Detection of Spectrum Sensing by using Coherent Detection Technique

Meenakshi[1], Rupinder kaur [2]
[1](Asst Professor in Electronics and communication/ Rayat Bahra College of Engineering &Nanotechnology / Punjab Technical University,/Punjab India)
[2](Asst Professoin Electronics and communication/Panjabi University Patiala/Punjab, India)

Abstract : *As, the radio spectrum for transmission is very limited but the usage of spectrum is increasing. So, to solve spectrum problem, new method is used. Wher ethe vacant spectrum sense by detector. There are different methods are used for spectrum sensing which are Transmitter detection, Co-operative detection, Interference base detection. In this paper transmission type coherent detection technique is used for spectrum sensing. For sensing the spectrum ROC curve is used where absent or present of primary users is sense through the probability of detection.*

Keywords *-Detection probability (P_d), Signal to noise ratio (SNR), ROC (Receiver Operating Characteristics), False alarm probability (P_{fa}), Primary users (PU), Secondary users (SU)*

I. INTRODUCTION

As the number of wireless connections increases, spectrum demand and spectrum congestion will become critical challenges in the forthcoming all-encompassing wireless world. In fact, future wireless networks will face spectrum scarcity as a result of the users' requirements, such as high multimedia data rate transmission over mobile networks [1]. So to solve this problem scientist developed the new concept called "Cognitive radio". Dynamic spectrum access (DSA) has been proposed as an alternative policy to allow the radio spectrum to more efficiently be used [2], [3]. In DSA, a piece of spectrum can be allocated to one or more users, which are called primary users (PUs); however, the use of that spectrum is not exclusively granted to these users, although they have higher priority in using it. Other users, which are referred to as secondary users (SUs), can also access the allocated spectrum as long as the PUs are not temporally using it or can share the spectrum with the SUs as long as the PUs' can properly be protected.

1. LITERATURE REVIEW

The concept of cognitive radio was first proposed by Joseph Mitola III in a seminar at KTH (the Royal Institute of Technology in Stockholm in 1998 and published in an article by Mitola and Mitola later described as the point in which wireless personal digital assistants (PDAs) and the related networks are sufficiently computationally intelligent about radio resources and related to computer-to-computer communications to detect user communications needs as a function of use context, and to provide radio resources and wireless services most appropriate to those needs [4]

2. SYSTEM ARCHITECTURE

The components of the cognitive radio network architecture, as shown in Figure 1.3, can be classified in two groups as the primary network and the cognitive network. Primary network is referred to as the legacy network that has an exclusive right to a certain spectrum band. While, cognitive network does not have a license to operate in the desired band the basic elements of the primary and unlicensed networks are defined as follows:

2.1Primary User

Primary user has a license to operate in a certain spectrum band. This access can be only controlled by its base-station and should not be affected by the operations of any other unauthorized user.

2.2 Primary Base-Station

Primary base-station is a fixed infrastructure network component which has a spectrum license. In principle, the primary base-station does not have any cognitive radio capability for sharing spectrum with cognitive radio users. However, primary base-station may be required to have both legacy and cognitive radio protocols for the primary network access of cognitive radio users.

2.3 Cognitive Radio User

Cognitive radio user has no spectrum license. Hence, the spectrum access is allowed only in an opportunistic manner.

2.4 Cognitive Radio Base-Station

Cognitive radio base-station is a fixed infrastructure component with cognitive radio capabilities. Cognitive radio base-station provides single hop connection to cognitive radio users without spectrum access license. As shown in Figure 1, cognitive radio users can either communicate with each other in a multi hop manner or access the base-station. Thus, in our cognitive radio network architecture, there are three different access types over heterogeneous networks, which show different implementation requirements as follows:

2.4.1 Cognitive Radio Network Access

Cognitive radio users can access their own cognitive radio base-station both in licensed and unlicensed spectrum bands. Since all interactions occur inside the cognitive radio network, their medium access scheme is independent of that of primary network.

2.4.2 Cognitive Radio Ad Hoc Access

Cognitive radio users can communicate with other cognitive radio users through ad hoc connection on both licensed and unlicensed spectrum bands. Also cognitive radio users can have their own medium access technology.

