ENERGY EFFICIENT FOR GREEN WIRELESS COMMUNICATION

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FINAL YEAR PROJECT 1

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ABSTRACT

Recent years have proved that the demands in cellular network has led to explosive growth in terms of number of subscribers. Due to this scenario, rapid growth in cellular network have increase the energy consumption in the base stations and have cause the increment of carbon emissions from the ICT industry. This matters has grabbed significant attention from people in the industry and also from academia because important action need to be done in order to reduce the operational expenditure, maintain the quality of service (QoS) and making these network greener. Thus, in this project, this paper will further discuss about the energy efficient for green wireless communication. Some overviews on energy efficient about data offloading, multiple input multiple output and cognitive radio are done. This project will also include about the spectrum sensing technique in cognitive radio towards green wireless communication. In this case, the energy detection as part of spectrum sensing in cognitive radio is compulsory to be investigated. The basic concept of spectrum sensing in cognitive radio is to sense the available spectrum. Specifically, in order to obtain the result, an energy detection algorithm has been proposed. This will be demonstrated using MATLAB software. The concept of sharing limited and valuable resources has been a potential challenge to promote energy efficient in green wireless communication.
ACKNOWLEDGEMENTS

With the name of Allah, Most Gracious, Most Merciful, I would like to express my gratitude because with His blessing with a good health, I finally managed to complete my Final Year Project 1 report on time. Despite there are many obstacles faced, but with the help and support from my parents, friends and lecturers I survive this course successfully.

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# TABLE OF CONTENTS

ABSTRACT........................................................................................................................................i

ACKNOWLEDGEMENTS..................................................................................................................ii

TABLE OF CONTENTS.................................................................................................................. iii-v

LIST OF TABLES .............................................................................................................................vii

LIST OF FIGURES ..........................................................................................................................vii

LIST OF ABBREVIATIONS.............................................................................................................. viii-ix

CHAPTER 1

1.1 BACKGROUND STUDY ..............................................................................................................1-3

1.2 MOTIVATION .............................................................................................................................3

1.3 PROBLEM STATEMENT ...........................................................................................................3-4

1.4 OBJECTIVES .............................................................................................................................5

1.5 REPORT ORGANIZATION .......................................................................................................5

CHAPTER 2

2.1 INTRODUCTION ......................................................................................................................6

2.2 BASIC CONECEPT ....................................................................................................................6

2.2.1 Basic Terminology of Cellular Data Offloading using Wifi .............................................6-8

2.2.2 Basic Terminology of MIMO .............................................................................................8-10

2.2.3 Basic Terminology of Cognitive Radio .............................................................................10-11

2.3 TOWARDS GREEN WIRELESS COMMUNICATION ............................................................12

2.4 COGNITIVE RADIO ARCHITECTURE ..................................................................................13-14
2.5 THE CLASSIFICATION OF TECHNIQUES FOR COGNITIVE RADIO

2.5.1 Matched Filter Detection .......................................................... 14-15
2.5.2 Energy Detection ........................................................................ 15-17
2.5.3 Cyclostationary Feature Detection ................................................. 17-18

2.6 SUMMARY ....................................................................................... 18

CHAPTER 3

3.1 INTRODUCTION ............................................................................. 19
3.2 DETECTION TASK ........................................................................... 20
3.2.1 Primary User Waveform ............................................................ 20
3.2.2 Processing on Waveform ............................................................ 20
3.2.3 Detection of waveform ............................................................... 20
3.3 CLASSIFICATION TASKS ............................................................... 21
3.3.1 Feature Extraction ....................................................................... 21
3.3.2 Classification .............................................................................. 21
3.4 PROPOSED ENERGY EFFICIENCY ALGORITHM ......................... 21-23
3.5 FLOW CHART FYP1 .......................................................................... 24
3.6 SUMMARY ....................................................................................... 24

CHAPTER 4

4.1 INTRODUCTION ............................................................................. 25
4.2 RESULT OF ENERGY DETECTION ................................................ 25-27
4.3 PERFORMANCE EVALUATION FOR PROPOSED ENERGY EFFICIENCY ALGORITHM ...........................................................27-28

CHAPTER 5

5.1 CONCLUSION .............................................................................................................29

5.2 FUTURE WORK ..........................................................................................................29-30

ANNEX 1 .........................................................................................................................31-34

BIBLIOGRAPHY .............................................................................................................35-37

TURNITIN RESULT .........................................................................................................38
LIST OF TABLES

Table 5.1: Gantt Chart Final Year Project 2 ....................................................... 30
LIST OF FIGURES

Figure 1.1 Growth forecast for global HSPA and LTE subscribers, 2012-2017.................................................................................................................. 7

Figure 1.2 Contribution of mobile communications to CO2 footprint in telecommunication industry in 2002 and estimated for 2020.................................................................................................................. 2

