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An Efficient Detection Of Primary Users Reoccupation In Cognitive Radio Systems By Active Sensing

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***Abstract*— In the past years, fixed spectrum assignment policies worked well. But today, due to the rapid increase in number of users in mobile communication as well as in other communication areas, arises a problem called 'spectrum scarcity'. It can be solved by developing a new communication paradigm that will use the existing spectrum efficiently. It is achieved with the help of cognitive radio. One of the main functions of the cognitive radio is spectrum sensing. In this paper, Spectrum sensing is carried out by Quite-Active sensing. In that, active sensing is carried out by spectral correlation function which is one of the cyclostationary feature detection with non-cooperative detection. Here, known pilot signals from the primary users base station are duplicated and reallocated in cognitive radio users modulating signal. The spectral correlation is carried out between the cognitive radio user and primary users. With the help of Spectral correlation function, we can efficiently detect the primary users reoccupation in cognitive radio systems. It will provide higher security because the pilots are added with the cognitive radio users modulating signal. And the simulation is carried out with the help of matlab and their results show the effectiveness of proposed approach**.

Keywords: **Active sensing, Cognitive radio, Cooperative detection, Cyclostationary feature detection, Quiet – Active sensing, Spectral correlation.**

I. INTRODUCTION

Today, Wireless communications communication rates and other requirements have rapidly extended. Due to this rapid growth, frequency assignments are getting difficult. Allocating new frequencies for new wireless services become very difficult. By efficiently using the existing spectrum, this problem can be solved. It can be effectively achieved through dynamic spectrum access with the help of cognitive radio.

A 'Cognitive Radio' is a radio that can change its transmitter parameters based on interaction with the environment in which it operates [1]. Cognitive radio functions are (1) spectrum sensing determines which portions of the spectrum is available and it also detects the presence of licensed users when a user operates in a licensed band, (2) Spectrum management selects the best available channel, (3) Spectrum sharing deals with coordinate access to this channel with

other users and (4) spectrum mobility function is to vacate the channel when a licensed user is detected. This paper deals with the spectrum sensing of cognitive radio.

Cognitive radio systems access the unused licensed bands for transmission in an opportunistic way and with limited interference to the primary users of the band [2]. Spectrum sensing function is used to determine the occupancy status of the spectrum, with the help of this we can avoid the interference between the primary users and cognitive radio users. Transmission frame structure consist of a series of superframes, and each superframe reserves quiet periods for spectrum sensing in some sub. frames [3]. Cognitive radio base station configure this quite sensing period and quite sensing schedule according to the system requirements. During the quiet sensing period, the cognitive radio users must suspend any kind of transmission on the band and it only sense whether or not the band is occupied by the primary users. The drawback in quiet sensing method is, it cannot detect the primary users reoccupation during the cognitive radio users data transmission period. It will result in inevitable interference to primary users. To solve this problem, full active sensing method emerged. Full active sensing requires much longer sensing time when compared to quite sensing to achieve same sensing performance [4]. So, it is not efficient for cognitive radio systems. This problem is overcome with the help of quiet-active sensing shown in figure 1(b).

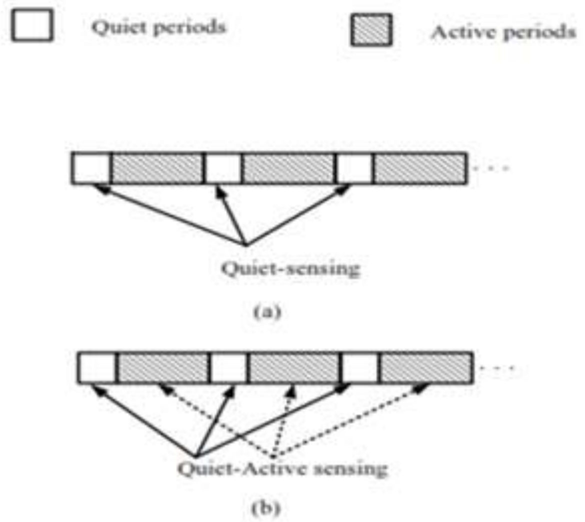

Figure 1 (a) Quiet-sensing (b) Quiet-Active sensing

In quiet-active sensing, the interference is greatly reduced because it performs quiet sensing during the quiet period and active sensing during the data transmission period. During the data transmission period, some cognitive radio users are transmitting / receiving information to / from the cognitive radio base station, whereas the idle cognitive radio users can sense the activities of primary users reoccupation while the cognitive radio transmissions are active [5].

