International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Analysis of Cognitive Radio a Way to Increase Spectrum Efficiency Using Periodogram

Kalindi Bakare[1], M. B. Limkar[2], Sonali Jadhav[3]

[1] Mumbai University, M.E. Student EXTC, ARMIET College of Engineering, Sapgaon, Mumbai, INDIA

[2]Assistant Prof. Department of Electronics, Terna College of Engineering, Nerul, Mumbai, INDIA

[3]Assistant Professor of EXTC Department, PVP College of Engineering, Sion, Mumbai, INDIA

Abstract: ***The topic of spectrum sensing and spectrum allocation has gained a great deal of interest in the context of cognitive radios for dynamic spectrum access networks. Spectrum sensing and allocation is one of the crucial functionalities of a cognitive radio in order to apply the radio environment. Different sensing and allocation techniques serve different purposes based on their advantages and drawbacks. Spectrum sensing is an inherent ability of cognitive radio to autonomously perform required calculations & detects unused spectrum that is spectrum holes in order to increase spectrum efficiency. In this paper various algorithms for spectrum sensing techniques are discussed &analysis of cognitive radio is done using energy detector spectrum sensing which is also called periodogram.***

Keywords: Cognitive radio, Spectrum sensing, Spectrum holes, Energy detection.

1. Introduction

The radio frequency spectrum is a natural resource and its efficient use is important issue. The spectrum bands are usually licensed to certain services, such as mobile, TV broadcast and satellite to avoid harmful interference between different networks to affect users. Most spectrum bands are allocated to certain services but worldwide spectrum occupancy measurements show that only some portion of the spectrum bands are used. In the development of future wireless systems, the spectrum utilization functionalities will play a key role due to the scarcity of unoccupied spectrum. Cognitive radios, with the capabilities to sense the operating environment, learn and adapt in real time according to environment creating a form of mesh network, are seen as a promising technology.

Now-a-day, the growing demand of wireless applications has put a lot of constraints on the usage of available radio spectrum which is limited and precious resource. However, a fixed spectrum assignment has lead to under utilization of spectrum as a great portion of licensed spectrum is not effectively utilized. Cognitive Radio (CR) is a promising technology which provides a novel way to improve utilization efficiency of available electromagnetic spectrum. It is able to sense the spectral environment over a wide frequency band and exploit this information to opportunistically provide wireless links that best meet the user communications requirements. Spectrum sensing helps to detect the spectrum holes (unutilized bands of the spectrum) providing high spectral resolution capability. The main objective is to detect spectrum and allocate this available spectrum according to time and frequency usages of secondary users. It gives good opportunity to use cognitive radio to use our natural resources efficiently.

Cognitive radios sense the radio spectrum in order to find unused frequency bands and use them in an agile manner. Transmission by the primary user must be detected reliably even in the low signal-to-noise ratio (SNR) regime and in the face of shadowing and fading. Communication signals are typically cyclostationary, and have many periodic statistical properties related to the symbol rate, the coding and modulation schemes as well as the guard periods, for example. These properties can be exploited in designing a detector, and for distinguishing between the primary and secondary users.

