ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

Energy Detection Using Discrete Wavelet Transform in Cognitive Radio System

Dakshata Patel, Prof. Vineeta P. Gejji

M. Tech, Dept. of E&C, KLS Gogte Institute of Technology, Belgaum, India

Associate Professor, Dept. of E&C, KLS Gogte Institute of Technology, Belgaum, India

ABSTRACT: Cognitive radio system is an intelligent wireless communication system. The main goal of Cognitive radio system is to optimized use of radio frequency spectrum, so that the maximum amount of data can be transmitted with the fewest transmission errors. Spectrum detection technique (also referred to as spectrum sensing) enables CR networks to adapt to the environment by detecting spectrum holes, and the most efficient way to detect the spectrum holes is to detect the presence of primary users .In this paper we have used time based dynamic spectrum allocation and DWT Energy detection method for selection of primary users.

KEYWORDS: Cognitive Radio System (CR), Radio Frequency Spectrum, Spectrum detection Techniques, Primary Users, DWPT

I. INTRODUCTION

Radio waves can be used for wireless communication. Radio waves are a form of electromagnetic radiation which cannot be perceived by human eyes or ears, and they are not harmful to the environment. Depending on their frequency radio waves can pass through solid objects and travel long distances. This makes them useful for mobile communications, broadcasting and many other wireless applications.

All communication devices that use digital radio transmissions operate in a similar way. They uses antenna for transmitting generated signal, to capture by the receiver and also to radiate into the environment. In the case of a mobile phone call, a caller's voice is converted by the handset into digital data, transmitted via radio to the network operator's nearest tower or base station, transferred to another base station serving the recipient's location, and then transmitted again to the recipient's phone, which converts the signal back into audio through the earpiece.

Cognitive radio system works under radio frequency spectrum. Cognitive radio system is an intelligent system which automatically detects the free channels in a wireless spectrum and ability to change its parameter for transmission enabling more communication to run concurrently and also improve radio operating behaviour. Cognitive radio system uses a number of technologies Adaptive Radio where the communications system monitors and modifies its own performance and Software Defined Radio (SDR) where traditional hardware components including mixers, modulators and amplifies have been replaced with intelligent software.

Cognitive Radio offers optimal diversity (in frequency, power, modulation, coding, space, time, polarization and so on) which leads to: Spectrum Efficiency, Higher bandwidth services, Graceful Degradation of Services, Improved Quality of Service, Commercial Exploitation, Benefits to the Service Provider, Future-proofed product, Common hardware platform, Flexible regulation, Emergency service communications, and Benefits to the Licensee.

Development of cognitive radios includes the following applications:

- Collaborative networks,
- Maintenance and fault detection networks,
- Self organized networks, and
- Cognitive multiple input multiple outputs (MIMO).

There are various new generation wireless applications and services in which we can add CR capabilities. Some of these applications are as follows Future (upcoming) internet services- upcoming internet services supporting wide band, high data rates, and seamless quality of service guarantee for various multimedia and other applications. Multimedia downloads in mobile- To download music, video and other files in portable player, requires moderate data

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

rates and good coverage. Communication during emergency services- we require localized coverage and moderate data rates at the time of emergency for communication. (Military, surveillance etc.) Wireless multimedia services- For audio, video distribution using wireless system requires higher data rates.

II. RELATED WORK

Haykin et.al[1] lists the following drivers for the development of cognitive radios in proved spectrum utilization, regulators , US Department of Defence, international driver examples, standardization bodies, IEEE push for the development of new standards with cognitive radio capabilities, and research programs.

A classical paper [3] in which he measure the performance of the energy detector is analyzed using probability of the detection Pd verses SNR curves for different value of probability operation of an AWGN channel, respectively, In this paper shows that by increasing in SNR performance of the energy detector is get increase .If the time bandwidth factor increase, the detection probability decreases. The false alarm also effect on the probability of the detection ie the probability of the detection increases with increase in the false alarm. So through this paper he gave the suitable result for the SNR for the energy detector.

paper[4] the simulation is based on the probability of the detection vs. the probability of the false alarm. The probability of the detection varies based on the SNR, False alarm probability and various time bandwidth factors. When the SNR increases the detection probability also increases and SNR =25 db is better when the probability of the detection is 1. As the bandwidth factor is increase the probability of the detection is get increase time bandwidth factor. If the false alarm increases, the detection probability increases.

