CONTOH

Proposal

Dynamic Spectrum Access Management System Using Cognitive Radio

---

To:
Chairman
Malaysian Communication and Multimedia Commission (MCMC)

By:

Norsheila Fisal (Project Leader)
Sharifah Kamilah bt Syed Yusof
Sharifah Hafizah bt Syed Ariffin
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
81310 UTM Skudai
Johor

Norashidah Md Din
Dept. of Electrical Engineering, College of Engineering
Universiti Tenaga Nasional
Km7, Jalan Kajang-Puchong
43009 Kajang
Selangor

Wan Haslina Hassan
Kulliyyah of Information and Communication Technology
International Islamic University Malaysia
PO Box 10
50728 Kuala Lumpur

CONTOH

TABLE OF CONTENTS

1.0 INTRODUCTION

Today's wireless networks are characterized by a fixed spectrum assignment policy. However, a large portion of the assigned spectrum is used sporadically and geographical variations in the utilization of assigned spectrum ranges from 15% to 85% with a high variance in time [1]. The limited available spectrum and the inefficiency in the spectrum usage necessitate a new communication paradigm to exploit the existing wireless spectrum opportunistically. This new networking paradigm is referred to as Dynamic Spectrum Access (DSA) and the key enabling technology of dynamic spectrum access networks is the Cognitive Radio (CR) [2]. CR technique provides the capability to use or share the spectrum in an opportunistic manner. Dynamic spectrum access algorithm allows the CR to operate in the best available channel.

Once a CR supports the capability to select the best available channel, the next challenge is to make the network protocols adaptive to the available spectrum. These functionalities of CR networks enable spectrum-aware communication protocols. Current wireless network environment employs heterogeneity in terms of both spectrum policy and communication technologies. Hence, a clear description of the CR network architecture is crucial for development of communication protocols. So far, networking-using CR is a recent topic. Therefore, the investigation on the potential of CR in providing dynamic spectrum access in the wireless communication application should be explored.

The main features of dynamic spectrum access in cognitive radio can be summarized as follows:

- **Spectrum sensing**: Detecting unused spectrum and sharing the spectrum without harmful interference with other users.
- **Spectrum decision**: Capturing the best available spectrum (depending on Signal to Interference ratio, SIR) to meet user requirement. This includes the MAC layer responsibility for coordinating access to the PHY.
- **Spectrum mobility**: Maintaining seamless communication requirement during the transition to better spectrum.
- **Spectrum sharing**: Providing the fair spectrum scheduling method among cognitive nodes In order to achieve the objectives, the following scopes will be covered:

The FCC commission in recent years has explored innovative ways to open new spectrum to commercial unlicensed use. Examples include the release of new spectrum in the 5-GHz U-NII band last year, as well as the opening up of 7.5 GHz of bandwidth for ultrawideband (UWB) signaling in the region between 3.1 and 10.6 GHz as shown in Figure 1. Though the power levels allowed for UWB were extremely low a roof of -41 dBm. The move marked the first time the FCC had allowed unlicensed use across otherwise licensed bands. In order to optimised the spectrum usage within the frequency band, CR is a comprehensive solution as it actively looks for unused spectrum and begins to transmit inside those bands.

In this project, only **spectrum decision** and **spectrum sharing** are considered to improve the spectrum utilization within the region of 3.1 and 10.6 GHz in order to allow coexistence of UWB unlicensed user within the licensed band [3].

