Volume 5, Issue 6, June 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Performance Analysis of Different Spectrum Sensing Techniques in Cognitive Radio Networks

Shashank Shekhar, Er. Himanshu Sharma
ECE Deptt, MMU, Mullana,
Ambala, India

Abstract- Spectrum sensing is an important and sensitive task in cognitive radio since interfering with other users is illegal. One of the main requirements of spectrum sensing is to detect the presence of the primary users as fast as possible. Cognitive radio arises to be a tempting solution to spectral crowding problem by introducing the opportunistic usage of frequency bands that are not occupied by licensed users. Cognitive radio with software-defined radio has been proposed as the means to promote the efficient use of the spectrum by exploiting the existing spectrum holes. The main objective of this paper is implement Cuckoo search optimization to spectrum sensing techniques used in cognitive radio to allow access to the secondary user in the case when band of frequency licensed to the main user is free and being wasted at that time.

Keywords- Spectrum Sensing, Energy Detection, Spectrum Holes.

I. INTRODUCTION

The race for occupying the increasing demand of bandwidth within a limited range of spectrum has given rise to a new technology known as **Cognitive Radio**. Spectrum sensing is an important and sensitive task in cognitive radio since interfering with other users is illegal [1]. Cognitive radio arises to be a tempting solution to spectral crowding problem by introducing the opportunistic usage of frequency bands that are not occupied by licensed users. In cognitive radio systems, unlicensed users need to have cognitive radio capabilities, such as sensing the spectrum reliably to check if it is being used by a licensed user [2].

II. SPECTRUM HOLES

A spectrum hole is a band of frequencies assigned to a primary user at a particular time and specific location, the band is not being used by that user. The underutilization of the electromagnetic spectrum leads us to think in terms of spectrum holes Spectrum utilization can be improved significantly by making it possible for a secondary user (who is not being serviced) to access a spectrum hole unoccupied by the primary user at the right location and the time in question. Cognitive radio with software-defined radio has been proposed as the means to promote the efficient use of the spectrum by exploiting the existing spectrum holes [3].

Spectrum holes are not stable and they migrate with frequency and time as shown in the Figure 1. The spectrum sensing algorithm is supposed to be fast enough to rapidly detect the moving holes in the spectrum in real time. Spectrum sensing is computational expensive and requires special hardware to implement. Moreover in the case of Low SNR scenario the noise power affects the operation of the spectrum sensing algorithm thereby affecting the hole detection process. The spectrum sensing algorithm used should be sensitive enough to distinguish between the signal power and the noise power. If the void spaces in the spectrum can be detected and utilized, then the problem of spectrum limitation can be solved to some extent [4].

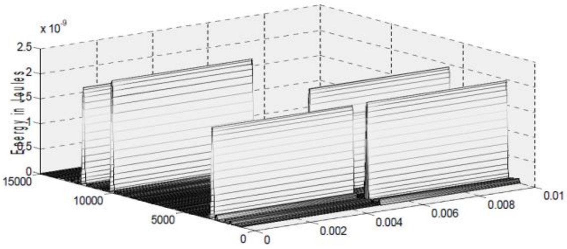

Figure 1: Migration of holes in the spectrum

III. COGNITIVE RADIO NETWORK

A cognitive radio network consists of secondary radio users that can perform spectrum sensing and then operate at the appropriate piece of unused spectrum. In the aspect of spectrum sensing, the radio measures certain characteristics of the radio waveform, and then decides if a primary system is actively using that spectrum. The energy detection method is chosen. The block diagram of an energy detector is shown in Figure 2. The input band pass filter removes the out of band signals by selecting the center frequency fc, and the bandwidth of interest W. It is assumed the secondary users have this information in order to perform spectrum sensing. After the signal is digitized by an analog to digital converter and a simple square and average device is used to estimate the received signal energy. Without loss of generality, assumed that the input signal to the energy detector is real. The estimated energy, u, is then compared with a threshold, λ, to decide if a signal is present (H_1) or not (H_0).

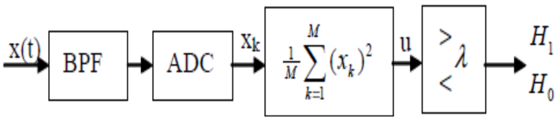

Figure 2: Block Diagram of Energy Detector

The threshold can be calculated based on two principles: constant false alarm rate (CFAR) and constant detection rate (CDR). In both CFAR and CDR cases, the noise power1 is needed to determine the threshold. It is assumed the exact noise variance is known and can be used to calculate the threshold [5].

