyze the energy detector algorithm implemented.

© Universiti Teknikal Malaysia Melaka

1.4 Project Scopes

For every design that is being done, it has to have limitations. This is to ensure the scope of study is not too wide. The work in the project is limited to the following elements:

(i) This project only focuses on MATLAB software which is used to make simulation and analyze the result.
(ii) Generate BPSK modulation waveform that will act as the input data for spectrum sensing.
(iii) Concentrated on spectrum sensing techniques which is energy detector.
(iv) Develop an energy detector algorithm to detect a spectrum hole.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

This chapter contains the literature review theoretical concept that applied in this project. It contains the information gathering of the project in order to complete the whole project. The main source is Cognitive Radio book and other sources are related journal.

2.1 Cognitive Radio

Cognitive radio is one of the new long term developments taking place and radio receiver and radio communications technology. According to the Federal Communications Commission (FCC), there are a lot of available spectrum bands temporarily and geographically even though they are allocated to the primary user [1]. It is indicated that scarcity of spectrum resources is not due to a fundamental lack of spectrum resources, but to inefficient spectrum allocation.

© Universiti Teknikal Malaysia Melaka

Cognitive radio is a radio which can sense its environment and has the capability to adapt some of its features, such as carrier frequency, modulation, and transmission bandwidth and transmission power allowing dynamic reuse of the available spectrum [2]. With the rapid deployment of various wireless systems, the limited radio spectrum is becoming increasingly crowded. On the other hand, it is evident that most of the allocated spectrum experience low utilization.

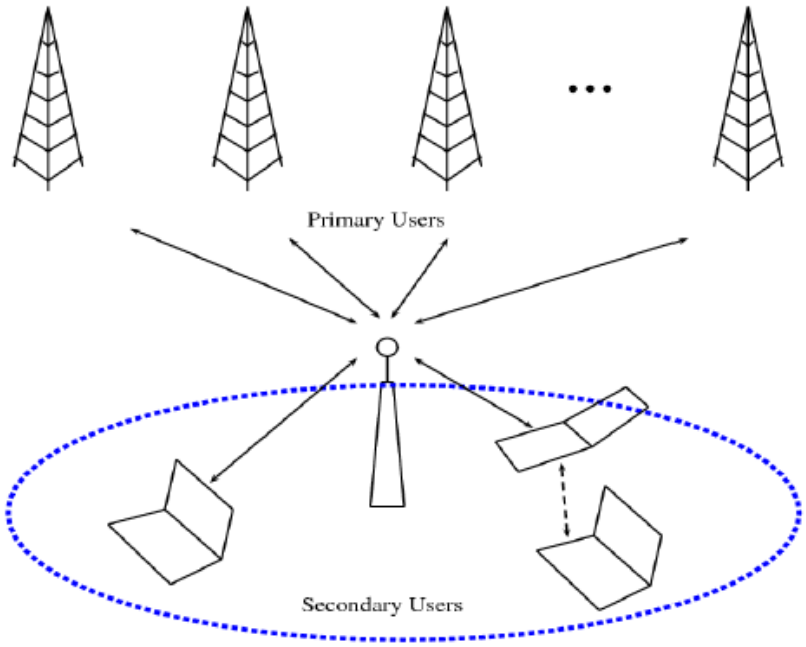

Figure 2.1: Primary Users and Secondary Users.

In wireless communication systems, cognitive radio consists of two categories. The two categories are the primary user (PU) and secondary user (SU) [6]. Based on the Figure 2.1, show that the primary user and the secondary user. The primary users are the licensed users where the users will be given the priority to use the frequency. While a secondary user is unlicensed users, where compare to the primary user, secondary user are not given the priority to use the frequency.

The primary users are the owners of the licensed spectrum. Cognitive radio is the secondary users of the spectrum allocated for the primary users, whereas enable spectrum admission and allocating by the secondary system. Cognitive radio will permit secondary networks to use new wireless spectrum from primary licensed network or to allocate the spectrum alongside the main networks. In this situation,

© Universiti Teknikal Malaysia Melaka

the cognitive radio (CR) technology can be an enhancement of the efficiency of spectrum allocations by adopting dynamic spectrum resource management [12].