2. Cognitive Radio: Approach to Increase Spectrum Efficiency

One of the most important findings from the measurements reported in [6] is that a large portion of the radio spectrum is not in use for significant periods of time in certain areas. Thus, there are a lot of spectrum holes, which are defined as a set of frequency bands assigned (licensed) to a user (we call this user as a primary user), but, at a particular time and specific geographic location, not being utilized by that user. On the other hand, the report also pointed out that most of the unlicensed spectra are heavily accessed by users and have high spectrum utilization thanks to the possibility of open access with relaxed regulations. These observations lead us to a key idea: the spectrum utilization can be drastically increased by allowing secondary users to access to the spectrum holes that are unutilized by the primary user at certain time and space. Cognitive radio has been proposed as a means to achieve such dynamics. A cognitive radio senses the spectral environment over a wide frequency band and exploits this information to opportunistically provide wireless links that can best meet the demand of the user, but also of its radio environments. The cognitive-radio devices have two important functionalities: spectrum sensing and adaptation. A secondary terminal first senses the spectrum environment in order to learn the frequency spectra unoccupied by primary users. Once such a spectrum hole is found, the secondary terminal adapts its transmission power, frequency band, modulation, etc., so that it minimizes the interference to the primary users. Even after starting the transmission, the secondary terminal should be able to detect or predict the appearance of a primary user so that it makes the spectrum available for the primary user. Basically, the primary users should not change their communication infrastructure due to these operations. Thus, these sensing (including the detection) and adaptation of the secondary users must be done independently of the primary users. Figure 1 shows an example of the spectrum utilization with ideal operation of cognitive radio. In the area 1 which is a region within communication range of primary users, the secondary users build communication links with frequency f1 while the primary users are not active on the communication links. On the other hand, in the area 2 which is out of communication range of primary users, the secondary users can continuously utilize this frequency band without the interference from/to the primary users. Note that, in the conventional system without cognitive radio, the frequency band f1 cannot be utilized by any user at any location. Thus, cognitive radio allows users to utilize a frequency band more densely in time and space, thereby leading to a drastic increase of the total spectrum efficiency.

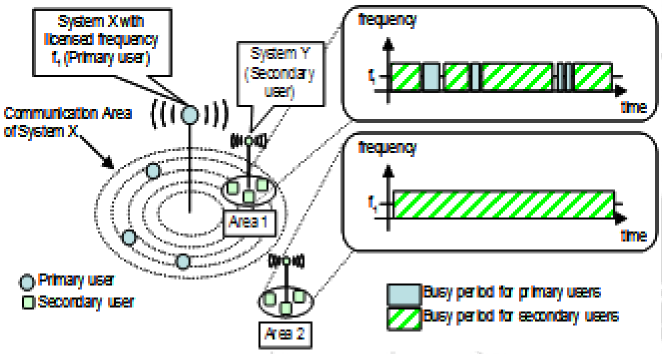

Figure1: Frequency utilization of primary and secondary users in Cognitive Radio Environment

3. Non-Cooperative Detection Methods

Basically, non-cooperative detection approach is based on the detection of the signal from a primary user. In the following we will present main three methods of non-cooperative detection. For efficient utilization of spectrum for cognitive radio, that has been of great interest in recent research. We will highlight some fundamental problems and present techniques for signal detection.

a) Energy Detection Technique
b) Matched Filter Detection Technique
c) Cyclostationary Detection Technique

a) Energy Detection Technique

Energy detector is well known spectrum sensing technique. It is based on the principle that the energy of the received signal to be detected is always higher than the energy of noise. Energy detector is said to be blind signal detector because it ignores the structure of received signal with known threshold. Threshold value can be fixed according to channel condition.

Energy Detection over AWGN Channels has analyzed in which ten carrier frequencies were used. [4][5]. Algorithm for energy detection is designed as follows.

1. First we have transmitted signals of primary user.
2. At the receiver, received signal 'y' is calculated by adding all received signals.
3. Then we have estimated power spectrum density of signal 'y' by using periodogram function in MATLAB. The integral of the PSD over a given frequency band computes the average power in the signal over that frequency band.
4. The signal power. is then compared with a threshold and if it is above the threshold, then the result of the detector is that a primary user is present.
5. Plot the probability of detection by using Marcumq function.

b) Matched filter detection

We have best sensing technique in an AWGN environment, and without knowledge of the signal structure is the energy detector. If we do some knowledge of the signal structure then we can achieve a better performance by using Matched filter detection. Matched filter detection achieves the optimal detection performance in AWGN channel, since it maximizes the SNR [4] [5]. Matched filter has the interesting property that no matter what the shape, time duration or bandwidth of the input waveform maximize the SNR ratio is simply twice the energy E contained in transmitted signal divided by number of the matched filter prior knowledge of primary user waveform is required.

Algorithm for Matched filter detection is designed as follows. First we have transmitted signals of primary user.

