# Spectrum Sensing Techniques in Cognitive Radio Cycle

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**Abstract - The Spectrum sensing techniques in cognitive Radio is presented in this paper. There are three Spectrum sensing techniques of cognitive radio such as cooperative, non-cooperative and interference based detection. Cooperative and non-cooperative techniques are nothing but transmitter detection and receiver detection respectively.Non-cooperative spectrum sensing techniques is classified in three techniques like energy detection, matched filter detection and cyclostationary feature detection.**

**Due to rapid researches in wireless communication and broader application of these wireless networks in the world, efficient utilization of the spectrum has been a persuasive issue for researchers. The development of an intelligent network that can adapt to varying channel conditions by analyzing available spectrum frequency band and increasing the efficiency of an otherwise underutilized spectrum. This paper focuses on the spectrum sensing techniques of the Cognitive Radio in order to detect and utilize empty spaces in the spectrum without creating interference to the primary user. The issue of spectrum underutilization in wireless communication can be solved using Cognitive Radio (CR) technology.**

## I.INTRODUCTION

A Cognitive Radio is an extension of modern Software Defined Radio. This extension creates new capabilities for users. The main potential advantages introduced by cognitive radio are improving spectrum utilization and increasing communication quality. 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. Such radio automatically detects available channels in wireless spectrum, then accordingly changes its transmission and reception parameters to allow more concurrent wireless communications in given spectrum band at one location. Cognitive radio network is complex multiuser wireless communication system to provide efficient use of radio spectrum. The idea of cognitive radio extends by using the concepts of hardware radio and software defined radio from a simple , single function device to a radio that senses its operating environment.

The concept of cognitive radio is that unlicensed users (cognitive radio users) can access the spectrum owned by licensed users (primary users) while they cannot interfere with primary users when exploiting spectrum. Thus to realize the technique of cognitive radio, a cognitive radio user must have the ability to measure, to sense and to learn channel characteristics and availabilities. In addition primary users can claim the spectrum anytime when they have data to send, thus cognitive radio users should be able to identify the presence of primary users in time and vacate the occupied bands immediately to prevent the interference to primary users.

## II.COGNITIVE RADIO CYCLE

In cognitive radio cycle, a cognitive radio monitors spectrum bands and captures their information and then detects spectrum spaces. The characteristics of the spectrum spaces that are detected spectrum sensing are estimated. Then appropriate spectrum band is chosen according to its characteristics and user requirements. Once operating spectrum band is determined, the communication can be performed over this spectrum band.

*1. 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.

*2. Spectrum Management:* It is the task of capturing the best available spectrum to meet user communication requirements.

*3. Spectrum Mobility:* It is defined as the process where the cognitive user exchanges its frequency of operation

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

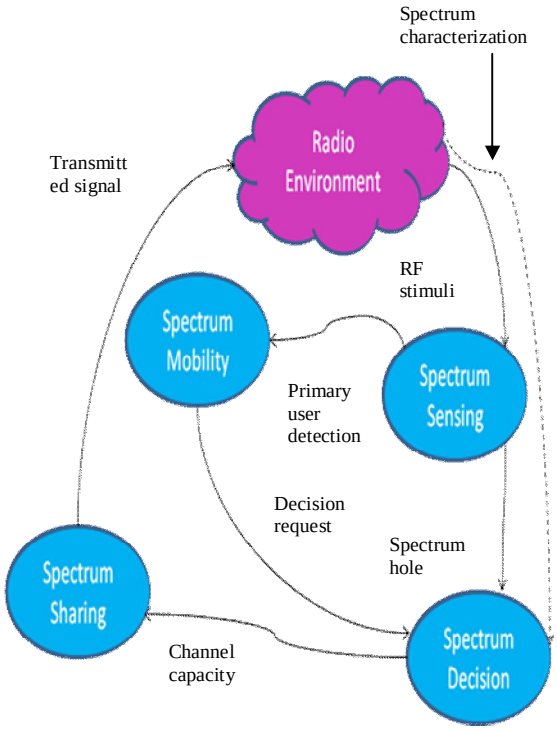


**Fig.2.1: Cognitive Radio Cycle**

## III.SPECTRUM SENSING

Spectrum sensing is defined as the task of finding of spectrum holes by sensing the radio spectrum in the local neighborhood of the cognitive radio receiver in unsupervised manner. The spectrum holes stands for those sub bands of the radio spectrum that are underutilized at particular instant of time and specific geographic location. Spectrum Sensing is the capability to determine and sense whether license user is present or absent. Objective of cognitive radio is that unlicensed user needs to detect the presence of licensed user or shift to another frequency band or stay in the same band by changing its modulation scheme to avoid interference. Spectrum Sensing involves the detection of the presence of a transmitted signal, by a given Receiver. The ability of a cognitive Radio to dynamically access the spectrum holes that dynamically appear is predicated upon its ability to detect these white spaces in the first place.