IV. COOPERATIVE SPECTRUM SENSING

One of the main requirements of spectrum sensing is to detect the presence of the primary users as fast as possible. For this reason, the CR users should continuously monitor the spectrum of the primary users and vacate it as soon as the primary user is detected. Spectrum sensing is usually performed in two successive stages: sensing and reporting. Consider the situation shown in Figure 3, in the sensing stage, every CR user (CU1, CU2, and CU3) performs spectrum sensing independently and make a decision about the observation to primary user (PU). In the reporting stage, all the local observation results are reported to a common receiver: fusion center (FC), and then a final decision will be made to indicate the absence or the presence of the primary user.

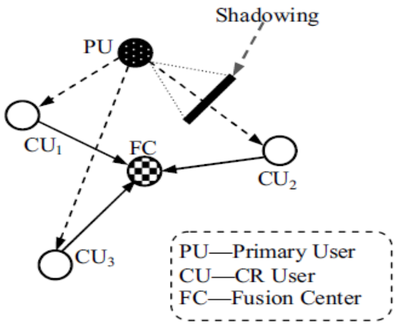

Figure 3: Cooperative spectrum sensing

Each and every CR user performs its spectrum sensing individually, which can be formulated as a binary hypothesis test between the following two hypothesis:

$$X_j(t) = \begin{cases} n(t) & H_0 \text{ (absent)} \\ H\, s(t) = n(t) & H_0 \text{ (present)} \end{cases}$$

Where Xj (t) is the signal received by the j-th CR user, s (t) is the primary user's transmitted signal, n (t) is the additive white Gaussian noise (AWGN) with a one sided power-spectral-density, N_o and h is the fading coefficient of the channel modeled as independent complex Gaussian random variables [6].

V. CUCKOO SEARCH

Cuckoo search (CS) is an optimization algorithm developed by Xin-she Yang and Suash Deb in 2009. It was inspired by the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of other host birds (of other species). Some host birds can engage direct conflict with the intruding cuckoos. For example, if a host bird discovers the eggs are not their own, it will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. Some cuckoo species such as the New Worldbrood-parasitic Tapera have evolved in such a way that female parasitic cuckoos are often very specialized in the mimicry in colors and pattern of the eggs of a few chosen host species .Cuckoo search idealized such breeding behavior, and thus can be applied for various optimization problems. It seems that it can outperform other metaheuristic algorithms in applications.

VI. RELATED WORK

The various techniques used for spectrum sensing in cognitive radio are discussed below:

A. Cooperative spectrum sensing in cognitive radio systems:

The problem of use the reliability of unlicensed users for cooperative spectrum sensing in cognitive radio systems by analyzing the Huffman encoding algorithm study by Xueqiang Zheng, Li Cui, Juan Chen, Qihui Wu and Jinlong Wang. A novel cooperative spectrum sensing algorithm in cognitive radio systems is presented. The close-form expressions for the average sending bits for each unlicensed user for cooperation and expression for the probability of the detection and the false-alarm for the novel cooperative spectrum sensing scheme [7] are derived. Finally, show through numerical results the potential cooperative spectrum sensing performance improvement with using the reliability of unlicensed users is shown.

B. Energy detection technique for spectrum sensing in cognitive radio:

With unprecedented growth of the subscribers in modern cellular and wireless data communications, there is an acute scarcity of additional bandwidth to meet the ever increasing demand. To make the constraint of additional bandwidth an easy task, utilization of the existing system has been a topic of interest now-a-days. Cognitive Radio is therefore, a new technique in which the spectral holes in unutilized spectrum are determined to be used for instantaneous communication by secondary users. The Cognitive Radio determines the occupancy of the frequency spectrum observed over a time interval by spectrum sensing methods. Spectrum sensing forms a key front end block of Cognitive Radio systems. The design and simulation of the spectrum sensing algorithm for Cognitive Radio under low SNR scenario study by Anirudh M. Rao, B. R. Kartikeyan, and Dipayan Mazumdar.

The Energy Based Spectrum Sensing (EBSS) technique has been identified for its relatively simple implementation [8]. In conventional PCA the ratio of the signal space power to the noise space power do not usually match the actual SNR. There is a correction factor for PCA technique which is then applied to the ratio of decomposed signal space power and the noise space power to equate it to the actual SNR. The noise power obtained through the modified PCA based technique and the chosen value of probability of false alarm determines the threshold energy for the EBSS algorithm. The method proposed in the study which is a combination of PCA and EBSS has been validated for wide range of SNRs, different probabilities of false alarm and frequencies of interest. The correction factor to the PCA and the clearly defined process for Threshold Energy computation invoking the PCA as well as the Radar principles.