Figure 2.1 Single 3G cell having multiple WiFi access points within its coverage area .................................................................................................................. 7

Figure 2.2: Propagation Component between Base Station and Mobile Station .................................................................................................................. 9

Figure 2.3: Example of 2X2 MIMO Configuration........................................ 9

Figure 2.4: Cognitive cycle.................................................................................. 11

Figure 2.5 Cognitive Radio Network Architecture........................................ 73

Figure 2.6: Block Diagram of Matched Filter .................................................. 15

Figure 2.7: The Block Diagram for Energy Detection .................................... 76

Figure 2.8: Block Diagram for Cyclostationary Feature Detection............... 17

Figure 3.1: Process of Spectrum Sensing in Cognitive Radio...................... 79

Figure 3.2: Ideal Scenario of Energy Detection ............................................. 22

Figure 3.3: Modify Noisy Scenario of Energy Detection .............................. 23

Figure 3.4: Flow Chart FYP 1 ......................................................................... 24

Figure 4.1: The output of Energy detection using BPSK at SNR 30db......... 26

Figure 4.2: The output of Energy detection using BPSK at SNR -30db ........ 27

Figure 4.3: SNR vs Probability of Detection and False alarm...................... 28

Figure 4.4: SNR vs Probability of Detection and False alarm...................... 28
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAGR</td>
<td>Compound Annual Growth Rate</td>
</tr>
<tr>
<td>GHG</td>
<td>Green House Gas</td>
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<tr>
<td>CO2</td>
<td>Carbon Dioxide</td>
</tr>
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<td>TELCOS</td>
<td>Telecom Operators</td>
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<td>CR</td>
<td>Cognitive Radio</td>
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<tr>
<td>3G</td>
<td>Third Generation</td>
</tr>
<tr>
<td>WiFi</td>
<td>Wireless Fidelity</td>
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<tr>
<td>QoS</td>
<td>Quality of Service</td>
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<tr>
<td>EM</td>
<td>Electromagnetic field</td>
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<tr>
<td>MIMO</td>
<td>Multiple Input Multiple Output</td>
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<tr>
<td>SNR</td>
<td>Signal to Noise Ratio</td>
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<td>AWGN</td>
<td>Additive White Gaussian Noise</td>
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<tr>
<td>NP</td>
<td>Neyma Pearson</td>
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<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<td>FFT</td>
<td>Fast Fourier Transform</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>BPSK</td>
<td>Binary Phase Shift Keying</td>
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<tr>
<td>QPSK</td>
<td>Quadrature Phase Shift Keying</td>
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<tr>
<td>ICT</td>
<td>Internet and Communications Technology</td>
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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND STUDY

Nowadays, people keep demands for faster internet connection at anytime and anywhere. Therefore, this matter has contributed a huge increase number of mobile internet subscribers. In Malaysia, we have a numbers of well-known networks operator companies such as Maxis Berhad, Celcom Axiata Berhad, and DiGi Telecommunications Sdn Bhd. With this matter, the data rate transmission rate doubles by a factor of approximately ten every five years [1] Figure 1 shows the number of subscribers in cellular networks have increased.

![Graph showing the growth of HSPA and LTE subscribers from 2012 to 2017.](image)

Figure 1.1: Growth forecast for global HSPA and LTE subscribers, 2012-2017

Based on Figure 1.1, we can see that the number of subscribers showed an increasing pattern from 2012 until 2017. This graph clearly gives an alarm warning to people in the ICT industry to realize what will happen to our
environment in future if the number of mobile internet subscribers increase drastically. According to Cisco forecast [2] and practical experiences of network operators, Mobile data traffic grows at a compound annual growth rate (CAGR) of 131 percent between 2008 and 2013, and exceed two Exabyte per month in 2013.

In such a scenario, the explosive growth of mobile data traffic has led to enhancement of greenhouse gas (GHG) emissions. One indicator is that even with the continued growth predicted for ICT, the total ICT impact is expected to account for no more than 2% of the total global greenhouse gas emissions in 2020. [3] Reported in article [4], the largest fraction of carbon dioxide emissions (CO2) from mobile communications occurs in the radio access network. As shown in figure 1.2, there are two pie charts of contribution of mobile communication to CO2 footprint in 2002 and estimated percent for 2020.

![Figure 1.2: Contribution of mobile communications to CO2 footprint in telecommunication industry in 2002 and estimated for 2020](image)
Therefore, the increase of GHG emissions has pushed the industries to come with green wireless communication. The green touch in wireless communication seems to be one of the best approach to lower the GHG emissions before it’s continue to destroy our environment. There is a lot of energy efficient for green wireless communication that can help to cope with this issue.