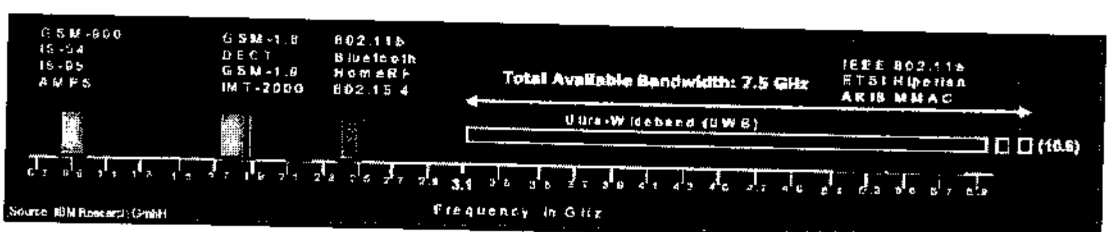

Figure 1: Spectrum of UWB and other services

2.0 LITERATURE REVIEW

Cognitive radio (CR) is a software-defined radio (SDR) with artificial intelligence, capable of sensing and reacting to their environment. This radio may be able to sense the current spectral environment and have some memory of past transmitted and received packets along with their power, bandwidth, and modulation. From all this, it can make better decision about how to optimize for some overall goal. Possible goal include achieving desired network capacity, minimizing interference to other signals or providing robust security and jamming protection.

Cognitive radio technology enables the use of spectrum in a dynamic manner. A cognitive radio can be defined as a radio that can change its transmitter parameters based on interaction with the environment in which it operates [4].

The main objective of cognitive radio is to obtain the best available spectrum through cognitive capability and reconfigurablility. Since most of the spectrum is already assigned, next important task is to share bandwidth among cognitive nodes without interfering with the transmission of other primary users. The cognitive radio enables the usage of temporally unused spectrum, which is referred to as spectrum hole and white space as illustrated in Figure 2.

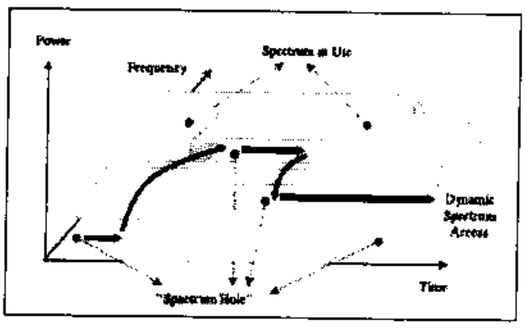

Figure 2: Spectrum hole concept

The components of the CR network architecture can be classified in two groups as the primary network and the secondary or cognitive network. Primary network is referred to as the legacy network that has an exclusive right to a certain spectrum band as shown in Figure 3. On the contrary, cognitive network does not have a license to operate in the desired band. The basic elements of the primary and unlicensed networks are defined as follows:

- *Primary User:*

Primary user has a license to operate in a certain spectrum band. This access can be only controlled by its base-station and should not be affected by the operations of any other unauthorized user.

- *Primary Base-Station:*

Primary base-station is a fixed infrastructure network component, which has a spectrum license. In principle, the primary base-station does not have any CR capability for sharing spectrum with CR users. However, primary base-station may be required to have both legacy and CR protocols for the primary network access of CR users.

- *CR User (Secondary User):*

CR user has no spectrum license. Hence, the spectrum access is allowed only in an opportunistic manner. Capabilities of the CR user include spectrum sensing, spectrum decision, spectrum handoff and CR MAC/routing/transport protocols. The CR user is assumed to have the capabilities to communicate with not only the base-station but also other CR users.

- *CR Base-Station:*

CR base-station is a fixed infrastructure component with CR capabilities. CR base-station provides single hop connection to CR users without spectrum access license.

- *CR Ad Hoc Access:*

CR users can communicate with other CR users through ad hoc connection on both licensed and unlicensed spectrum bands. Also CR users can have their own medium access technology.

- *Primary Network Access:*

The CR user can access the primary base-station through the licensed band, if the primary network is allowed. Unlike other access types, CR users should support the medium access technology of primary network. Furthermore, primary base-station should support CR capabilities.

Ultrawideband (UWB) technology has generated a great deal of interest in broadband wireless communication. Since UWB signals are spread over a broad swath of spectrum shown in Figure 1, it has also generated a great deal of controversy in causing unacceptable interference to the existing users of the same and nearby bands, especially at bands where the power levels near the noise floor. The potential for interference has been studied extensively [Foerster]. A variety of techniques have been explored by researcher in the UWB community, to improve the coexistence of these signals.

