Energy Detection Based Spectrum Sensing For Cognitive Radio Using Fusion Rules

M.Lakshmi[1] , R.Saravanan[2] , R.Muthaiah[3]

[1]mlakshmi.s15@gmail.com

[2]saravanan_r@ict.sastra.edu

[3]sjamuthaiah@core.sastra.edu

[1]PG student ,School of Computing(VLSI), SASTRA University, Thanjavur-613402,Tamilnadu, India

[2] Assistant professor II, School of Computing(VLSI), SASTRA University, Thanjavur-613402,Tamilnadu, India

[3]Associate professor,School of Computing(VLSI), SASTRA University, Thanjavur-613402,Tamilnadu, India

Abstract —— Cognitive Radio is an emerging technology which avoids the congestion in wireless communication by exploiting unused radio spectrum . The Spectrum sensing plays a fundamental requirement of CR which finds an unused free spectrum and detects the licensed user transmissions. Energy detection constitutes a preferred approach for cognitive rdio spectrum sensing due to its simple applicability. In this paper OR & AND rules are used for the energy detection. In this case probability of miss detection (Pmd) & probability of false alarm (pfa) are estimated using probability density function (PDF) and the thresholds are fixed according to various energy levels and they are shown in simulation results. The simulation results show that our proposed method improves the probability of detection(Pd) and reduce the probability of error, & provides better accuracy. Probability of false alarm (Pfa) falls below the single user case.

Index Terms—AND rule, Cognitive Radio(CR),Energy detection,False alarm Probability (p_{fa}), OR rule , Primary users (PU), Probability of detection (P_d), Secondary users(SU), Spectrum sensing.

1 INTRODUCTION

CR is an persuasive resolution to the spectral congestion crisis by establishing the opportunistic exploitation of unused frequency bands that are not significantly engaged through a licensed users. They cannot be utilized by users other than the license CR users at the moment. OFDM is one of the most extensively used technologies in recent wireless communication systems which has the latent of satisfying the necessities of cognitive radios intrinsically or with minor changes. With it interoperability among the different protocols, it becomes easier. Cognitive Radio networks are wisely detects the available primary band to eliminates the nonexistence of PUs. The methods of spectrum sensing provides more spectrum utilization chances to the CR users with no intrusive with the process of the licensed network.

Three major methods used in spectrum sensing are

1)Energy detection
2)Cyclostationary

3)Matched filter

Among the above 3 methods Energy detection is a basic and popular method. Since Cyclostationary or Feature detection based spectrum sensing uses the exclusive prototype of the signal to sense its existence. But it is more complicated to implement and sensitive to the impairments between the cyclic frequency, carrier frequency and sampling frequency.Matched filter Performs coherent detection. But it acquires optimal solution to the signal detection but it requires priori knowledge on the received signal.

2 ENERGY DETECTION BASED SPECTRUM SENSING

This energy detection utilizes received signal energy to resolve an occurrence of primary signals. In general Cognitive Radio handlers have no estimations to be provide with any preceding knowledge about the primary signals that can be present with in a particular frequency

band. whenever the secondary user cannot get together any plenty knowledge, then the energy detection can be used due to its capability to perform without the signal structure to be detected.Energy detection can be done by comparing energy of a received signal in a certain frequency band to properly set decision threshold. If the signal energy lies greater with the decision threshold, then the frequency channel is stated to be busy. Otherwise the channel is supposed to be idle (free) and could be accessed by CR users. Energy detection could be used in both Time domain and Frequency domain operations. They are shown in Figure.1,Figure.2
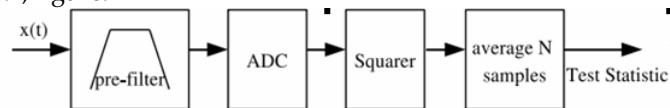

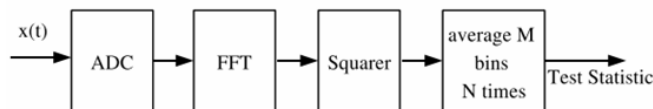Figure.1. Time domain representation of energy detection

Figure.2. Frequency domain representation of energy detection

In this energy detection, energy of an averaged signal is subjected to two hypothetical test functions.

        1) H0 (PU is absent)

        2) HI (PU is in operation)

Under H0

    $x[n] = w[n]$; (noise only presence)

Under H1

    $x[n] = s[n] + w[n]$; (presence of signal with noise)

Here, n = 0, 1, 2, ..., N-1, N represents the index of sample, w[n] specifies the noise and s[n] is the primary signal required to detect. H0 is the hypothesis which means that the received signal consists of the noise only. In case of H0 is true then the decision value will be less than the threshold γ. So the detector will conclude that there is no availability of the vacant spectrum. On the other hand, if H1 is true then the received signal has both signal and noise, the decision value will be larger than the threshold γ. So the detector concludes that the vacant spectrum is available. The threshold [2] is chosen so as to control parameters such as probability of False alarm (P_{fa}) and probability of Detection (P_d).

