REVIEW OF COGNITIVE RADIO NETWORK

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Abstract— In current day wireless communication has become the most popular communication. Because of this growing demand on wireless applications has put a lot of constraints on the available radio spectrum which is incomplete and expensive. In permanent spectrum assignments there are many frequencies that are not being accurately used. So cognitive radio helps us to use these idle frequency bands which are also called as "White Spaces". This is an exceptional approach to improve exploitation of radio electromagnetic spectrum. In Establishing the cognitive radio there are four important methods. In this paper we are going to discuss about the first and most important method to implement cognitive radio i.e., "spectrum sensing". The challenges, issues and techniques that are involved in spectrum sensing will discussed in detail.

Keywords— Spectrum Sensing, Cognitive Radio, Energy Detection and Matched Filter Detection.

1. Introduction

Due to the improved usage of wireless communications in private, commercial and governmental capacities, capable spectrum utilization has become a prime topic of interest. The Federal Communications Commission (FCC) governs spectrum usage and allocates detailed ranges to licensed users. However, some spectrum ranges are congested, while some are under-utilized. The congested spectrum shrinks general value of service for users in that part. This outcome summary data transmission rates, low latencies, and improved possibility of mistakes. A possible result to this incompetence problem is cognitive radios (CR), which execute two main tasks. First, a CR searches the spectrum and establishes which elements are unoccupied, a system known as spectrum sensing.

Second, a CR decides a method of allocating secondary users to the unoccupied spectrum without interfering with the primary users. Cognitive radio networks could significantly vary the present methods that wireless communications activate in the future by dynamically allocating spectrum usage and ultimately provide a better quality of service to users. This review will discuss the first aspect of spectrum management, which is spectrum sensing. Spectrum sensing allows cognitive radios to be aware of the surroundings by determining which frequencies are in use. Many technical papers have documented the various spectrum sensing techniques. The purpose of this paper is to aggregate the results of different research papers and compare the methods based on a variety of performance metrics. Such performance metrics include detection accuracy, complexity, robustness and

flexibility of design choices. Sensing algorithms such as energy detector, coherent based, Cyclostationarity based, matched filtering, and a hybrid technique will be analyzed and compared.

2. Cognitive Radio

Cognitive Radio is a radio for wireless communications in which either a network or a wireless node changes its transmission or reception parameters based on the interaction with the environment to communicate effectively without interfering with the licensed users.

If we observe the frequency range between 80 MHz to 750MHz, then this frequency range can be sub-divided into three different sub-categories which are given as the following:-

- Spectrum bands which remain empty most of the stretch

- Spectrum bands which are partially engaged

- Spectrum bands which re Congested Bands

In common terms, the cognitive radio provides a new function to use the vacant or empty licensed spectrum by temporarily allocating it to the secondary users in such a way that they do not interfere with the primary users or the obstruction to the compensated users is reserved to a minimum.

For the secondary or unlicensed users being able to use the licensed spectrum the following:-

- The frequency band should be scanned thoroughly to decide dissimilar unfilled bands

- The best accessible spectrum band should be selected for the secondary user. The selection can be made on the basis of obligation of the secondary user's application.

- The power level must be reserved to the minimum potential value before transmitting on the selected bands to avoid intrusion with other users. It will also help in, maximizing the number of unlicensed users of the spectrum of interest.

Cognitive Radio works on this dynamic Spectrum Management principle which explains the topic of spectrum under operation in wireless communication in a superior way. This radio provides a highly dependable communication.
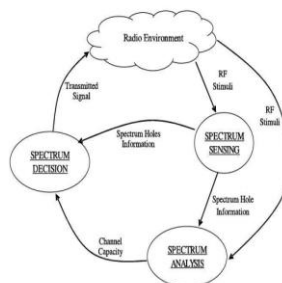

Figure 1 Cognitive Cycle

Main functions of Cognitive Radio. There are

- Spectrum Sensing

- Spectrum Management
- Spectrum Sharing
- Spectrum Mobility

Cognitive radio has four major purposes. They are Spectrum Sensing, Spectrum management, Spectrum Sharing and Spectrum Mobility. Spectrum Sensing is to recognize the attendance of licensed users and unused frequency bands i.e., white spaces in those licensed bands. Spectrum Management is to recognize how long the secondary users can use those white spaces. Spectrum Sharing is to share the white spaces (spectrum hole) fairly among the secondary users. Spectrum Mobility is to continue uninterrupted communication during the conversion to improved spectrum.