In [5], the active sensing is carried out with an energy detector. Energy detectors are poor performance in the presence of in-band interference, sensitivity to uncertainty in the background noise [6]. Due to this drawback of an energy detector, alternate approach was proposed using cyclostationary feature detector [7].

Cyclostationary feature detection can be defined as, in general modulated signals are coupled with pulse trains, sine wave carriers, hopping sequences, repeating spreading which result in built-in periodicity. These modulated signals undergo cyclostationarity because their mean and autocorrelation exhibit periodicity. Using spectral correlation function, these features are detected. The advantage of spectral correlation function is that it differentiates the modulated signal energy from the noise energy, because the noise is a wide-sense stationary signal with no correlation. And the modulated signals are cyclostationary with spectral correlation due to the embedded redundancy of signal periodicity [1].

Active sensing with spectral correlation function is carried out in [8,9]. In this paper, the known pilot signals from primary users base station are reallocated and duplicated in the cognitive radio users modulating signal. With the help of spectral correlation function, active sensing is carried out here. It provides higher security because the pilot signals are added with the modulating signal.

The organization of this paper is as follows. Active sensing is described in section II. Section III deals with materials and methods. Simulation results are provided in section IV. Section V concludes this paper.

II. ACTIVE SENSING

In Quiet-active sensing, the quiet sensing period and quiet sensing schedule are configured by cognitive radio base station based on the system requirement. During the data transmission period, the active sensing is carried out. This paper focuses on active sensing (not full active sensing). Here active sensing is carried out with spectral correlation function which is one of the cyclostationary feature detector.

From the received signals of spectrum sensors, it generate spectral correlation features and then based on that features, it can assist the spectrum sensors in detecting the primary users reoccupation. Spectral correlation feature can be generated by duplicating the known pilots of primary users base station signal in cognitive radio users modulating signal. These duplicated pilot signals are reallocated inorder to avoid overlap with the primary users original pilot signal.

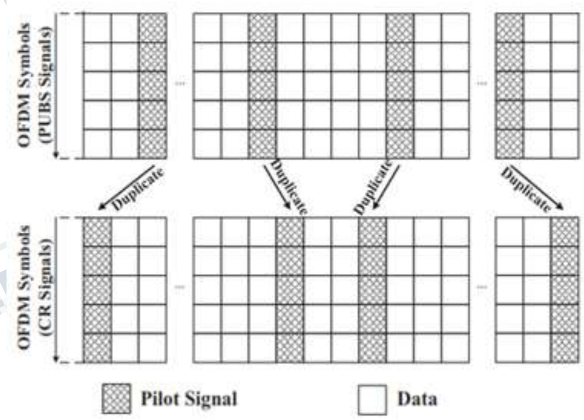

Figure 2 Active sensing signal structure [9]

In figure 2, the horizontal axis represent the modulating signal and the vertical axis represent the OFDM symbols of the primary users base station and cognitive radio signals in the frequency domain respectively. In the primary users base station signal, the modulating signals with oblique lines are the continual pilot tones. Duplicating the pilots of the primary users base station signal, the cognitive radio transmitter maps these pilots on its own signal. Therefore, the spectrum sensors received signals are correlated. Thus, the spectrum sensors received signal will become correlated when reoccupation of primary users occurs during the data transmission periods. So, the activities of primary users can be easily detected by computing the spectral correlation function of the received signals.

If we coexist multiple cognitive radio networks in this method, the reallocated pilot of one cognitive radio network must not overlap with another cognitive radio network. This can be achieved by accomplishing a number of patterns for pilot reallocation are predesigned and are known by all the coexisting cognitive radio networks.

A.False alarm probability

It can be defined as the cognitive radio system will be over conservative because it falsely assumed that the primary user is active.

For a given decision threshold λ, the false-alarm probability can be evaluated by [9]

$$P_{FA}(\lambda) = Q((\lambda - K\mu_0)/\sqrt{K}\,\sigma_0) \qquad (1)$$

Where K represents spectral correlation features and μ_0 represents the mean and σ_0^2 represents variance.

