



Co-Operative Spectrum Sensing In Cognitive Radio Network in ISM Band

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ABSTRACT

One of the promising solution for the underutilized spectrum in the wireless communication is cognitive radio network. It gives the solution for the unlicensed users (i.e. Secondary users) by utilizing the unused spectrum in the licensed users (i.e. Primary users). Spectrum sensing plays a vital role in cognitive radio network for the secondary users which identifies the unused spectrum through the spectrum sensing techniques. In this paper spectrum sensing techniques are compared for the cognitive radio network in ISM band with various aspects of spectrum sensing problem. The result shows there is a significant improvement in the performance of co-operative spectrum sensing in the probability of detection and probability of false alarm.

Keywords: Cognitive radio network, Co-operative spectrum sensing, ISM band (Industrial, scientific and medical radio band).

I. INTRODUCTION

Due to the rapid growth in the wireless communication there is a shortage in the available radio spectrum. The innovative technique which can use the spectrum effectively is cognitive radio network. The main aspect is, the unused spectrum in the primary users can be utilized for the secondary users without causing any interference to the primary users. The important concept in the cognitive radio network is, it has the ability to measure, sense, learn and aware. In cognitive radio network we have two types of users. They are Primary users and Secondary users. The Primary users are licensed users (i.e. they have legal rights to use the spectrum with high priority). The Secondary users are unlicensed users (i.e. they have low priority to use the spectrum without causing any interference to the primary users). In the conventional method it is inflexible to sense the spectrum which has vacant bands, which is not utilized by the primary users. A recent survey was made on the spectrum utilization of the licensed spectrum in the wireless communication. It says that licensed spectrum is utilized rarely and also not effectively used. From this observation, there are vacant bands in the primary users.

These vacant bands can be utilized by the secondary users. In order to use, the secondary users should have the cognitive radio capability. Spectrum sensing is the main function of the cognitive radio network in the RF environment to find the unused frequency bands (i.e. white spaces or spectrum holes) for the secondary users.

II. SPECTRUM SENSING

The objective of the spectrum sensing in cognitive radio network is to detect the unused spectrum or vacant bands from the primary users for the use of secondary users without causing any interference to primary users.

The main work is to identify the spectrum holes for the secondary users to utilize it. Cognitive radio network has the way to sense the spectrum.

There are some spectrum sensing basics for cognitive radio spectrum.

Continuous spectrum sensing: The cognitive radio system should continuously sense the spectrum occupancy.

Monitor type of transmission: the cognitive radio system should able to find the transmission type which is received.

