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ENERGY DETECTOR ASSISTED BY GEOLOCATION DATABASE SCHEME UTILIZING RADAR BANDS

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ABSTRACT

Cognitive Radio (CR) is an intelligent method for opportunistic access of idle resources and a solution for spectrum resources scarcity. In this article a new technique for spectrum access is proposed. This technique combines energy detector with geolocation database. The proposed technique is employed in radar bands of (960-1400 MHz, 2.7-3.6 GHz and 5-5.85 GHz). These bands occupy quite large bandwidth and they are utilized only about 5% of the time. The new proposed technique is expected to solve the problem of hidden receivers faced by energy detector. It also poses a solution for the static nature of geolocation database method. It minimizes the interference caused by secondary users by improving the probability of detection. Furthermore, it improves the spectrum utilization through the improvement of false alarm probability.

Keywords: cognitive radio, energy detector, geolocation database.

1. INTRODUCTION

Wireless communication systems have developed very quickly in the past few decades. However the spectrum resources available for these systems are becoming scarce due to the fixed manner in which they are assigned. Assigning spectrum in a fixed manner is found to be quite inefficient, since it results in underutilization of available spectrum [1].

Cognitive radio (CR) concept was introduced to overcome this problem. The basic principle of CR is to identify and gather the necessary information about the other radios in the environment that are using the same spectral resources and then come up with a method to make interference to and from those radios as minimum as possible [1].

In CR technology, the secondary users (SUs) take advantage of the spectrum resources assigned to the licensed primary users (PUs) when this PUs are not using these resources without causing interference to incumbent systems [2]. Occupancy of spectrum bands varies from one band to another. According to [3, 4], Radio frequency measurements pointed that radar bands between 960-1400MHz, 2.7-3.6 GHz and 5-5.85GHz occupancy is very low, usually under 5%, and static throughout a day period. Therefore these Bands present a very good opportunity for cognitive radio networks deployment. As these bands are rarely used throughout a day period, there lies a great opportunity and solution for spectrum scarcity.

In [5] the authors stated that, in order to declare a certain band of frequencies at a specific location to be utilized by CR devices then two aspects must be taken under consideration. First, whether the attributes of that specific band suits the SU requirements or not, secondly, how will the coexisting SU system affect the performance of the PU system [5].

The remaining of this paper is structured as follows; Section 2 is spectrum access techniques, in which both techniques, geolocation database and energy detector are discussed. Section 3 introduces the proposed hybrid scheme. Initial simulation assumptions are illustrated in section 4. Finally the conclusions are drawn in section 5.

2. SPECTRUM ACCESS TECHNIQUES

There are three main spectrum access methods, namely spectrum sensing, geolocation database, and lastly beacon signaling.

Spectrum Sensing has attracted the most attention from the CR research community, due to the fact that it does not need any alterations in PU systems or additional infrastructure and also for its flexibility. One of the most appealing reasons in favor of spectrum sensing techniques is its ability to adapt in real time to changes in the radio environment. Basically there are three standard spectrum sensing methods which are, Matched Filter (MF), Energy Detection (ED) and Cyclostationary based detection (CD).

This paper focuses on Energy Detection and geoloaction database techniques.

2.1 Energy detection

This approach is the most common spectrum sensing scheme, due to its low implementation and computational complexities. Furthermore it is considered more generic as there is no need for any prior knowledge about the primary user's signal [5, 7, 8, 9, 10, 11]. In this method, the signal is detected by comparing the output of

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the energy detector with a threshold that depends on the noise floor [8].

However, this technique has many limitations including, performance degradation in low SNR values [7, 8, 9, 10], high sensitivity to noise variance uncertainty [7, 9, 10]. Furthermore it cannot distinguish noise and interference from primary users, and finally selection of the threshold for detecting licensed users poses a problem in this technique [5, 8].

Two hypothesis of received signal are considered. H_0 When the PU is absent and H_1 when the PU is present.

$$H_1: y(n) = s(n) + u(n) \quad (1)$$

$$H_0: y(n) = u(n) \quad (2)$$

Where y(n) is the received signal, s(n) is the PU signal and u(n) is AWGN noise with zero mean. Test statistics is given by

$$= X = \sum_{n=1}^{N} |y(n)|^2 \quad (3)$$

Where X is the energy of the received signal and N is number of samples. Probability of detection (P_d) and probability of false alarm (P_{fa}) are given as [9].

$$P_d = P(X > \lambda|H_1) = Q\left(\frac{(\lambda - N(\sigma_s^2 + \sigma_w^2))}{\sqrt{2N(\sigma_s^2 + \sigma_w^2)^2}}\right) \quad (4)$$

$$P_{fa} = P(X > \lambda|H_0) = Q\left(\frac{(\lambda - N(\sigma_w^2))}{\sqrt{2N(\sigma_w)^4}}\right) \quad (5)$$

Probability of miss detection is

$$P_{md} = 1 - P_d \quad (6)$$

And probability of decision error is given by

$$P_e = P_{fa} + P_{md} \quad (7)$$

Where, λ is threshold used to determine the presence and absence of PU. σ^2_s and σ^2_w represent signal and noise respectively. The threshold can be calculated from equation (5) as:

$$\lambda = Q^{-1}(P_{fa})\sqrt{2N(\sigma_w)^4} + N\sigma_w^2 \quad (8)$$

2.2 Geoloactoin database (GL-DB)

In this technique, a centralized database stores information about PUs spectrum position and use. The secondary devices estimate their location and send it to the database, and in turn the database sends back the available channels to the connected secondary devices. In contrast to spectrum sensing techniques, this approach uses theoretical propagation models instead of Real-time RF measurements to calculate the interference crated between communication systems [6].

