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SPECTRUM SENSING SURVEY IN COGNITIVE RADIO

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Abstract-In today's technology, we need more robust and flexible communication systems. The radio electromagnetic spectrum is not utilized in full and hence the emergence of cognitive radio in which Secondary User (SU) utilizes the spectrum holes in the Primary User (PU). In this paper, we are going to discuss the various methods in spectrum sensing, (i.e) sensing of the PU by the SU. If the PU is not using the spectrum, then the SU utilizes it.

Keywords – Cyclostationary, Matched filter, Spectrum sensing, Cognitive radio, Energy detection

I.INTRODUCTION

It is a fact that radio spectrum is underutilized and the bandwidth is not scarce, but is not used in full capacity. Cognitive radio comes under dynamic spectrum management, which learns about its environment and then adapts itself to use the spectrum hole when the PU is absent. When the PU appears and if the SU is utilizing the channel, then the SU must vacate the channel it is using for the PU. The SU must use the spectrum without interference to the PU. Based on the learning process the cognitive radio will change its operating frequency, modulation, protocol, etc. There are four major duties done by the cognitive radio and they are

1) Spectrum sensing
2) Spectrum sharing
3) Spectrum management
4) Spectrum mobility

The main features of cognitive radio

Cognitive capability: It is the ability of the cognitive radio to sense the spectrum holes [1].

Cognitive re-configurability: Cognitive radio is an enhancement of the software defined radio. So re-configurability is dynamically changing the parameters of the radio without actually doing anything with the hardware [1].

In terms of occupancy the sub- bands of the radio spectrum can be categorized as white spaces, black spaces and gray spaces. White space is free of SUs, black spaces are full of SUs and gray spaces are partially occupied by SUs.

II.SPECTRUM SENSING (SS)

Spectrum sensing is the timely sensing of the spectrum holes so that the SU can utilize the unused spectrum when the PU is not available [2]. As regards to the four functions of cognitive radio spectrum sensing plays an important role in the sensing the availability of the spectrum hole. SS can be broadly classified into non-cooperative sensing, co-operative sensing and interference based sensing. Non-cooperative sensing can be further classified into various methods like matched filter, energy detection, and cyclostationary method. In the non-cooperative sensing method the cognitive radio senses by itself the channel state and it takes no help from other radio nodes whereas in co-operative sensing the cognitive radio shares information with the other radio nodes in identifying the primary user. Inteference based detection is based on the interference temperature level so as to not cause any hindrance to the primary user.

A)NON-COOPERATIVE TECHNIQUES

(i) Energy Detection

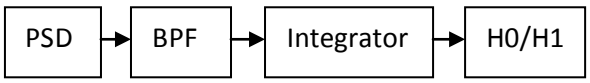

Figure1: Block diagram of energy detector

Energy detection is a kind of signal detection mechanism where energy of the channel is calculated so as to calculate whether there is absence or presence of the PU. For energy detection the parameters about the primary user signal is not needed [2]. It can be implemented in both time and frequency domains. The important part is the fixation of threshold in this method. Above the particular threshold there is presence of primary user and below that threshold there is absence of the primary user. In this method the power spectral density (PSD) is calculated and passed through a bandpass filter of a particular bandwidth and is integrated over a time interval. The integrator output is then compared with the predefined threshold and then the decision is made whether there is absence or presence of the PU [2]. However there are many disadvantages to the energy detection method and they are

1) The time taken to sense the presence or absence of a signal is high
2) There is uncertainty of the noise power
3) Energy detection cannot be used to detect spread spectrum signals.

(ii) Matched Filter based detection

The matched filter technique maximizes the SNR ratio and is an optimum filtering technique in communication systems [2]. But for matched filter technique to detect the absence or presence

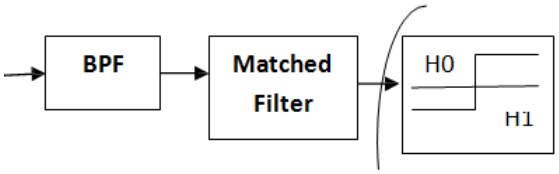

Figure2: Block diagram of matched filter

PU, the SU must know all the parameters about the primary user [2]. The operation performed by matched filter is similar to correlation. The received signal is convolved with the filter response which is time shifted version of the reference signal. One of the main advantages of this method is that it requires shorter sensing time for certain probability of detection or probability of false alarm. It performs well when the noise is Gaussian and when there is prior knowledge about the primary signal.

One of the significant disadvantages of this method is that it needs prior knowledge about the signal and needs exact synchronization [2]. Implementing the sensing unit with this method is more complex since cognitive radio needs receivers for all types of signals. It consumes large power because it requires implementation of various receiver algorithms.

(iii) Cyclostationary based detection

Cyclostationary based detection depends on the periodicity of the signals such as mean and auto-correlation [3]. When the cyclic spectral density is found for the signal the periodicity can be easily highlighted. The primary signal periodicity can be easily highlighted by taking the correlation [4]. Fourier transform of correlated signals results in peaks at frequencies specific for that signal and searching for these peaks results in identifying the primary user [4]. Noise is random in nature and it doesn't get highlighted when taking the correlation. The advantages of this method are that it can work well for low SNR conditions and it has the capability to distinguish between the primary user signal and noise [3]. The disadvantage is that since all the cyclic frequencies are calculated the complexity is higher.

B)COOPERATIVE TECHNIQUES

Cooperative techniques can be broadly classified into two types (i) Centralized approach and (ii) De-centralized approach.

(i) Centralized Approach

In centralized approach the there is a cognitive radio controller called as a fusion center within the network which collects all the sensing information. When one of the cognitive radios in the network senses a primary user it sends the information to the fusion center and then the controller determines the band which can be used and which cannot be used. The controller informs all the cognitive radios in the network by broadcast method.

(ii) De-centralized Approach

In decentralized approach there is no fusion center and it uses a distributed sensing approach. Here the cognitive radio when it detects the PU it vacates the channel without informing all other nodes in the network. Thus in the decentralized method there is no coordination and hence it is more prone to interference unlike the centralized approach

III.CONCLUSION:

Comparative investigation of all SS techniques

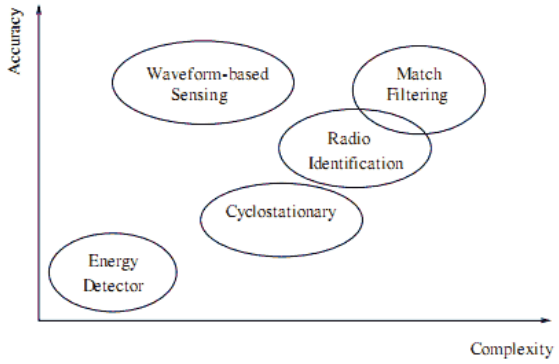

Figure3: Comparative investigation of all SS techniques

Among the three methods discussed in this paper energy detection is a basic and popular method, but it is low in accuracy. The Matched filter is having the highest accuracy and it is more complex to build because it needs complete knowledge about the primary user signal. A cognitive radio receiver built with this sensing technique is more complex as it has to tune itself for various primary user frequencies. The cylcostationary method is not as basic as energy detection or very complex as match filtering and its accuracy is better than energy detection but still lower than the matched filter technique. Cylcostationary method depends heavily on the periodicity of signals.

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