III. TYPES OF SPECTRUM SENSING

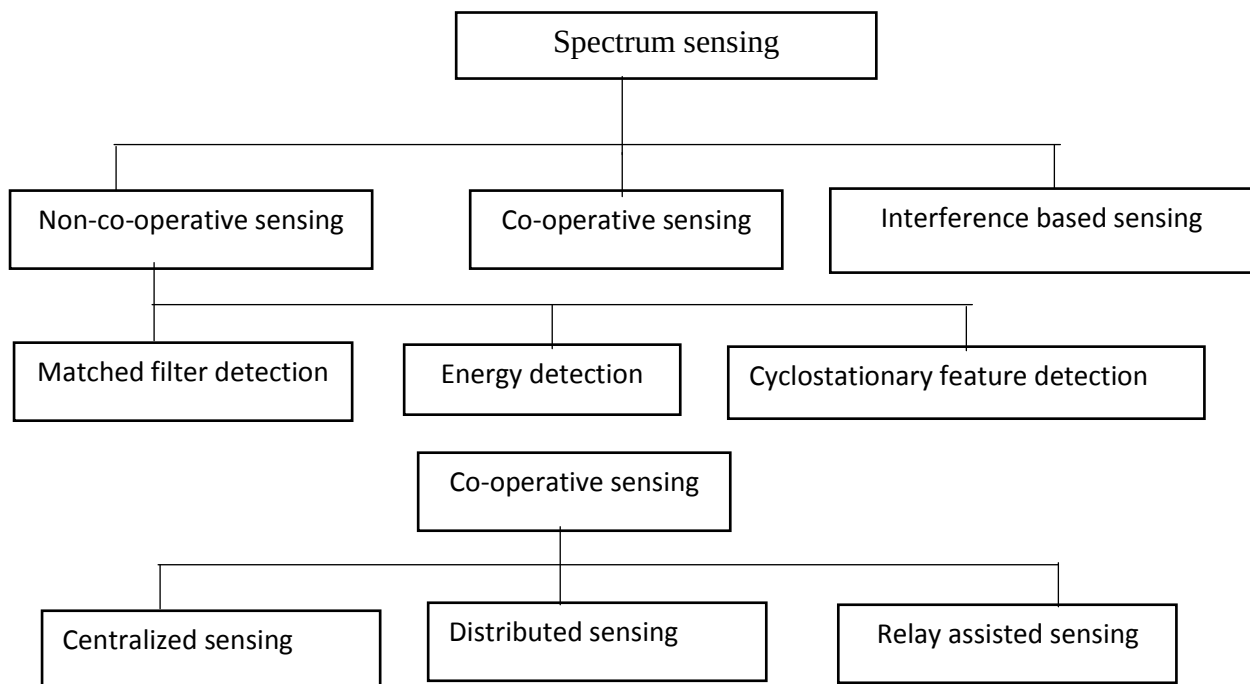


Figure 1. Spectrum sensing techniques

Basically there are three types of sensing techniques in cognitive radio network. They are Non co-operative spectrum sensing, co-operative spectrum sensing and interference based sensing. All the techniques will sense the channel whether it is idle or not. If the channel is idle then it will sense and it will inform to secondary users to utilize the channel. Spectrum sensing techniques will have some considerations in order to sense. Each techniques will have their method. Cognitive radio has some methodologies to sense the spectrum. They are

- **Spectrum sensing bandwidth:** Based on the number of channels on which the system will sense whether they are occupied. By sensing channels apart from the one currently in use, the system will be able to build up a picture of alternative channels that can be used should the current one become occupied.
- **Transmission type sensing:** Identifying the transmission of the primary user for the channel. It must also identify transmissions of other units in the same system as itself. It should also be able to identify other types of transmission that may be spurious signals, etc.
- **Spectrum sensing accuracy:** The cognitive radio spectrum sensing mechanism must be able to detect any other signal levels accurately so that the number of false alarms can be minimized.

- **Spectrum sensing timing windows:** The cognitive radio spectrum sensing methodology allows some time slots when it does not transmit to enable the system to detect other signals.

IV. NON CO-OPERATIVE SPECTRUM SENSING

In the Non co-operative spectrum sensing, the cognitive radio will acts on its own and detect the signals according it's configure.