GL-DB spectrum technique was proposed by FCC as a suitable method for opportunistic spectrum sharing in Radar bands as it provides adequate protection to radar systems. However, this method ignores temporal opportunities resulting from radar mobility, highly directive antennas and predictable sweep patterns. As a results this leaves a large portion of spectrum resources underutilized [3].

The following diagram represents a basic architecture for GL-DB technique.

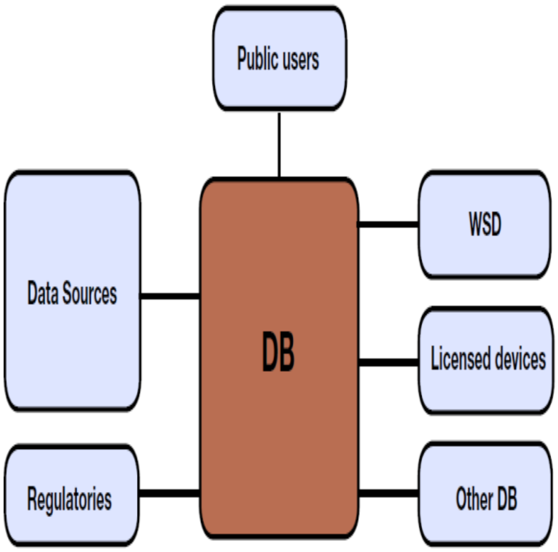

Figure-1. Database architecture.

3. HYBRID SPECTRUM ACCESS TECHNIQUES

This Method Is A Combination Of Two Spectrum Access Techniques Namely, Energy Detection And Geolocation Database. As Mentioned Earlier In The Related Works Section, Both Of These Techniques Have Drawbacks. For Example, Ed Cannot Identify Hidden Receivers, On The Other Hand Gl-Db‘S Liability Lies In The Lack Of Recognizing Temporal Spectrum Opportunities. Therefore This Technique Was Proposed To Overcome This Issue. In this technique the secondary users' devices cognitive capabilities are complemented with a priori information about the primary users in that specific band provided by the database.

In Figure-3, the channels' occupancy information is retrieved from the geoloaction database. This information is used to book vacant channels for secondary usage. The booked channels are then sensed using energy detection method to find out whether they are available or not. The decision of whether a specific channel is

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occupied or not is based on the process of energy detection sensing technique described in section 2 of this paper.

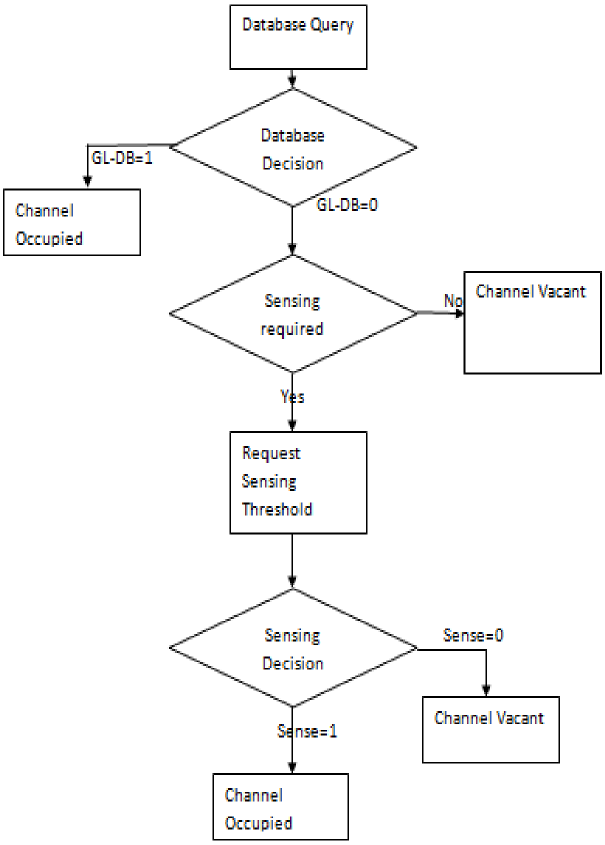

Figure-2. Proposed scheme.

