Spectrum Sensing in Cognitive Radio using Energy Detection under Non Fading Environment

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Abstract:-The growing demand for wireless applications leads to the effective utilization of available spectrum. The explosion of wireless applications creates an ever-increasing demand for more radio spectrum. However these bands are significantly underutilized due to static allocation. The issue of spectrum underutilization can be solved in a better way by using cognitive radio technology.
Cognitive Radio can able to sense smartly and adapts with the changing environment. The main issues with cognitive radios are that it should not interfere with the primary users and should vacate the band when it is required. For this purpose energy detector is discussed in this paper and performance evaluation of this is calculated. The performance evaluation is done between cooperative and non cooperative spectrum sensing schemes under non fading environment.

Key words: *Cognitive radio-Energy detection-Non fading environment.*

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I. INTRODUCTION:

Cognitive radios is a latest trend in wireless communication technology which interacts with real time environment to dynamically alter its operating parameters such as transmit power, carrier frequency, modulation to acclimate itself with the environment whenever there is a statistical change in the incoming radio frequency with the sole purpose to take advantage of the available spectrum without causing interference to primary users[1].

CR Consists of the following important steps
1. Spectrum sensing
2. Spectrum decision
3. Spectrum sharing
4. Spectrum mobility

Spectrum sensing is the process of a cognitive radio sensing the channel and determining if a primary user is present, detecting the spectrum holes. Spectrum management is selecting the best available channel (for a cognitive user) over the available channels. Spectrum sharing is the allocation of available frequencies between the cognitive users. Spectrum mobility is the case when a secondary user rapidly allocates the channel to the primary user when a primary user wants to retransmit again.

The most efficient way to detect spectrum holes is to detect the primary users which receives data within the communication range. But it is difficult for a cognitive radio to have a direct measurement of a channel between a primary receiver and a transmitter. Generally, the spectrum sensing techniques can classify as [3];

Non- cooperative detection:-This form of spectrum sensing occurs when a cognitive radio acts on its own. The cognitive radio will configure itself according to the signals it can detect and the information with which it is preloaded.

Cooperative detection:- Within a cooperative cognitive radio spectrum sensing systems ,sensing will be undertaken by a number of different radios within a cognitive radio network. Typically a central station will receive reports of signals from a variety of radios in the network and adjust the overall cognitive radio network to suit.

Energy detector (ED) is a one of the best spectrum sensing technique that does not require prior information about the primary signal. This will give best results at low SNR. Cooperative spectrum sensing technique is proposed to eliminate the effects of shadowing and multipath fading on the spectrum sensing of primary user [2].
Hence, this work evaluates the performance of the energy detection based spectrum sensing technique in Additive White Gaussian Noise (AWGN) channel.

II. SYSTEM MODEL

In an energy detector, the received signal ie.input signal is filtered using a band pass filter (BPF). The band pass filter reduces the bandwidth of the noise. The output signal from the integrator is compared with a threshold value so that the presence of primary is detected. Figure 1 shows a block diagram of an energy detector.

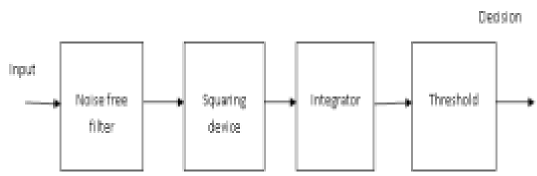

Figure 1. Block Diagram of Energy Detector

The hypothesis problem can be defined as

$$y(t) = \begin{cases} \mathcal{H}_0: & n(t) \\ \mathcal{H}_1: & hs(t) + n(t). \end{cases}$$

Where y (t) is the received signal by the cognitive user, s (t) is the transmitted signal from the licensed user, n (t) is the Additive White Gaussian Noise (AWGN), and h is the amplitude gain of the channel. H0 states that there is no licensed user signal in the analyzed spectrum band. H1 indicates that there exists a Primary user signal.

To measure the performance of the energy detector the following metrics are used
1. The probability of detection (PD)
2. The probability of false alarm (PFA)
3. The probability of missed detection (PM)

The (PD) is an indicator of the level of interference protection provided to the primary user. A false alarm event occurs when the detector assigns H1, when the right decision is H0. The probability of this occurrence is termed as a probability of false alarm. The probability of declaring the spectrum space vacant H0, in fact occupied H1, is referred to as the probability of missed detection (PM).
Algorithm for energy detection.

1. First step is to transmit signals of primary user.
2. At receiver, the received signal y(t) is calculated
3. Estimate the power spectrum density of signal y(t)
4. The signal power is compared with a threshold and if it is found above the threshold, then the result of the detector is that a primary user is present otherwise not present
5. Plot the probability of detection, Probability of false alarm

III. PROBABILITY OF DETECTION

Probability of Detection for AWGN Channel

The additive white Gaussian noise (AWGN) is a channel model where the only harm to communication is noise; with a constant spectral density. In this model, noise have zero mean and is assumed as white over the considered bandwidth [7].

