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Analysis of Different Spectrum Sensing Techniques in Cognitive Radio Network

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Abstract-***Cognitive radio permits unlicensed users to access licensed frequency bands through dynamic spectrum access so as to reduce spectrum deficiency. This requires intelligent spectrum sensing techniques like co-operative sensing which creates use of information from number of users. The main challenge in any cognitive radio system is to maximize secondary user's throughput while limiting interference imposed on licensed users. In this consideration finding the optimal sensing and transmission timing strategies and accurate sensing techniques are of great importance in a cognitive radio network. In this paper, examine different on Matched filtering, Energy detection and Cyclostationary feature detection cognitive radio spectrum sensing techniques over AWGN, Rician fading and Rayleigh fading channel. It also contain combined analysis of Matched filtering, Energy detection and Cyclostationary feature detection technique for common scenario through decision accuracy vs SNR plots over AWGN, Rician fading and Rayleigh fading channel.***

Keyword–*Cognitive Radio (CR), Additive White Gaussian Noise (AWGN), Dynamic Spectrum Allocation (DSA), Primary User (PU), Secondary User (SU).*

1. INTRODUCTION

In wireless communication systems, the right to access the spectrum is generally defined by frequency, transmission power, spectrum owner (i.e., licensee), type of use, and the duration of license. Usually, a license is assigned to one licensee, and the use of spectrum by this licensee must be conformed to the specification in the license. In the older spectrum licensing schemes, the license cannot change the type of use or transfer the right to other licensees. Moreover, the radio spectrum is licensed for larger regions and generally in larger chunks. All these factors in the current model for spectrum allocation and assignment limit the use and result in low utilization of the frequency spectrum. Because the existing and new wireless applications and services are demanding for more transmission capacity and more data transmission hence, the utilization of the radio spectrum needs to be improved .[1]

To get better the efficiency and utilization of the radio spectrum, the above mentioned limitations should be amended by modifying the spectrum licensing scheme and adopting a dynamic spectrum management model. The basic idea is to make spectrum access more flexible by allowing the unlicensed users to access the radio spectrum

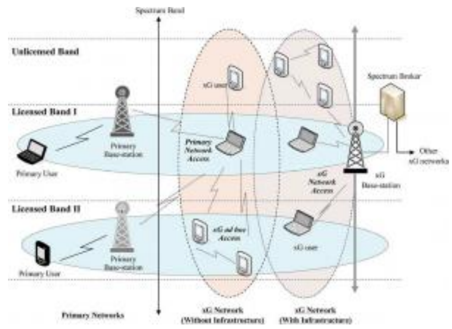


Fig 1: Cognitive Radio Network

under certain conditions and restrictions. Because the traditional wireless systems were designed to operate on a dedicated frequency band, they are not able to utilize the improved flexibility provided by this spectrum licensing scheme. Therefore, the concept of cognitive radio (CR) emerged, the main goal of which is to provide adaptability to wireless transmission through dynamic spectrum access (DSA) so that the utilization of the frequency spectrum can be enhanced without losing the benefits associated with static spectrum allocation.[1][2]

2. COGNITIVE RADIO NETWORK

The formal definition for Cognitive Radio is given as "Cognitive Radio is a radio for wireless communication in which either a network or a wireless node changes its transmission or reception parameter based on the interaction with the environment to communicate effectively without interfacing with the licensed users."

The term "Cognitive Radio" (CR) was coined by Joe Mitola in 1999-2000, in a number of publications and in his PhD thesis. The term was intended to describe intelligent radios that can autonomously make decisions using gathered information about the RF environment through model-based reasoning, and can also learn and plan according to their past experience. Clearly, such a level of intelligence requires the radio to be self-aware, as well as content and context-aware. [3][4]

The main important characteristics of Cognitive radio [5]

- *Cognitive capability:* Cognitive Capability explains the ability to capture or sense the information from its radio environment of the radio technology. Joseph Mitola first explained the cognitive capability in term of the cognitive cycle "a cognitive radio continually observes the environment, orients itself, creates plans, decides, and then acts"
- *Reconfigurability*: Cognitive capability suggest the spectrum awareness, Reconfigurability refers to radio capability to modify the functions, enables the cognitive radio to be programmed dynamically in accordance with radio environment (frequency, transmission power, modulation scheme, communication protocol).