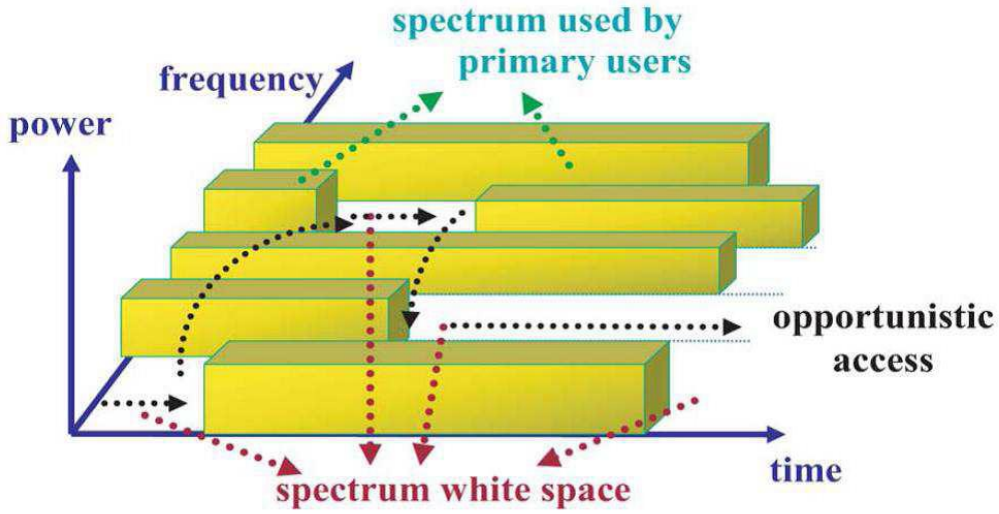

Figure 2.2: Spectrum Structure of The Cognitive Radio [3].

Several main functions of cognitive radio, which consists spectrum sensing, power control, and spectrum management [1]. Spectrum sensing is an important requirement of the cognitive radio network in order to sense or detect empty spectrum. Spectrum sensing detects the presence of signals in the frequency spectrum.

There are three categories of spectrum sensing techniques, that is transmitter detection, cooperative detection, and interference based sensing [1]. Transmitter detection is a capability of cognitive radio to determine the present signal from the primary transmitter in certain spectrum. Transmitter detection consists of three types, matched filter detection, energy detection, and cyclostationary detection.

