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A Brief Review of Cognitive Radio Networks (CRN)

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***Abstract*—** Cognitive radio is viewed as a fresh approach for improving the utilization of a precious natural resource: the radio electromagnetic spectrum. Cognitive Radio is a new technique in which the spectral holes in unutilized spectrum are determined to be used for immediate communication by secondary users. The Cognitive Radio determines the occupancy of the frequency spectrum experiential over a time interval by spectrum sensing methods. Spectrum sensing forms a key front end block of Cognitive Radio systems. Various spectrum sensing techniques used in cognitive radio. Energy detection based spectrum sensing has been used for widely for primary user (PU) signal. With the help of multiple secondary users (SU) in the cognitive radio network, diverse cooperative sensing schemes are investigated to enhance the energy detection performance. Secondly when the sensing nodes undergo from fading, shadowing, and time-varying nature of wireless channels, it desires to set a long observation time for all of the nodes to make choices and forward the effects to fusion center, which induce the harsh degradation of the sensing presentation. An asynchronous cooperative spectrum sensing method, in which the cognitive radio user with high SNR complete the detection earlier than the one with low SNR, and the fusion center, makes the final decision depending on the original local decision.

***Index Terms*—** **Spectrum Holes, EBSS technique, Relay-Based Cooperative Spectrum Sensing, Asynchronous Cooperative Spectrum Sensing**

INTRODUCTION

1. INTRODUCTION TO COGNITIVE RADIO NETWOKS:

The race for occupying the escalating demand of bandwidth within a limited range of spectrum has given rise to a new technology known as Cognitive Radio [1].Since cognitive radios are considered as lower priority or secondary users (SU) who scavenge temporarily unused licensed spectrum exclusively allocated to a primary user (PU), the fundamental requirement for them is to avoid interference to the potential PUs in their vicinity [2]. With the rapid development of wireless communications, the ever escalating demand for limited spectrum resources will eventually cause spectrum scarcity problem [3].Cognitive radio arises to be a tempting solution to phantom crowding problem by introducing the opportunistic usage of frequency bands that are not engaged by licensed users. In cognitive radio systems, unlicensed users need to have cognitive radio capabilities, such as observing the spectrum reliably to check if it is being used by a licensed user [1].

1.2 SPECTRUM SENSING IN COGNITIVE RADIO

1.2.1 SPECTRUM HOLES:

If we were to scan portions of the radio spectrum including the revenue-rich urban regions, we would find that

1) Some frequency bands in the spectrum are largely unoccupied most of the time;

2) Some other frequency bands are only incompletely occupied;

3) The remaining frequency bands are heavily used [4].

A spectrum hole is a band of frequencies allocated to a primary user at a particular time and specific location, the band is not being used by that user. The less utilization of the electromagnetic spectrum leads us to think in terms of spectrum holes [1]. It is observed that Even after efficient allocation of bandwidth by the Telecommunication regulatory body, the spectrum is used wastefully. The Figure 1 illustrates the occupancy of the spectrum, it is seen that the spectrum is not carefully used and there are void spaces or holes in the spectrum. The reasons for the under utilization of the spectrum are:

1. The possession of the spectrum is high during the day time and less during the night time (cellular phone spectrum).

2. The occurrence of guard bands in the spectrum to prevent adjacent channel interference. There will be N-1 guard bands for a N channel OFDM. The picket bands in a 256 channel OFDM can consume up to 10% of the total channel bandwidth.. Guard bands reduce the sensitivity to spectral leakage in multicarrier communication. In parallel more complicated radios which can change modulation techniques [5].

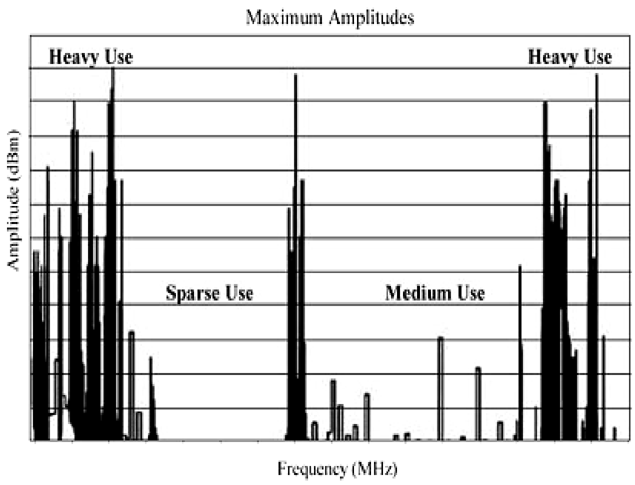

Fig. 1 Occupancy of the spectrum [5].