Comprehensive approach to manage the frequency spectrum is through Cognitive Radio. The idea behind cognitive radio is that performance can be improved and interference reduced if wireless systems were aware of other RF signals in their environment [5]. The improvements accrued from this technology could be dramatic; while communication engineers have historically though of channel capacity and Shannon's Law simply in terms of bandwith, a cognitive radio takes an expanded view of the channel by managing time, frequency, space, power, and coding. Unfortunately, the benefits from device centric spectrum management (as opposed to policy-based spectrum management) are only fully realized when all devices in a frequency band are cognitive, so that they can negotiate. In this project, collaborative coexistence using CR should be able to optimize:

- . Cost of connection
- . Data rate
- . Error rate
- . Quality of service (QoS)

By controlling:

- Protocol (if multiple available)
- Power levels
- Frequency of transmission
- Timing

Reference:

[1] Akyildiz et al 'NeXt generation/dynamic spectrum access/cognitive radio wireless networks: a survey', Vol. 50, Issue 13, (September 2006) pg.: 2127 – 2159, 2006, Elsevier North-Holland, Inc. New York, NY, USA

[2] Mitola J, and Maguire G., Cognitive radio; Making software radios more personal, IEEE Personal Communications (1999)
[3]Information Society Directorate General, Paris, 2004
[4] Cabric D. et al, A Cognitive radio Approach for usage of virtual unlicensed spectrum. IST,Mobile Summit 2005.
[5]Forrester, J. R., Interference modeling of pulse-based UWB waveforms on narrowband systems, October 2002.
[6] Lansford J., University Radio: Making New Spectrum (sort of), 2002 Fourth Annual International Symposium On Advanced Radio Technologies, Boulder, March 4-6 2002.

