Spectrum Sensing In Cognitive Receiver Under Correlated Channel

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Abstract— In this context, Cognitive Radio (CR) is considered a promising candidate for enhancing the spectrum efficiency of communication systems because it is aware of its operating environments and can adjust its parameters dynamically. They can boost up spectrum utilization signi cantly, by dynamically accessing unused primary spectrum while bringing no harm to primary users. In this paper we are using to spectrum sensing methods for sensing the spectrum of cognitive radio for allocating free spectrum to new primary user. We use eigenvalue baser spectrum sensing if the signal to ratio of the signal is greater than unity otherwise cyclostationary spectrum sensing method because cyclostationary is good at low signals. This two methods are combined in this paper and we can call it as an hybrid method. Also we compare the performance of cognitive radio in correlated and uncorrelated channel by the same hybrid method. Simulation results indicate that we will get a better out in both correlated and uncorrelated channels

Keywords— **Cognitive radio, Spectrum sensing, Eigenvalue spectrum sensing, cyclostationary spectrum sensing, hybrid method, correlated channel, uncorrelated channel**

I. INTRODUCTION

The wireless communication systems encounter multipath fading in any environment where there is multipath propagation and there is some movement of elements, within the wireless communications system. This may include the radio transmitter or receiver position, or in the elements that give rise to the reflections. The multipath fading can often be relatively deep i.e. the signals fade completely away, whereas at other times the fading may not cause the signal to fall below a useable strength. The fading channel could be modeled with Nakagami-m distribution if the fading is severe compared to the Rayleigh distribution model [1].

The Rayleigh distribution is a special case of Nakagami-m when m=1.In multi path channels, small scale fading is the main issue to concentrate for communication engineer. Due to this small scale fading, the signal strength gets rapid fluctuations over a small travel distance. Wireless broadband systems offer different sources of diversity to combat fading, which can be properly exploited by a proper coding and transmission scheme. Multiple antennas and space time codes can be used to obtain spatial diversity [1] .The issue of spectrum underutilization in wireless communication can be solved in a better way using Cognitive radio (CR) technology. Cognitive radios are designed in order to provide highly reliable communication for all users of the network, wherever and whenever needed and to facilitate effective utilization of the radio spectrum. A cognitive radio is an intelligent radio that can be programmed and configured dynamically. Its transceiver is designed to use the best wireless channels in its vicinity [3]. Such a radio automatically detects available channels in wireless spectrum, then accordingly changes its transmission or reception parameters to allow more concurrent wireless communications in a given spectrum band at one location.

Cognitive Radio (CR) is a system/model for wireless communication. It is built on software defined radio which is an emerging technology providing a platform for flexible radio systems, multiservice, multi-standard, multiband, reconfigurable and reprogrammable by software for Personal Communication Services (PCS). It uses the methodology of sensing and learning from the environment and adapting to statistical variations in real time.

The network or wireless node changes its transmission or reception parameters to communicate efficiently anywhere and anytime avoiding interference with licensed or unlicensed users for efficient utilization of the radio spectrum. Cognitive modules in the transmitter and receiver must work in a harmonious manner which is achieved via a feedback channel connecting them [4]. Receiver is enabled to convey information on the performance of the forward link to the transmitter. Thus CR by necessity is an example of a feedback communication system. The concept was first originated by Defense Advance Research Products Agency (DARPA) scientist, Dr. Joseph Mitola and the result of that concept is IEEE 802.22 ,

Cognitive Radio (CR) is a key technology that can help mitigate scarcity of spectrum. The most essential task of CR is to detect licensed user/Primary User (PU); if PU is absent, then spectrum is available for cognitive radio user/Secondary User (SU) and is called spectrum hole/white space. The process of detection of PU is achieved by sensing radio environment and is called spectrum sensing [2-4]. The prime concerns of spectrum sensing are about two things first, the primary system should not be disturbed by Communication and secondly, spectrum holes should be detected efficiently for required throughput and quality of service (QoS) [5].

