Development of Combining Method Based Spectrum Sensing Mechanism Using Centralized Combining

[1]Baby Swati Dubey, [2]Sandeep Dubey
[1]M-Tech Scholar, [2]Assistant Professor
[12]Department of Electronics & Communication Engineering, RGPM, Bhopal

Abstract- The cognitive radio performs two operations, the first being the dynamic access of unused spectrum and second being transmission on the available spectrum until the licensed user is detected. This paper addresses the study of cooperative spectrum sensing, for centralized network architecture, which involves enhanced energy detection based local sensing method which is further, simulated using MATLAB. By analyzing the conclusions drawn from this research paper, it is reconfirmed that the adopted enhanced energy detection provides a better sensing performance than the traditional energy detection described in literature and provides an enhancement of 20.25% in detection probability for the simulation done in this dissertation.

Keywords: CR, CRN, Het-Net, Cyclo-Stationary Detection, Centralized Co-operative Spectrum Sensing, Hybrid Mechanism.

I. INTRODUCTION

The 21st century has seen an explosion in personal wireless devices resulting in the advent of high end technological devices calling for colossal data transmission capability and speed. Most of the available radio spectrum (ranging from 3Khz-300Ghz) has been already allocated to various sectors of service such as mobile communication, defense, microwave communication, television etc. Radio transmission starts at VLF (very low frequency) range extending to VHF (very high frequency) and UHF (ultra-high frequency) bands. Thus it is evident that different parts of the spectrum are used for different technologies and applications. The spectrum is composed of several frequency bands which are slotted into channels and each band is used for a special purpose. The radio spectrum is a very scarce and valuable asset for every radio engineer and so great emphasis has to be given on its optimum usage.

II. LITERATURE SURVEY

[1] Jaewoo So et al: In cooperative spectrum sensing, a multi-bit combination rule shows better sensing performance than one-bit hard combination rules at the sacrifice of the reporting overhead. In order to overcome the trade-off between the sensing performance and the reporting overhead, we propose a novel group-based multi-bit cooperative spectrum sensing scheme with a limited reporting overhead. The proposed scheme adopts contention based reporting in order to restrain the reporting overhead while achieving multiuser diversity with an increased number of secondary users (SUs).

[2] Younes Abdi Mahmoudaliloo: Presents the notion of dynamic spectrum sensing along with better spectrum sensing schemes for cognitive radio networks (CRNs). These schemes are developed by considering a diverse collection of different processes and parameters. The research focuses on centralized cooperative spectrum sensing where the sensing nodes report their findings to a Fusion Centre (FC), where a global decision about the availability of spectrum is made.

[3] Devender et al: It is explained that the non-cooperative spectrum sensing scenario involves every SU node sensing its environment and making its individual decision about the presence or absence of a PU on its own whereas in the cooperative scenario, every SU node shares the results of its detection with other nodes and the shared information is taken into consideration to arrive at a final decision.

[4] Md. Shamim Hossain et al: This work presents a study on the performance of a cooperative spectrum sensing scheme that uses energy detection at every cooperating node and employs hard decision fusion at the FC, for the non-fading and fading scenarios. The non-fading environment is modelled by AWGN channel while for the fading scenario, Rayleigh, Rician and Nakagami channels are used. It is found that the process of spectrum sensing becomes harder in the presence of fading. It is observed that performance of energy detector degrades more in Nakagami channel than the Rayleigh and Rician channels. It is observed that in the Rician channel, because of the LOS signal, the sensing performance is better than in other channels.

[5] Chilakala Sudhamani et al: This work aims at calculating the total bit error rate (BER) for the traditional decision fusion rules viz. AND rule, OR rule and Majority rule with traditional energy detector. The observations reveal that as SNR increases, the noise level decreases and the detection probability increases, resulting in a decreased BER. It is concluded that for the improved energy detector, AND rule performs better than OR and Majority rules.

[6] Waleed Ejaz et al: This work puts forward the scenario of a CRN with heterogeneous sensing devices. Here, a CRN with sensing nodes employing different local sensing methodologies is described and a performance analysis of hard and soft combination for this network is proposed.

[7] Ting Peng et al: This work proposes a novel hard decision fusion algorithm designed to combat the effects of the spectrum sensing data falsification (SSDF) attacks. SSDF attacks mislead the FC to make incorrect decisions about spectrum availability. SSDF attacks are launched by malicious users (MUs) hidden within the primary network, mimicking a PU.

[8] James D. Gadze et al: In this work the authors provide a detailed study of the energy detection(ED) technique. The study aims at assessing the performance of an energy detector for non-fading and fading channel scenarios. The authors suggest that ED performed over a Rayleigh channel exhibits a tough detection performance compared to that of AWGN channel.

