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Implementation of Double Threshold Based Re-Sensing for Spectrum Energy Detection in Cognitive Radio

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Abstract— A cognitive radio is defined as a radio that can change its transmitter parameters based on the interaction with the environment in which it operates. It has the ability to sense and gather information such as the transmission frequency, bandwidth, power, modulation from the surrounding environment as well as has the ability of reconfigurability to swiftly adapt the operational parameters, for optimal performance, according to the information sensed. In cognitive radio network, the secondary users are allowed to utilize the frequency bands of primary users when these bands are not currently being used. To support this spectrum reuse functionality, the secondary users are required to sense the radio frequency environment, and once the primary users are found to be active, the secondary users are required to vacate the channel within a certain amount of time. In order to detect effectively the existence of primary user various techniques of spectrum sensing have been followed such as waveform, cyclostationary, entropy detection etc. But the adopted method for spectrum sensing is by using energy detection because of its less complexity in the primary user detection. Single, conventional double threshold techniques are proposed using energy detection, these are the existing methods. But in this scenario double threshold with re-sensing is implemented, for the effective detection of the primary user. Effective modulation technique has to be chosen for the implementation and resensing of the spectrum has to be performed if the detected energy lies between the two thresholds considered by increasing the number of samples, re-sensing has to be continued until the energy detected is greater than the highest threshold.

Keywords—Double Threshold, Resensing, Cognitive Radio

1. INTRODUCTION

Spectrum sensing is the method used in Cognitive Radio (CR) to find the unused spectrum. Based on spectrum sensing only other functions of CR can be implemented. So for Cognitive Radio, efficient spectrum sensing is compulsory and Spectrum sensing is an important aspect that maximizes the opportunistic usage of available spectrum. The cognitive/ secondary users have to sense the spectrum repeatedly to prevent interference to licensed users. In recent years, the rapid growth in wireless service increases the demand for the frequency spectrum. As a precious resource, the radio spectrum must be perfectly managed to maximize the utilization and minimize the interference. To meet the growing demand, new broadband communication technologies have been introduced to utilize the radio spectrum effectively. The spectrum use is intense on certain portions while a significant amount of spectrum remains underutilized. High utilization is common in the cellular and FM radio bands, while other bands indicate low usage levels. Most of the licensed users do not transmit all the time in all geographic locations where the license covers [1]. Records from the FCC indicate that spectrum allocated in the bands below 3GHz have a utilization range of 15% to 85%. The available spectrum is underutilized due to the static allocation of the spectrum. In the conventional spectrum management method, each operator is allocated with a certain frequency band and the licensed user operates in that particular band.

Hence it is tedious to find the vacant bands to deploy new services. Consequently, techniques that provide new ways of exploiting the available spectrum are required. As a result, Dynamic Spectrum Access (DSA) was proposed to solve the inefficiency caused by the static allocation of spectrum [2]. With this concept, use of existing radio spectrum is enhanced by opportunistic spectrum access (OSA) of the frequency bands that are not occupied by the licensed or primary user. Hence an efficient solution to overcome the underutilization of the spectrum band is obtained by the Cognitive Radio (CR) technology. Spectrum sensing by far is the most important component for the establishment of cognitive radio.

Spectrum sensing is the task of obtaining awareness about the spectrum usage and existence of primary users in a geographical area.

2.Related Work

Tellambura et al [12] investigate the generalized energy detector in which the squaring operation in conventional detector is replaced by positive operation. Expression for SNR wall is derived using various distributions and suggested that uniform distribution provides better performance than other distributions.

Saumya Dwivedi et al [13] discuss about the detection capability of a radio system that can be improved, when the sensing process is performed collectively by a group of nodes so that the effects of wireless fading and shadowing can be reduced. Considering the cooperative approach causes new security threats to the system as nodes can report false sensing data to reach a false decision. A secure cooperative spectrum sensing in cognitive radio networks is analysed. These algorithms provide an exact resolution about the presence or absence of some spectrum channels, ensuring the contribution from incapable users as well as malicious ones is discarded.

Duan et al [14] propose a new cooperative spectrum sensing algorithm based on reputation order to eliminate the fail sensing problem for a cognitive radio system with double threshold detector. The closed forms is derived for the normalized average number of sensing bits, the probabilities of the detection and the false-alarm . The average number of sensing bits decreases without sensing failure and the sensing performance is maximized when compared with the conventional double threshold detection and single threshold detection.