Spectrum sensing technique can be categorized into two types. They are: Direct and Indirect Techniques. Direct Technique is also called as frequency domain out in which estimation is carried out directly from signal approach. Where as in Indirect Technique (also called as time domain approach), in this technique estimation is performed using autocorrelation of the signal.

*Types of spectrum sensing techniques*

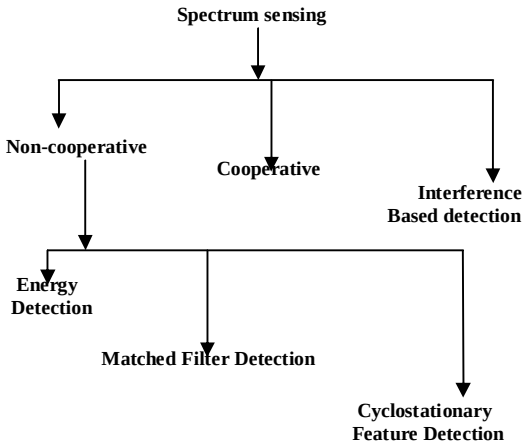


**Fig.3.1.Types of spectrum sensing techniques**

*A.Non-cooperative Sensing technique*

Non-cooperative Sensing Technique means SU relies on its sole effort to detect the presence of a PU transmission on a particular spectrum band. This technique has three types which shows in above diagram **.**

*1. Energy Detection*

If the secondary user cannot gather sufficient information about the PU signal, the optimal detector is an energy detector, also called as a radiometer. Energy detection is a non coherent detection method that is used to detect the licensed User signal. If the

noise power is known, then energy detector is good choice It is a simple method in which prior knowledge of primary or licensed user signal is not required, it is one of popular and easiest sensing technique of non-cooperative sensing in cognitive
radio networks. It is common method for detection of unknown signals**.**

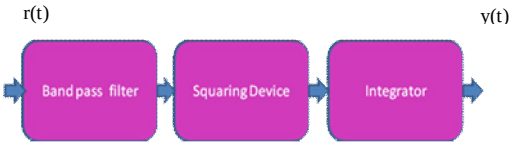


**Fig.3.2 Block Diagram Of Energy Detection**

The above block diagram is of energy detection which consists three blocks such as band pass filter, squaring device and integrator. The band pass filter selects the specific band of frequency to which user wants to sense. After the band pass filter there is a

squaring device which is used to measure the received energy. The energy which is found by squaring device is then passed through integrator which determines the observation interval, T. Now the output of integrator, Y is compared with a value called threshold, λ and if the values are above the threshold, it will consider that primary user is present otherwise absent.

*Drawbacks Of Energy Detection*:

1. It requires a longer sensing time to achieve good results

2. It is unable to differentiate between source of received energy i.e. it cannot distinguish between noise and primary user.

*2. Matched Filter Detection*

The decision making on whether the signal is present or not can be facilitated if we pass the signal through a filter, which will accentuate the useful signal signal and suppress the noise at the same time. Such a filter which will peak out the signal component at some instant and suppress the noise amplitude at the same time has to be designed. This will give a sharp contrast between the signal and the noise, and if the signal is present, the output will appear to have a large peak at this instant. If the signal is absent at this instant, no such peak will appear. This arrangement will make it possible to decide whether the signal is present or absent with minimum probability of error. The filter which accomplishes this is known as matched filter.

Main purpose of the filter is, to decrease the noise component and to increase the signal component at the same instant. This is obviously equivalent to maximizing the signal amplitude to the noise amplitude ratio at some instant at the output. It proves more convenient if we go for square of amplitudes. Hence the matched filter is designed in such a way that it will maximize the ratio of the square of signal amplitude to the square of the noise amplitude.


**Fig..3.2 Block Diagram Of Matched Filter Detection**

The above block diagram is of matched filter detection which consists three blocks such as band pass filter, matched filter and decision making block. Matched filter operation is equivalent to correlation in which the unknown signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal. The operation of matched filter detection is expressed as

$$Y[n] = \sum_{k=-\infty}^{\infty} h[n-k]x[k]$$

Where 'x' is not the known signal and is convolved with the 'h', the impulse response of matched filter that is matched to the reference signal for maximizing the SNR. Detection by using matched filter is useful only in cases where the information from the primary users is known to the cognitive users. Matched filter detection require less detection time. When the information of the licensed user signal is known to the Cognitive Radio user, Matched filter detection is good Detection in noise.

*Drawbacks of Matched Filter Detection*

1. It requires a prior knowledge of every primary signal.

2. CR would need a dedicated receiver for every type of primary user.

*3.cyclostationary Feature Detection*

The cyclostationary feature detection technique exploits the statistical feature built into a primary signal. Generally, the background noise and interference do not correlate to time or frequency domains. Hence, if the secondary user has statistical information about the correlation feature of the primary signal, it can increase sensing accuracy.