The concept of cooperative spectrum sensing is also studied and it is concluded that for both noon cooperative and cooperative scenarios, ED technique performs better in AWGN channel than in fading channels.

[9] Muthu meenakshi et al: This work provides a brief on the traditional energy detection scheme. The work suggests that the performance of energy detection degrades considerably in low SNR conditions also, that it cannot reliably detect PU signals under varying noise condition, signal fading and shadowing. The paper proposes a novel energy detection scheme, which is an optimised traditional ED having two thresholds instead of one. The performance analysis suggests that the proposed enhanced ED scheme significantly improves spectrum sensing accuracy under varying SNR conditions and outperforms the traditional ED without much increase in complexity.

[10] O. P. Meena et al: This work reviews information fusion methods employed in cooperative spectrum sensing and provides an analysis of the decision fusion rules along with the simulation results. The work put forwards the performance analysis the soft and hard combination rules and deduces that the soft combination technique outperforms the hard combination scheme but at the cost of increased reporting channel bandwidth.

III. PROBLEM STATEMENT

Based on the literature review in the above sections, the researcher found the following research:

Most of the researchers working in the field of cooperative spectrum sensing (CSS) algorithms have shown interest in energy detection due to its simplicity. Hence this research focuses on improving energy detection scheme.

IV. PROPOSED METHODOLOGY

The purpose of this research was primarily to find out a way that would optimize spectrum sensing in cognitive radio networks. A thorough analysis of existing research in the domain of spectrum sensing for cognitive radio puts forward the need of hybrid combining spectrum sensing to combat issues like multipath fading, receiver uncertainty etc. The factors that become crucial for this research are as follows:

1. To know the various schemes for optimizing combining sensing existing in literature and to study the effects of local sensing on the overall system performance.
2. Find an optimized energy detection scheme that performs better than the traditional energy detector.
3. Put forward more accurate cooperative spectrum sensing by implementing local sensing through the optimized energy detector.
4. Develop a unique learning approach that works well and stable under all conditions.

The algorithm for improved energy detector (illustrated in figure 1) starts with the traditional energy detection followed by additional checks.

