Periodicity based Cyclostationary Spectrum Sensing in Cognitive Radio Networks

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ABSTRACT

The last decade has witnessed a growing demand for wireless radio spectrum due to the rapid deployment of new wireless devices and applications. Spectrum is a precious resource and thus underutilization of a large part of allocated spectrum is not acceptable. Cognitive radio (CR) is proposed as a promising solution for increasing spectrum utilization and thereby helping to mitigate spectrum scarcity. CR is capable of sensing the unused spectrum bands and adapt to operate in the vacant bands. Once cognitive radios detect the presence of a primary user in their operating band, they must vacate the band immediately. Hence, accurate spectrum sensing is an essential feature of CR systems. In this paper, a cyclostationary spectrum sensing method for identifying the presence of primary user is introduced which uses the concept of periodicity in OFDM signals. In existing method,the periodicity of pilot signals in the OFDM symbols is used to detect the signals. The proposed scheme is robust to the detection of primary user signal with guard interval insertion in the OFDM signals which use the concept of periodicity. The power spectral density of average and true method which defines the spectrum power is compared and the simulation results are given in this paper. It is observed from the results that true power spectral density method is well suitable for CR which enables perfect sensing over primary users.

Keywords: Cognitive Radio (CR), Orthogonal frequency division multiplexing (OFDM), Power spectral density (PSD), Spectrum sensing.

1. INTRODUCTION

With rapid growth in the wireless devices and applications, the usages of spectrum resources play a vital role in the current wireless scenario. In particular most part of the allocated spectrum to the licensed users is idle, results in demand of allocation of spectrum to users called spectrum scarcity. The underutilization of spectrum in wireless communication can be solved in a better way by using the technology called cognitive radio. Recent studies by the FCC, Spectrum Policy Task Force have reported vast temporal and geographic variations in the usage of allocated spectrum with utilization ranging from 15 to 85% [1]. The large portions of the spectrum are unused as illustrated in Figure1. Cognitive radio can change its transmitter parameters based on interaction with environment in which it operates. It consists of four main functional blocks such as spectrum sensing, spectrum management, spectrum sharing and spectrum mobility. Spectrum sensing aims to determine availability of spectrum and the presence of the licensed users.

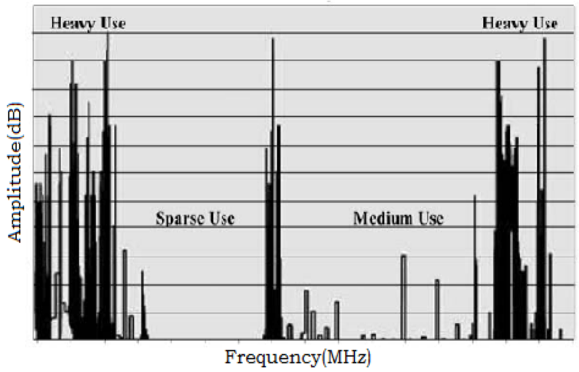

Figure 1: Spectrum Utilization

Spectrum management is to predicthow long the spectrum holes are likely to remain available for use to cognitive radio users. Spectrum sharing is to distribute the spectrumholes fairly among the secondary users. Spectrum mobility is to control seamless communication requirements during the transition to better spectrum [2].

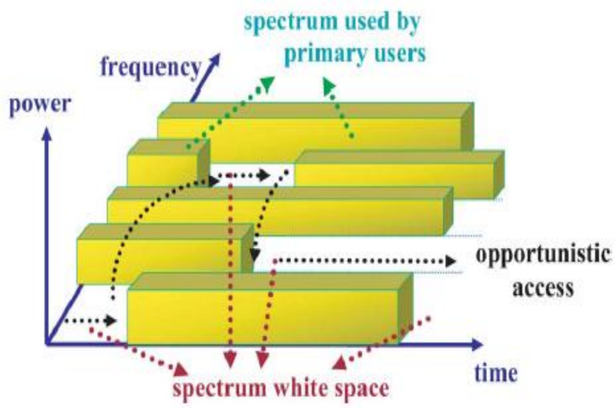

Figure 2: Representation of spectrum holes

Figure2 shows the schematic representation of spectrum holes in a band of certain frequency with time. Among all other functions, spectrum sensing is considered as a decisive task to establishcognitive radio networks.

In wireless communication networks, uncertainties in received signal strength arises due to channel fading or shadowing which may wrongly interpret about the primary users. Therefore, cognitive radios should be more sensitive to distinguish a faded or shadowed primary signal from a white space. Any uncertainty in the received power of the primary signal translates into a higher detection sensitivity requirement. Under severe fading, a single cognitive radio depends on local sensing may be unable to achieve fair sensitivity.This issue may be handled by having a group of cognitive radios called cooperative sensing, which share their local measurements and collectively decide on the occupancy state of a licensed band. Blind channel identification in OFDM systems using cyclostationarity was discussed in [3].