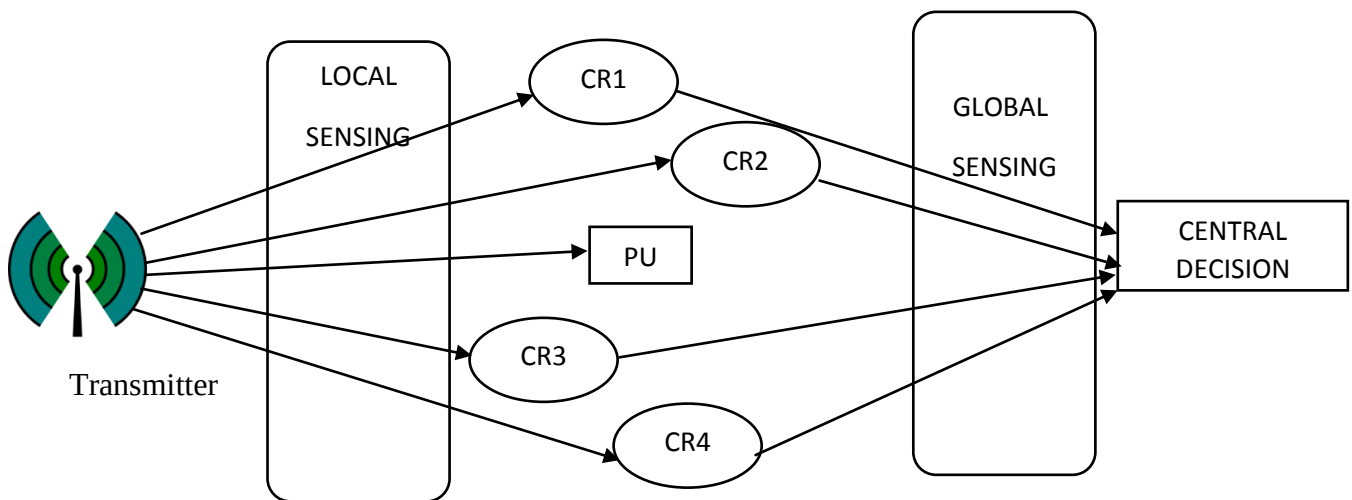


Figure 2. Non Co-operative spectrum sensing

It represents the cognitive radio node senses the channel through local sensing and reports to the central decision fusion through global sensing. The cognitive radio (CR) node will sense in its way. There are three types of spectrum sensing in Non-co-operative spectrum sensing. They are Matched filter detection, Energy detection and Cyclostationary feature detection methods.

Matched filter detection:

In this method linear filter is designed in order to maximize the output signal to noise ratio for the input signal. For this secondary user should have some knowledge about the primary user, then only the matched filter detection technique can be used. It can be expressed as

$$Y(n) = \sum h(n-k) x(k) \text{ where } k \text{ varies from } -\infty \text{ to } \infty$$

Where x represents unknown signal

Where h represents impulse response of matched filter that is matched to reference signal from maximum SNR.

Disadvantages:

- It requires a prior knowledge of every primary signal.
- It should be a dedicated receiver for primary user.

Energy detection method:

In this method received signal energy is calculated in order to find the presence of primary user. The energy level of received signal should be more than threshold energy level, then only we can consider that the primary user is present.

Disadvantages:

- The sensing time is high
- It cannot be used to detect the spread spectrum signals.
- It cannot distinguish the primary signals from the cognitive radio user's signals.

Cyclostationary feature detection:

In this method considering the cyclostationary features we can easily detect the primary user transmission. The cyclostationary features are generated by the periodicity in the signal or its mean and correlation. In order to distinguish the primary user from the noise the periodic pattern is used. The received signal is said to be cyclostationary if the mean and autocorrelation shows periodicity. The primary user's signals are coupled with spreading codes and cyclic prefix.

Disadvantages:

- Partial information of primary user is required.
- Computation cost is high.