Sakharale,M.S, in paper[5] was proposed to measure the received signal power and estimated noise power . It is also consider the probability of the detection of the received signal with the respect SNR. The simulation results had shown the performance of the two stage wavelet packet decomposition with db5 as wavelet filter and chooses BPSK as PU signal, where the experiment is performed under AWGN channel and SNR is changed from -10 to 0 dB . The energy detection algorithm which is based for evaluating the performance of the once we decompose our signal at higher level and also by increasing the SNR range of the signal we cannot determine better result .The evaluation of the WPED is quit robust method for the spectrum sensing when the noise is unknown.

Omar A. M .Aly Abdel-Rahman Al-Qawasmi also proposed a paper [6]. In this paper is proposed for the precession sensing in a cognitive radio system is the energy detector based on Wavelet Packet Transform (WPT). However, energy detector sensing is affected by signal to noise ratio (SNR) in this paper; a new immune algorithm for spectrum sensing is introduced. This algorithm combines two powerful tools: the wavelet packet analysis and Higher-Order -Statistics (HOS).The use of the proposed technique makes spectrum sensing possible in very low SNR condition. This allows better utilization of the unoccupied spectrum and high spectrum efficiency usage. The proposed algorithm is able to identify the unoccupied sub channel especially at very low SNR; the proposed algorithm has been tested for SNR down to -4 dB and proved to work successfully. A comparison between the proposed algorithm and various energy detectors has been done.

III. PROPOSED SYSTEM

In Cognitive Radio system, there are two types of users: primary users and secondary users. Primary users are licensed users who are assigned with certain channels, and secondary users are unlicensed users who are allowed to use the channels assigned to a primary user only when they do not cause any harmful interference to the primary user. Is showed in figure1 and includes following components:

A. Create Primary User:

We create a list of primary users because as if a primary user's signal is detected, the secondary user should not use those channels to avoid interfering with the transmission of the primary user. To avoid these interfaces before starting transmission we will identify all the primary users.

B. Initialize Spectrum

In this module, initialize the 5 Carrier Frequency Bands for Users and also initialize Message Frequency and the Sampling Frequency.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

C. Assign timer to Primary Uses:

Primary users and cognitive radios share the spectrum under time domain. When the primary user starts accessing its spectrum a timer is assigned. Sensing the usage of spectrum in the time domain will determine vacant time slots for opportunistic use. Figure 2 shows the usage opportunity in the frequency and time domain