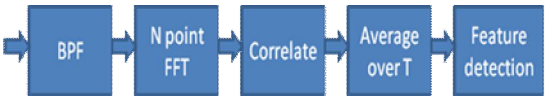


**Fig.3.3 Block Diagram Of Cyclostationary Feature Detection**

The above block diagram is of cyclostationary feature detection which consists five blocks such as band pass filter point FFT, correlate, average over T and feature detection. Cyclostationary feature detection is robust to noise uncertainties and performs better than energy detection in low SNR regions. Although it requires a priori knowledge of the signal characteristics, cyclostationary feature detection is capable of distinguishing the CR transmissions from various types of PU signals. This eliminates the synchronization requirement of energy detection in cooperative sensing. Moreover, CR users may not be required to keep silent during cooperative sensing and thus improving the overall CR throughput. This method has its own shortcomings owing to its high computational complexity and long sensing time. Due to these issues, this detection method is less common than energy detection in cooperative sensing.

*Drawbacks of Cyclostationary Feature Detection*

1. This feature detection can only be applicable for few primary signals with characteristics.

2. It requires an increase in cost and complexity for the time shift correlation process and frequency-domain transformation respectively and it requires long sensing time.

*B. Cooperative Sensing Technique*

Cooperative sensing allows SUs to cooperate and consolidate their spectrum sensing efforts in order to reach a more accurate conclusion about

spectrum availability. This approach of spectrum sensing comes as a solution to a major drawback of non-cooperative sensing, that is the effect of the hidden node problem on the sensing outcome.

Cooperative sensing technique is classified in following techniques:

*1) Decentralized Uncoordinated Techniques:* In uncoordinated techniques Cognitive Radio will independently detects the channel and will vacate the channel when it finds a primary user without informing the other users. So Cognitive Radio users will experience bad channel realizations detect the channel incorrectly thereby causing interference at the primary receiver. So these are not advantageous when compared to coordinated techniques.

2) Centralized Coordinated Techniques*:* Here in this technique we have Cognitive Radio controller. When one Cognitive Radio detects the presence of primary user then it intimates the Cognitive Radio controller about it. Then that controller informs all the Cognitive radio users by broadcast method. This is further more classified into two types as partially cooperative in which network nodes cooperate only in sensing the channel. The other technique is totally cooperative in which nodes cooperate in relaying each other's information in addition to cooperatively sensing the channel.

*3) Decentralized Coordinated Techniques***:** This type of coordination implies building up a network of cognitive radios without having the need of a controller. Various algorithms have been proposed for the decentralized techniques among which are the gossiping algorithms or clustering schemes, where cognitive users gather to clusters, auto coordinating themselves. The cooperative spectrum sensing raises the need for a control channel, which can be implemented as a dedicated frequency channel or as an underlay UWB channel.

*Drawbacks of Cooperative Sensing Technique*

Cooperative technique even has drawback like the CR users need to perform sensing at periodic time intervals as sensed information become fast due to factors like mobility, channel impairments etc.

*C.Interference Based Detection Technique*

Interference based detection depends upon primary receiver detection and interference temperature management.

*1) Primary Receiver Detection:* Primary receiver emits the local oscillator (LO) leakage power from its RF front end while receiving the data from primary transmitter. It has been suggested as a method to detect primary user by mounting a low cost sensor node close to a primary user's receiver in order to detect the local oscillator (LO) leakage power emitted by the RF front end of the primary user's receiver which are within the communication range of CR system users. The local sensor then reports the sensed information to the CR users so that they can identify the spectrum occupancy status. We note that this method can also be used to identify the spectrum opportunities to operate CR users in spectrum overlay.

*2) Interference Temperature Management:* Unlike the primary receiver detection, the basic idea behind the interference temperature management is to set up an upper interference limit for given frequency band in specific geographic location such that the CR users are not allowed to cause harmful interference while using the specific band in specific area. Typically, CR user transmitters control their interference by regulating their transmission power based on their locations with respect to primary users. This method basically concentrates on measuring interference at the receiver .The operating principle of this method is like an UWB technology where the CR users are allowed to coexist and transmit simultaneously with primary users using low transmit power that is restricted by the interference temperature level so as not to cause harmful interference to primary users.

## IV.CONCLUSION

In this paper we discuss about three spectrum sensing techniques of cognitive radio such as cooperative, non-cooperative and interference based detection. Non-cooperative spectrum sensing technique and its three type are discussed in detail with its drawbacks. The main potential advantages introduced by cognitive radio are improving spectrum utilization and increasing communication quality. Cyclostationary feature detection shows the better detection performance as compared with the matched filter and energy detection techniques. We also said about important the importance of cooperation between Secondary users to avoid interference.

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