1.3 SPECTRUM SENSING TECHNIQUES:

1.3.1 Energy Based Spectrum Sensing (EBSS) technique:

The block diagram of a energy detector is shown in Fig. 2.

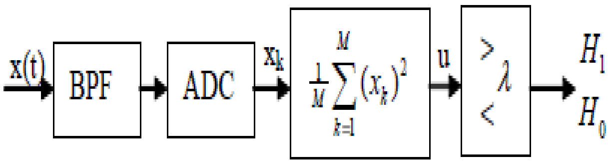

Fig.2 Block diagram of a energy detector [3].

The energy detection method is simple in implementation since it does not require the knowledge about the formation of the primary signal. The energy detection method calculates the energy of the input signal and matched it with a threshold power value. The signal is said to be present at a particular frequency if the energy of the signal surpass the Energy level of the threshold. The Figure 3 illustrates the flowchart of the energy detection method [5].

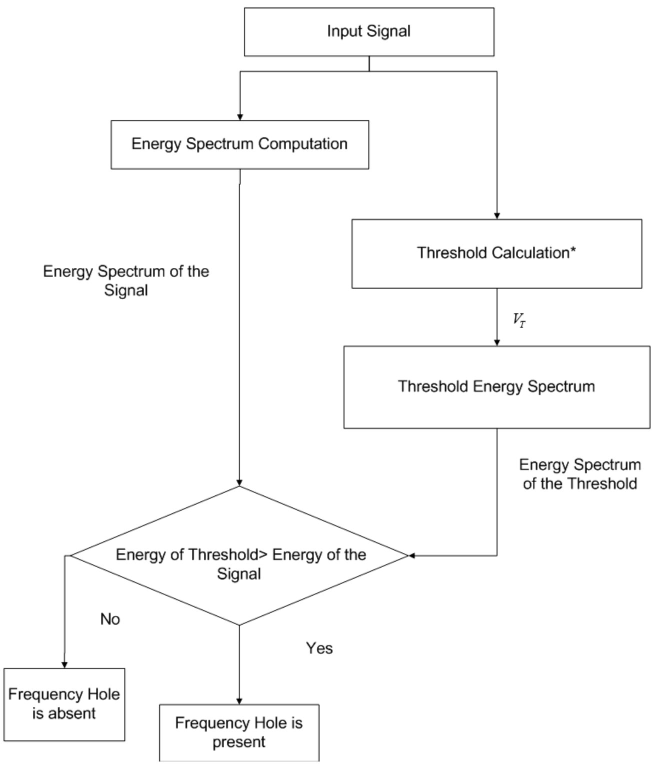

Figure 3 energy detection method [5]

1.3.2 Relay-Based Cooperative Spectrum Sensing in Cognitive Radio Networks:

CSS model is quantified based on the recognition probability as a performance measure. However, the relaying channels are over layed and a single-hop CR network model is considered. Similarly, the relaying links are overlooked in. cooperative relay technology offers an efficient method to improve the performance of both spectrum sensing and secondary transmissions. Particularly, radio Transmission can be optimized in terms of spectrum efficiency through a dual analysis of the spectrum sensing and the secondary transmissions [6].

1.3.3 Asynchronous Cooperative Spectrum Sensing in Cognitive Radio:

spectrum sensing network need to set a observation time long enough to ensure every node of the network can conduct the detection with the desired detection probability when the primary user is present. In order to decrease the sensing time and improve the agility of the spectrum sensing network, a detection scheme enabling the node with high SNR to finish the detection and report the result to fusion center earlier than the one with low SNR [7]