V. CO-OPERATIVE SPECTRUM SENSING

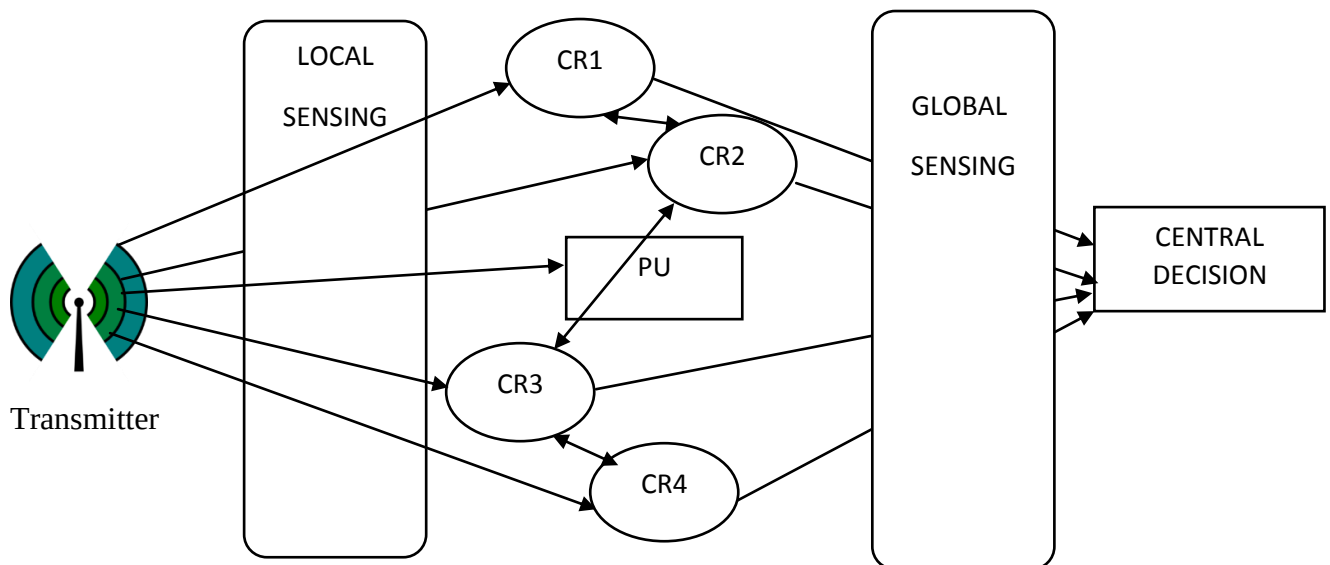


Figure 3. Co-operative spectrum sensing

In this co-operative spectrum sensing the cognitive radio node senses the channel. After sensing the information it will communicate with each other and shares the information among the cognitive radio nodes and sends the information to the central decision fusion. From that information the central decision fusion will take decision and senses the spectrum. Considering the types of co-operative spectrum sensing, Centralized sensing and Distributed sensing plays a vital role.

Centralized sensing:

In this method among themselves a network is created and one of the node will acts as a master node. The remaining nodes from the networks detect the channels and give the information to the master node. The master node decides to use the spectrum.

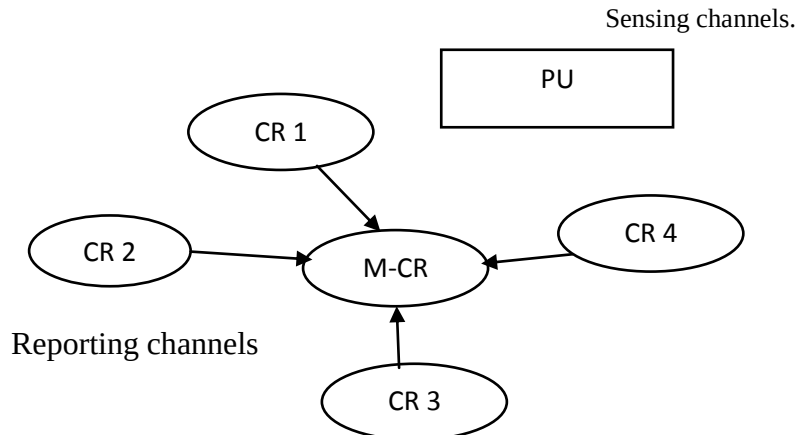


Fig 4. Centralized sensing

Distributed sensing:

In this method there is no master node within the network. The sensed information was shared with their relative nodes. From that shared information they can make their own decision to use the spectrum effectively.

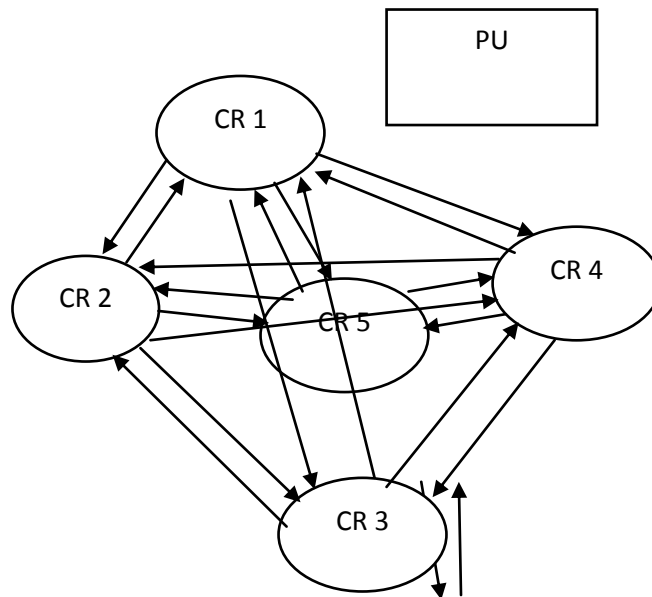


Fig 5. Distributed sensing

From the diagram we can observe that each node shares the information to the other nodes. it is called distributed sensing.