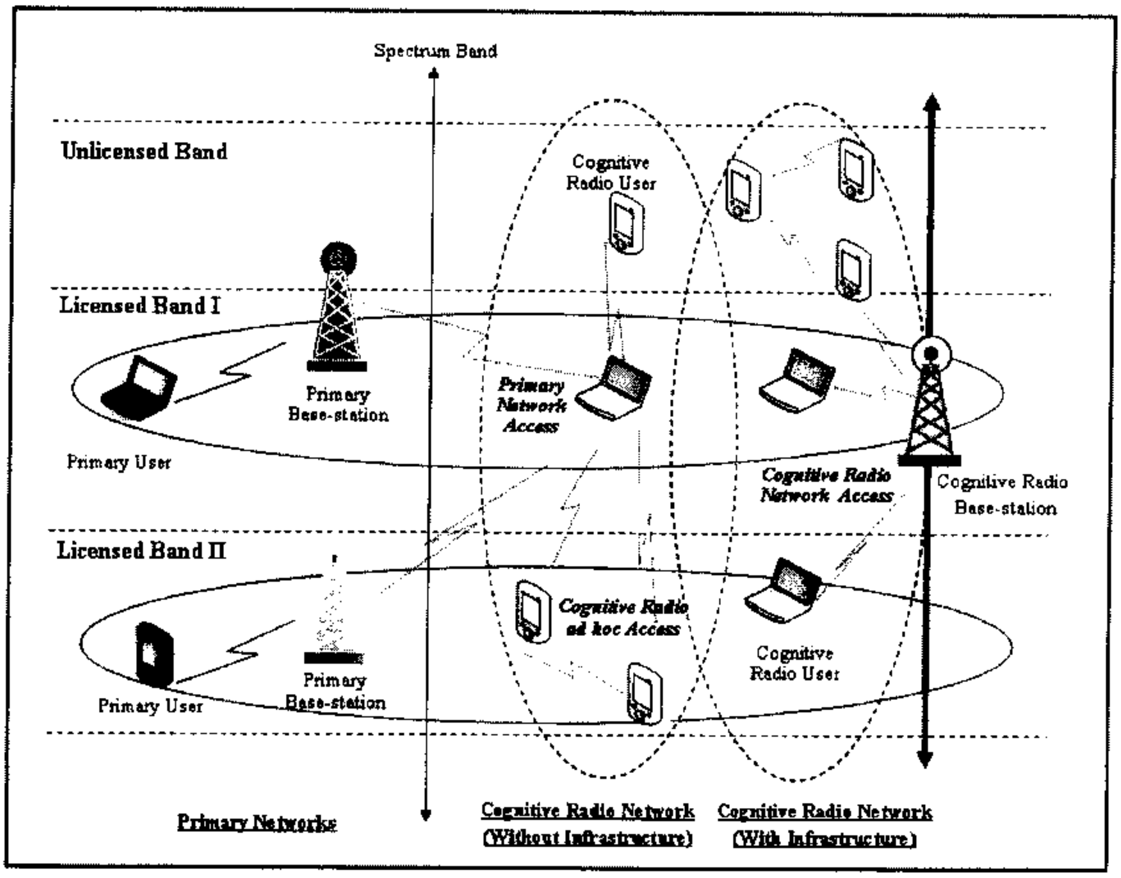

Figure 3. Cognitive radio network architecture.

3.0 OBJECTIVES

The objectives of the research work are to:

- Determine the interference temperature threshold limit to accessing licensed band (spectrum decision),
- Coordinate access into the license band (spectrum sharing)
- Provide effective management and efficient use of spectrum in the licensed band.

The spectrum decision and spectrum sharing are considered to improve the spectrum utilization within the region of 3.1 and 10.6 GHz in order to allow coexistence of UWB unlicensed user within the licensed band.

4.0 PROJECT IMPORTANCE AND BENEFITS

With the recent demand in personal wireless technologies, the unlicensed bands become crowded with everything from wireless networks to digital cordless phones. The most popular unlicensed band is the Industrial, Scientific, and Medical (ISM) bands at 900MHz, 2.4 GHz, and 5.8GHz. Within these frequency ranges, anyone can transmit at any time, as long as their power does not exceed to the licensed band.

Current spectrum policy causes problem such as congestion due to the increasing number of users on limited spectrum. Inefficiency in the spectrum management and wastage due to such greedy algorithm leads to a very poor spectrum utilization in the licensed band. The limited available spectrum and the inefficiency in the spectrum usage require a new management of spectrum utilization in the licensed band. This new networking paradigm of spectrum management is referred to as Cognitive Radio Networks. The philosophy of Cognitive Radio (CR) is to search for spatial in frequency and time where the measured interference (from other licensed and unlicensed networks and noise) is low enough to achieve communication at a target capacity.

The proposed dynamic spectrum access using cognitive radio efficiently use the radio spectrum by allowing the co-existence of licensed and unlicensed users within the same band. The major contribution of the work is that the radio spectrum can be effectively managed and efficiently utilized.

5.0 SCOPE OF WORK

The work will focus on:

i. Developing Mathematical model for interference interactions between primary and secondary users of a particular bandwidth and at a particular frequency.

ii. Proposing an optimized medium access control (MAC) mechanism for cognitive radio multiple access

iii. Regulate a stable and controlled interference power

6.0 RESEARCH METHODOLOGY

The Dynamic Spectrum Access (DSA) method is proposed to overcome the current policy problem in the presence of primary users and many other secondary users. Basically, DSA decides based on interference temperature parameters in order to select frequency and to shift frequency dynamically in wireless communication. Dynamic spectrum access techniques allow the cognitive radio to operate in the best available channel.

More specifically, the cognitive radio technology will enable the users to determine which portions of the spectrum is available and detect the presence of primary users when secondary user operates in a primary bands, select the best available channel, coordinate access to this channel with others, and vacate the channel when a primary user is detected.

The research approach taken is categorized into several phases below:

i. Develop ITM mathematical model for interference interactions between primary and secondary users of a particular bandwidth and at a particular frequency.
   - Measure interference temperature
   - Analyze ITM model from a purely stochastic perspective
   - Determine the interference temperature limit

ii. Propose an optimized medium access control (MAC) mechanism for cognitive radio multiple access
   - Develop Interference Temperature Multiple Access (ITMA) architecture
   - Develop ITMA simulator
   - Spectrum decision and sharing based on interference analysis