© Universiti Teknikal Malaysia Melaka

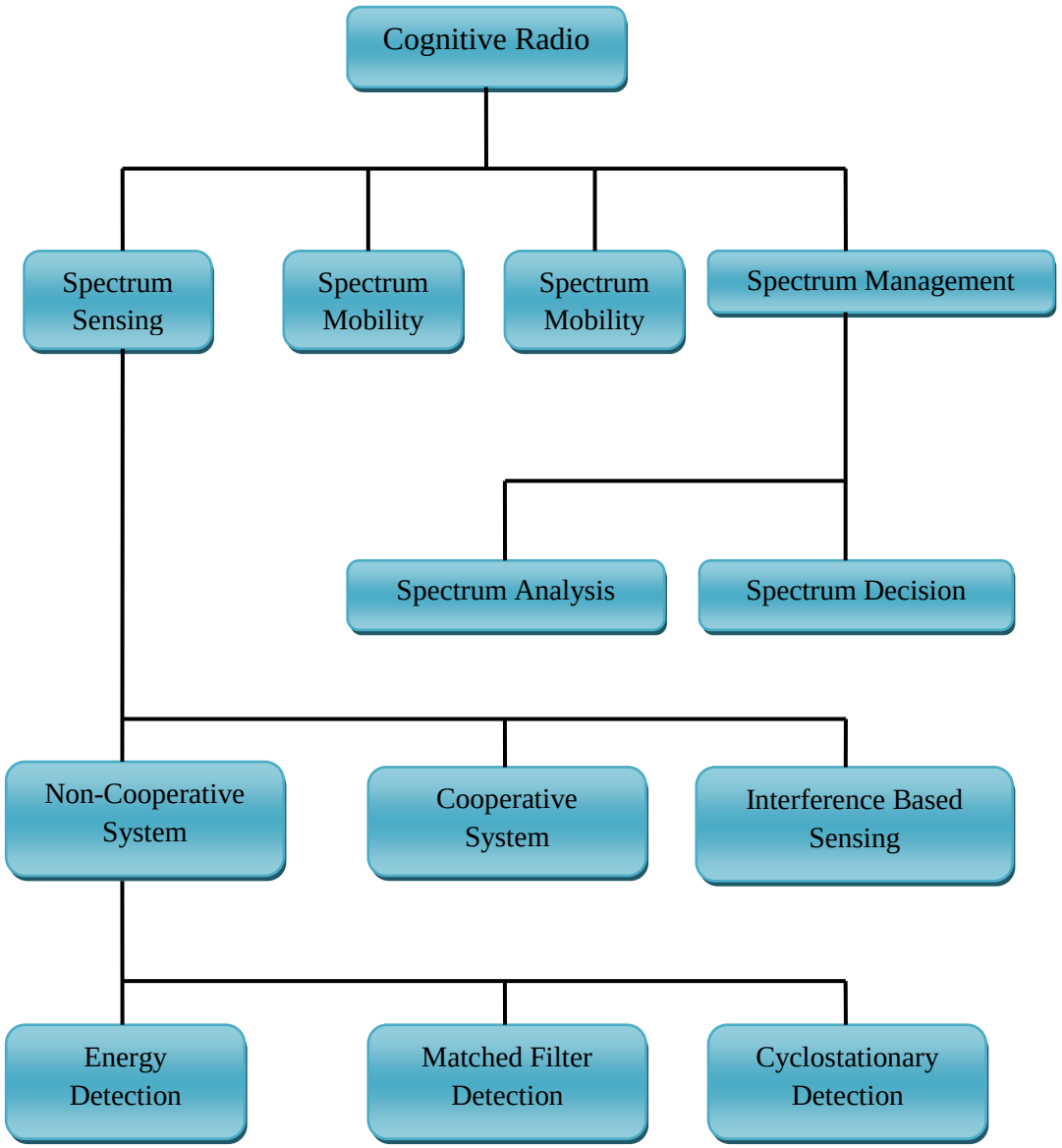

Figure 2.3: Main Functions of Cognitive Radio.

© Universiti Teknikal Malaysia Melaka

In spectrum sensing, there are some issues and challenges that need to be considered in spectrum sensing, in order to make spectrum sensing in cognitive radio as a better solution to overcome the problems of lack of frequencies. Among these are noise uncertainty, channel uncertainty, and detecting interference limit [2].

In wireless communications networks, the problem of channel uncertainty arises where there are some uncertainties at the received signal strength where caused by the channel disappearing (fading) or shadowing that maybe are wrong explained that the primary system is placed out of the secondary user's interference scope as the main primary signal, where could be experiencing a deep fade or being deeply shadowed by obstacles [4].

Therefore, cognitive radios have to be extra sensitive to discriminate a faded or shadowed main primary signal from a white space. Each uncertainty in the received power of the primary signal translates into a higher detection sensitivity requirement. Moreover, the possibility of a single cognitive radio that depends on the local sensing where the increased sensitivity is not possible to achieve. Therefore, cooperative sensing are required to handle these issues where needed to allocate locale measurements and select the occupancy state on a licensed band.

In the noise uncertainty, to find the accurate sense of primary signal will be determined with the minimum SNR as the following given:

$$\gamma_{min} = \frac{P_p L(D+R)}{N} \qquad (1)$$

Where,

N = Noise power,

P_p = Primary user of transmitting power,

D = Secondary user of interference range,

R = Maximum distance between primary transmitter and corresponding receiver.

Based on the equation in (1), the value of the noise power will obtained by the receiver. However, when the noise power estimation become limited, the temperature variations effect happens.

© Universiti Teknikal Malaysia Melaka