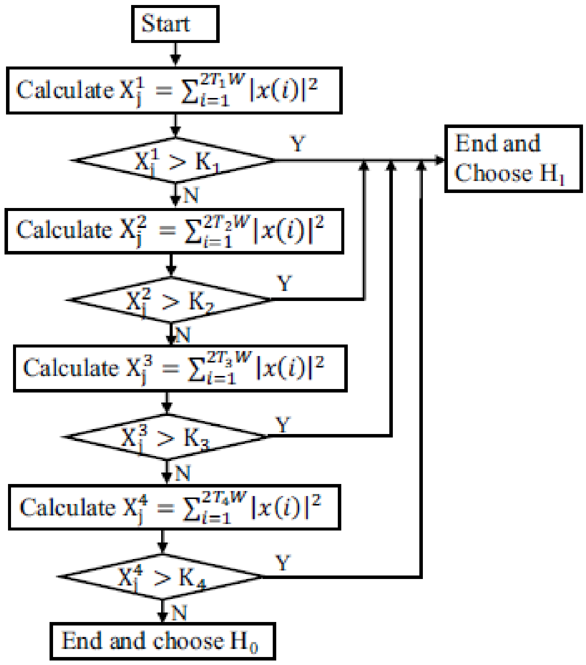

Figure 4 Flow chart of asynchronous energy sensing [7]

1.4 PROTOCOLS USED IN RELAY BASED NETWORKS:

Relay-based networks employ each an AF protocol or decode-and-forward (DF) protocol**.** The DF protocol offers a significant bandwidth diminution of the relayed signals. However, the AF protocol moves the complexity from local radios to the fusion center and allows the soft-fusion strategy to be implemented at the receiver which has been proved to be an optimal integration technique [6].

LITERATURE SURVEY

Shashank Shekhar et al.(2015) Cognitive radio with software-defined radio has been proposed as the means to promote the efficient use of the spectrum by utilizing the existing spectrum holes. The main objective of this paper is implement Cuckoo search expansions to spectrum sensing techniques used in cognitive radio to allow access to the secondary user in the case when band of occurrence licensed to the main user is free and being wasted at that time.

Bin Shent et al. (2008) a updated version of the classic energy detection model is presented, where the noise power uncertainty (U) is introduced into threshold setting. With a sensible approximate derivation, we provide accurate predictions of SNRwall restrictions applied by U in Rayleigh fading environments. In addition, by employing a simple hard decision fusion rule, the collaborative gain in spectrum sensing presentation is also quantified with respect to U. Our analysis and numerical results confirm that collaboration can considerably improve the spectrum sensing performance in a noise power fluctuating environment.

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Zhuan Ye1 et al.(2008) In this paper, author analyze the performance of spectrum sensing based on energy finding. We do not presume the exact noise variance is known a priori. Instead, an estimated noise variance is used to compute the threshold used in the spectrum sensing relied on energy detection. Author proposes a new analytical model to estimate the statistical performance of the energy detection. Some characteristics of this model, and analyze how these characteristics influence the performance of spectrum sensing. The analytical results are verified through numerical examples and simulations. Through these examples, author demonstrates the effectiveness of our analytical model: author show how it can be used to set the suitable threshold such that more spectrum sharing can be facilitated, especially when integrated with cooperative spectrum sensing method.

Anirudh M. Rao (2010) The Energy Based Spectrum Sensing (EBSS) technique has been recognized for its relatively simple achievement. However in the published literature on EBSS, the formula for the Threshold Energy computation needs both clarity and defined steps. An attempt has been made to improve the traditional EBSS technique by integrating it with the statistical Principal Component Analysis (PCA) technique.

Sattar Hussain(2014) This paper suggests performance analysis of relay based cognitive radio (CR) networks and suggests a detect-amplifyand-forward (DAF) relaying method for cooperative spectrum sensing over non-identical Nakagami-*m* fading channels. An complex statistical method is introduced to derive new precise closed-form expressions for average false alarm probability and average detection probability.Author introduce a novel approximation to alleviate the computational complexity of the suggested models. This paper points out the irregularity of several assumptions that are typically used for performance analysis of CR networks and explains that channel fading on the relaying links yields similar presentation degradations as on the sensing channel. The study also present that it is not necessary to incorporate all CRs in the supportive process and that a small number of reliable radios are adequate to achieve practical detection level. Matched with the Amplify-and-forward strategy, refraining the greatly faded relays in the DAF strategy improves the detection accuracy and minimizes the bandwidth prerequisite of the relaying links. The suggested analysis could lead to instinctive system design guidelines for CR networks impaired with non-matching faded channels.