Treeumnuk et al. [15] wrote about cognitive radios (CR) that detect the use of spectrum and adjust the transmitted signals to meet particular spectral constraints to be used in the next generation of wireless systems. These systems should be able to dynamically access the frequency spectrum. In cooperative spectrum sensing, a FC (fusion center) took in local sensing information from several Cognitive Radios and combined it to generate better discretion on channel use.

Ghadikolaei et al [16] researched on modelling, performance analysis, and optimization of a distributed secondary network with a random sensing order policy for cognitive radio spectrum sensing, coordination and utilization. Specifically, once PUs' return, SUs generate a random order of available bands, and in a distributed manner, find optimal transmission and handoff opportunities.

Huang et al. [17] discussed the nature of talent in the energy-efficient Cognitive Radio based wireless access network by dividing them into different features, like transmit, cooperative radio and tiny cells. Visualizing green power energy as an essential energy source in the potential network form exceedingly depends on the dynamics of the existing spectrum and green power.

Atapattu et al [18] investigate the detection performance of an energy detector used for spectrum sensing in cognitive radio networks under very low signal-to-noise ratio (SNR) levels. A closed-form expression is derived for the average missed-detection probability over Rayleigh fading and Nakagami-m fading channels. To reduce the total error rate, an optimal threshold is considered.

Rabiee et al [19] studied the throughput performance of different energy detection (ED) schemes. Two of them were Improved ED or IED and Double Threshold-based IED. They were also subject to many detection constraints, in cases of two reporting channels. The latter method came back as favourite with maximum achievable throughput that was achievable over imperfect reporting channels.

Vien et al [20] used FC to help decide on spectrum availability for secondary users. Cooperative spectrum sensing was the technique used in CRNs. To enhance performance for sensing, a hybrid double-threshold based energy detection (HDTED) was incorporated. This method enabled each SU to exploit both local and global decisions to finally make a decision on the availability of spectrum.

Bagwari et al [21] wrote of analysis between proposed multiple energy detectors (MED) and cyclostationary feature detector-based spectrum sensing techniques based on comparisons. The final MED model used a spectrum sensing scheme called adaptive double-threshold (ADT).

3. Double Threshold method based energy sensing of spectrum.

In conventional energy detection technique, the secondary users take their decision by comparing the statistics with a predetermined threshold value. In double threshold detection method two thresholds are taken to decide about the presence or the absence of the signal. The selection of single threshold, inability to detect the spread spectrum signal and inability to differentiate between the

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interference signal and PU signal under low SNR condition are the main flaws in the case of the existing energy detection scheme.

MFD technique can be used only when the prerequisite information like modulation type, pilot carrier, pulse shape and spreading codes, etc. are known in prior to the cognitive user. In order to access all the prior information regarding the PU signal, synchronization is must between the cognitive user terminal and the primary user transmitter.

Single threshold flowchart has been provided below with all the necessary parameters for the estimation are also provided.

Flowchart for the double threshold method

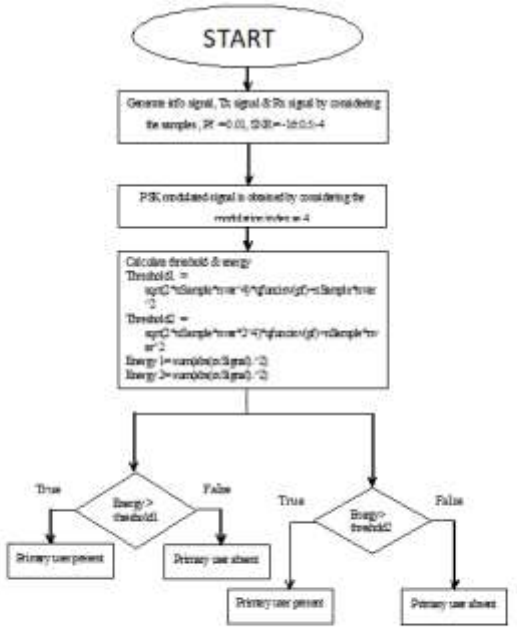

Figure 3.1: Flow chart for double threshold.

Above flowchart gives the information about the working principle of double threshold model. From the generation of the transmission signal and the reception of the signal using modulation index considered as four. Then the threshold calculation and energy calculation is performed.

