COOPERATIVE SPECTRUM SENSING FOR COGNITIVE RADIO

SURAYA BINTI KHALID

A project report submitted in partial fulfilment of
the requirements for the award of the degree of
Master of Engineering (Electronics & Telecommunications)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2016

Specially dedicated to my parents for their prayers and endless encouragement throughout this journey

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my thesis supervisor, Dr. Kamaludin Mohd Yusof, for his knowledge, willing encouragement, continuous guidance, and friendship. Without his continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to Universiti Teknologi Malaysia (UTM) Librarians for their assistance in supplying the relevant literatures. I thank my fellow postgraduate students who have selflessly supported and enabled the pursuit of this dream. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions.

Last but not least, I would like to thank my family members; my father Hj. Khalid Bin Harun, my mother Hjh. Zabadah Binti Adam and my siblings for supporting me spiritually and endlessly.

ABSTRACT

Cognitive Radio (CR) is a technology which improves the spectrum utilization which some frequency bands is unoccupied or temporary vacate by the users. It is designed to detect communication opportunities in wireless system and to be aware of and sensitive to the changes in its surroundings. However, hidden node has become one of the major problems in cognitive network. Thus, the spectrum sensing is designed to operate cooperatively. If a number of CRs from several locations are sensing the spectrum, they can share the information before making the decision to use the spectrum. This thesis proposes energy detection method on Centralized Cooperative Spectrum Sensing (CCSS) based for simulation and data measurement analysis by including Rayleigh fading channel and Additive White Gaussian Noise (AWGN) into the simulation. Results show cooperative spectrum sensing enhance the detection probability and improve the performance of spectrum sensing.

ABSTRAK

Radio Kognitif (CR) adalah teknologi yang meningkatkan penggunaan spektrum yang beberapa jalur frekuensi yang tidak diduduki atau sementara mengosongkan oleh pengguna. Ia direka untuk mengesan peluang komunikasi dalam sistem tanpa wayar dan untuk menyedari dan peka terhadap perubahan dalam kawasan sekitarnya. Walau bagaimanapun, nod tersembunyi telah menjadi salah satu masalah utama dalam rangkaian kognitif. Oleh itu, sensing spektrum direka bentuk untuk beroperasi secara kerjasama. Jika beberapa CR dari beberapa lokasi sedang mengesan spektrum, mereka boleh berkongsi maklumat sebelum membuat keputusan untuk menggunakan spektrum. Tesis ini mencadangkan kaedah pengesanan tenaga pada *Centralized Cooperative Spectrum Sensing (CCSS)* berdasarkan analisis simulasi dan data pengukuran dengan memasukkan *Rayleigh fading channel* dan *Additive White Gaussian Noise (AWGN)* ke dalam simulasi. Keputusan menunjukkan kerjasama spektrum sensing meningkatkan kebarangkalian pengesanan dan meningkatkan prestasi pengesanan spektrum.

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LIST OF ABBREVIATION

CR	-	Cognitive Radio
CCSS	-	Centralized Cooperative Spectrum Sensing
AWGN	-	Additive White Gaussian Noise
dB	-	Decibel
GHz	-	Gigahertz
SNR	-	Signal over Noise Ratio
MFD	-	Matched Filter Detector
ED	-	Energy Detection
CSFD	-	Cyclo-stationary Feature Detection
PU	-	Primary User
FC	-	Fusion Centre
USRP	-	Universal Serial Radio Peripheral

LIST OF SYMBOLS

T	-	Detection dependent test statistic
γ	-	predefined threshold
ρ	-	SNR
σ^2	-	thermal noise power
$\|\| \|\|_F$	-	the Frobenius norm
λ_1	-	Eigenvalue

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CHAPTER 1

INTRODUCTION

1.1 Background

Wireless spectrum is one of the important resources required for radio communications. Since spectrum utilization is controlled all over the world, so crucial services can be provided and protected from interference. As technology keeps improving, wireless application and services are expanding, and spectrum allocation is limited. With the high demand from users, the spectrums are becoming overcrowded and facing interferences.

Cognitive Radio (CR) is a technology which improves the spectrum utilization which some frequency bands is unoccupied or temporary vacate by the users. The CR technology enables secondary (unlicensed) user to access unused spectrum or called as “white space” from primary (licensed) user. It is designed to detect communication opportunities in wireless system and to be aware of and sensitive to the changes in its surroundings. Cognitive users need to continuously monitor spectrum to detect the presence of primary users to avoid interference or destruction towards them. By continuous sensing, CR has to withdraw instantly from spectrum once primary user is detected.

Spectrum sensing can be categorized into three methods which are Matched Filter Detector (MFD), Energy Detection (ED) and Cyclo-stationary Feature Detection (CSFD). ED is the simplest and basic sensing method and has been studied widely [4]. Hidden node has become one of the major problems in cognitive network. Hidden node happen when low received power from primary user is detected by a single CR and has been presumed as unoccupied spectrum, and which it is caused by shadowing and fading channel.

Referring to figure 1.1, CR has been set with pre-defined threshold as it is to bound the transmitted signal and noise signal. When CR is sensing the spectrum and detect signals from primary users except the lower signal than the threshold, it is assume as unoccupied spectrum, and the signal from this primary user is called as hidden node. Thus, cognitive user has interfered PU’s privacy and lead to interference. This has motivated for multiple CRs to communicate with each other cooperatively to avoid hidden node and make the false alarm. Recent work has shown that cooperative spectrum sensing enhance and improve the detection probability.