C. Energy detection of unknown signals over fading channels:

The problem of energy detection of an unknown signal over a multipath channel study by Fadel F. Digham, Mohamed-Slim Alouini and and Marvin K. Simon. It begins with the no-diversity case, and then presents some alternative closed-form expressions for the probability of detection to those recently reported in the study. The detection capability is boosted by implementing both square-law combining [9] and square-law selection diversity schemes.

D. Energy Detection using Estimated Noise Variance for Spectrum Sensing in Cognitive Radio Networks:

The performance of spectrum sensing based on energy detection study by Zhuan Ye, Gokhan Memik, John Grosspietsch [10]. An estimated noise variance is used to calculate the threshold used in the spectrum sensing based on energy detection. A new analytical model to evaluate the statistical performance of the energy detection. The analytical results are verified through numerical examples and simulations. Through these examples, the effectiveness of our analytical model: it can be used to set the appropriate threshold such that more spectrum sharing can be done, especially when connected with cooperative spectrum sensing method.

E. Asynchronous cooperative spectrum sensing in cognitive radio:

In cognitive radio networks, the cognitive radio users can be collaborated to perform spectrum sensing so as to detect the primary user more accurately study by Xiong Zhang, Zhandding Qiu and dazhong Mu. However, when the sensing nodes are affected from fading, shadowing, and time-varying nature of wireless channels, it is needed to set a long observation time for all of the nodes to make decisions and forward the results to fusion center, which results in the severe degradation of the sensing performance. An asynchronous cooperative spectrum sensing method is the one in which the cognitive radio user with high SNR finishes the detection earlier than the one with low SNR, and then the duty of fusion center is to make the final decision depending on the earliest local decision. The proposed method can exploit the user’s SNR diversity so that the sensing performance can be improved. Simulation results in reduction of detection time significantly at the expense of a little sensing performance degradation compared to the conventional cooperative spectrum sensing.

F. Cooperative Spectrum Sensing in Cognitive Radio Networks Over Non-Identical Nakagami-m Channels:

The analysis of relaybased cognitive radio (CR) networks and presents a detect-amplifyand- forward (DAF) relaying strategy for cooperative spectrum sensing over non-identical Nakagami-*m* fading channels study by Sattar Hussain and Xavier N. Fernendo. An advanced statistical approach is introduced to derive new exact closed-form expressions for average false alarm probability and average detection probability. The inconsistency of several assumptions that are typically used for performance analysis of CR networks and reveals that channel fading on the relaying links yields similar performance degradations as it yields on the sensing channel. The literature study also shows that it is not necessary to incorporate all CRs in the cooperative process and that a small number of reliable radios are enough to achieve practical detection level. When compared with the amplify-and-forward strategy, the heavily faded relays in the DAF strategy improve the detection accuracy and reduce the bandwidth requirement of the relay links. The analysis presented could lead to intuitive system design guidelines for CR networks impaired with non-identical faded channels.

VII. PROPOSED WORK

In this paper a meta-heuristic optimization technique, Cuckoo Search (CS) is implemented. In the proposed technique, the least energy nodes are formed as subordinate chains. The feasibility of the scheme is manifested by the simulation results on comparison with the traditional techniques.

Algorithm
Objective function f(x), x = (x1,..., xd)T
Generate initial population of
n host nests xi (i = 1, 2,..., n)
while (t < MaxGeneration) or
(stop criterion)
Get a cuckoo randomly by Levy
flights
evaluate its quality/fitness Fi
Choose a nest among n (say, j) randomly
if (Fi > Fj),
replace j by the new solution;
end
Fractions (pa) of worse nests are abandoned and new ones are built;
Keep the best solutions (or nests with quality solutions);
Rank the solutions and find the current best
end while
Post process results and visualization
The worse nets are abandoned in normal Cuckoo Search. In order to compensate the unequal energy dissipation, the best nets (or) energy users are allowed to join.