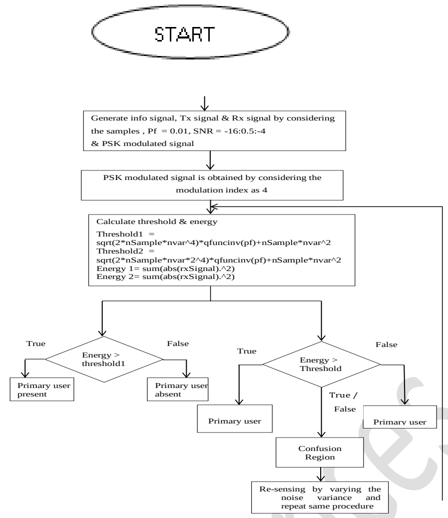

Figure 3.2: Flowchart for proposed system model

The decision device depicts the presence or absence of primary user. If the energy of the signal is greater than the threshold value, it indicates the presence of primary user. If it is less than the threshold value, the primary user is absent, hence the secondary user can access the spectrum. The performance of the energy detection depends greatly on setting the detection threshold and the SNR level of the received signal [9]. To adjust the threshold of detection, energy detector requires the knowledge of power of noise in the band to be sensed.

Figure 3.2 shows about the flowchart which gives the information about the working principle of re sensing double threshold model. From the generation of the transmission signal and the reception of the signal using modulation index considered as four. Then the threshold calculation and energy calculation is performed. Consider y(n) be the received signal at the cognitive radio terminal and x(n) be the transmitted signal at the primary nodes. We assume channel noise w(n) as Additive White Gaussian Noise

(AWGN) with zero mean and unit variance and number of samples as N.

The received signal y(t) consists of actual information and that added with the White Noise, practical scenario is of the same, since no signal is ideal it should be added with a noise component since white noise is called as the accumulation of all the noises, that is considered as the final one, and it also should ensure that the requirement of the samples will gets increased if the SNR is considered to be the largest, i.e. at large SNR the requirement of N is small, and for the small SNR, N should be large.

Algorithm proposed for the work

Step 1 : select p_{fa}= [0.01:0.01:0.1] and N = 1000 samples

Step 2 : compute the test static, given by

$$T(y) = \frac{1}{N}\sum_{n=1}^{N}|y(n)|^2$$

Step 3: Calculate the value of two thresholds V_{th0} and V_{th1}

Step 4: If test static is $\begin{cases} > \mathbf{V_{th0}} : \textbf{primary user is present} \\ \mathbf{V_{th1}} < \mathbf{T(y)} < \mathbf{V_{th0}} : \textbf{Re} - \textbf{sensing} \\ < \mathbf{V_{th1}} : \textbf{Primary user absent} \end{cases}$

Step 5: for re-sensing increment the value of N and go to step2.

Step 6: repeat from step 2 till a decision is made.

4. RESULTS

Introduction

Results, we compared among different values of SNR and Pd by using various modulation techniques. Because modulation plays a key role in varying the received signal parameters such as modulation index and if the signal is of digital then we need to consider about the number of samples etc.

4.1.Table: Simulation Parameters

S.no	Parameter	Values
1	N	1000.
2	SNR	-16:0.5:-4
3	M	4 for all the modulation techniques.
4	QPSK, BPSK,PSK Modulator	With Modulation index as 4.
5	No.of simulations	1000
6	Noise type	AWGN
7	Nvar	Represents noise variance which is considered as (1/SNR)
8	Threshold	This value is calculated based upon the Q factor and number of samples.

4.2. Pd V/S SNR for double threshold method.

A comparative analysis between single and double threshold is simulated, to show the better performance of the double threshold usage than the single threshold. Because the fixing of the threshold is very important in our entire analysis, we may give the values of the threshold for our convenience but it is important to consider the noise factor into the criteria also, because at low SNR the analyzing of the samples gets increases.