1.2 Classification

The methods of spectrum sensing are based on three different techniques namely energy detection, matched filter and cyclostationary feature detection. The energy detection is based on measuring the energy received over an observation interval. The output signal is the test statistic and is compared with a threshold. This method cannot discriminate between the primary signal and noise, and hence makes it difficult to set the threshold used for primary user detection, especially at low SNR. This energy is compared with a threshold to decide on the presence of the signal of interest. However, energy detectors are widely used because of their simplicity. It is easy to implement and has low computational complexity. Since the received energy is compared to a threshold in energy detector-based sensing, the threshold selection affects the performance of the method significantly [4].

Matched filter is an optimal detection technique when the cognitive radio has a priori knowledge of the primary user signal and it is based on correlating the known primary signal with the observed signal. The problem of this method is that it is difficult to have an a priori knowledge of the primary signal. The matched filter detection requires short time for sensing, even though its complexity is high when operating with different types of primary user systems. In this method, the receiver has to achieve coherency with the input signal by using timing and carrier synchronization. The need for a priori knowledge is the main disadvantage of the matched filtering method. The requirement of synchronization between the transmitter and the receiver is another disadvantage of this method[5]. The cyclostationary feature detection takes advantage of the fact that most of the primary user signals have built-in periodicities. Thus, this embedded redundancy can be used for detection of cyclostationary signals in a background of noise using a spectral correlation function. This method is free of noise interference but it requires long observation times. Cyclostationary features are the inherent results of the periodic structures of the modulated signals, such as sinusoidal carriers, pulse trains, hopping sequences or cyclic prefixes. Due to this built-in periodicity, modulated signals are cyclostationary with spectral correlation [6].

2. PERIODICITY REPRESENTATIONS

A key limitation of cyclostationary signatures when implemented in orthogonal frequency division multiplex (OFDM) based systems is the sensitivity exhibited in time-variant multipath Rayleigh fading environments. Although OFDM-based systems offer robust performance under multipath conditions, detection of cyclostationary signatures can be severely degraded. The robustness in multipath fading environments is the key advantages of OFDM based system. OFDM effectively converts a high data rate serial stream to a number of closely spaced parallel low-rate streams. As a result, OFDM symbols typically have a long duration in comparison to single carrier transmission schemes and hence a reduced sensitivity to inter-symbol interference.

In addition, a guard interval is added to each symbol transmitted. This serves to collect multipath signal components arriving within the duration of the guard interval and allows them to be used to constructively contribute to the received symbol. In order to take advantage of a guard interval to overcome the effects of multipath fading, symbol timing estimation is required. Accordingly, signatures become more difficult to detect and coordination may become impossible. This paper presents approaches for effectively overcoming multipath sensitivity in the detection of cyclostationary signatures. Techniques are used to identify the periodicity of the signal which enables to detect the presence of primary users. The power spectral density of the received OFDM signal should be very appropriate so that CR user make a perfect decision.

3. SIMULATION RESULTS

A cognitive radio networks in which the CR primary users using OFDM signal is considered for communication.In this simulation, QPSK signal is chosen with carrier frequency fc =5 MHz, symbol rate R=2 Mbps and sample rate fs=25MHz. Fig3 shows the amplitude variation of Ichannel OFDM signal versus number of samples in which guard interval is added for maintaining cyclostationarity. In the receiver section, the signals may get faded while transmission, which may results in amplitude variation and hence the cyclostationarity gets degraded in the signal.

3.1 Fading analysis of I channel and Q channel in OFDM signal

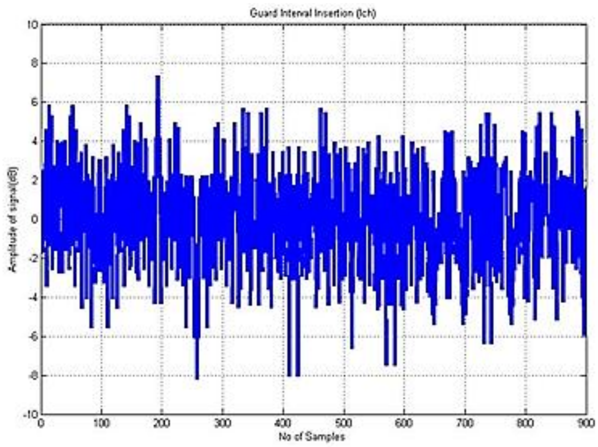

Figure 3: Guard interval insertion in I channel

The graph shown in Fig3 represents the number of samples versus amplitude with guard interval insertion in I channel. Fig4 represents the amplitude variation of I channel OFDM signal in the receiver section. From the graph shown in Fig3 and Fig4, it is observed that the signals at the receiving side gets faded and hence degradation in the detection of primary user. From the Fig5 and Fig6, it is clearly noted that, the receiving signal at Q channel also gets faded.