B.Mis-detection probability

A Probability that the cognitive radio system mis-detect that the primary user is not active. But, actually primary user is active.

The detection probability can be evaluated by [9]

$$P_D(\lambda) = Q((\lambda - K\mu_1)/\sqrt{K}\,\sigma_1) \qquad (2)$$

Where λ represents the decision threshold, K represents spectral correlation features and μ_1 represents the mean and σ_1^2 represents variance respectively.

The Mis-detection probability can be evaluated by

$$P_{MD}(\lambda) = 1 - P_D(\lambda) \qquad (3)$$

III. MATERIALS AND METHODS

The simulation is carried out with the help of MATLAB. Here 52 OFDM (orthogonal frequency division multiplexing) samples and 4 bit pilot signals are used here. Only 2 primary users are taken into account here. The better signal coverage is obtained here, because the signal transfer ratio lies in between 80% to 85% . If the signal transfer ratio is high, the accessing mechanism works well.

IV. SIMULATION RESULTS

The following simulation results show the effectiveness of the proposed method.

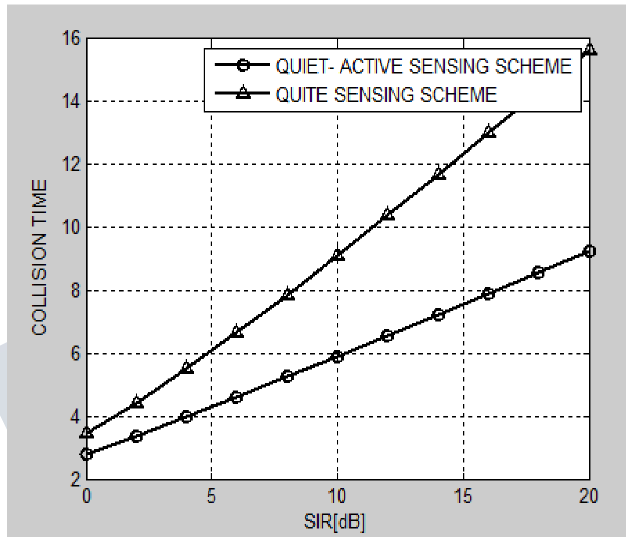

Figure 3 Comparison of Quiet-active sensing and Quiet sensing

Figure 3 shows that quiet-active sensing performs better when compared to quiet- sensing in terms of collision time versus signal to interference ratio.

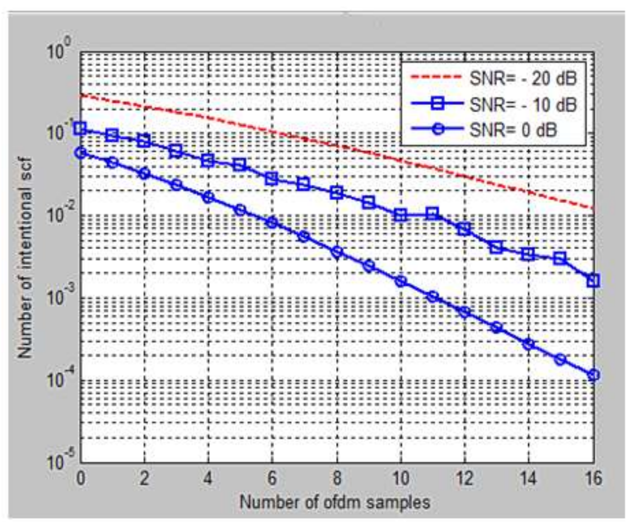

Figure 4 Relationship between the number of OFDM symbols for sensing time (T) and the number of intentional SCF features (K)

In Figure 4, we demonstrate the flexibility of the proposed method, in which the number of spectral correlation features and the sensing time are all manageable. Inorder to meet its own sensing requirements, the cognitive radio system can dynamically arrange the parameter pair, K and T. It also shows the tradeoff between the sensing time and the number of intentional Spectral correlation features. The simulation results show that when the sensing time is limited, the sensing performance can be maintained by embedding more intentional spectral correlation features in the signal, and vice versa.