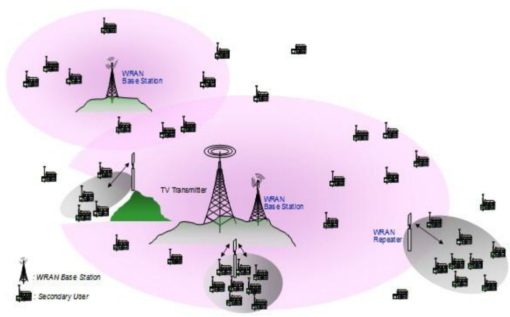
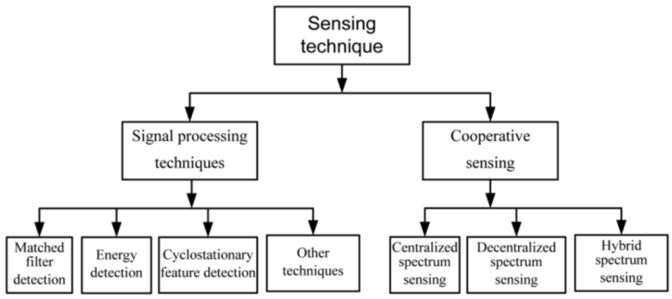


Fig 2: An 802.22 System Development Scenario

The CR is a "smarter radio" in the sense that it can sense channels that contain signals from a large class of heterogeneous devices, networks, and services. On the basis of this sensing, the radio will implement sophisticated algorithms to share the limited- bandwidth channel with other users in order to achieve efficient wireless communication. In this way, the CR concept generalizes the idea of multiple access involving devices in a single homogeneous system to multiple access among devices in different radio spectrums using different radio transmission techniques and hence different systems (i.e., inter-system multiple access as opposed to the more traditional intra-system multiple access), which have different priorities in accessing the spectrum. [1][2]

2.1 Cognitive Cycle



There are four main steps in Cognitive cycle

Spectrum Sensing: It refers to detect the unused spectrum and sharing it without harmful interference with other users. It is an important requirement of the Cognitive Radio network to sense spectrum holes, detecting primary users is the most efficient way to detect spectrum holes.

Spectrum Management: It is the task of capturing the best available spectrum to meet user communication requirements.[5]

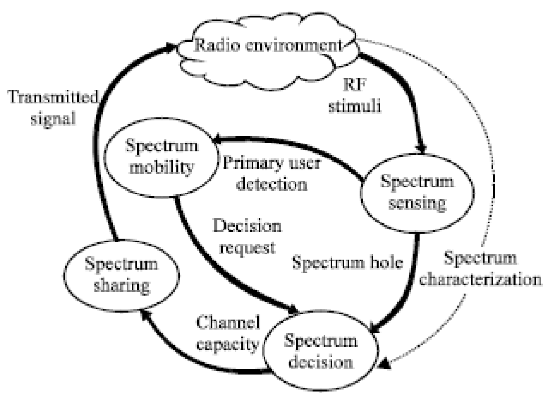


Fig 3: Cognitive Cycle [7]

Spectrum Mobility: It is defined as the process where the cognitive user exchanges its frequency of operation.[6]

Spectrum Sharing: This refers to providing a fair spectrum scheduling method among the users. Sharing is the major challenge in the open spectrum usage.[6]

3. SPECTRUM SENSING

Spectrum Sensing i.e. checking the frequency spectrum for empty bands forms the prime part of the cognitive radio. There are number of schemes for spectrum sensing like energy detector and matched filter. But the earlier functions properly for elevated signal to noise ratio (SNR) value whereas the latter's complexity is very high. These constraints led to implementing a detector which performed well under low SNR conditions as well and with complexity not as high as the matched filter. Cyclostationary detector turned out to be the choice for such specifications. [3]

In co-operative sensing (decision from number of users taken into consideration), number of users lead to more overhead and thus takes time for final decision. Hence better decision cost us time and efficiency. Lowering the detection threshold increases the detection as well as the chances of false detection. Thus one cannot lower the threshold value at will. The thesis presents an algorithm for finding an optimal number of users and a couple of threshold optimization schemes. [5]

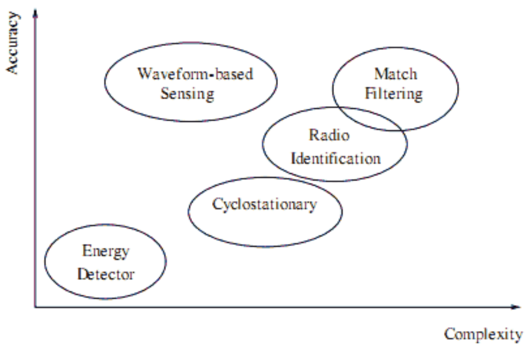


Fig 4: Spectrum Sensing Techniques [5]

3.1 Signal Processing Techniques for Cognitive Radio

A. Matched-Filtering Technique:

Matched-filtering is known as the optimum method for detection of primary users when the transmitted signal is known. The main advantage of matched filtering is the short time to achieve a certain probability of false alarm or probability of miss detection as compared to other methods. Matched-filtering requires cognitive radio to demodulate received signals. Hence, it requires perfect knowledge of the primary users signalling features such as bandwidth, operating frequency, modulation type and order, pulse shaping, and frame format.