VIII. RESULTS

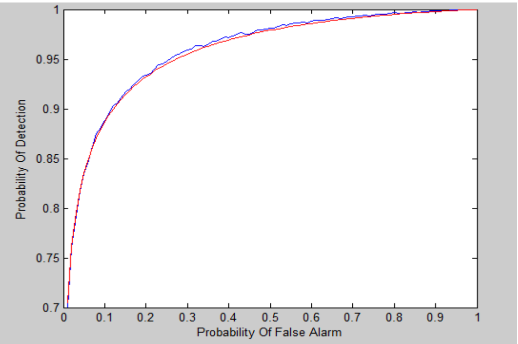

Figure 8.1: Probability of false alarm vs Probability of detection

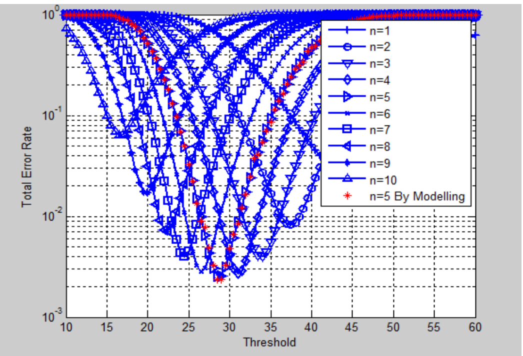

Figure 8.2: Threshold vs Total error rate

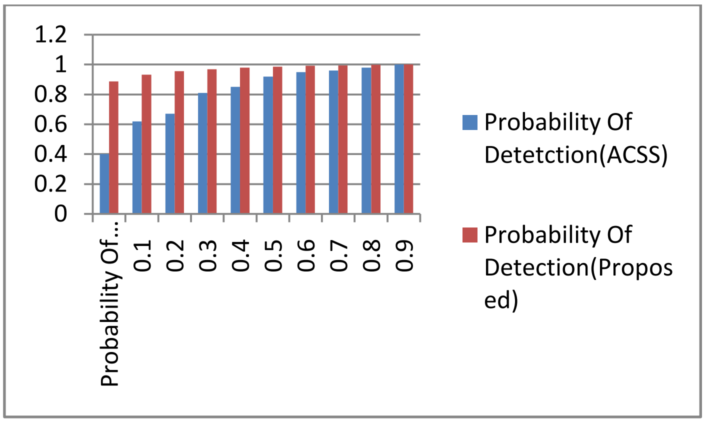

Figure 8.3: Comparison of Probability of detection in ACSS & Proposed Approach

IX. CONCLUSION

The sensitivity of spectrum sensing in cognitive radio networks can be improved by using asynchronous cooperative spectrum sensing method by applying cuckoo search optimization. The expected probability of false alarm or detection for spectrum sensing using energy detection method is evaluated.

REFERENCES

[1] Xueqiang Zheng, Li Kui, Juan Chen, Qihui Wu, Jinlong Wang, "Cooperative spectrum sensing in cognitive radio systems", Institute of Communications Engineering, PLA Univ. of Sci. & Tech., Nanjing 210007, China,2008

[2] Anirudh M. Rao., B. R. karthikeyan, Dipayan Mazumdar, Govind R. kadambi, "Energy Detection technique for spectrum sensing in cognitive radio", Signal Processing and Communication Technologies M. S. Ramaiah School of Advanced Studies, Bengalore, Volume 9, Issue 1, April 2010.

[3] Simon Haykin, Life Fellow, "Cognitive Radio: Brain empowered wireless communications", IEEE, IEEE Journal on selected areas in communication, Vol. 23, No. 2, Feb 2005.

[4] Fadel F. Digham, Mohamed-Slim Alouini, Marvin K. Simon, "On the energy detection of unknown signals over fading channels", IEEE, IEEE transactions on communications, Vol. 55, No. 1, Jan 2007.

[5] Zhuan Ye, Gokhan Memik, John Grosspietsch, "Energy detection using estimated noise variance for spectrum sensing in cognitive radio networks", Wireless Solution Research Center, Motorola Labs, Schaumbarg, IL, USA, Department of EECS, Northwestern University, Evanston, IL, USA, 1525-3511/08/$25.00, IEEE, 2008.

[6] Xiong Zhang, Zhengding Qiu, Dazhong Mu, "Asynchronous cooperative spectrum sensing in cognitive radio", Institute of Information science, Beijing Jiaotong University, Beijing, 100044, P.R. China, College of Electronics and Information Engineering, Taiuyan University, of Science and Technology, Taiuyan, 030024, P.R. China, ICSP, 2008. [7] Sattar Hussain, Xavier N. Fernendo, "Over non-identical Nakagami-m channels", IEEE, IEEE transactions on communications, Vol. 62, No. 8, August 2014.

[8] Bin Shen, Longyang Huang, Chengshi Zhao, Zheng Zhou, Kyungsup Kwak, "Energy detection based spectrum sensing for cognitive radios in noise of uncertain power", Graduate school of Technology and Telecommunication, Inha University, Incheon, 402-751, Korea, school of Telecommunication Engineering, Beijing University of Posts and Telecommunications, Beijing, 100-876, China, 978-1-42442336-1/08/$25.00, IEEE, 2008.

[9] Abhay Bindal, Abhijeet Kumar, Himanshu Sharma, "Performance Analysis of MIMO System in Mobile Communication", International Conference on Signal, Image and Video Processing (ICSIVP), 2012.

[10] Sakshi Babbar, Abhijeet Kumar, "PAPR Reduction in OFDM Systems Using a Non-linear Polynomial Function", Volume 2, Issue 10, October 2012.