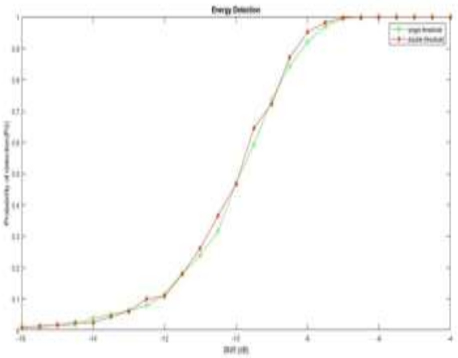

Figure 4.1: simulation result of energy detection of primary user using single and double threshold methods

When the results are analyzed a more better and appropriate results can be found out by using the double threshold phenomenon than that of the single threshold because of this kind of the analysis it will be very clear that whatever may be further step is considered that should be more appropriate and very much better to the approach which is followed in the second method of double threshold process

Table 4.2: Detection probabilities comparison between single and double threshold

Pd(%) comparison

S.No	SNR(dB)	Single threshold	Double threshold
1	-16	0.07	0.17
2	-14	0.37	0.37
3	-12	12.3	17.6
4	-10	44	61
5	-4	85.4	95.4

On simulating the Pd estimation with the existing single and double threshold methods an improvement in the Pd is obtained with double threshold method. The overall improvement is of about 32.6% from single to double threshold method.

A comparison of Pd between single threshold and double threshold methods have been shown, and it can be known from the above analysis that double threshold gives more accurate results than that of single threshold. For more better approximation an average of all the results were to be chosen and the average is needed to be compared with each and every parameter that which is taken for the above measurement to get the deviation in the values so that the approach will be very clear to get the accurate output.

A much more needed observation between the threshold and the Pf is as shown below which gives the information about the theoretical and practical comparison.

4.3 Probability of Detection Pd v/s SNR for Re-Sensing double threshold method

Now the work for the re-sensing method of double threshold for the probability of primary user detection has proven the better analysis besides the existing conventional models of single and double threshold methods.

This is proven from the figure given below, as it compares the parameters of probability of detection with the SNR for all the threshold methods and the parameters detected for all the thresholds has been noted down.

A final conclusion of result related to the work simulated below. The parameters detected were also provided here with the threshold and the energy cases at two threshold incidents

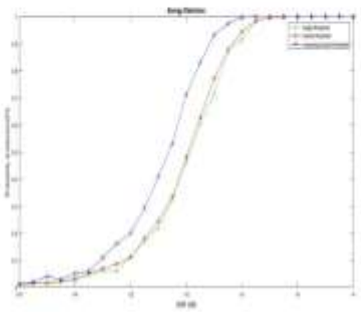

Figure 4.2: simulation result of energy detection of primary user using single and double threshold method and proposed double threshold methods.

The result which are obtained now gives much more enhanced output than the existing two methods, the parameters detected were also provided here with the threshold and the energy cases at two threshold incidents.

By using the modulation technique of PSK the above simulated analysis has been done. It is analysed after performing the analysis on single and threshold models and observing the parameters like Pd , Pf and SNR.

Now the values which came very far better than the existing once because of the method that followed gave those results, and hence with the comparison of the existing results with a clear comparison in the aspects of the Pd it can be proved that proposed model is the better one than the other. The detected parameters in the different case of the two thresholds were considered and compared. From the result it can be concluded that much more Pd is possible with the modern approach which was described now.

6. CONCLUSIONS

Modulation type to be chosen for the analysis of the better probability of detection has been performed and PSK modulation is chosen because at low SNRs the detection probability has been more for 8-PSK rather than BPSK and QPSK.It has been observed that the improvement of Pd for PSK is 33.2% more than QPSK and 54.6% more for BPSK.

Overall improvement in Pd with respect to re-sensing method of double threshold with conventional double threshold is found as 64.3% this got achieved by varying the noise variance by fixing the number of samples as constant. Average improvement in Pd for existing single and double threshold method is found as 32%.

Analysis of the spectrum probability of detection (Pd) using single threshold and conventional double threshold methods in AWGN noise is performed. These methods are analyzed on the basis of important parameters such as SNR, probability of detection and probability of false alarm. For various Probability of false alarm values average improvement in Pd between SNR = -20db and SNR = -16dB is found as 24%.

From the readings obtained by simulating the Pd against SNR, the bandwidth of the spectrum is observed as 2MHz.so for analyzing this spectrum width a number of 1000 samples is considered, this gives the information that if there is the need to extend the analysis for larger spectrum then consideration of more samples is needed, by considering the large bandwidths, practical applications like cellular operations can be analyzed, this work will be the basis for working on larger applications.

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