iii. Develop spectral shaping
   - Regulate and control interference power

The work is divided into two major parts: the spectrum decisioning and spectrum sharing of the proposed dynamic spectrum access system mechanism. In wireless radio networks, the unused spectrum bands will be spread over wide frequency range to both primary and secondary users. These unused spectrum bands detected through spectrum sensing show different characteristic accordingly to not only the time varying radio environment but also the spectrum band information such as the operating frequency and interference power. The spectrum decisioning cognitive engine will be mainly on the ITM mechanism as shown in the flowchart shown in Figure 4. ITMA relies on the cognitive radio ability to sense its environment and regulate bandwidth and power usage on a per packet basis. It uses interference temperature to sense its environment, and transmits the desired capacity C, using the bandwidth and power derived from Interference Temperature Model. The lower MAC layer is responsible for coordinating access to the PHY, and implementing the basic mechanism of the Interference temperature model.

Spectrum sharing algorithm includes the spectrum decisioning as illustrated in Figure 5. The simulation work will be carried out on NS simulator and MATLAB software package.

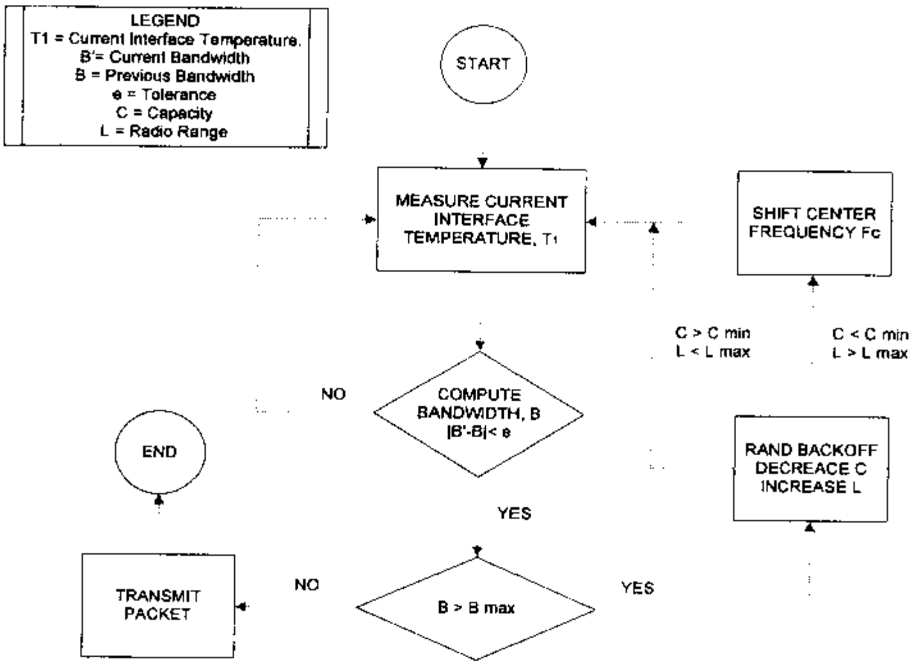

Figure 4: Spectrum decisioning algorithm

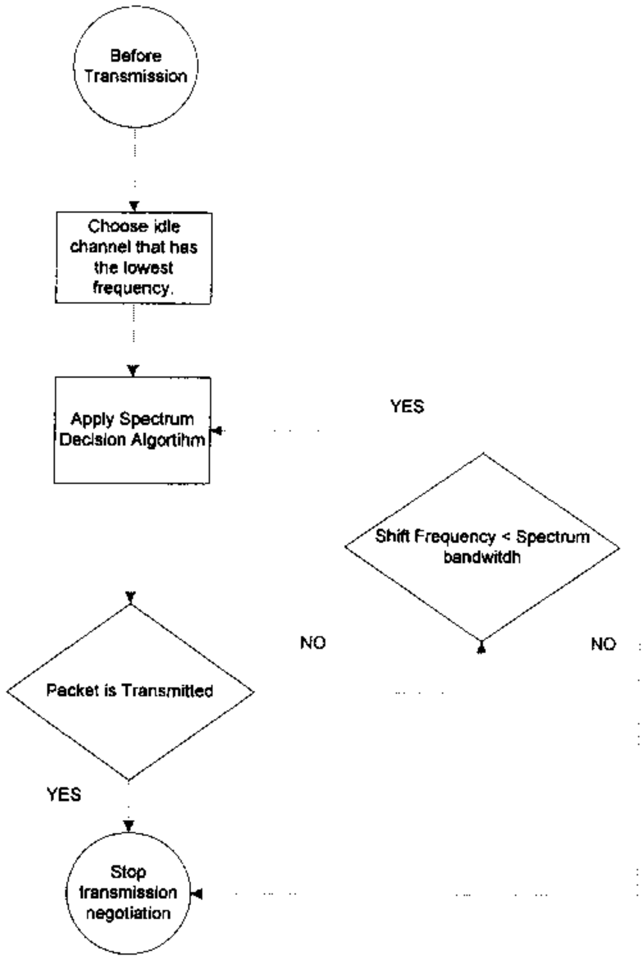

Figure 5: Spectrum sharing algorithm

Special Equipment

1) Wireless cards for mobile devices/equipment.
2) Wireless access points
3) Matlab programming tools

Facilities

1) Network Interfacing
2) Digital Scope
3) Spectrum Analyzer

7.0 PROJECT ACTIVITIES AND SHEDULES

Research Schedule:

Activities	**mth/year**	to	**mth/year**
1) Study of multiple accesses in CR networks	Sept/07		Feb/08
2) Development of Interference temperature mathematical model (ITM)	Nov/07		March/08
3) Development of Interference Temperature Multiple Access (ITMA)	Nov/07		June/08
5) Simulation of ITMA MAC model	Jan/08		Aug/08
6) Spectral shaping	April/08		Nov/08
7) Results analysis and verification work	Sept/08		Feb/09
8) Project report	Dec/08		Feb/09