3 CYCLOSTATIONARY

Cyclostationary or Feature detection based spectrum sensing utilizes the exclusive prototype of the signal to detect its existence. It is trickier to the CR handler's transmissions by abusing the cyclostationary characteristics of the received signals. Features of cyclostationary are produced using regularities in signal or in its functions such as Mean and ACF are calculated sensitively to the impairments between the cyclic frequency, carrier frequency and sampling frequency. Cyclostationary is a scheme for detecting primary induced to aid spectrum sensing. In place of PSD, cyclic correlation function is used for detecting signals exist in a known spectrum. The procedures of cyclostationary based detection can be used to discriminate the noise from PU signals. But it is more difficult to implement and sensitive to the impairments between the cyclic frequency, carrier frequency and sampling frequency.

4 MATCHED FILTER

It performs coherent detection.[3].It acquires optimal solution to the signal detection but it requires preceding knowledge on the received signal. Matched-filtering is acknowledged as the most favorable techniques for the sensing of PUs while the transmitted signal is known. The foremost benefit of matched filter is the tiny time to attain a particular set probability of false alarm or probability of miss detection as compared to remaining methods. In reality, the required number of samples can be developed as O (1/SNR) for a target to get probability of false alarm at low Signal to Noise Ratios of matched-filter.[3]Here the transmitted signal is passed through the channel where the additive white Gaussian noise is getting included to the signal and outputted the mixed signal. This mixed signal is given as an input of the filter.Then the matched filter input is convolved with the impulse response of the matched filter and the matched filter output is then compared with the decision threshold for primary user detection.

Figure.3.Matched filter diagram

5 SYSTEM MODEL

In this paper OR & AND rules or proposed for the energy detection. In non cooperative spectrum sensing[4] an improved energy detector is used for noiseless

communication. Cooperative sensing offers diversity gains against channel fading effects since the odds of multiple radios experiencing undesirable fading conditions simultaneously. Here OR & AND Rule are proposed for detection of received signal energy. Performance of AND rule is used in low P_{fa}. Detecting an existence of a certain signal transmission is complicated hence any special cases of CR arises with added constraints on detection systems. First, the SNR of signal from the licensed PU received by the cognitive radio SU may extremely small. It is due to SU have to make sure that secondary users are not interfere even if PU transmissions during at the edge of its coverage range. SUs located in primary user's range is called protected region. It can strongly interfere in PU's communication. Hence, the SU still at boundary of guard band sense primary signal although a decoding signal is impossible .Secondly, SUs are not cognizant the perfect transmission plan used by the PU. Moreover , the SU have not any accessibility to train & synchronize signals for PU transmission. It means that SUs are forced to make use of noncoherent energy detectors.Besides the difficulties arises due to low SNR , Hidden-terminal problem also occurs due to shadowing .SUs can shadowed far from PU's transmitter but primary receiver may close to the SU are not shadowed from the primary transmitter.If a SU transmits, it can get in the way with the primary receiver's reception. In the proposed system, fusing decisions rules are proposed to resolve the above mentioned problems. Data fusing at spread sensors is an vital part of decentralized detection process.

Figure.4.Data Fusion centre

In cognitive radio applications sensors observes partially dependent data due to correlated shadowing. There are two commonly used decision fusion rules in spectrum sensing, they are namely hard and soft decision. In case of Hard decisions the individual cognitive radio makes the 1-bit decision according to the presence of the PU. The bit-1specifies that PU uses the spectrum channel, so that CR user have no access. Spectrum will be accessible if CR user makes bit 0. After a surveillance of PU signal, local detection frontwards PU to the data fusion centre. ultimate decision is taken by connecting all local detections together. There are two rules in hard decision are OR& AND rule. In case of OR rule, minimum one of the CR users concerned in sensing can decides the presence of the PU . In contradiction AND rule decides the presence of PU while

primary signal is detected by every CR users, In other words every local decision of CR user is H1. Spectrum sensors achieves a hypotheses [1] H0 (null hypothesis indicating that the sensed channel is available) vs.H1 (alternative). If the sensor of a secondary user mistakesH0 for H1 (false alarm), the secondary user may refrain from transmitting, and a spectrum opportunity is overlooked. On the other hand, if the detector mistakes H1 for H0 (miss detection), a misidentification of spectrum opportunity occurs the secondary user collides with a primary user if it trusts the sensing outcome.