4. INITIAL RESULTS AND ANALYSIS

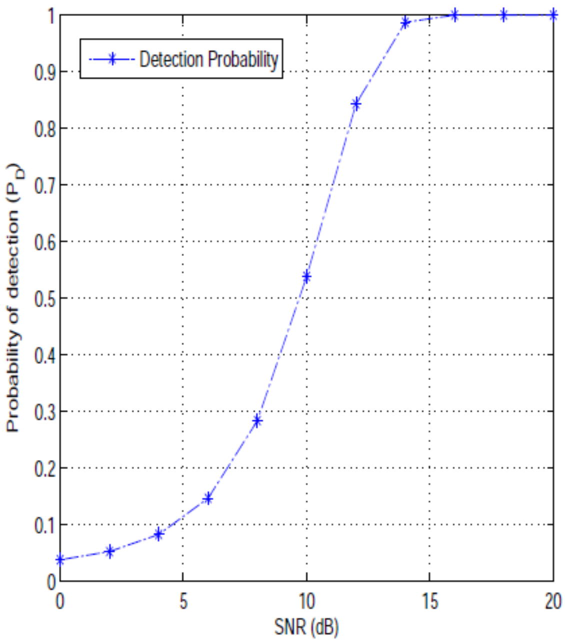

Figure-3. Effect of SNR on probability of detection PD, in AWGN.

Figure-3 shows the performance of Energy detector operating under AWGN with probability of false alarm and number of samples set to 0.1 and 1000 respectively. From this figure, as the value of signal to noise ratio is increased the detection probability improves. This is consistent with the concept of energy detector.

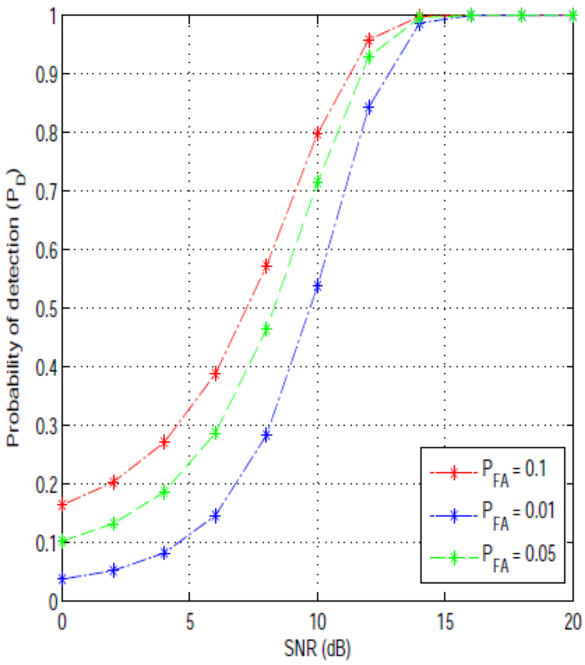

Figure-4. Probability of detection Vs SNR with varying values of false alarm probability in AWGN.

In Figure-4 the effect of changing the probability of false alarm on detection probability is investigated. As shown in the figure when the P_{fa} is increased from 0.01 to 0.05 at a specific SNR value the probability of detection improves by 1.7 times.

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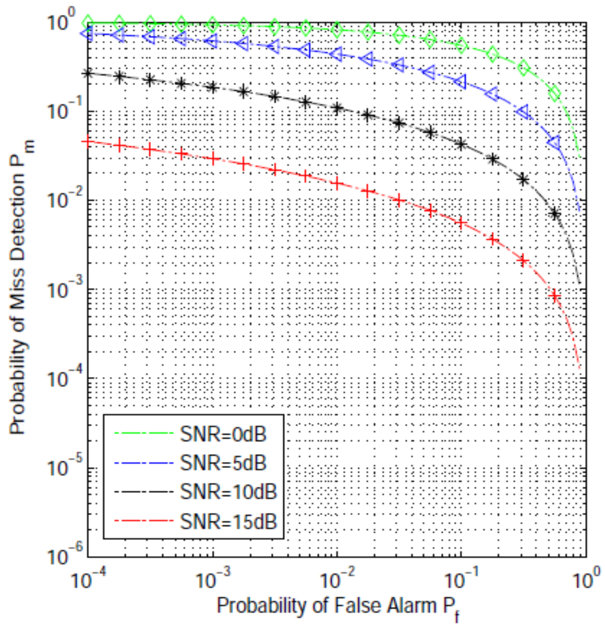

Figure-5. Receiver Operating Characteristics (ROC) curves for energy detection over AWGN.

Figure-5 illustrates the relationship between probability of miss detection and probability of false alarm. Probability of miss detection is a complement for the probability of detection (P_{MD}= 1-P_D).

CONCLUSIONS

The electromagnetic spectrum is becoming scarce with the rapid growth of wireless communications applications. Cognitive radio concept is one of the solutions for this scarcity. In this paper a new spectrum access technique is proposed. This technique combines energy detector with geolocation database to overcome the flaws of the individual techniques discussed in the open literature. This technique yields a better utilization of the white spaces in the electromagnetic spectrum as it eliminates the problem of hidden receivers encountered by Energy detector method. Also it introduces dynamicity to the static nature of geolocation database approach.

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