1.2 MOTIVATION

In recent times, telecom operators (TELCOS) companies has shown their interest in energy efficient for green wireless communication. The reduction of energy become the important target for industries because they can access economic benefit, save the environment and also for marketing reasons. Green wireless communication is one of the way to stop the amount of greenhouse gas emissions from keep increasing. In these case, ICT technology become one of the major contributors to environmental damage. Despite the green wireless communication is infancy among us as students, but with early exposure in this issue will make us realize how important is our role as next generation in the industry to come with fresh idea to overcome this problem. There are still a lot of research has been conducted. In this project will investigate in more details about the techniques of energy efficient for green wireless communication.

1.3 PROBLEM STATEMENT

Recently, the increase in greenhouse gas (GHG) emissions give a big impact to all of us. Thus, the increment of carbon footprint not only can destroy our environment, it is also give a warning call to people in ICT industry to take an actions. This is because our telecommunication industry listed as contributor in
the increase of carbon dioxide (CO2). Since it is reported that the total energy consumed by infrastructure of cellular wireless networks, wired communication networks and the Internet takes up more than 3 percent of the worldwide electric energy consumption nowadays. [5] With the current demand form users for high speed data rate and a huge increase in the number of mobile subscribers, has forced telecom operator to build more base stations for next generation mobile networks. The action of add more base stations has led to undesired consequence where the growth of wireless networks’ energy consumption will cause an increase of the global carbon dioxide (CO2) emissions, and impose more and more challenging operational costs for operators. This has initiated the need to innovate in the field of energy efficient communications, as wireless network infrastructures as a whole have contributed a significant portion of the total carbon emission of a telecommunication system. As such, wireless networks can play an important role in helping to alleviate the global warming. Various energy efficient networking technologies can be designed to reduce power consumption. Generally speaking, energy efficiency is an alternative that use less energy to accomplish certain task like file transfer, make a phone call and so on. This realization has introduced to green wireless communication where this green touch doubtless capable to help to reduce the amount of greenhouse gas emissions. In consequence to green wireless, there are many approaches can be applied in order to achieve optimum energy efficient in wireless technology. Forasmuch as the technology more advance in future, it is an urgent task to save the environment from global carbon dioxide (CO2) emissions before it is growing faster than originally estimated.
1.4 OBJECTIVES

Due to time constraints to complete the tasks in one semester, the main objectives consists only two, which are:

1. To modify an algorithm for energy detection for green wireless communication.
2. To improve energy efficiency technique in green wireless communication.

1.5 REPORT ORGANIZATION

For the rest of the paper is methodized as follows: In chapter 2, there are literature overviews about the techniques of green wireless communication. In chapter 3, states the methodology of the research and follows by the discussion and analysis in chapter 4. Lastly, in chapter 5 presents conclusion of the research and lays out of future works.
CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter 2 include the summary the techniques for energy efficient for green wireless communication. The energy efficient focused on three techniques and at the end only suitable approach will be implemented.

2.2 BASIC CONCEPT

2.2.1 Basic Terminology of Cellular Data Offloading using Wifi

The increase number of base station results in increase energy consumption and carbon footprint, particularly in remote areas where base stations rely on inefficient and polluting diesel generators for power. [6] In tandem with this, cellular data offloading through WiFi where it is basically focus on energy efficient network operation through dynamic spectrum and traffic load management techniques is discussed.

In recent year [6], spectrum management has entered new paradigms where more freedom has been created for system to be able to dynamically assess which spectrum bands to use and use them. There are three basic types of cellular data offloading which are cellular - cellular offloading, cellular - WiFi offloading and cellular - white-Fi offloading. Since in this project focus on wireless communication, cellular data offloading through WiFi is more interesting for discussion.
In cellular – WiFi offloading, based on [6] there are two architectures for coupling WiFi and cellular (3G) networks: loose coupling and tight coupling. Cellular data offloading where it is focus to reduce the operation cost and provide a good performance for transmission capacity for hungry services on mobile network can be one of the good approach for green wireless communication. For the first architecture, loose coupling is a networks that independent and not require major co-operation between them. In [6] the service continuity is provided by roaming between the two networks. While for tightly coupled, the network share common core and the network functions are centrally manage and control. Based on Figure 2.1, shows the single 3G cell with multiple WiFi access point. Typically, a WiFi access point has much smaller coverage area than 3G base station but in contrast WiFi can provide higher data rates.

![Figure 2.1: Single 3G cell having multiple WiFi access points within its coverage area. [6](image)](image)

Ashwini R Pawar et al. in [7] mention, mobile data offloading can be used to decrease strain on macro cell, reduce congestion and make better use of available network resources. In addition, data offloading also able to low the cost and have
transmission capacity for hungry services on the mobile network. Data offloading also useful to maintain the quality of service (QoS) for customer.