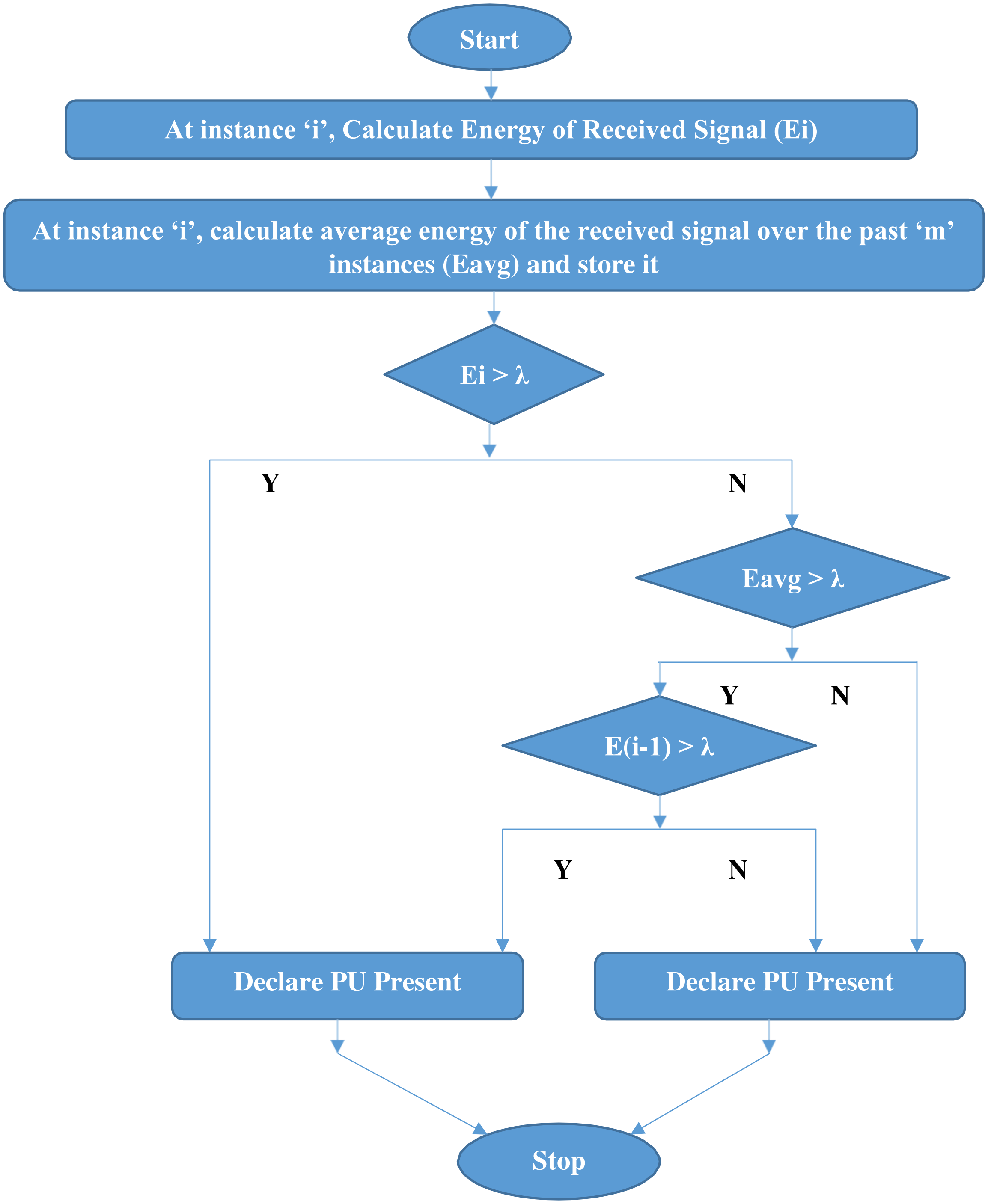

Figure 1: Flow Chart for Enhanced Energy Detection

In the first step, the instantaneous energy and the average energy of a fixed predefined number of previous instances is calculated and stored. In case if any PU is not detected in the first check, the situation is recertified by checking the average energy of past instances. In case, the average energy value of the past sensing instances also comes out to be greater than the predefined threshold, the energy value at the immediate past instance is calculated and compared with the threshold and if this value also becomes greater than the threshold, the PU user is declared to be present. Thus a misperception at the first stage gets rectified at the subsequent stages, making the improved algorithm more robust and foolproof.

At any sensing instant 'i', the first test statistic (**E**(**y**)) is the measured received signal energy observed over an observation interval and the second statistic is the average instantaneous energy for past 'M' sensing instants. For any sensing instant 'i' the instantaneous energy of the immediate past sensing instant i.e. $(i-1)^{th}$ instant is also calculated, if the need arises. Equations give the mathematical expressions for the test statistics given by equation below.

$$E(y) = \frac{1}{L}\Sigma\ |(k)|^2 \qquad \text{For k=0… (L-1)}$$

$$Eavg = \frac{1}{M}\Sigma\ Ej \qquad \text{Where j = [(i-M)…..i]}$$

Here, y(k) is the PU signal received at the cognitive radio node and λ represents the decision threshold.

Algorithm for optimized energy detection

Input: received primary user signal at secondary node, number of input samples to be taken.

Output: null hypotheses (H0) or absolute hypotheses (H1)

Design parameters: probability of false alarm and decision threshold

Performance metric: probability of detection

At every sensing instant ***'i'***

do

Calculate Ei

Calculate *Eavg*

If

$E_i > \lambda$

Decide H1

Else

If

$E_{avg} > \lambda$ *then*

If

$E_{(i-1)} > \lambda$ *then*

Decide H1

Else

Decide H0

End if

End if

End if.

IV CONCLUSION

Although the research in this paper accomplished a promising result of **"**Optimization of centralized combining hybrid sensing for cognitive radio networks**"**, there always exists a scope of improvement in every work which is also described in this chapter.

1. The enhanced energy detector (EED) provides a better detection probability in comparison with the tradition energy detector (TED), providing an enhancement of 20.25% in detection probability for the simulation proposed in this dissertation.
2. The enhanced energy detection scheme reduces the average probability of missed detection by 34.78%, for the simulation proposed in this dissertation.
3. The enhanced energy detector reduces the average bit error probability by 16.66%, for the simulation proposed in this dissertation.
4. The enhanced energy detection proves to be a better sensing algorithm as it provides an improvement of 12.20% in the test quality, for the simulation proposed in this dissertation.
5. The proposed optimized spectrum sensing provides higher mean probability of detection in comparison to the traditional cooperative spectrum sensing for all the hard combination rules. The increase in mean probability of detection (which is 71.48%) is most significant for the Majority rule and least significant for AND rule (which is 0.00256%) for the simulation proposed in this dissertation.
6. The OR rule outperforms the Majority and AND rule in terms of probability of detection, for the simulation proposed in this dissertation.
7. The Majority rule provides better detection probability for increasing values of SNR, for the simulation proposed in this dissertation.
8. The detection performance for Majority rule improves as the number of secondary user (SU) nodes increase, for the simulation proposed in this dissertation.

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