II. SPECTRUM SENSING

Here in this thesis we are considering the main two spectrum sensing techniques for cognitive radios which are eigenvalue spectrum sensing and Cyclostationary spectrum sensing method. The cyclostationary detection is based on auto-correlation function, but in [6] the authors exploited the mean characteristics of the primary signals to improve the channel sensing in time domain and called it one-order cyclostationary detection.

Although the performance of cyclostationary detection is a bit better than that of one-order cyclostationary detection, this gain is due to hardware complexity and power consumed by additional multiplying algorithm [7]. For commercial implementation of CRs, it is necessary to minimize hardware complexity and power consumption. There-fore, we are using the one-order cyclostationary detection instead of the higher-order cyclostationary detection.

III. EIGENVALUE BASED DETECTION

This MME approach is semi asymptotic in nature since the bound for the maximum eigenvalue is calculated based on the TW distribution instead of the asymptotic distribution while the minimum eigenvalue is evaluated based on asymptotic analysis [8][6]. The difference between MP-based asymptotic approach and the TW approach is that the MP-based approach uses deterministic asymptotic bounds for the a.e.p.d.f. support while the TW approach uses the pdf of the maximum/minimum eigenvalue for finite dimensions. The binary hypothesis testing problem for this technique can be written as:

$$\text{Decision} = \begin{cases} H_0 & \text{if } \frac{\lambda_{max}(R(N))}{\lambda_{min}(R(N))} \leq \gamma_1 \\ H_1, & \text{otherwise} \end{cases} \quad (1)$$

$$\gamma_1 = \frac{b}{a} \left(1 + \frac{(\sqrt{N}+\sqrt{M})^{-2/3}}{NM^{1/6}} F_{TW_2}^{-1}(1 - P_f)\right) \quad (2)$$

$$a = \left(N^{1/2} - M^{1/2}\right) \quad (3)$$

$$b = \left(N^{1/2} + M^{1/2}\right) \quad (4)$$

IV. CYCLOSTATIONARY METHOD

Commonly, the primary modulated wave-forms are coupled with patterns characterized as cyclostationary features like sine wave carriers, pulse trains, repeating spreading, hoping sequences or cyclic prefixes inducing periodicity [9]. CR can detect a random signal with a specific modulation type in the presence of random stochastic noise by exploiting the periodic statistics like mean and autocorrelation of the primary waveform. The cyclostationary detection is based on auto-correlation function, but in [10] the authors exploited the mean characteristics of the primary signals to improve the channel sensing in time domain and called it one-order cyclostationary detection. Cyclostationary method is good at low signals so it is used if the received signal have low signal compared to the noise signal generated.

Although the performance of cyclostationary detection is a bit better than that of one-order cyclostationary detection, this gain is due to hardware complexity and power consumed by additional multiplying algorithm [11]. For commercial implementation of CRs, it is necessary to minimize hardware complexity and power consumption. There-fore, we are using the one-order cyclostationary detection instead of the higher-order cyclostationary detection. block diagram of cyclostationary method is shown below in Fig 1.

$$Y[n] = \sum_{K=-\infty}^{\infty} h[n-k]x[k] \quad (5)$$

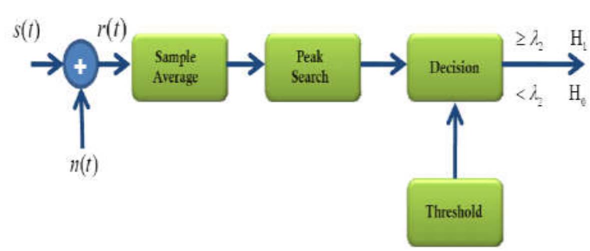

Fig. 1 Block diagram of cyclostationary method.

V. HYBRID METHOD

Hybrid method is the combination of eigenvalue method and cyclostationary method. The block diagram representation of such an idea is shown below in Fig 2.