Kyunghan Lee et al. in [8] conclude offloading is an effective for accommodating the current and future traffic growth which means this technique is suitable for green touch in wireless communication. The terms of accommodating traffic growth clearly state that data offloading is energy efficient for green wireless communication.

2.2.2 Basic Terminology of MIMO

Multiple input and multiple out is an antenna technology use in wireless communication where it is use multiple antenna to transmit and receive signals. During the signal transmissions, there is several obstacles that may cause errors such as fading, multipath, noise and interference. Usually, a single antenna is used at the source and at the destination. In several cases, the problem with multipath effects has risen. Based on [9] when an electromagnetic field (EM) is met obstruction such as hills, canyons, buildings, and utility wires, the wave fronts are scattered portions of the signal causes problems such as fading, cut-out (cliff effect) and intermittent reception (picket fencing). All this obstacles may decrease the data speed and increase the number of errors. Figure 2.2 illustrates the situation of multipath propagation causes signal fading.
By using MIMO system, it will help to overcome the problem caused by multipath wave propagation. MIMO configuration can be in any several of type for example a 2x2 MIMO configuration where it is use two antenna to transmit and two antenna to receive the signals. Multipath problem occurs when the signal transmitted arrive at the destination at various times. With MIMO, [10] the receiving end uses an algorithm or special signal processing to sort out the multiple signals to produce one signal that has the originally transmitted data.

Mohammed H. Alcharif et al. in [1], the advantage of MIMO is it can optimizes the tradeoff between energy reduction and throughout where at the same time decrease co-channel interference. In addition, by using MIMO approach also can save significant energy during network operation. Other benefits of MIMO had mention in [11], it can improve energy saving, processing
time and the impact on network service. All of this benefits prove MIMO is suitable approach for green wireless communication since it use less energy to accomplish the task.

Ir. Dr. Rosdiadee Nordin in [12] has introduced massive MIMO for applications of Green Communication for current and future mobile networks. Massive MIMO or also known as Very Large MIMO is a new research filed where the base stations are equipped with large number of antennas compared to the previous MIMO system. Massive MIMO is one of the energy efficient that can help to reduce the amount of greenhouse gas emissions because it is improved energy efficiency and reduce interferences.

2.2.3 Basic Terminology of Cognitive Radio

Cognitive radio is a system of sensing available spectrum in network environment. CR or can be assumed as smart radio, in [13] is defined as a wireless radio device that can adapt to its operating environment via sensing in order to facilitate efficient communication. To overcome the explosive growth in data network offload, wisely use and optimal sharing of available spectrum is a very important thing.

In cognitive radio system, the three main steps of cognitive cycle which are spectrum sensing, spectrum analysis and make decision to choose the spectrum as shows in Figure 2.4. In sensing spectrum process, it is important in cognitive radio to start sense the radio environment and find the available spectrum band. After that, the CR system need to analysis the spectrum that get from the
spectrum sensing process. Lastly, CR system need to decide on which spectrum is appropriate according to its capabilities e.g. the data rate, bandwidth and the transmission mode.

![Cognitive cycle](image)

**Figure 2.4: Cognitive cycle**

Gurkan Gur et al. in [14], cognitive radio are supposed to couple energy efficiency with efficient spectrum usage in order to support green communications. Noted that “to consume only when necessary” (spectrum, energy, hardware) is in contrast with the consumer society tendencies promoted by the cultural logic of late capitalism.

Jacques Palicot in [15] has been presented the use of cognitive radio in order to offer it to become Green Radio Communication. The fact that CR could easily be used to reduce electromagnetic radiation has been lighted in the article.

Mauro De Sanctis et al. in [16] also claims that cognitive radio is another approach which opens new strategies for the use of spectrum and power in wireless communication. Reduce in spectrum sensing, use directional antennas and proper dynamic resource allocation mechanism can make CR networks be spectrally efficient and energy efficient.
2.3 TOWARDS GREEN WIRELESS COMMUNICATION

Based on all energy efficient listed above, cognitive radio is the main idea in this project because of the low cost and easy to be implemented. For the data offloading using Wifi, it is require more time to do research on it since this technique is still infancy. Lots of work need to be done if we want to implement data offloading in this project. While for MIMO, it may require more cost because the use of multiple antenna for transmit and receive the data signal. From overall, cognitive radio is suitable technique for green wireless communication in terms of the budget and time provided for student.