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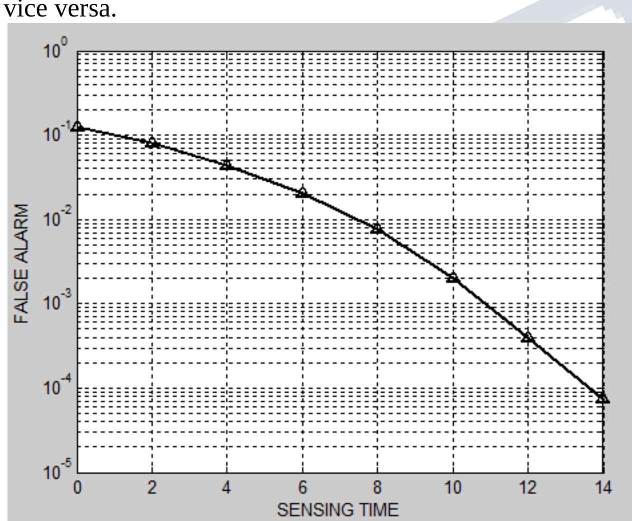

Figure 5 False alarm probability versus sensing time

Figure 5 shows the relationship between the false alarm probability and the sensing time. False alarm probability gradually decreases if the sensing time increases. Quiet-active sensing has more sensing time when compared to quiet sensing. So, the false alarm probability is very low in Quiet-active sensing in comparison with quiet sensing.

Figure 6 shows the misdetection probability versus SNR for different M values (probability). Misdetection probability can also be defined as cognitive radio users induce strong interference to primary users in the shared spectrum by mis-detecting that the primary user is not active.

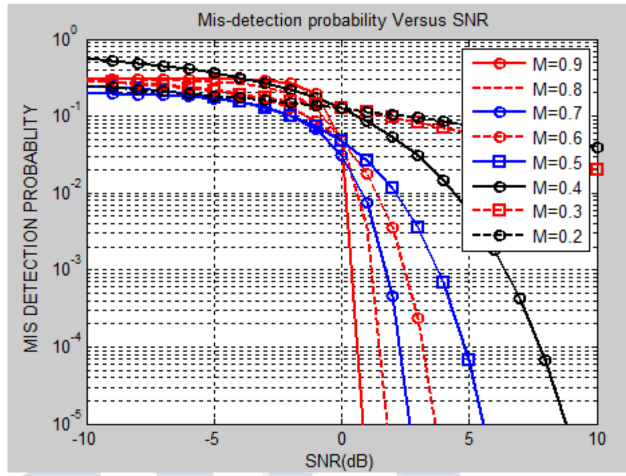

Figure 6 Mis-detection probability Versus SNR for different M values

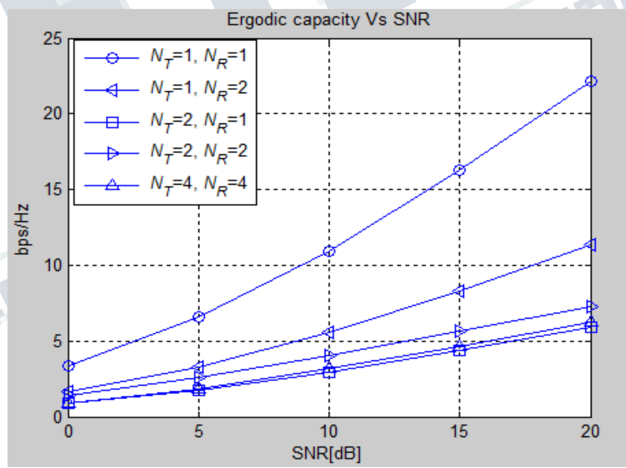

Figure 7 Ergodic capacity Versus SNR

Figure 7 describes the sensing ratio in terms of ergodic capacity versus SNR. Ergodic capacity is nothing but Shannon capacity, which defines the maximum data rate that can be transmitted over the channel with asymptotically small error probability.

IV. CONCLUSION

In this paper, we have proposed an efficient detection of primary users reoccupation in cognitive radio systems by active sensing. The proposed method duplicates and reallocates the known pilot signals of the primary users base station in the cognitive radio modulating signal. It provides higher security because the pilots are added with the modulating signal instead of with the subcarriers. Based on the spectral correlation function, the active sensing is carried out. By this way we can efficiently detect the primary users reoccupation in cognitive radio systems.

Here single cognitive radio network is used. In future this work can be extended to multiple cognitive radio network with minimum collision rate and also to provide better performance while using Nagakami fading channels.

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