5.1 FUSION RULES (OR&AND RULE)

5.1.1 HARD DECISION COUNTING RULES

In a hard decision counting rule[5], the fusion center implements an n–out-of-M rule that decides on the signal present hypothesis whenever at least n out of the M local decisions indicate H1.Assuming uncorrelated decisions, the P_d at the fusion center is follows as

$$P_d = \sum_{n}^{M} \binom{M}{k} P_{d,i}^k (1 - P_{d,i})^{M-k}$$

(1)

Where $P_{d,i}$ is the probability of detection for individual node

5.1.2 OR RULE

Cooperative detection performance with this fusion rule can obtained by setting n=1 in equation (1)

$$P_{d,OR} = 1 - \left(1 - P_{d,i}\right)^M$$

(2)

5.1.3 AND RULE

The fusion center's decision is calculated by a logic AND of the received hard decision statistics.Cooperative detection performance fusion rule can be obtained by setting n=M in equation

$$P_{d,AND} = P_{d,i}^M$$

(3)

Where $\lfloor \cdot \rfloor$ represents the floor operator.

OR rule decides H1 which indicates the presence of Primary user, while minimum 1 user should sense the PU , whereas AND rule decides H1 while every CR user ahead their bit-1 local detections. While two CR users are combined to detect the PU signal, OR rule can provide a

better P_d than AND rule. The centre of data fusion decides H1 when minimum one CR user detect the PU signal for OR rule. While in AND rule, every local detections of CR users must be H1 to decide the existence of PU signal. When SNR is larger than 10 dB, both rules can provides best possible probability of detection. Propagation losses causes Low SNR due to fading and shadowing.
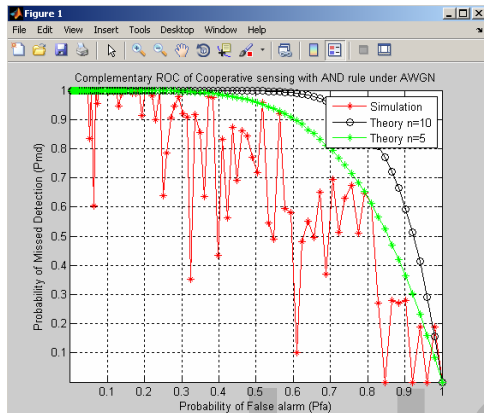
6 SIMULATION RESULTS

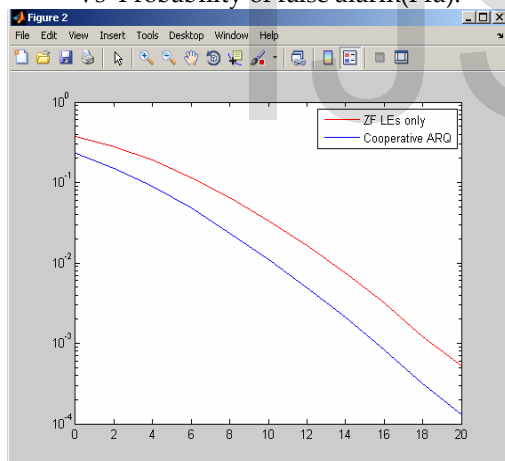Figure.5. Probability of miss detection (Pmd) Vs Probability of false alarm(Pfa).

Figure.6.SNR Vs BER

REFERENCES

[1]   Q. Zhao, L. Tong, A. Swami, and Y. Chen,"Decentralized cognitive MAC for opportunistic spectrum access in ad hoc networks: APOMDP framework," IEEE J. Select. Areas Commun., vol. 25, no. 3,pp. 589–600, Apr. 2007.

[2]   Zhuan Ye, Gokhan Memik, John Grossietsch, "Energy Detection using Estimated Noise Variance for Spectrum Sesning in Cognitive Radio Networks", Proceedings of WCNC 2008

[3]   J. Unnikrishnan and V. V. Veeravalli, "Decentralized detection with correlated observations," in Proc. Asilomar Conf. Signals, Systems, andComputers, Nov. 2007.

[4]   Yi-bing Li, Xing Liu, Wei Meng, "Multi-node Spectrum Detection Based on the Credibility in Cognitive Radio System,' 5th International Conference on Wireless Communication, Networking and Mobile Computing, pp. 1-4, 2009

[5]   N. Armi, N.M. Saad & M. Arshad "Hard Decision Fusion based Cooperative SpectrumSensing in Cognitive Radio System," ITB J. ICT Vol. 3, No. 2, 2009, 109-122

7 CONCLUSION

Thus the Energy detection has done using the Fusion rule and the simulation results are shown using Matlab.From the results it is clear that the in secondary users AND rule's target is to achieve reduced false alarm probability(Pfa).In primary users OR rule can achieve higher spectrum utilization while the AND could protect the PU better. And hence these OR&AND rule provides better Frequency estimation , high speed energy detection .