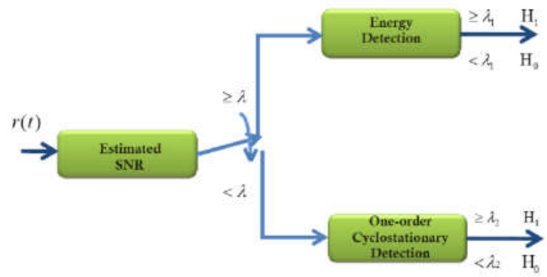

Fig. 2 Block diagram of combined sensing technique.

In this method first we find the SNR from the environment and according to a threshold value the signal is fed to either eigenvalue method or cyclostationary method. If the value is less than or equal to the threshold we fed it to ED and if not then fed it to MF detector. By doing so the effective sensing efficiency is improved and we obtain a better probability of detection than if either of one is individually used [4].

As a two-stage wideband spectrum sensing technique, a scheme combining a coarse sensing and _ne sensing was proposed by Y. Hur et al. [12]. In initial stage, the coarse sensing is performed over the entire frequency range with a wide bandwidth. A wavelet transform based Multi-Resolution Spectrum Sensing (MRSS) technique is presented as a coarse sensing. In the first stage, the occupied and candidate spectrum segments are identified. In the second stage, fine sensing is applied on candidate spectrum segments to detect unique features of modulated signals. Conformation of an unoccupied segment is done by careful fine sensing [13].

VI. Simulation Results

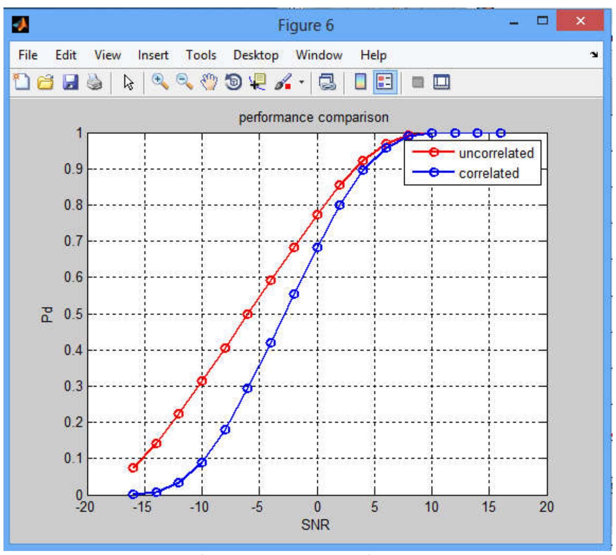

Fig. 3 Output comparison

Here from the stimulation output we got an idea about the performance of cognitive radio under correlated and uncorrelated channel. The output graph have SNR as the axis variable and probability of detection as the y axis variable.

VII. Conclusions

In this paper, spectrum sensing problems in the presence of channel/noise correlation have been considered in the context of a cognitive radio. The performance of eigenvalue-based SS techniques has been studied in the presence of noise/channel correlation. It has been noted that noise correlation degrades the performance and channel correlation enhances the performance of the SCN-based SS techniques. Then we do an another method of spectrum sensing called cyclostationary spectrum sensing technique, combination of this two method is called hybrid method. Furthermore, theoretical expressions of the received signal's covariance matrix have been derived under signal plus noise hypothesis in the presence of channel correlation and in the presence of both channel/noise correlation.

Moreover, an SNR estimation technique based on the maximum eigenvalue of the received signal's covariance matrix has been presented in order to estimate the PU SNR in the presence of both channel/noise correlation. The performance of the proposed technique has been evaluated in terms of normalized MSE. It can be concluded that the PU SNR can be reliably estimated using the proposed technique when the CR sensing module is aware of the channel/noise correlation.

ACKNOWLEDGMENT

The authors would like to thank anonymous reviewers for providing their valuable suggestions.

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