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Efficient Spectrum Sensing In Cognitive Radio Using Energy Detection Method using Time Domain

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Abstract- Cognitive Radio has been receiving increasing attention in academic field, industry and government. Today's wireless networks are characterized by a fixed spectrum assignment policy. However, a large portion of the assigned spectrum is used sporadically and with geographical variations in the utilization of assigned spectrum ranges from 15% to 85% with a high variance at times time. 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 NeXt Generation (xG) Networks as well as Dynamic Spectrum Access (DSA) and cognitive radio networks. While sensing the spectrum following points should be considered.(i) Spectrum sensing bandwidth: There are a number of issues associated with the spectrum sensing bandwidth. The first is effectively the number of channels on which the system will sense whether they are occupied.(ii) Transmission type sensing: The system must be capable of identifying the transmission of the primary user for the channel. It must also identify transmissions of other units in the same system as itself (iii) Spectrum sensing accuracy***:*** The cognitive radio spectrum sensing mechanism must be able to detect any other signal levels accurately so that the number of false alarms is minimized. (iv) Spectrum sensing timing windows***:*** It is necessary that the cognitive radio spectrum sensing methodology allows time slots when it does not transmit to enable the system to detect other signals. Different spectrum sensing techniques are available. Through this paper we would like to share the analysis and results obtained for time and frequency domain using new threshold formula in energy detection method.

Index Terms- Cognitive radio, Threshold, Sampled frequency, False alarm probability, Detection probability, Modulation type.

1. INTRODUCTION

With the growing need for wireless communication wireless spectrum resources have been exhausted. Spectrum sensing technique is key functionality for identifying the spectrum

usage status over a wide frequency range covering various communication standards. Its most critical performance requirements are accuracy and time of spectrum sensing.

Various spectrum sensing method have been proposed so far [6-8]. The energy detection method enables fast sensing speed and simple implementation. However as its sensing accuracy depends on selection of threshold level.

Presently, wireless communication is in need of spectrum resources. Since the Spectrum resources are limited, the available spectrum resources must be utilized intelligently. The technique used for identifying the spectrum usage is called Spectrum sensing. Accuracy and time are the most important parameters of spectrum sensing [14]. Various spectrum sensing methods are available. The energy detection method is one of the methods available for fast sensing. The implementation of this method is also simple. However, its sensing accuracy depends on selection of threshold level [6, 8].

Cognitive radio is an intelligent wireless communication system which adaptively reconfigures itself to maximize resource utilization [1]. IEEE 1900 is a standard initiated by IEEE for the CR networks [9]. Figure 1 gives application scenarios where dynamic and opportunistic spectrum access is used [9]. In these scenarios, sensors are sometimes standalone or can form a small network of collaborating sensors giving information about the available spectrum [9]. Figure 2 shows various interfaces suggested by IEEE 1900.6 standards. Data archive interface is used to store sensed information. Cognitive engine interface is used to utilize cognitive capabilities. Implementation of spectrum access policies is also carried out by this interface. Sensor interface is used to get sensing information. Information exchange between various interfaces is necessary [9].

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The rest of the paper is organised as follows. Section II explains related work. Section III gives detailed system model. Section IV explains proposed system and section V concludes the paper

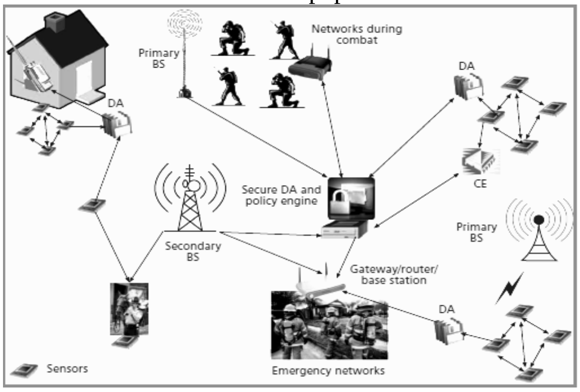

Figure 1. Application scenarios [9]

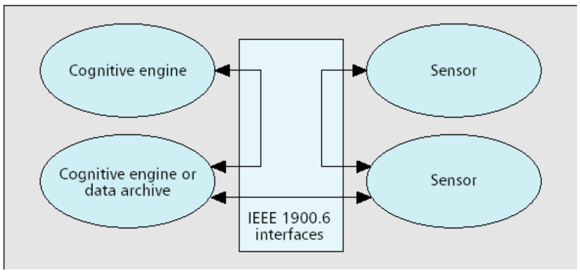

Figure 2 Entities and interfaces [9].

2 RELATED WORK

This paper (12) analyses the energy detector that is commonly used to detect the presence of unknown information-bearing signals. The algorithm simply compares the energy (or power) in a sliding window to a threshold. The analysis allows for arbitrary spectra of information bearing signal and noise processes. It yields two equations that relate five variables/parameters: the probability of false detection, the probability of missing a detection, window length, detection threshold, and signal to noise ratio (SNR). The probability density function of the detection variable is shown to be approximately Gamma distributed. All of the theoretical expressions and approximations are substantiated with simulation results. This paper develops two equations (approximations) that relate two performance measures to three design parameters. That is, they relate the probability of false detection and the probability of missing detection to window length, detection threshold, and signal-to-noise ratio (SNR). While the approximations developed are not exact, they are very useful in determining the window length and the decision threshold.