Probability of detection Pd and false Alarm Pf can be evaluated

$$P_d = P\left(Y' > \wedge \mid H_1\right) \tag{1}$$

$$P_f = P\left(Y' > \wedge \mid H_0\right) \tag{2}$$

Where Λ is decision threshold, Also, Pf can be written in terms of Probability density function as

$$P_f = \int_{\wedge}^{\infty} f_{Y'}(y)dy \tag{3}$$

$$P_f = \frac{1}{\left(2^d \Gamma(d)\right)} \int_{\wedge}^{\infty} y^{d-1} e^{-(y/2)} dy \tag{4}$$

Dividing and multiplying the RHS of above equation by 2d-1, we get,

$$P_f = \frac{1}{2\Gamma(d)} \int_{\wedge}^{\infty} \left(\frac{y}{2}\right)^{d-1} e^{-\left(\frac{y}{2}\right)} dy \tag{5}$$

Substituting $\frac{y}{2} = t, \frac{dy}{2} = dt$ and changing the limits of integration to,(^/2,∞) we get,

$$P_f = \frac{1}{2\Gamma(d)} \int_{\frac{\wedge}{2}}^{\infty} t^{d-1} e^{-(t)} dt \tag{6}$$

(or)

$$P_f = \frac{\Gamma\left(d, \frac{\wedge}{2}\right)}{\Gamma(d)} \tag{7}$$

Where, Γ (.) is the incomplete gamma function. Now, probability of detection can be written by making use of cumulative distribution function

$$P_d = 1 - F_{Y'}(\wedge) \tag{8}$$

The cumulative distribution function (CDF) of Y’ can be obtained

$$F_{y'}(y) = 1 - Q_d \sqrt{\lambda}, \sqrt{\wedge} \tag{9}$$

Therefore using (8) and (9), probability of detection Pd for AWGN channel is

$$P_d = Q_d\left(\sqrt{\lambda}, \sqrt{\wedge}\right) \tag{10}$$

$$P_d = Q_d\left(\sqrt{2\gamma}, \sqrt{\wedge}\right) \tag{11}$$

IV.SIMULATION MODEL

Thus the performance of an energy detector applied for non fading channel is evaluated using MATLAB version R2011 using the system parameters such as :

SNR: -10 dB No of users : 5,10

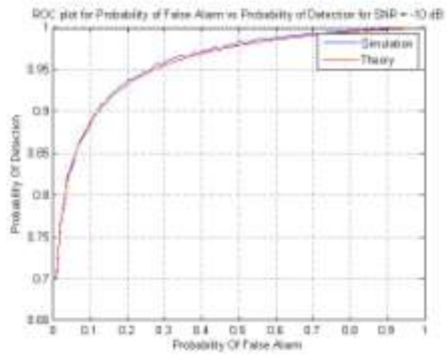

Figure2 : ROC curve for non cooperative communication

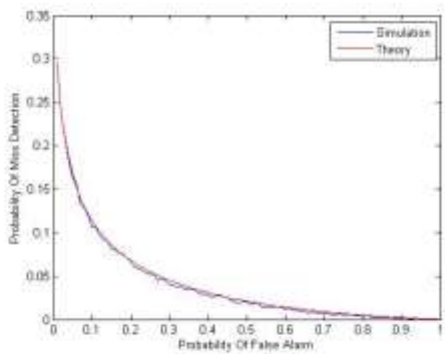

Figure 3: ROC curve for PMD Vs PFA

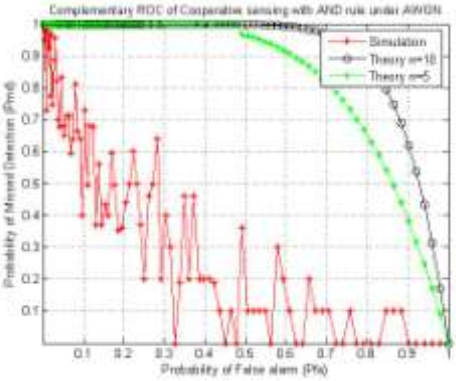

Figure 4 : Complimentary ROC curve for cooperative communication

Figure 2,3 and 4 shows the ROC curve for AWGN Channel under cooperative and Non cooperative Communication.
The Cooperative Communication with increase in users give the best performance over the Non cooperative environment.

V.CONCLUSION

The spectrum sensing using energy detector has been discussed. The performance of this in CSS scenario has been studied over AWGN channel. Significant reduction in probability of missed detection have been achieved with this sensing technique as evidenced from the simulation results.

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