1. At the receiver, received signal y (t) s calculated by adding all received signals.
2. Add AWGN in received signal.

$$Yr(t) = y(t) + n(t)$$

3. Convolute the Yr(t) with impulse response h(t) of Matched filter.
   Here h(t) is taken as the received signal of each primary user. For example if received signal y1(t) from first primary user then convolution becomes

$$Yr(t)*h(t) = \int_0^t Yr(T)\, h(t-T)\, dT$$

   Where h(t)=y1(t). Similarly it is done for all primary users.
4. By using convolution, matched filter will match the received signal with primary user signals If it is matched it will show peak value at that particular carrier frequency of PU.
5. Draw the frequency spectrum of Yr(t) using FFT.
6. Peak values which are present in the frequency spectrum are then compared with a threshold and if it is above the threshold, then the result of the detector is that a primary user is present.

This method is optimal in the sense that it maximizes the SNR, minimizing the decision errors. However this method is not practical since it require the cognitive user to know the primary user's signaling type.

c) Cyclostationary Detection

Cyclostationary detection is a method for detecting primary user transmissions by exploiting the Cyclostationary features of the received signals. Cyclostationary features are caused by the periodicity in the signal or in its statistics like mean and autocorrelation or they can be intentionally induced to assist spectrum sensing. Instead of power spectral density (PSD), cyclic correlation function is used for detecting signals present in a given spectrum. The Cyclostationary based detection algorithms can differentiate noise from primary user's signals. This is a result of the fact that noise is wide-sense stationary (WSS) with no correlation while modulated signals are Cyclostationary with spectral correlation due to the redundancy of signal periodicities. [4] [5]

Algorithm for Cyclostationary detection is designed as follows;

1. First we have transmitted signals of primary user.
2. At the receiver, received signal y(t)s calculated by adding all received signals.
3. Add AWGN in received signal. Yr(t) = y(t) + n(t).
4. Multiply the signal Yr (t) by Hamming window.
5. Then multiply by positive and negative exponential function and calculate x1 and x2 respectively.
6. Calculate cyclic autocorrelation of x1 and x2 in frequency domain.
7. Estimate the cyclic spectral density (CSD) function.
8. The channel is considered to be busy if the cyclic autocorrelation of the signals received by the SU at the cyclic frequency is nonzero; otherwise, the channel is vacant

The flows chart in figure 2 shows the complete flow of the process in Energy detection spectrum sensing or periodogram. This flow chart shows the working of periodogram to calculate the power spectral density of the transmitted signal using the amplitude modulation. At the end, the summed frequency is compared with the threshold value, and if threshold is less than the frequency then it assumes that primary user is absent and vice-versa if threshold is more than frequency. [1]

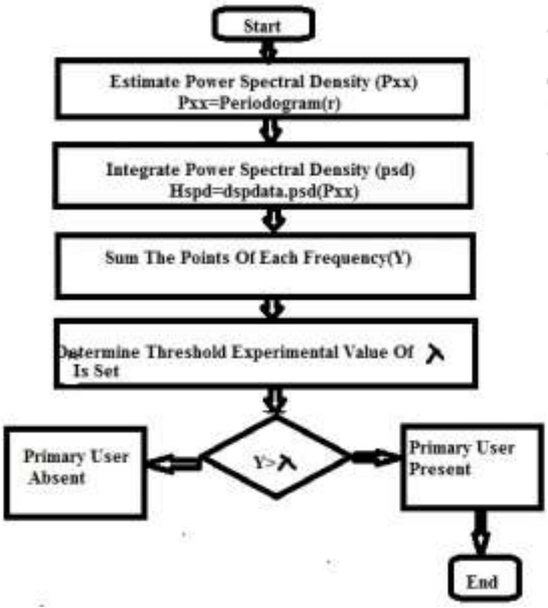

Figure2: Flow of The Process in Energy detection spectrum sensing or periodogram

4. Analysis of Cognitive Radio

The analysis of cognitive radio is done using energy detection based approach also known as periodogram .The model shows five primary users where each user's message is modulated by using amplitude modulation. Summation of five primary signals shows the transmitted signal. Periodogram method is used to estimate the power spectral density of the transmitted signal. Using this Cognition process is displayed among the primary users and secondary users. [2][3]