Paper (13) gives blindly combine the signal samples. Similar to energy detection, blindly combined energy detection (BCED) does not need any information of the source signal and the channel *a priori*. BCED can be much better than ED for highly correlated signals, and most importantly, it does not need noise power estimation and overcomes ED's susceptibility to noise uncertainty. Also, perfect synchronization is not required. Simulations based on wireless microphone signals and randomly generated signals are presented to verify the methods. BCED does not require any information (total blind). OCED can be treated as an ideal case and used as an upper bound. ED does not need the source signal property but needs the noise power. BCED can be much better than ED for highly correlated signals, and most importantly, it does not need noise power estimation and overcomes ED's susceptibility to noise uncertainty. BCED can be used for various signal detection applications without knowledge of the source signal and the channel.

Paper (14) gives the energy detection based cooperative sensing scheme greatly reduces the quiet period overhead (for sensing measurement) as well as sensing reporting overhead of the secondary systems and the power scheduling algorithm dynamically allocate the transmission power of the cooperative sensor nodes based on the channel statistics of the links to the BS as well as the quality of the sensing measurement. In order to obtain design insights, they also derive the asymptotic sensing performance of the proposed cooperative sensing framework based on the mobility model. They show that the false alarm and mis-detection performance of the proposed cooperative sensing framework improve as we increase the number of cooperative sensor nodes.

Paper (15) gives the performance of cooperative spectrum sensing with energy detection in cognitive radio networks. It has been found that the optimal decision voting rule to minimize the total error probability is the half-voting rule.A method of numerically obtaining the optimal detection threshold has been presented. In addition, an efficient spectrum sensing algorithm has been proposed which requires fewer than the total number of cognitive radios in cooperative spectrum sensing while satisfying a given error bound.

So we propose a system for spectrum sensing in cognitive radio using time domain method. Proposed system will use energy detection method for detection of signals. It is independent of modulation used for transmission of signal, phase or any other parameter. It simply tells if the radio resource is available at any given time instant or not.

3 SYSTEM MODEL

As shown in fig. 4. Parameter assumptions for system model: Number of cognitive radios = 18.

Type of radio = TVUHF.

TVUHF spectrum frequency range =470 MHz to 890MHz. TVUHF spectrum bandwidth = 6MHz.

Total channels = 70.

Modulation type = 16 QAM.

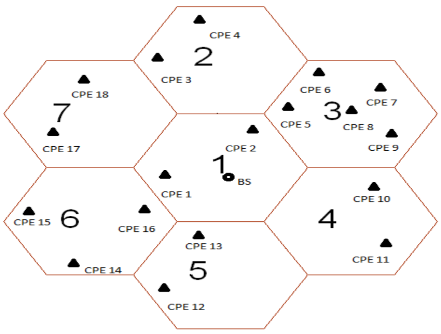

Figure 3: System model.

Sensing parameters are considered here Spectrum band for different radios (TVUHF, GSM, WiFi), Modulation type, SNR, Bandwidth, Pfa . Spectrum band is declared to be busy. Otherwise the band is supposed to be idle and could be accessed by CR users. The spectrum sensing problem can be formulated as a binary hypothesis testing problem with the following two hypothesis [10].

H0 : y[n] = w[n] n = 1; 2; : : : ;N……………………(1)

H1 : y[n] = x[n] + w[n] n = 1; 2; : : : ;N…………….(2)

Where

Y[N] received signal

H0 primary absent

H1 primary present

W[n] noise signal

X[n] spectrum signal

N number of samples

Decision threshold is an important aspect. The decision threshold λ could be chosen for an optimum trade-off between Pd and Pfa. However this would require knowledge of noise and detected powers. Observation time ts is 0.01sec. Number of samples (N) as per Nyquist criteria

N=2*ts*BW……………….(3)

The energy detection principle, measures the energy received in a primary band during an observation interval (ts) and declares the current channel state Si as busy hypothesis (H1). If the measured energy is greater than a properly set predefined threshold or idle hypothesis (H0) otherwise.BW is bandwidth of the signal.

$$Ti = \sum_{n=1}^{N} | Si[n] |^2 ....(4)$$

Where

Ti test computed in ith sensing events

$$\lambda = Q^{-1}(Pfa * \sqrt{2N} + N)\sigma_n^2 ....(5)$$

In eq.(5) Q function is the tail probability of the standard normal distribution.