In cognitive radio system, it can be assumed as one of green touch for green wireless communication because of it spectrum sensing. This system use the unused spectrum from the primary network to avoid wastage of the spectrum. Spectrum is a natural resource which should not be wasted but to shared. At the same time, CR user may not give any interference to primary user as long as the total interference power from secondary user and primary user is remain below a certain threshold level. [16]. The basic idea of allowing secondary user to use licensed radio spectrum of primary user has great promise towards green communication because it can reduce the mobile data traffic. This is because we have problem with the limitation of frequency spectrum while the demand for higher data rate keep increasing year by year.
2.4 COGNITIVE RADIO ARCHITECTURE

For the cognitive radio architecture, Figure 2.5 shows that there are two important roles in CR which are primary network and CR network. For primary network, it is a network with the rights for a specific spectrum band and primary user is the user that has license to use the spectrum band. Usually, primary user doesn’t get effect by any change with the existence of unlicensed user along the spectrum band. In addition, for CR network, it is a network where the spectrum access is allowed only in opportunistic manner and does not have license to operate in a desired band. [17] CR network consists of CR user, CR base-station and spectrum broker.

![Figure 2.5 Cognitive Radio Network Architecture](image)

In CR network, CR user or also known as secondary user is allowed to use licensed spectrum from primary user as long as it is not cause any harmful interference on primary network. Besides that, cognitive radio base-station is the
one that help cognitive user to access to other networks and basically this base station is fixed infrastructure component provides single hop connection to CR users without any license of radio spectrum. [17] For spectrum broker, it is function to provide network sharing for CR network and act as centralized that keep all information about spectrum resources.

2.5 THE CLASSIFICATION OF TECHNIQUES FOR COGNITIVE RADIO

In cognitive radio system, spectrum sensing is the important thing in order to find the available spectrum holes for the secondary user. There are various spectrum sensing techniques in CR system such as energy detection, matched filter detection, wave-form detection, cyclostationary feature detection and cooperative detection. [18] In this research, we focus on three spectrum sensing techniques which are energy detection, matched filter and cyclostationary feature detection.

2.5.1 Matched Filter Detection

In matched filter detection sensing, this technique must have enough knowledge about the primary waveform. This technique is use in CR system to provide the maximum signal-to-noise ratio (SNR). Since it is provide a maximum SNR ratio, this technique can give a very accurate result. Figure 2.6 [17] depicts the block diagram of matched filter sensing technique. Firstly from the block diagram, the signal receive by the secondary user is as the equation (2.1) [19]

\[
r(t) = s(t) + n(t)
\]

(2.1)

where \( t \) is AWGN noise, \( r(t) \) is convolves with known signal pattern given in equation (2.2)
\[ h(t) = s(T - (t + \tau)) \quad (2.2) \]

and at the output of the matched filter it will compared with a threshold level to figure out the existences of primary user.

![Block Diagram of Matched Filter](image)

**Figure 2.6: Block Diagram of Matched Filter [17]**

In contrast, even though matched filter spectrum sensing technique is the best technique of CR system due to the accurate result and less time consuming with high processing gain [17] but in the other side matched filter need to have knowledge about the primary user waveform. If the CR system does not have this information, it is difficult to perform this technique and also due to the security issue of primary user does not share its information. [19]

### 2.5.2 Energy Detection

For the case of insufficient of information about the primary user’s waveform, matched filter detection is not a good choice for spectrum sensing. In energy detection technique, it is use to detect the presence or absence of the primary user using the signal detection (also known as radiometer). [20] Refer to Figure 2.7 for the block diagram of energy detection. The block diagram use the signal in time domain where we assumed \( y(t) \) is real and the signal is converted from analogue to digital using ADC. After that, the signal is being squared by squaring device and observe the average and finally the output is compared with a threshold level, \( \lambda \), to determine whether the primary user is exist or not. [21][17]
As stated in [20], the common approach used in energy detection is based on the Neyman-Pearson (NP) lemma. The NP lemma increase the probability of detection (Pd) for a given probability false alarm (Pfa). Probability detection give a high probability of primary user absences, with this information form the Pd, CR user is allowed to use the spectrum band. For probability false alarm, the high value of Pfa inform about there is minimum use in spectrum band. Given in equation (3) and (4) the formulas for Pd and Pfa [17],

\[
Pd = P \left( Y > \frac{\lambda}{H_1} \right) = Qm(\sqrt{2Y}, \sqrt{\lambda}) \quad (2.3)
\]

\[
Pfa = P \left( Y > \frac{\lambda}{H_0} \right) = \frac{\Gamma(m, \frac{\lambda}{2})}{\Gamma(m)} \quad (2.4)
\]

Where \( Y \) is the SNR, \( m = TW \) is the (observation/sensing) time bandwidth product \( \Gamma(\cdot) \) and \( \Gamma(\cdot,\cdot) \) are complete and incomplete gamma functions, \( Qm(\cdot) \) is the generalized Marcum Q-function.

Thus, energy detection technique is a simple technique of sensing spectrum because it does not require a detection of primary user’s information and low in computational and also has the ability to be implemented in almost all cases. Unfortunately, major drawback of energy detection is it only can inform about the absence or presence of the primary user but it cannot differentiate between signal
power and noise power. [17] The problem of energy detection is more on the performance where it cannot give accurate noise power.