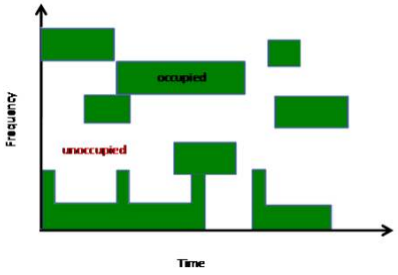

Figure 2: frequency and time domain

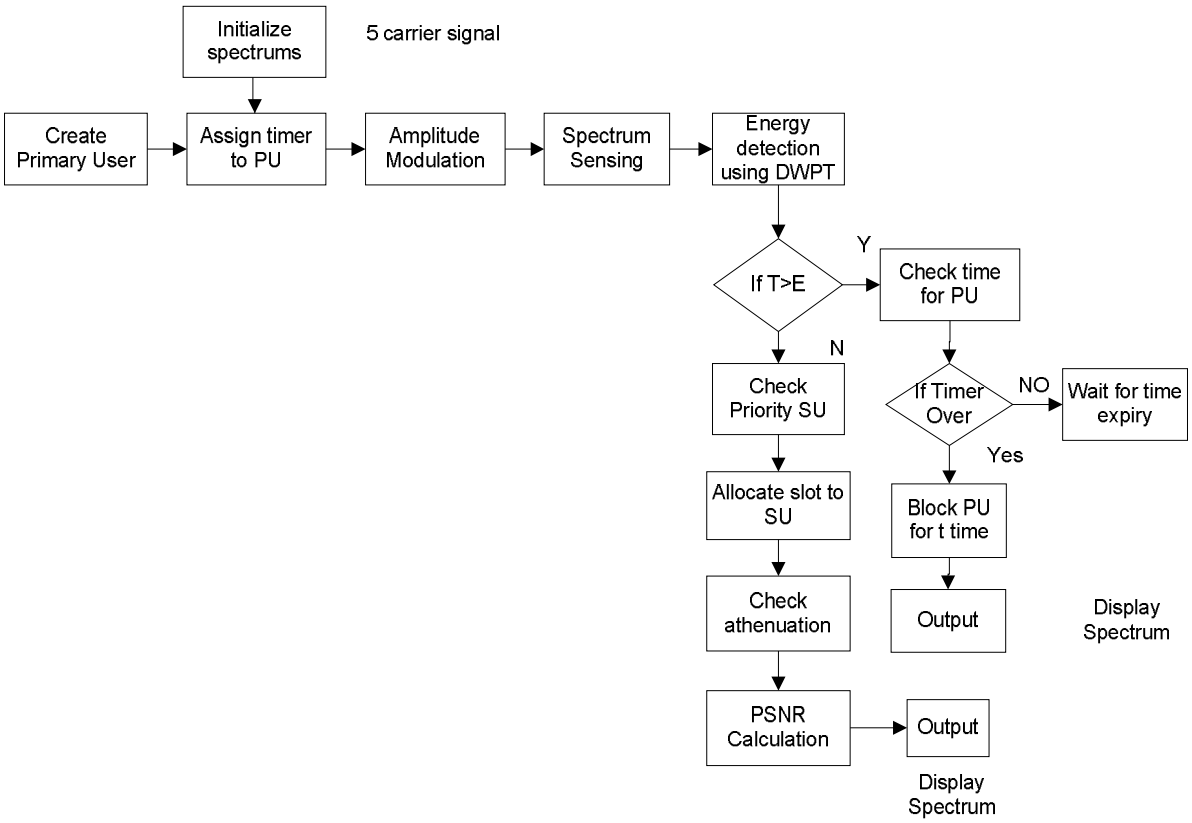

Figure 1: Proposed Architecture.

D. Amplitude Modulation

Modulates user data over the respective frequency band using amplitude modulation

E. Spectrum Sensing

Spectrum Sensing: It refers to detecting the unused spectrum and sharing it without harmful interference with other users. It is an important requirement of the Cognitive Radio network to sense spectrum holes, detecting primary users is the most efficient way to detect spectrum holes. Can classify the RF spectrum into three types:

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

- black spaces,
- gray spaces and
- white spaces

Black spaces are occupied by high power local interfere some of the time and unlicensed users should avoid those spaces at that time. Gray spaces are partially occupied by low power interference, but they are still candidates for secondary use. White spaces are free RF interference except for ambient noise made up of natural and artificial forms of noise, e.g. thermal noise, transient reflection and impulsive noise. White spaces are obvious candidates for secondary use.

There are several different ways to sensing techniques can classified as transmitter detection, cooperative detection and interference-based detection. The classification of spectrum sensing techniques:

- Matched filter detection
- Energy detection
- Feature detection
- Cooperative detection
- Interference-based detection

In this paper, we will use an Energy detection technique using DWT.

F. DWT

Energy detection (also denoted as non-coherent detection), is the signal detection mechanism using an energy detector (also known as radiometer) to specify the presence or absence of signal in the band.

DWT based energy detector, is first performed to select unoccupied candidate channels, and then one of the channels is examined by the fine sensing to detect weak signals. Finally, using outputs of above the sensing stages, unoccupied channel set is made for unlicensed (or CR) users. DWT can separate a given frequency band into a low frequency sub band and a high-frequency sub band. The proposed DWT based energy detector is designed based on this property. Before commenting about the idea, we first assume that B_i and B_c are an interested frequency band (or scanning range) and a bandwidth of each channel respectively. We also assume that the ratio of between B_i and B_c is a power of 2. The procedure of the idea, DWT based energy detector, is shown in Figure 3

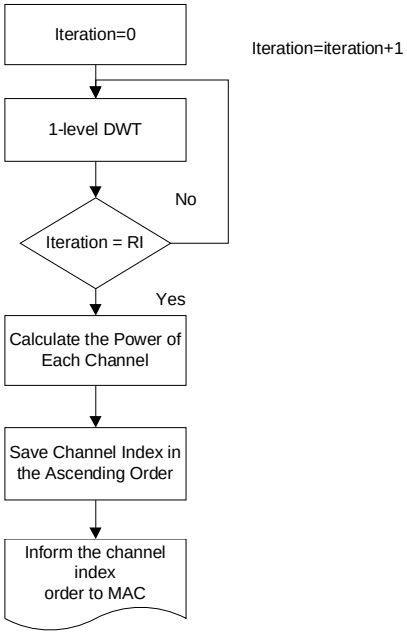

Figure 3: Flowchart for DWT

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

The classical method is based on the energy detection of the energy detector in which analog signal is passes through the band pass filter(BPF) with central frequency of 128MHz removes the frequency which is out of the band . This analog signal is which have central frequency f_c and sideband of $f_c - f_m$, $f_c + f_m$, where fm is message frequency of 64 MHz This signal is passing through the analog to digital converter which gives the digital bit streams y[n] which is given as follows:

y[n] = s[n]+ w[n] n= 0,1,2,.....N-1 s and w (n) is additive white Gaussian noise σ_s

Where s(n) is primary user (PU) signal with Zero mean and variance of w(n) . According to these method two hypotheses is can be tested in it. (AWGN) with zero mean and variance σ_w

H0:y(n) = w(n) n = 0,1,.....N-1

But if signal is represented by $s(n) \neq 0$.Then it shows the presence of primary user

H0: y (n) = s (n) + w(n) n= 0,1,……..N-1

So the digital bit stream will be processed separately by few steps which described as follows.

- A random signal is generated
- Additive White Gaussian noise is added.
- The signal is added with AWGN and the new signal is obtained whose WPT is found out
- y (n) is sent to WPT to estimate current noise power σ_w^{*2} and signal powerσ_s^{*2}.
- By calculating the energy of y(n) we get the test statistic

$$y = \sum_{n=0}^{N-1} |y(n)|^2 \quad (1)$$

- The level of threshold is decided and variance is calculated.
- Probability of detection is calculated at various SNR Using different WPT families. The test of statistic Y is a random variable whose PDF is measured on the basis of the Chi- Square distribution function, but when the value of the N is sufficiently larger then it is mandatory to focus on the Gaussian distribution function using central limit theorem.

The signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor. Once the threshold is selected for detecting the primary users following steps are continued

a) If threshold T is greater than Energy detected E, check for time slot assigned for Primary users if time is left, secondary users need to wait for time expiry for spectrum use.
b) If the time slot for primary user is over then block that slot and check for priority for allocation of secondary users and before allocating the spectrum licence for secondary users need to be authenticated and the allocate the particular slot for the users.

G. PSNR Calculation:

Peak Signal to Noise Ratio is the maximum possible power of signal and the power of corrupting noise. For improving the performance of detectors we implemented PSNR calculation. PSNR is mostly easily defined via the mean squared error (MSE).The mean squared error (MSE) of an estimator measure the average of the squares of errors that is the difference between the estimator and what is estimated. The MSE is the second moment (about the origin) of the error, and thus incorporates both the variance of the estimator and is bias. MAXI is higher and better, Acceptable values for wireless transmission quality loss are considered to be about 20dB to 25dB Calculation of PSNR: For three detectors PSNR is calculated using formula in simulation

a) $$PSNR = 10 * \log_{10}\left(\frac{Max_1^L}{MSE}\right) \quad (2)$$

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

IV. EXPECTED RESULTS

In this section shows different performance evaluation graphs as a result of our proposed system.