2.4.3 Primary Network Access

The cognitive radio user can access the primary base-station through the licensed band, if the primary network is allowed. Unlike other access types, cognitive radio users should support the medium access technology of primary network. Furthermore, primary base-station should support cognitive radio capabilities.

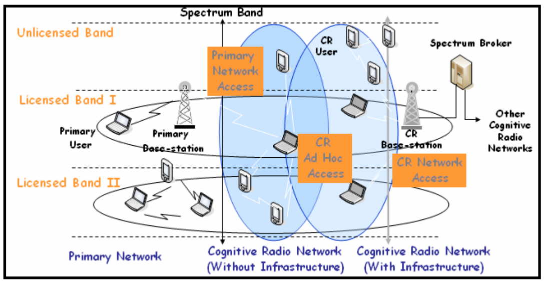


Fig 1 Cognitive radio network architecture

3 Spectrum Sensing

The main challenge to the Cognitive radios is the spectrum sensing. In spectrum sensing there is a need to find spectrum holes in the radio environment for CR users. However it is difficult for CR to have a direct measurement of channel between primary transmitter and receiver. A CR cannot transmit and detect the radio environment simultaneously, thus, we need such spectrum sensing techniques that take less time for sensing the radio environment. [5]

3 CLASSIFICATIONS OF TECHNIQUES

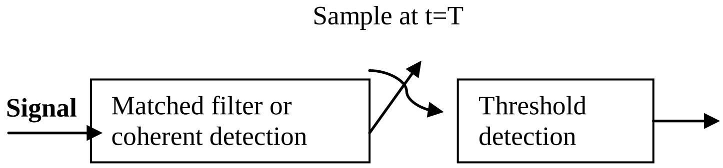
The spectrum sensing techniques for cognitive radio (CR) were classified into three categories

- Transmitter detection.
- Co-operative detection.
- Interference base detection

From these techniques transmission technique is subdivides into three parts:
Energy detection, Matched filter and Cyclostationary feature detection

4 MATCHED FILTER TECHNIQUES OR COHERENT DETECTION TECHNIQUE

A matched filter is a linear filter designed to provide the maximum signal-to noise ratio at its output for a given transmitted waveform [6]. Figure 4.1 depicts the block diagram of matched filter. The signal received by CR is input to matched filter which is r (t) = s (t) + n (t). The matched filter convolves the r (t) with h (t) where h (t) = s (T-t + τ). Finally the output of matched filter is compared with a threshold λ to decide whether the primary user is present or not.



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4.1 Characterization of The Matched Filter
Signal detection using the matched filter was studied in 2006 by Cabric, et. al. in [7]. They show that $\hat{S}$ is Gaussian:

$$\hat{S} \sim \begin{cases} N(0, \sigma_n^2 \varepsilon), & H_0 \\ N(\varepsilon, \sigma_n^2 \varepsilon) & H_1 \end{cases} \qquad (4.1)$$

(4.1)

Where σ_n^2 is the variance of the noise and

$$\varepsilon = \sum_{k=1}^{N} x(k)^2 \qquad (4.2)$$

(4.2)

Based on this information, the probabilities of false alarm P_f and detection P_d are:

$$P_f = Q(\frac{\hat{S}}{\sqrt{\varepsilon \sigma_n^2}}. \qquad (4.3)$$

and

$$P_d = Q(\frac{\hat{S} - \varepsilon}{\sqrt{\varepsilon \sigma_n^2}}) \qquad (4.4)$$

5 RESULTS AND DISCUSSION

In this paper, the simulation tool used is MATLAB 2012a.