3. Spectrum Sensing

The main challenge of the cognitive radio is that the secondary user requirements to identify the attendance of primary user and to speedily quit the frequency band if the matching primary radio appears in order to avoid intrusion to primary users. Spectrum sensing method can be classified into two types. They are: Direct and Indirect methods. Direct Technique is also called as frequency domain out in which opinion is passed out straight from signal approach. Where as in Indirect Technique evaluation is performed using autocorrelation of the signal.
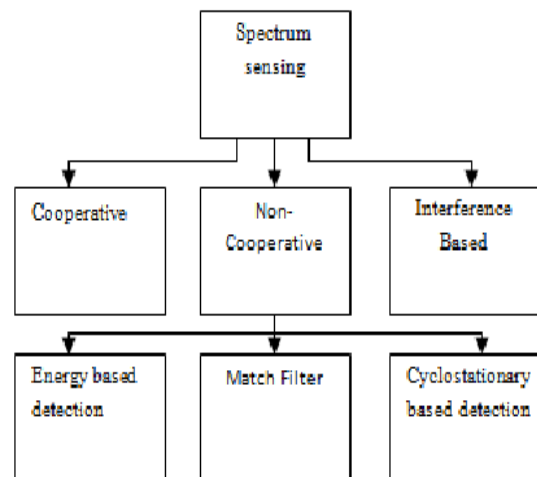

Figure 2 Classification of Spectrum Sensing

Matched Filter Detection

The matched filter detection method needs a demodulation of the PU's in sequence signal at PHY and MAC layers, such as the modulation type and order, pulse shaping, packet format, operating frequency, bandwidth, etc. CR wireless sensors receive that in sequence from the PU's pilots, preambles, synchronization words or diffusion codes etc. The benefit of the matched filter technique is that it takes a short time and needs less examples of the expected signal. This decreases the received signal SNR and number of signal examples required. However, matched filter detection methods use substantial power and need high computational difficulty and ideal information of the objective users.

Energy Detection

Energy detection notices the signal based on the sensed energy. This does not need previous information of the PU's signals. This is especially accepted technique because of its effortlessness. The major disadvantage of this method is its lesser correctness. Energy detection cannot differentiate the PUs' signal from the SUs' signal. This method cannot be used to sense increase spectrum signals and has reduced act under a low SNR.

Mathematical model for Energy detection is particular by the following two hypotheses:

H0: (primary user is absent) $y(n) =$
$u(n).n = 1, 2, . . . ,N$
H1: (primary user is present) $y(n) =$
$u(n)+s(n).$ $n = 1, 2, . . . ,N$
Where s (n) is the primary user signaland u (n) is noise.

Cyclostationary Detection

In cyclostationary feature-detection methods, adjusted signals are joined with sine wave carriers, pulse trains, frequent spreading, hopping sequences, or cyclic prefixes. The

cyclostationary characteristic detection method provides improved performance, even in low SNR sections. This has good signal categorization aptitude. However, it is more difficult than energy detection and high speed sensing cannot be attained. This cannot work if the target signal's personality is unknown.
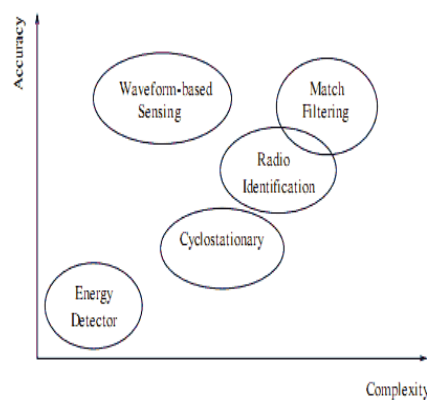

Figure 3 Compare Difference Sensing Ranges

Results and Implementation

Assume that are interested in the frequency band with carrier frequency fc and bandwidth W and the received signal is sampled at sampling frequency fs. Think about the problem of sensing a signal in additive white Gaussian noise (AWGN), and then the spectrum sensing is used to choose between the following two hypotheses, when the primary user is active, the distinct received signal at the secondary user can be represented as,

$$H1: Y[n] = u[n] + S[n] \ldots\ldots (I)$$

This is the output under hypothesis H1. When the primary user is inactive, the received signal is given by

$$H0: Y[n] = u[n] \ldots (II)$$

H0 is Primary User is absent and H1 is Primary User is Present.

Figure 4 shows that probability of false alarm increases when probability of detection increases for proposed algorithm compared to the theoretical value.