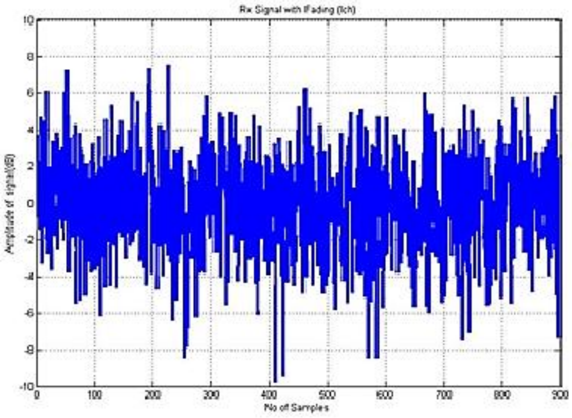

Figure 4: Fading in the receiver side I channel

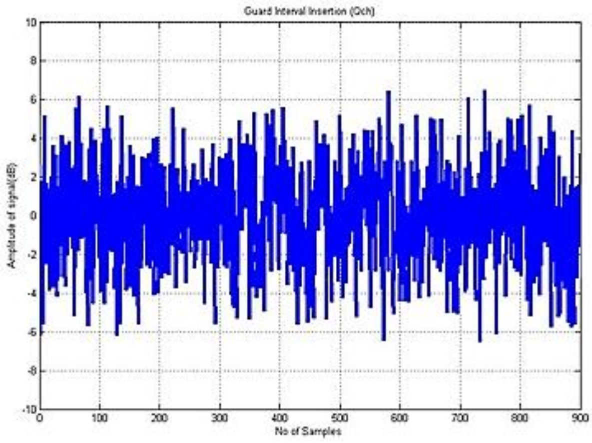

Figure 5: Guard interval insertion in Q channel

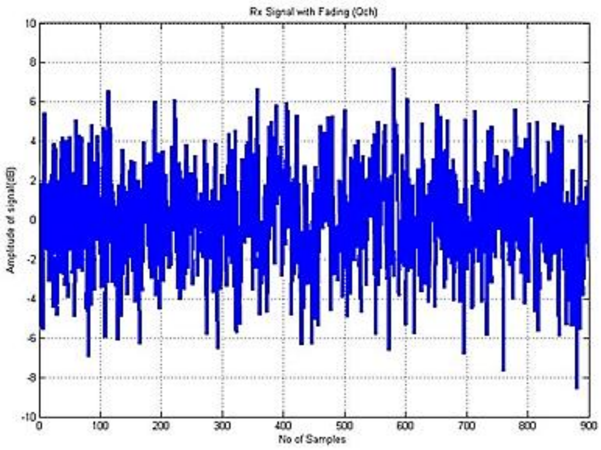

Figure 6: Fading in the receiver side Q channel

3.2 Comparison of true and average PSD of OFDM signal

The power spectral density which defines the specific power of the signal at particular frequency can be introduced for relating the presence of signal. In order to identifying the presence of primary user signal the spectrum power value must be very desirable. The comparison of power spectral density of average and true method is shown in Fig7.The comparison results shows that the average method have dramatic variation in spectrum power when compared with the true method. From the comparison results, the true method PSD in OFDM is well suitable for cognitive radio to identify the primary users.

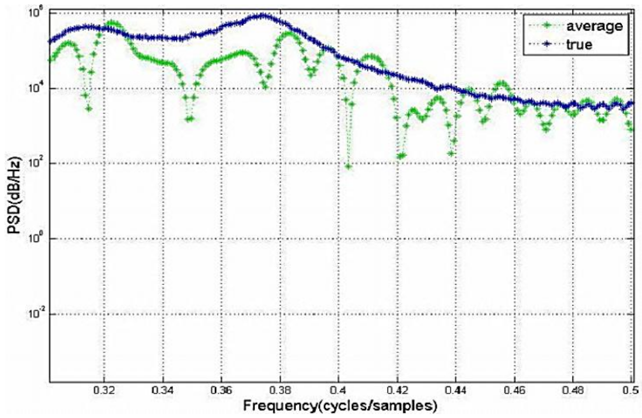

Figure 7:Comparison of average and true PSD

4. CONCLUSION

Cognitive radio (CR) is proposed as a promising solution for increasing spectrum utilization and thereby helping to mitigate spectrum scarcity. Hence, accurate spectrum sensing is an essential feature of CR systems. In this paper, a periodicity based cyclostationary spectrum sensing in cognitive radio networks is introduced.Guard interval insertion in the signal for identifying the presence of primary user is introduced which use the concept of periodicity in OFDM signals. In existing method, the periodicity of pilot signals in the OFDM symbols is used to detect the signals. The proposed scheme is robust to the detection of primary user signal with guard interval insertion in the OFDM signals which use the concept of periodicity. The power spectral density of average and true method which defines the spectrum power is compared. From the simulation results, it is observed that the true method of power spectral density enables the CR to make a perfect sensing over primary users and well suitable for cognitive radio in identifying the primary users.

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