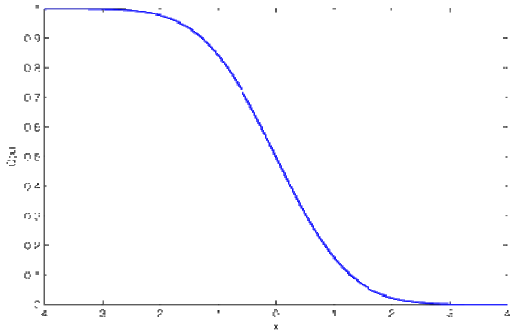

Figure:4 Q -function

σ_n is noise signal power variance. N is number of samples. Pfa is False alarm probability.

5 EXPERIMENTATION AND RESULTS

Graphical user interface (GUI) is shown in fig. 6.

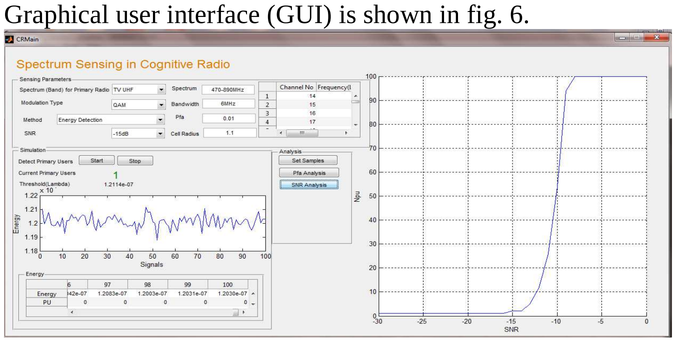

Figure 5: GUI for Spectrum Sensing.

Analysis of time domain spectrum sensing for TVUHF radio is as shown in figure 6.

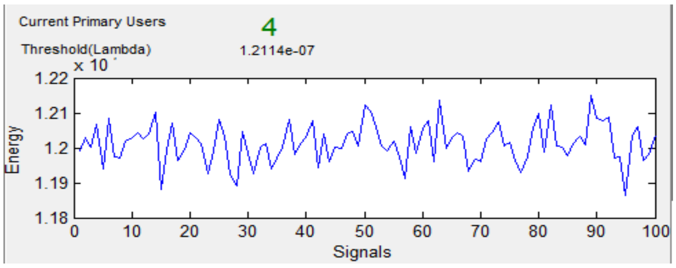

Figure 6: Sensed TVUHF spectrum at SNR= -10 dB.

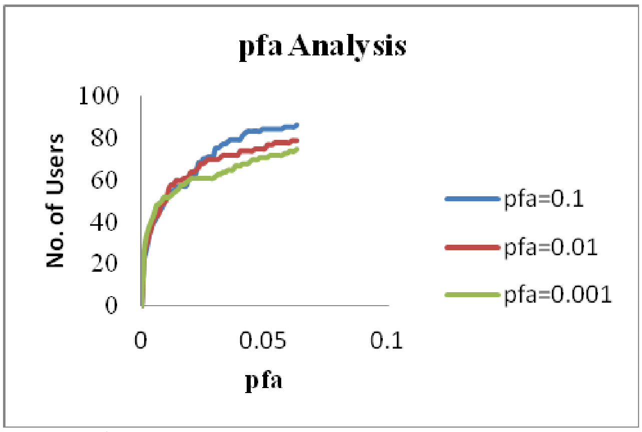

Figure 7: Pfa analysis

In figure 7 shows analysis of Pfa for different values of pfa, at SNR=-10Db.We get maximum number of users are more than 80 at Pfa=0.1. number of users reduces to 76 at Pfa=0.01,number of users are reduces to 70 at Pfa=0.001.So we may conclude here pfa=0.1 is prefered in our system.In Figure 8 shows analysis of SNR for different SNR values.We get appropriate SNR analysis at Pfa=0.1.We get maximum number of users when SNR is less as SNR increases detection reduces.

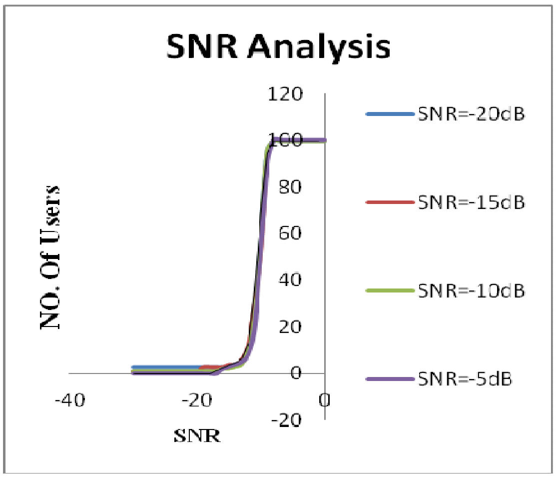

Figure 8: percentage Detection Analysis for TVUHF.

6 CONCLUSION

In time domain analysis we get detection for number of users as per threshold formula. As per analysis of pfa preferable pfa=0.1. As per analysis of SNR detection is best when noise is low. In time domain we do not get frequency of the user. So our future work is related with frequency domain. Present work is related with 16QAM modulation. Our future work is related to analysis and implementation of digital modulation OFDM in cognitive radio.

Our future work will be performing spectrum sensing using frequency domain method.

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