Figure 3 shows all the 5 primary users as present

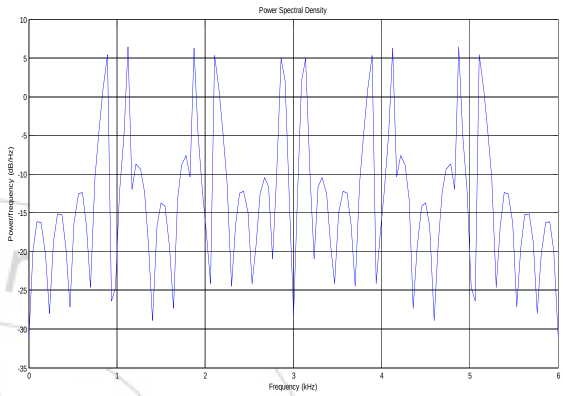

Figure 3: Power Spectral Density of 5 users

To explain the cognition process, here primary users are assumed to have frequencies 1,2,3,4 and 5 MHz Figure 3 shows the Power Spectral Density (PSD) of the transmitted signal, we can see the frequency peaks for all the five primary users, which implies that all the 5 users are present.

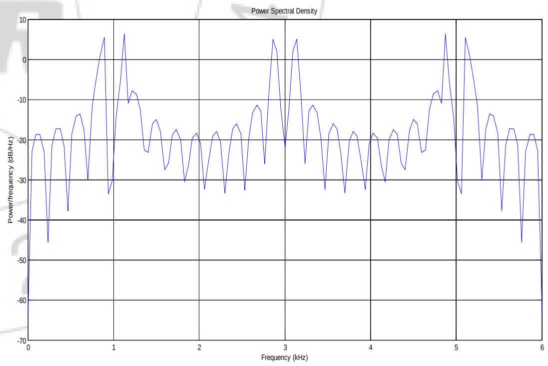

Figure 4(a): Power Spectral Density when user 2and 4 Leave Spectrum free

When users 2 and 4 leave the spectrum free then secondary user can access the band. Figure 4(a) shows that users 1, 3, and 5 are present while 2 and 4 absent because there is no frequency peaks for it.

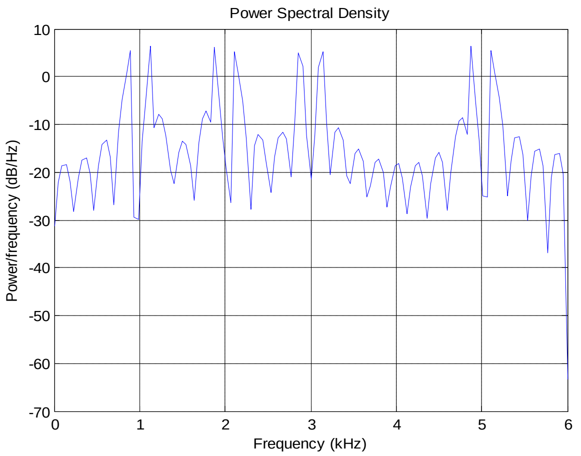

Figure 4(b): Power Spectral Density When First Gap allocated to Secondary User

Cognitive Radio system will search the first available gap (Spectrum hole) in the spectrum and automatically assign it to the secondary user .The first available gap was occupied by the secondary user it is shown in the Figure 4(b)

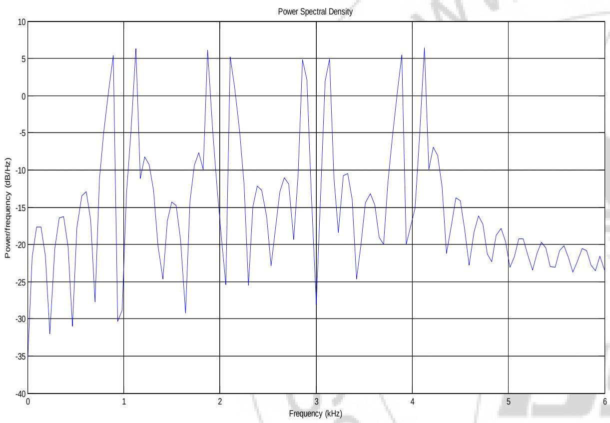

Figure 5(a): Power spectral density when user 5 leave spectrum free

When user 5 leaves the spectrum free then secondary user can access the band. Figure5 (a) shows that users 1, 2, 3 and 4 are present while 5 is absent because there is no frequency peak for it.