Xiong Zhang et al.(2008) In this paper, author propose an asynchronous supportive spectrum sensing method, in which the cognitive radio user with high SNR finishes the observation former than the one with low SNR, and the fusion center create the final decision depending on the earliest local decision. The suggested method can exploit the user's SNR diversity so that the sensing performance can be improved. Simulation results show that the detection time is condensed significantly at the expense of a little sensing performance degradation matched to the conventional cooperative spectrum sensing.

Fadel F. Digham(2007) This letter addresses the problem of energy finding of an unknown signal over a multipath channel. It starts with the no-diversity case, and suggests some substitute closed-form expressions for the probability of detection to those newly reported in the literature. Detection potential is boosted by implementing both square-law combining and square-law selection diversity schemes.

Ref. No.	Year	Tech/Method used	Parameter used	findings
1	2015	Various spectrum sensing techniques	Spectrum Sensing, Energy Detection, Spectrum Holes	Asynchronous cooperative spectrum sensing method cuckoo search optimization sensitivity of spectrum sensing in CRN can be improved.
2	2008	Energy detection based spectrum sensing	Collaborative Sensing, Energy detection in noise power uncertainty	improvements on spectrum sensing performance in various parameters of interest, e.g. required average SNR for given desired PU signal detection performance, collaborative ROC and gains of SNR needed for overcoming U.
3	2008	energy detection using estimated noise variance for spectrum sensing	constant false alarm rate (CFAR) ,constant detection rate (CDR),SNR	thresholdsetting method can facilitate more spectrum sharingopportunities where the probability of false alarm is minimized and the desired probability of detection of the primary systems is assured
4	2010	Principal component analysis based The energy detection method for spectrum sensing	Energy Based Spectrum Sensing, Threshold Energy, Signal Space Power, PCA Technique	PCA based detection technique allows computation of noise power and threshold
5	2014	performance of CSS with diversity reception and channels impaired with Nakagami-*m* fading. Based on two relaying strategies,	decode and forward, detection probability, false alarm probability, cooperative spectrum sensing,	the detection accuracy varies with the number of cooperative users, the fading severity, and the power constraint DAF strategy shows that it is not necessary to incorporate all CRs in the cooperative process and a small number of reliable

		namely, the amplify-and-forward strategy and the detect-amplify-and-forward strategy		radios is enough to achieve practical detection level.
6	2008	Asynchronous energy detector at the Nodes	CR users, AWGN, Detection rule at the nodes, SNR	required observation time of the method is decreased considerably at the expense of a little detection performance degradation
7.	2008	Cooperative spectrum sensing	Cooperative spectrum sensing system model, The detection method for unlicensed users	Proper combination of decision and quantization with the local test statistic, it is possible to achieve high probabilities of detection even in the case that the prior knowledge of licensed user is unknown.
8	2007	sampling theory-based approach performance of an energy detector for an unknown transmit signal under both AWGN and fading channels.	Diversity schemes, energy detection, fading channels, low-power applications	improvement in detection capability when receive diversity schemes are employed

Conclusion

Cognitive radio (CR) is a type of wireless communication in which a transceiver can intelligently detect which correspondence channels are in use and which are not, and instantly budge into vacant channels while ignoring occupied ones. This optimizes the use of existing radio-frequency (RF) spectrum while minimizing Interference to other users. A "hole" is said to be present at a exacting frequency if the energy of the threshold is greater than the energy of the signal. Spectrum sensing in cognitive radio is a big issue. Various techniques have been researched to improve the spectrum sensing and results shows improvement in spectrum sensing like The sensitivity of spectrum sensing in cognitive radio networks can be improved by using asynchronous cooperative spectrum sensing method by applying cuckoo search optimization., instead of the exact noise variance threshold setting method, an estimated noise variance threshold in energy detection can facilitate more spectrum division opportunities when integrate with cooperative spectrum sensing, where the probability of forged alarm is diminished and the desired probability of detection of the primary systems is guaranteed.(Principal component analysis) PCA based detection technique allows computation of noise power and threshold.Two relaying strategies, that is, the amplify-and-forward Strategy and the detect-amplify-and-forward strategy show that the way the detection accuracy varies with the number of cooperative users, the fading cruelty, and the power constraint. Required observation time of the Asynchronous energy detector at the nodes method is decreased considerably as opposed to conventional spectrum sensing schemes at the expense of a little detection performance degradation. Also by proper combination of decision and quantization with the local test statistic, it is possible to achieve high probabilities of detection even in the case that the prior knowledge of licensed user is unknown.

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