5.1 Roc Curve For Nonfluctuating Coherent Detection For False Alarm Probability (P_{fa}) At 0.1.

The performance of coherent detection is study using the ROC curve. Monte-Carlo method is used for simulation. Figure 5.1 illustrates the Non fluctuating ROC (Receiver Operating Characteristics) curves i.e. Detection probability (P_d) versus signal to noise ratio (SNR) using coherent detection method for spectrum sensing. The graph is plotted for 0.1value ofP_{fa} over AWGN channel. When the $\mathbf{P_{fa}}$ is 0.1 db then probability of detection is 0.995

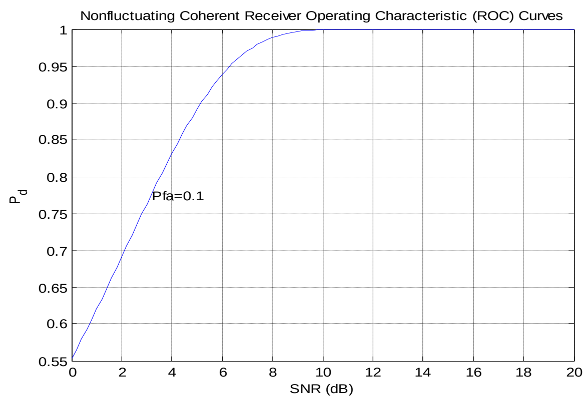

Fig 5.1 ROC curve for probability of detection versus SNR for 0.1 $\mathbf{P_{fa}}$

5.2 Roc Curve For Nonfluctuating Coherent Detection For False Alarm Probability (P_{fa}) At 0.01.

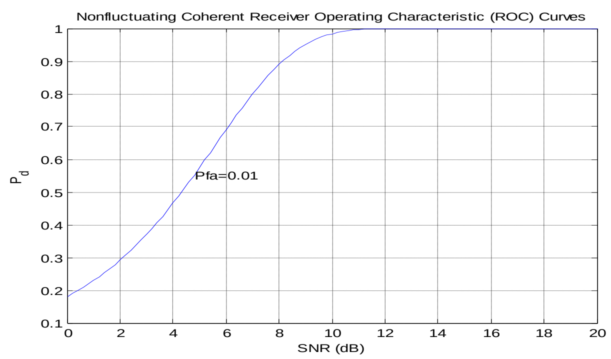

Fig 5.2 ROC curve for probability of detection versus SNR for 0.01 $\mathbf{P_{fa}}$

Figure 5.2 illustrates the Non fluctuating ROC (Receiver Operating Characteristics) curves i.e. Detection probability (P_d) versus signal to noise ratio (SNR) using coherent detection method for spectrum sensing. The graph is plotted for 0.01value ofP_{fa} over AWGN channel. When the P_{fa} is 0.01 db then probability of detection is 0.999 as compare to P_{fa} =0.1 the value of probability of detection increases

5.3 Roc Curve For Nonfluctuating Coherent Detection For False Alarm Probability (P_{fa}) At 0.001.

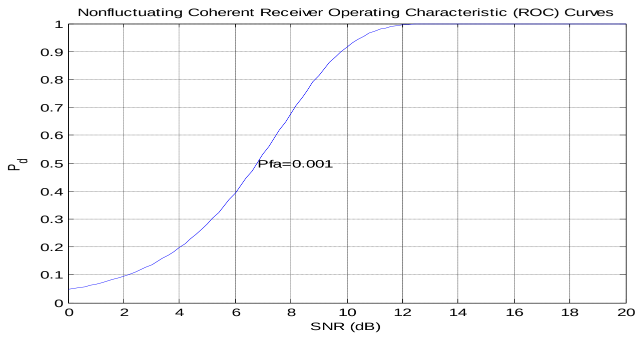

Fig 5.3 ROC curve for probability of detection versus SNR for 0.001 $\mathbf{P_{fa}}$

Figure 5.3 illustrates the Non fluctuating ROC (Receiver Operating Characteristics) curves i.e. Detection probability (P_d) versus signal to noise ratio (SNR) using coherent detection method for spectrum sensing. The graph is plotted for 0.001value ofP_{fa} over AWGN channel. When the P_{fa} is 0.001 db then probability of detection is 1.000as compare to P_{fa} =0.01 the value of probability of detection increases.