2.5.3 Cyclostationary Feature Detection

Cyclostationary feature detection is a sensing spectrum technique that used spectral correlation methodology to detect the user because it use the cyclic correlation perform. [19] In Figure 2.8 illustrate the block diagram for the Cyclostationary feature detection process.

![Block Diagram for Cyclostationary Feature Detection](image)

Based on Figure 2.8, if the correlation factor is more than the threshold level, this indicate the existence of primary user in spectrum band. [17]

Thus, the advantages of cyclostationary feature detection are this technique able to compare between primary user signals from the noise and also can be implemented at very low signal to noise ratio (SNR). This case is different to energy detection where it cannot be able to differentiate between the noise and the primary user, where it is only give information about the existence of the primary user. Also, this spectrum sensing technique does not require prior knowledge about the primary user as matched filter detection need. From the overview, this feature detection technique can be the best technique between energy detector and matched filter detector. In contrast, cyclostationary feature detection have disadvantages in terms of the computationally is very complex that consume more
time for sensing and the spectral calculation require a very long calculation. Also, it need to deal with all frequency to generate spectral correlation function. [20]

2.6 SUMMARY

This chapter review all the techniques for cognitive radio for green wireless communication. From the overall techniques listed for cognitive radio, energy detection is the most suitable approach for spectrum sensing because of the low computational and can be implemented easily. Energy detection can help to build the cognitive radio system if there is not enough information about the primary user waveform and also to avoid errors that come from complex computational. Also, energy detector require low cost compared to matched filter detection and cyclostationary detection.
CHAPTER 3

METHODOLOGY

2.1 INTRODUCTION

In this chapter, the discussion will explain how the cognitive radio spectrum sensing works around the radio environment. The technique be used is energy detection. The process of spectrum sensing is shown in Figure 3.1.

Before start with the process, first process need to have the primary user transmission process. Any input receive form the primary user is converted into sequence of bits. Then, the bits, b[n] are protect from other interference by adding some redundant bits. The data symbol, s[n] is get from the grouping the bits into symbol and go through the shaping filter Pt(t) and lastly the signal is modulate to generate the radio frequency for transmissions. [17] While at the receiver, the mentioned steps above are still the same but occur in reverse way to get the original input signal.

![Figure 3.1: Process of Spectrum Sensing in Cognitive Radio][17]
2.2 DETECTION TASK

In this task, it is important for cognitive radio system to start with some detection work before it classified the waveform. In detection task involve three steps: primary user waveform, processing of the waveform and detection if waveform.

2.2.1 Primary Users Waveform

The very first step of cognitive radio spectrum sensing is to check whether there is present of primary user waveform around the radio environment. This waveform later on will extracted in classification tasks.

2.2.2 Processing on Waveform

After finished the process of figuring out the existence of primary user in radio environment, the next step is to proceed to processing the waveform using energy detection technique. If there is present of primary user, then both can communicate to each other. If primary user is absence, then it will try to get some parameter information of primary user such as operating frequency and modulation scheme. [17]

2.2.3 Detection of waveform

This process is dealing with the identification of the particular feature. This is due to the different primary user at certain time and the spectrum band might have different technologies on it. Because of the different technologies, we need to concern about the features like the operating frequency and modulation type.
3.3 Classification Tasks

After successfully detecting the presence of primary user in radio environment, next we move to classification tasks which involve two steps: feature extraction and classification of waveform.

3.3.1 Feature Extraction

During this process, the features of primary user’s waveform are being extracted so that it can easily classified in the last step. In this case, we are care about two features of primary user’s waveform which is operating frequency and modulation type.

3.3.2 Classification

Classification is the last step of spectrum sensing in cognitive radio. During this process, the primary user’s waveform is classify using the features extracted from the previous step. In addition, this classification usually related to well-known wireless technologies such as Wireless LAN and Bluetooth. With this step can make it easier to identify what kind of technologies been use for the next primary user’s waveform because the information of the previous technology is being stored.

3.4 Proposed Energy Efficiency Algorithm

In this section, correctly detects the primary user existences in primary spectrum is necessary to get a better performance of CR. Cognitive radio can be said as a green radio in terms of the spectrum sharing and good management of scarce resources. But, the drawback of energy detection comes when the cognitive user
need to be in active state to sense around the radio environment. This active state absolutely consumes almost the same as power to transmit the data signal. Plus, it does not guarantee much spectrum opportunities if primary user occupy the spectrum for a long period of time. Hence, the good performance of CR is depends on how it can avoid probability false alarm during the primary user detection. Also, as mention before energy detection technique cannot work very well in low signal to noise ratio because it cannot be able to differentiate between signal power and noise power.