In this case, the CR cannot always detect the presence of the primary user, and thus it is acceptable to contact the channel while the PU is still in function. To explain this problem, multiple CRs can be considered to work together in spectrum sensing. Cooperative spectrum sensing can significantly increase the detection probability in fading channels.
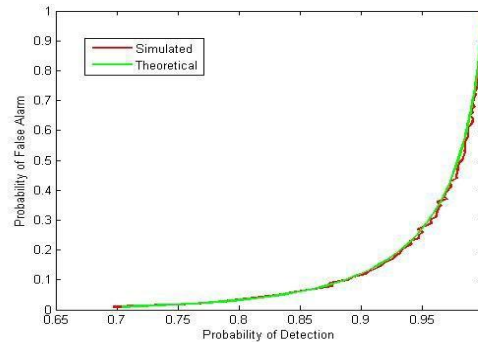

Figure 4 Curve of Probability of False Alarm Vs Probability of Detection for a Cognitive Radio

- Every CR performs its own local spectrum sensing measurements separately and after that makes a binary decision on whether the PU is present or not.

- All of the CRs forward their decisions to a general receiver.

- The familiar receiver fuses the CR decisions and makes a last decision to assume the absence or presence of the PU.
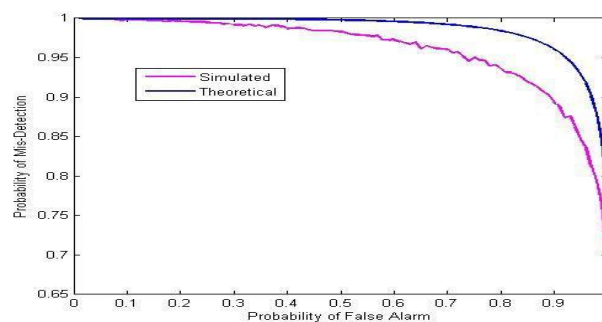

Figure 5 Curve of Probability of False Alarm Vs Probability of Missed Detection for a Cognitive Radio

Figure 5 shows that probability of Missed-detection decreases when the probability of flash alarm increases. So the operating position is to be preferred as a point, where in the ratio of probability of Missed detection and the probability of false alarm becomes one.

In order to compare the performances for different threshold values, receiver operating characteristic (ROC) curves preserve be used. ROC curves allocate us to discover the connection between the sensitivity (probability of detection) and specificity (false alarm

rate) of a sensing method for a variety of different thresholds, thus allowing the resolve of an optimal threshold. One of the most demanding issues of spectrum sensing is the unknown terminal problem, which happens when the cognitive radio is shadowed or in deep fade.

In the above cooperative spectrum sensing algorithm, each one cooperative partner makes a binary decision based on its local observation and then forwards one bit of the decision to the general receiver.
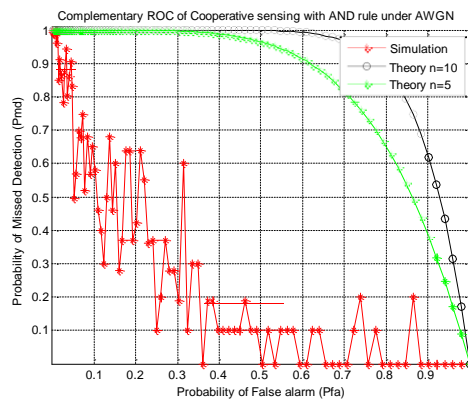

Figure 6 Complementary ROC of Cooperative Sensing Under AWGN Channel

Fig.6 shows the performance results of cooperative spectrum sensing for dissimilar numbers of CRs over Rayleigh fading channels with an SNR n = 10 dB. It is seen that the probability of miss detection is significantly reduced when the number of cooperative CRs increases, for a specified probability of false alarm. Theoretical averages for these probabilities under fading condition with the purpose of authenticate these theoretical results and to achieve simulations over a huge number of channel gains and achieve averages. Hence the simulation results are in good competition with theoretical results.

5. Conclusion

Cognitive radio, which is one of the hard works to exploit the obtainable spectrum additional efficiently through opportunistic spectrum usage, has become a stimulating and capable concept. One of the significant elements of cognitive radio is sensing the obtainable spectrum opportunities. In the new spectrum management paradigm, licensed users can share their spectrum with unlicensed users (referred to as secondary users), thereby increasing the effectiveness of spectrum operation. This technique of sharing is often called Dynamic Spectrum Access (DSA). Mostly used three types of recognition there are energy detection, matched filter detection and cyclostationary detection. In this detection used to find out the probability of false alarm and probability of detection.

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