Benefits of co-operative spectrum sensing:

- All topologies of the co-operative networks reduces the detection time.
- Sensitivity threshold is achieved.

VI. COMPARISON

The simulation results of both Co-operative spectrum sensing and Non-co-operative spectrum sensing are compared. A set of simulations performed based on energy for the detection of primary user. Based on the concept of centralized spectrum sensing techniques the receiver operating receiver characteristics of the spectrum sensing methods are simulated. The co-operative spectrum sensing has the better performance of probability of detection and probability of false alarm.

Probability of detection

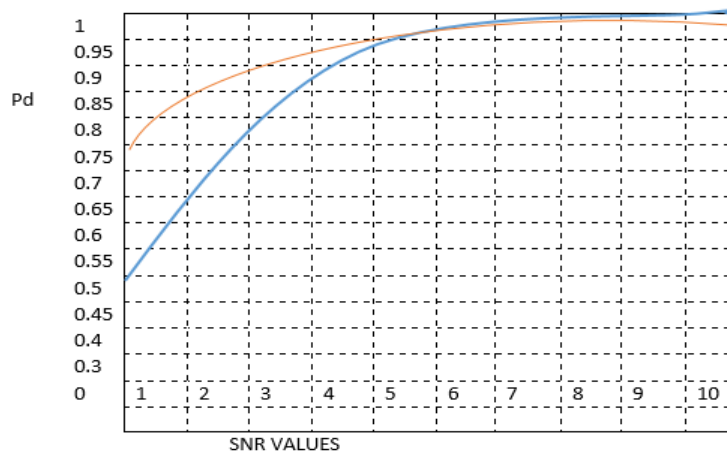


Fig 6. Receiver operating characteristics for co-operative and non-co-operative spectrum sensing

Probability of false alarm

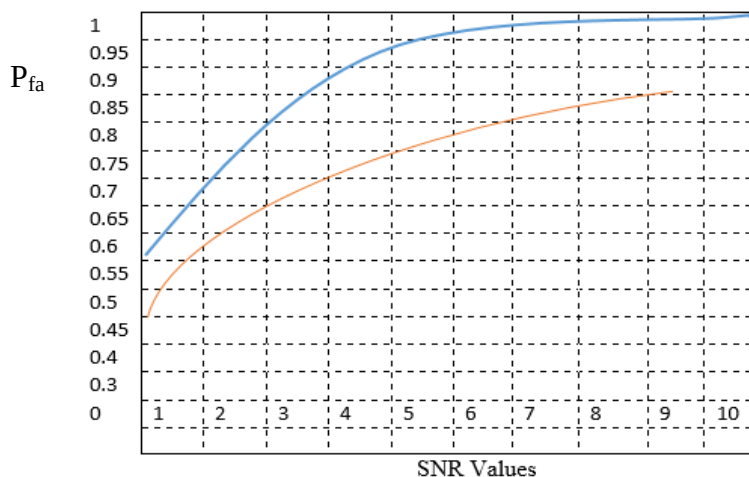


Fig 7. Receiver operating characteristics for co-operative and non-co-operative spectrum sensing

VII. CONCLUSION

To increase the efficiency of spectrum usage in the RF spectrum we are utilizing the unused frequency bands in the primary users. For this cognitive radio network plays a vital role to utilize the available spectrum more effectively. In this article we discussed the spectrum sensing techniques for cognitive radio network in Ism



band.co-operative spectrum sensing is considered the best for spectrum sensing and it gives a flexible policy for the dynamic access to the spectrum.

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