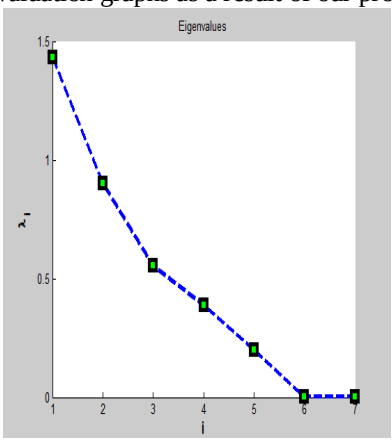

Figure 4: Shows the graph for eigenvalues

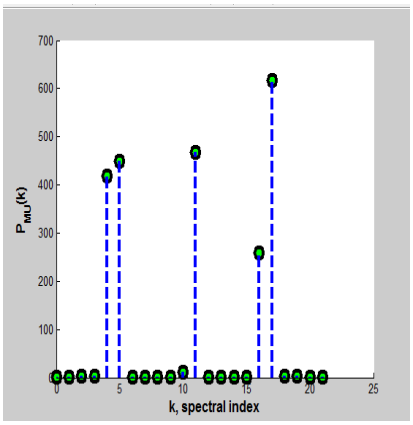

Figure 5: Shows the graph of frequency graph

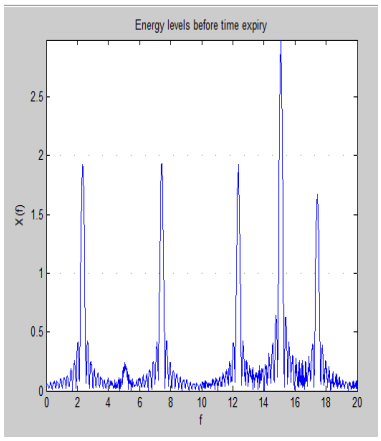

Figure 6: Shows the graph of Energy levels before time expiry.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

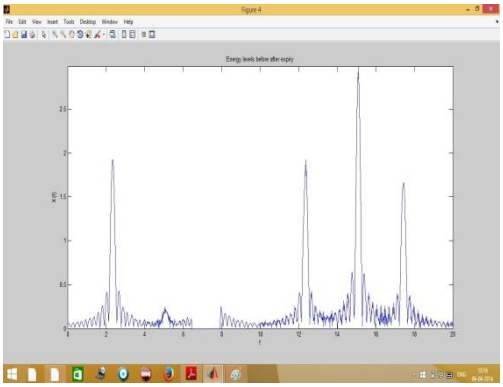

Figure 7.shows graph after sensing

V. CONCLUSION

Energy detection is the most common way of spectrum sensing because of its low computational and implementation complexities. In this paper DWT energy detection algorithm is used to find the frequency spectrum is vacant or not. Results of performance evaluation shows the results of frequency spectrum, energy levels based on time and efficient allocation of spectrum for secondary users.

REFERENCES

[1]. S. Haykin, "Cognitive Radio: Brain-empowered wireless Communications," IEEE J. Sel. Areas Communication, Vol. 23, pp. 201- 220, 2005.
[2]. Simon Haykin, David J. Thomson and Jeffrey H. Reed, "Sensing for Cognitive Radio" IEEE transaction Communication, Vol.97, No. 5, pp. 0018-9219, 2009
[3]. Sumit Lohan and Rita Mahaj "Performance Evaluation of New Energy Detection Based Spectrum Sensing Methods" in Cognitive Radio International Journal of Scientific & Engineering Research, Volume 4, Issue 7, ISSN 2229-5518, IJSER 2013, pp 1999-2004, 2013.
[4]. Md.Shamin Hossain and Md. Ibrahim Abdullah and Mohammad Alamgir Hossain "Energy Detection performance of the spectrum sensing in cognitive radio" I.J. Information Technology and Computer Science, Vol. 11, pp 11-17 ,2012.
[5]. Ms. Shrutika S. Sawant1, Prof. M. S. Kumbhar "Wavelet Packet Transform Based Energy Detector for Spectrum Sensing " International Journal of Emerging Technology and Advanced Engineering ,ISSN 2250-2459, Vol. 2, No. 3, 2012
[6]. Omar A. M. Aly, Abdel-Rahman Al-Qawasmi and Ahmed G. Abo-khalil "Noise Immune Spectrum Sensing Algorithm for Cognitive Radio" National Telecommunication Institute, Egypt April 16, 18, 2013.
[7]. Raza Umar, Asrar U. H. Sheikh, Mohamed Deriche "Unveiling the Hidden Assumptions of Energy Detector Based Spectrum Sensing for Cognitive Radios", IEEE Transaction. Communication, surey and tutorials, Vol. 3, No.99 pp 1-16 ISSN :1553-877X , 2013.
[8]. Youngwoo Youn, Hyoungsuk Jeon, Hoiyoon Jung Discrete "Wavelet Packet Transform based Energy Detector for Cognitive Radios" IEEE Transaction Information and Communication ,pp 26412645 ISSN 1550-2252 ,2007
[9]. Sung-Hyun Kim "Selective Discrete Wavelet Packet Transform Based Energy Detector For Cognitive radios "Information and communication, pp 49, 2009.
[10]. Arti Gupta , Savitri Katariya "performance evalution of the energy detection using Haar waveletfor spectrum sensing in cognitive radio "International Journal of Engineering Research and Technology Vol. 1, No. 9, pp. 2278 – 0181, 2012, ISSN.