5.4 Roc Curve For Nonfluctuating Coherent Detection For False Alarm Probability (P_{fa}) At 0.0001.

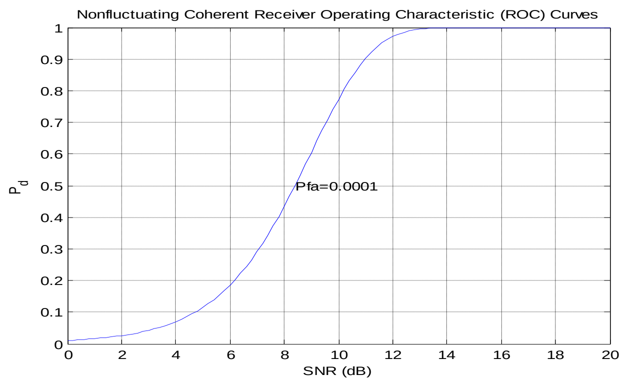

Fig 5.4ROC curve for probability of detection versus SNR for 0.0001 $\mathbf{P_{fa}}$

Figure 5.4 illustrates the Non fluctuating ROC (Receiver Operating Characteristics) curves i.e. Detection probability (P_d) versus signal to noise ratio (SNR) using coherent detection method for spectrum sensing. The graph is plotted for 0.0001value ofP_{fa} over AWGN channel.When the P_{fa} is 0.0001 db then probability of detection is 1.000

5.5 Comparision Of Roc Curve For Nonfluctuating Coherent Detection For Different Values Of False Alarm Probability (P_{fa})

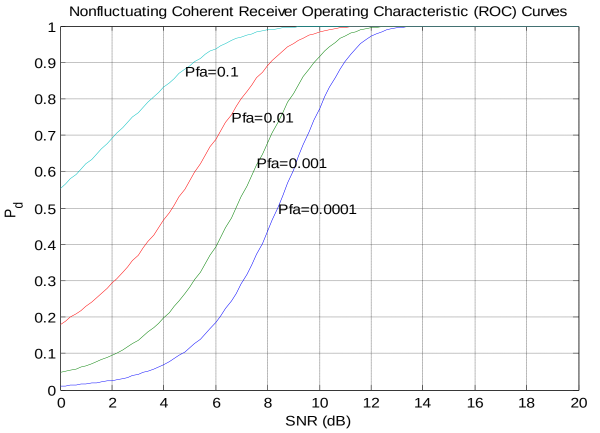

Fig 5.5ROC curve for coherent detection for different $\mathbf{P_{fa}}$

Figure 5.5 illustrates The Non fluctuating ROC (Receiver Operating Characteristics) curves i.e. Probability of detection (P_d) versus signal to noise ratio (SNR) using coherent detection method for spectrum sensing. The graph is plotted for different P_{fa} value over AWGN channel and it shows that with increase in False alarm probability (P_{fa}), the probability of detection increases and is quantified in Table 5.2. This graph shows the comparison of different values of False alarm probability (P_{fa}). It depicts that by varying the small amount of False alarm probability (P_{fa}) value there is large amount of Probability of detection (P_d) value changes. At the 0.1 value probabilityof False alarm, the probability of detection is maximum.

Table 5.1Table of coherent detection for Signal to Noise verse Probability of Detection over different values of (P_{fa})

Signal to Noise Ratio (in dB)	**Probability of Detection (P_{fa} = 0.0001)**	**Probability of Detection (P_{fa} = 0.001)**	**Probability of Detection (P_{fa} = 0.01)**	**Probability of Detection (P_{fa} = 0.1)**
10	**0.774**	**0.916**	**0.984**	**0.999**
11	**0.903**	**0.973**	**0.996**	**0.999**
12	**0.972**	**0.994**	**0.999**	**1.000**
13	**0.995**	**0.999**	**1.000**	**1.000**

In this table calculate the values of Probability of Detection (P_{fa}) verses SNR over different values of Probability of False alarm **(**P_{fa})with increases in Probability of False alarm**(**P_{fa}) the Probability of Detection(P_{fa}) increases which shows that the Probability of primary user occurrence is high.

6. CONCLUSION

In this paper , the coherent or matched filter spectrum sensing technique have been discussed The Performance of Spectrum Sensing technique has been evaluated using Non fluctuating ROC (Receiver Operating Characteristics) curves of Probability of detection versus signal to noise ratio (SNR). The performance of spectrum sensing method improves with increase in False alarm probability (P_{fa}). As compare to Cyclo-stationary feature detection and Energy detection method, the coherent or matched filter detection gives better performance and requires less signal samples to achieve good detection.

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