With that, in [22] has proposed energy efficiency algorithm to overcome the drawbacks of energy detection technique. One of the key scenario is signal detection in ideal (without any noise) and noisy scenarios. This modified algorithm use different SNRs to detect the primary user. Refer Figure 3.2 – 3.3 to compare between ideal scenarios with noisy scenario.

Figure 3.2: Ideal Scenario of Energy Detection
Figure 3.3: Modify Noisy Scenario of Energy Detection

The methodology for both scenarios start with receive the signal from primary user and then it is transmitted in ideal (without noise) and noisy channel and proceed by the transceiver and finally the spectrum start is about to begin. After get the signal, it will transform into frequency domain using fast Fourier transform and then the data will be squaring and at the end the FFT will converted into useable frequency by method called averaging. Once this is completed, the data will be compared with threshold to identify either the primary user is present or absence.
3.5 FLOW CHART FINAL PROJECT 1

![Flow Chart]

Figure 3.4: Flow Chart FYP 1

3.6 SUMMARY

From the overall of this chapter, the implementation of energy detection spectrum sensing has been described in details. The implementation of this technique starts from the sensing process and then proceed to the classification process. Thus, modified algorithm had been found from [22] articles to overcome the drawback of energy detection technique to get more accurate result.
CHAPTER 4
FUTURE RESULT AND ANALYSIS

4.1 INTRODUCTION

In this chapter, the results of energy detector spectrum sensing is collected from the references as a result samples. All the results shown in this chapter are preliminary result for this project that will be compared in future work. More details in future work will be discussed in Chapter 5.

4.2 RESULT OF ENERGY DETECTION

Energy detection, one of the simplest technique of cognitive radio which is able to sense the present and absence of primary user. This technique will measure energy received from primary user and will compared it with a threshold level. If the value of energy is more than threshold level, means there is existence of primary user and vice versa. To done this technique, MATLAB software is used to demonstrate the main idea of energy detection. For the first step, there are two types of primary transmitter in spectrum sensing that can be used which are BPSK and QPSK modulation technique. In this project, we choose BPSK modulation.

The results are taken from article [17]. Figure 4.1-4.2, shows the result of energy detection technique using BPSK. Refer Annex 1 for the MATLAB code for primary users transmitter and energy detection. Figure 4.1 used signal to noise ration of 30db while figure 4.2 used -30db. From the figure we can identify the
different when using high SNR and low SNR. As mentioned in Chapter 2, energy detection cannot perform very well in low SNR. For low SNR, the suitable technique can be used is Cyclostationary detection but this technique has drawbacks in terms of complexity computationally and time consuming.

From Figure 4.1, the output clearly shows there is a peak exactly at 200Hz representing the existence of primary user. While for Figure 4.2, shows the output of energy detection using -30db of SNR. What we can observed here, the performance of energy detection is very poor. This is because the output shows many peaks, almost at all frequencies. With that, energy detector claims primary user exist at all along the spectrum. Although in Figure 4.1 shows there is only one primary user exist at 200Hz, but in low SNR conditions energy detection cannot differentiate either that is noise power of signal power. That is the disadvantage of energy detection.
PERFORMANCE EVALUATION FOR PROPOSED ENERGY EFFICIENCY ALGORITHM

After done with the simulation of energy detection in MATLAB, then the process proceed to the proposed energy efficiency algorithm. In this algorithm, energy detection technique is modified to achieve better performance in cognitive radio. Shows in figure 4.3, there is plotted SNR versus the probability of detection and probability of false alarm. The graph for probability detection reach to 100 percent detection of primary user when the SNR value is 10dB and zero percent of probability false alarm all along the SNR value. The result of probability false alarm prove that the detection is noise free.
For sensing time impact, figure 4.4 shows the result if we use different sensing time. The time used are one second and two seconds. From the observation, the result is still the same as figure 4.3 even use different sensing time. Same performance can be achieved using low sensing time to save more sensing energy. All these result are taken from article [22].

Figure 4.3: SNR vs Probability of Detection and False alarm

Figure 4.4: SNR vs Probability of Detection and False alarm
CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

To sum up, one of the objectives of Final Year Project 1 have been successful achieved. The objective to survey the wireless connections on energy consumption have been done by doing survey on some of energy efficient for green wireless communication. By done a lot of research from journals, articles, books and websites, student able to understand the idea of energy efficient in wireless communication. Base on the preliminary result in Chapter 4, we believes that cognitive radio is one of best approach towards green wireless communication in order to cope with the increase in greenhouse gas emissions.

5.2 FUTURE WORK

In Final Year Project 2, the simulation for energy detection technique in will be implemented. From the result in next project will be compared with the preliminary result in final project 1. Also, the design and proposed energy efficient algorithm for energy detection to have optimum wireless connection link where use less energy.