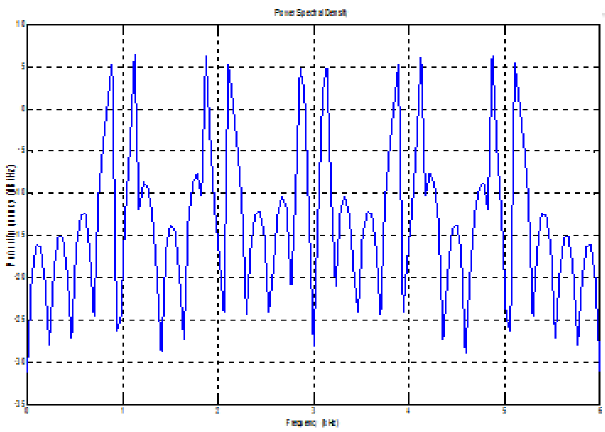

Figure 5 (b): Power Spectral Density when Spectrum gap is allocated to secondary user

The available gap of user 5 was occupied by the secondary user as shown in the Figure5 (b).

References

[1] Bhumika Pahwa Information Technology Department, Banasthali Vidyapith Jaipur Rajasthan, India, “Simulation of Cognitive Radio Using Periodogram" International Journal of Engineering Research & Technology (IJERT)
Vol. 2 Issue 9, September - 2013
IJERT
ISSN: 2278-0181 pp 2217-2219.

[2] Anurag Bansal and Ms. Rita Mahajan, “Building cognitive radio syatems using matlab”, International Journal of Electronics and Computer Science Engineering, Volume 1, Number 3

[3] Tushar D. Mohite1, Dr. M. S. Gaikwad2, Prof. S. B. Gholap Dept. of Electronics and Telecommunication Engineering STES’s Sinhgad Institute of Technology, Lonavala, University of Pune, India
“Cognitive Radio System Analysis Using MATLAB” International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 3, March 2014)
156. pp 158-159

[4] Seema Hanchate Assit. prof. Electronic & tele. UMIT, SNDT University, Mumbai, India,
Shisha Neema prof.Electronics&tele.UMIT, SNDT University, Mumbai, India
Sanjay pawer prof.Electronics &tele.UMIT, SNDT University, Mumbai, India, Vivek Dethe Research scholar Of master of Engg.Vidyalankar Inst of Tech
“Implementation of spectrum sensing algorithms in cognitive radio” Volume 4, Issue 7, July 2014 ISSN: 2277 128X International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper Available online at: www.ijarcsse.com

[5] Tevfik Y¨ucek and H¨useyin Arslan,‖ A Survey of Spectrum Sensing Algorithms for Cognitive Radio Applications‖, IEEE communications surveys & tutorials, vol. 11, no. 1, first quarter 2009

[6] IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 13, NO. 3, MARCH 2014 “Two Dimension Spectrum Allocation for Cognitive Radio Networks” Changle Li, Member, IEEE, Zhe Liu, Xiaoyan Geng, Mo Dong, Feng Yang, Xiaoying Gan, Xiaohua Tian, and Xinbing Wang, Senior Member, IEEE

Author Profile

Miss. Kalindi Bakare , received the B.E. degree in Electronics Engineering from Rajarambapu Institute of Technology Sakharale, Islampur in 2006 from Shivaji University Kolhapur, India

Prof. Maruti Limkar, Working as Assistant Professor at Department of Electronics, Terna College of Engineering, Nerul, Mumbai, India

Prof. Sonali Jadhav ,Working as Assistant Professor at EXTC Department, PVP College of Engineering, Sion, Mumbai, India