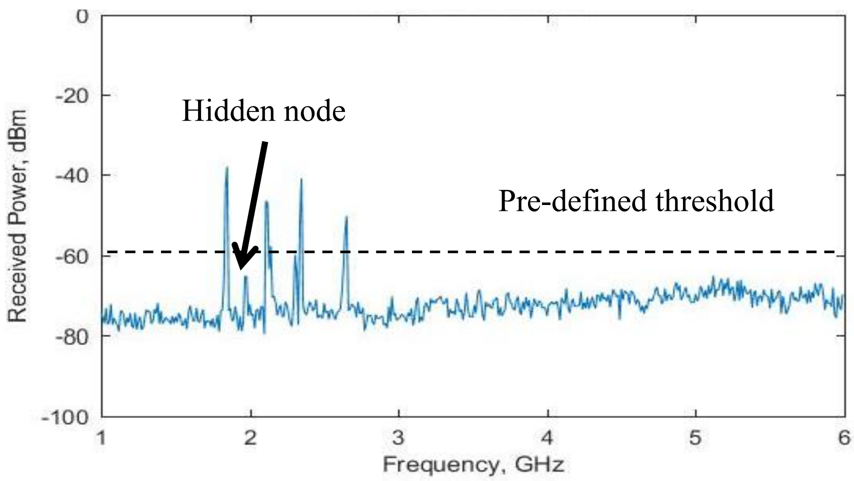

Figure 1.1 Hidden node

Centralized cooperative spectrum sensing (CCSS) is one of a cooperative sensing method where multiple of CR users incorporated to detect the primary user (PU) [19]. CRs are set to send the observed data to fusion centre and make the decision. As the PU transmitting the signal, CRs will always be aware and keep updating the signal status to fusion centre.

Cooperative spectrum sensing is designed for multiple CRs to compliant with each other where m is more than 1 (m > 1). Cognitive system needs two or more CRs to operate cooperatively by sending the decision to fusion centre (FC). FC then will make the final decision for each CR to borrow the spectrum or not.

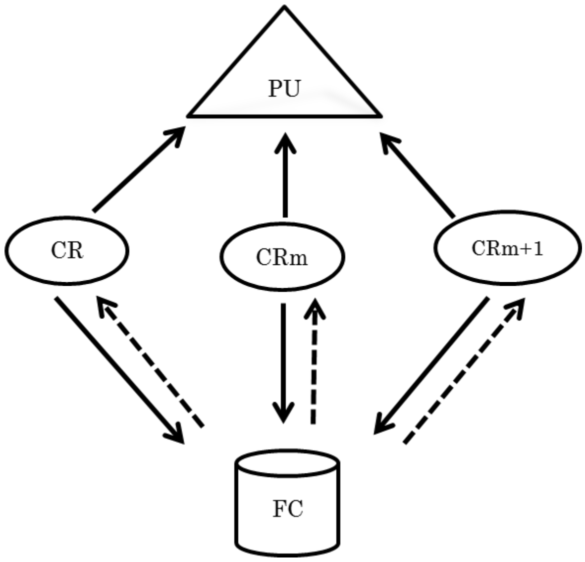

Figure 1.2 Centralised Cooperative Spectrum Sensing

1.2 Problem Statement

Since secondary users can borrow the licensed band, they must alert with the primary users' presence in the short time and evacuate the band for primary users. The agility and accuracy of the vacate spectrum sensing and blind cognitive radio over hidden node has been a challenge in CR network. Thus, the spectrum sensing is designed to operate cooperatively. If a number of CRs from several locations are sensing the spectrum, they can share the information before making the decision to use the spectrum.

1.3 Objectives

The objectives of this project are

i. to develop a cooperative sensing simulator based on energy detector using MATLAB
ii. to performs real-time data measurement using Universal Serial Radio Peripheral (USRP) and spectrum analyzer.
iii. to study and analyse the performance of the data measurement.

1.4 Scope of Work

The following scope of work will be the guideline during the process of the proposed research:

i. The work presented is concentrating on energy detection (ED) as the spectrum sensing technique.
ii. Centralized cooperative spectrum sensing (CCSS) where CR will send collected data to fusion centre and make the decision.
iii. This study includes Rayleigh fading channel and Additive White Gaussian Noise (AWGN).

iv. Assumption of CR and FC channel on reporting decisions independent fading channels is made.

v. Experiment Setup will use Universal Software Radio Peripheral (USRP) as non-mobility PU and spectrum analyzer as CR to observe the signal. 5 samples of received data will be collected from each node.

1.5 Project Report Online

This report consists of five chapters. Chapter 1 describes the background study as an introduction covering project overview, problem statement, objective and scope of work. Chapter 2 is the literature review which discusses and summarizes the basic concept, theories, system modelling, and spectrum sensing techniques. Chapter 3 covers on the project methodology where it covers the simulation process and experiment setup for real time data measurement. Chapter 4 will discuss and analyse the simulation results and measurement data and chapter 5 will conclude the findings of the study and propose recommendation for future work.

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