Milestone	**Mth/year**
1) ITM mathematical model	February/08
2) ITMA MAC	August/08
3) Improved spectrum utilization factor	February/09

CONTOH

Research Activity	2007				2008												2009								
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	O	S
1. Study of multiple access and CR networks																									
2. Development of Interference temperature model (ITM)																									
3. Development of Interference Temperature Multiple access (ITMA)																									
4. Simulation of ITMA MACmodel																									
5. Spectral Shaping																									
6. Results analysis and verification																									
7. Project report																									
Technology Transfer Activities																									
1. ITM mathematical model						●																			
2. ITMA MAC												●													
3. Improved spectrum utilization factor																		●							

CONTOH

8.0 PROJECT COSTING

Table 1 shows the proposed costing for this project.

D. BUDGET

	Budget details	Amount requested		
		Year 1 Sept –Dis 2007 (RM)	**Year 2** Jan-Dis 2008 (RM)	**Year 3** Jan-Feb 2009 (RM)
	Salary and wages 3 Masters students i) Allowance RM1500/ month/per person	16000	48000	9000
	Travelling Expenses ❑ Group meeting (kick off, mid-term & final) ❑ International Conference ❑ National Conference	4000	7000 18000 6000	4000 6000 4000
	Rental Digital Spectrum Analyzer Workstation		10000 10000	
	Research Material and Supplies ❑ Books, Journal and Stationeries	2000	5000	2000
	Maintenance and Minor Repair Services Upgrade workstation. Maintenance	5000	10000 10000	
	Professional Services, Training for subjects for 3 Weeks to 3 Months & other services: ❑ Training ❑ Professional Talk ❑ Programming expertise	6000	6000 6000	
	Equipment ❑ Upgrade MATLAB license version 7.3 ❑ New MATLAB license version 7.3 (2) ❑ Wireless LAN Network Cards (3) ❑ Wireless Access point (3)	10000 20000 5000 5000		
	AMOUNT	**73000**	**136000**	**25000**
	TOTAL AMOUNT			**234000**

CONTOH

<u>SCHEDULE C</u>

(which is to be taken and construed as an essential part of this Agreement)

GUIDE TO

SPECTRUM RESEARCH COLLABORATION PROGRAM

WITH INSTITUTIONS OF HIGHER LEARNING

2007