For future research study, more design can be done for example a project of wireless sensor network using Zigbee that use to scan the suitable duration for energy detection in clear channel assessment sensing method for IEEE 802.15.4 transceiver. Due to time constraints, we have no chances to done this experiment in this FYP1 because this experiment require long time for the implementation.
Table 5.1: Gantt Chart Final Year Project 2

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- Expected Progress
- Midterm Break
Annex 1

MATLAB script transmitter.m: Primary Users Transmitter

close all;
clear all;

% PARAMETERS
% freq = 200;   % operating frequency
Fs = 20*freq; % sampling frequency
L = 100;      % Number of samples per symbol period
T_s = 1/Fs;   % Sampling period
T = T_s*T_s/1/f;
alpha = 0.5;  % Roll-off factor for the (square-root) raised cosine filters
N = 8*L;      % N+1 is the length of the square-root raised-cosine filter.
sigma = 0;    % Standard deviation of channel noise

h = 1;        % Channel impulse response

% SOURCE: Take input data from user for transmission
%
pt_dt = input('Data you want to send: ','s');
R = isempty(pt_dt):
   if R == 1
       pt_dt = 'Waleed Ejaz';
   else
       pt_dt = pt_dt;
   end
display(pt_dt);
RR = double(pt_dt);
b = 1;
Rp = dec2bin(RR,7);
[TA TC] = size(Rp);

for ll = 1:1:TA
    for lg = 1:1:TC
        msg(bb) = Rp(ll,lg);
        bb = bb + 1;
    end
end

rt = 1;  ht = 1;
for ls = 1:1:TA
    for ll = 1:2:(TC-1)
        Inp_msg(rt,(ht:ht+1)) = Rp(ls,ll:ll+1);
        rt = rt + 1;
    end
end
end
%
% Transmit Filter
%

pt remains cos(p(N,L, alpha)); % Transmit filter
xT = conv(f expander(msg, L), pT); % Transmit signal
%
% Modulation
%
display('Select Type of Modulation');
display('1. BPSK');
display('2. QPSK');
Mod_Type = input('Please Enter the Type of Modulation: ', 's');
Carrier = [];
%
% BPSK Modulation
%
if (Mod_Type == '1')
display('Binary PSK');
for ii = 1:length(T)
car = sin(2*pi*freq*T(ii)); % CARRIER TO BE TRANSMITTED
end

for ii = 1:length(xT)
if xT(ii) == 0
    car = 1*car1;
else
    car = -1*car1;
end
Carrier = [Carrier car];
end
%
% QPSK Modulation
%
else if (Mod_Type == '2')
for ii = 1:length(T)
car1 = sin(2*pi*freq*T(ii)+369); % CARRIER TO BE TRANSMITTED
car2 = sin(2*pi*freq*T(ii)+90); % CARRIER TO BE TRANSMITTED
car3 = sin(2*pi*freq*T(ii)+180); % CARRIER TO BE TRANSMITTED
car4 = sin(2*pi*freq*T(ii)+270); % CARRIER TO BE TRANSMITTED
end
for ii = 1:length(Inp_msg)
    if Inp_msg(ii) == '00'
        car = car1;
    else if Inp_msg(ii) == '01'
        car = car2;
    else if Inp_msg(ii) == '10'
        car = car3;
    else if Inp_msg(ii) == '11'
        car = car4;
    end
end

Carrier = [Carrier car];
end
end

% CHANNEL
%

xR = conv(h,Carrier);
xR = xR + sigma_v*randn(size(xR)); % Received signal
MATLAB Script energy.m

Pxx = periodogram(xR);
Hpsd = dspdata.psd(Pxx,Fs,Fs);
plot(Hpsd)

freq = []; o = 1;
len = 6537 * 0.5;
n_len = floor(len/2000);

for p = 1:1:n_len
    fre(o) = sum(Pxx(p:p+n_len));
    o = o + 1;
end
sa = [];
count = 0;

for w = 1:1:length(freq)
    if (freq(w) > 5000)
        count = count + 1;
        sa = [sa w];
    end
end

count_m = 0;
if (count > 1)
    E(1,1) = 1;
else if (count == 0)
    E(1,2) = 1;
end
end
BIBLIOGRAPHY


[13] Prof. Yuh-Shyan Chen, “Chapter 4: Green Wireless Communication via Cognitive Dimension” Department of Computer Science and Information Engineering National Taipei University, (ND)


ABSTRACT

In the past few years, demand in cellular networks by users has led to explosive growth in number of subscribers. Due to this scenario, rapid growth in cellular network has increased energy consumption in the base stations and cause the increment of carbon emissions in ICT industry. All this matters have grabbed significant attention from people in the industry and also from academia because important action need to be done in order to reduce the operational expenditure, maintain the quality of service (QoS) for users and making these network greener. Thus, in this paper we discusses about the energy efficient for green wireless communication. We do some overview on energy efficient which are data offloading, multiple input multiple output and cognitive radio.