B. Energy Detector Based Sensing:

Energy detector based approach which is also known as radiometry or periodogram, is the most common way of spectrum sensing because of its low computational and implementation complexities. It is more generic method as receivers do not need any knowledge on the primary users' signal. The signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor. [10]

C. Cyclostationary-Based Sensing:

Cyclostationary feature detection is a method for detecting primary user transmissions by exploiting the cyclostationary features of the received signals. Cyclostationary features are caused by the periodicity in the signal or in its statistics like mean and autocorrelation or they can be intentionally induced to assist spectrum sensing.

D. Waveform-Based Sensing:

Patterns known are usually utilized in wireless systems to assist synchronization or for other purposes. A preamble is a known sequence transmitted before each burst and a mixable is transmitted in the middle of a burst or slot. In the presence of a known pattern, sensing can be performed by correlating the received signal with a known copy of itself. This method is only applicable to systems with known signal patterns, and it is termed as waveform-based sensing or coherent sensing. [7][8]

3.2 Cooperative Techniques for Cognitive radio

High sensitivity requirements on the cognitive user can be alleviated if multiple CR users cooperate in sensing the channel. Various topologies are currently used and are broadly

Decentralized Uncoordinated Techniques:

The cognitive users in the network don't have any kind of cooperation which means that each CR user will independently detect the channel, and if a CR user detects the primary user it would vacate the channel without informing the other users. Uncoordinated techniques are fallible in comparison with coordinated techniques. Therefore, CR users that experience bad channel realizations detect the channel incorrectly thereby causing interference at the primary receiver.

A. *Centralized Coordinated Techniques:*

In such networks, an infrastructure deployment is assumed for the CR users. One CR that detects the presence of a primary transmitter or receiver, informs a CR controller which can be a wired immobile device or another CR user. The CR controller notifies all the CR users in its range by means of a broadcast control message. Centralized schemes can be further classified according to their level of cooperation as: Partially cooperative where network nodes cooperate only in sensing the channel. CR users independently detect the channel and inform the CR controller which then notifies all the CR users; and totally cooperative Schemes where nodes cooperate in relaying each other's information in addition to cooperatively sensing the channel [12].

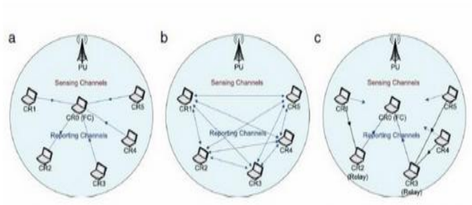


Figure 5: Cooperative sensing techniques: a-Centralised Coordinated, b Decentralised Coordinated, and c-Decentralised Uncoordinated [10].

Fig 6: Comparison of different techniques for spectrum sensing methods in terms of sensing accuracies and implementation complexities.[7]

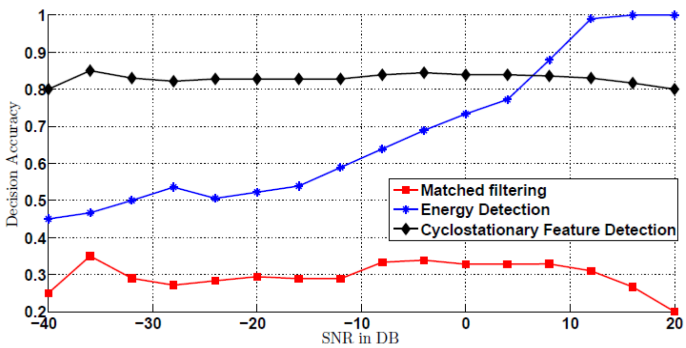


Fig 7: AWGN Channel

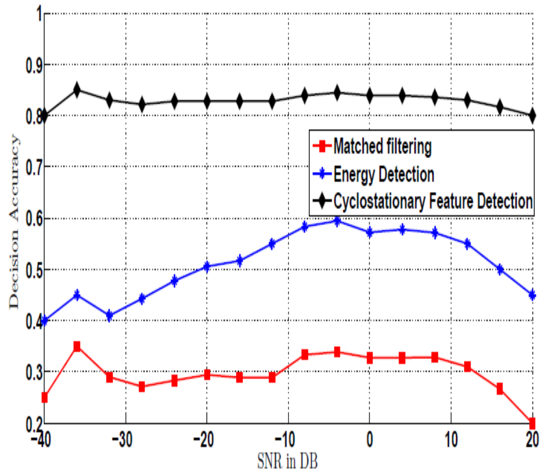


Fig 8: Rayleigh Fading Channel

4. CONCLUSION

Cognitive radio is the promising technique for utilizing the available spectrum optimally. The important aspect of cognitive radio is spectrum sensing from that identifying the opportunistic spectrum for secondary user communication.

In this paper, we have projected a survey paper based on cognitive radio network associated to spectrum sensing techniques. It explains the four primary role of a cognitive radio: spectrum sensing, spectrum management, spectrum sharing, and spectrum mobility. After that in this paper we are focus over spectrum sensing techniques as well as different approach used for accessing licensed spectrum by secondary user.

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