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Review of Cooperative Sensing and Non Cooperative Sensing in Cognitive Radios

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ABSTRACT

Cognitive radio has been very skilled and advantageous technology for best use of underutilized spectrum.CR system includes primary users who are licensed and secondary users who are seek to courteously use the spectrum when primary user is not active. The motivation behind CR is to improve spectrum utilization. CR contains four basic operations: (a) spectral analysis (b) spectral sensing (c) spectral sharing (d) spectral decision. Spectrum Sensing is the essential and challenging component in CR. It senses the spectrum availability and sharing without disturbing other users Cooperative sensing can be used to avoid multipath fading and interference with licensed users. This paper presents various techniques of cooperative and non cooperative sensing techniques. Based on that method, energy detection is the most popular and low computational method.There are several types of cooperative techniques like centralizeddistributed, distributed and relay assisted which are discussed in the paper. Finally,various elements present in cooperative sensing is discussed in the paper like cooperation models, hypothesis testing and control channel which makes sensing more reliable and efficient.

Keywords- Cooperative Sensing, Data Fusion, Fusion Centre, Hard Combining,SpectrumSensing, Non Cooperative Sensing

I. Introduction

In today's era, when there is rapid advance in wireless technology there is huge demand for spectrum as number of users are increasing and comparatively less spectrum is available in industry. The inundate spectrum reduces the overall quality of service. so to overcome the issue of scarcity of spectrum. Cognitive radio technique is used so that spectrum can be used efficiently. It runs on SDR (Software Define Radio). Cognitive radio consists of two types of users: Primary users which are licensed and another one is Secondary users which are unlicensed. Cognitive radio consists of three components that is sense, learn and adapt. Cognitive cycle consists of four basic operations: Spectral analysis, Spectral sensing, Spectral sharing and Spectral decision. Spectral analysis is based on spectral sensing and analyzing the vacant band. Spectrum decision is the call of reconfiguration for the channel and protocol required. Spectrum sensing is the extremely important component of CR. It senses the spectrum availability and sharing without disturbing other users. When licensed user shares its spectrum with unlicensed user it is called spectrum sharing. It can only send data when spectrum is not in use by licensed one. Cooperative Sensing can be used to solve the problem that arises while doing sensing like interference, false alarm and detection problem. In cooperative sensing central unit senses and broadcast information to other radios. The most important reasons why cognitive is different from any other conventional radio is that user can send unlimited number of signals using cognitive radio and reconfiguration can be done at any time. It can also manage its operation according to need of environment. The main use of cognitive radio is to utilize unused spectrum. Cognitive radio must sense the environment and detect the availability of primary user.

The demonstration of spectrum sensing depends on two standards (a) chances of false alarm which correspond to chances of SU states PU is present when spectrum is actually idle (b) chance of detection which corresponds to chances of SU state that PU is present when PU is present in spectrum. In figure 1, CR1 and CR2 are within the transmission range (PU, TX) and CR3 is present outside transmission range. Because of various duplicates of PU, CR2 encounter multipath fading and that outcome in overlook of PU signal. CR3 bears instability issue since it is situated outside sensing range of transmitter of transmitter and unaware of the

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presence of primary receivers. As a result, the transmission from CR3 may obstruct with the reception at PU RX. [1]

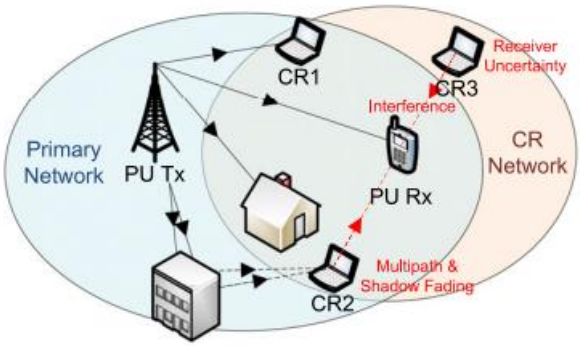

Figure 1.Principle of spectrum sensing [1]

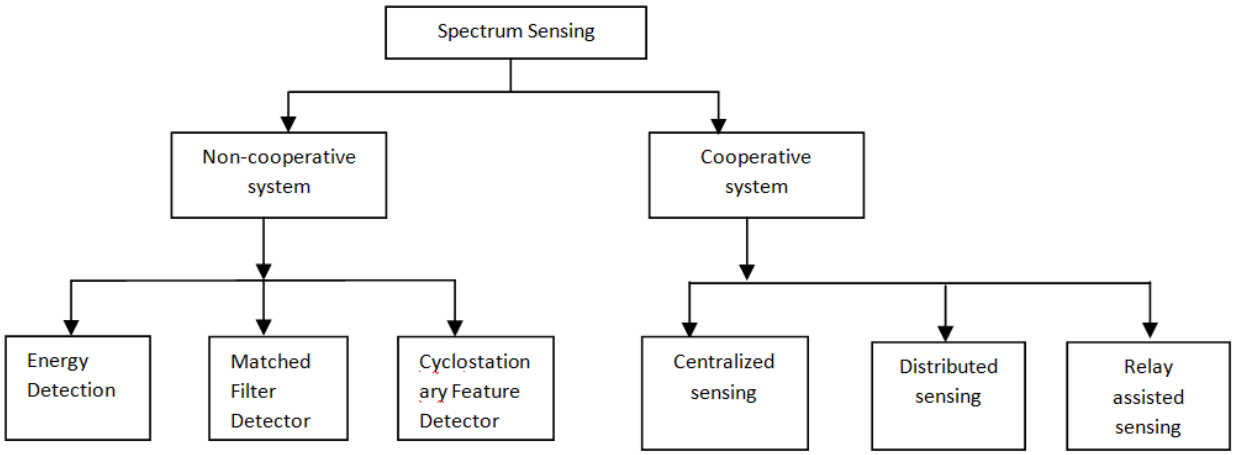

Figure 2. Spectrum sensing techniques

As shown in figure 2, there are two approaches used for sensing purpose as sensing is main component of cognitive radio. The main point of cooperative sensing is to ensure that all the nodes of cognitive radio should know when to sense, which spectrum to sense and how the information is shared to other cognitive radio.

II. Cooperative sensing

As shown in figure 3 (a),a common device called fusion centre FC collects all the information from all the cognitive radio connected through a node. The goal of fusion centre is to select the relative frequency band or spectrum and instruct all cognitive radio to perform local sensing. Fusion centre combines all the result obtained from various cognitive radios.Distributed unlike centralized, does not require fusion centre for making cooperative result. In this method cognitive radio impart with each other and takes mutual decision on the basis of availability and unavailability of primary user. The iteration is repeated until one decision is made. This is depicted in figure 3(b). In relay assisted sensing, which is shown in figure 3 (c), each cognitive radio senses the channel and if primary user is detected by cognitive radio then that channel is vacated without giving prior knowledge to other cognitive radio nodes. In this method, sensing information is given in multiple hops and these hops are called relays.

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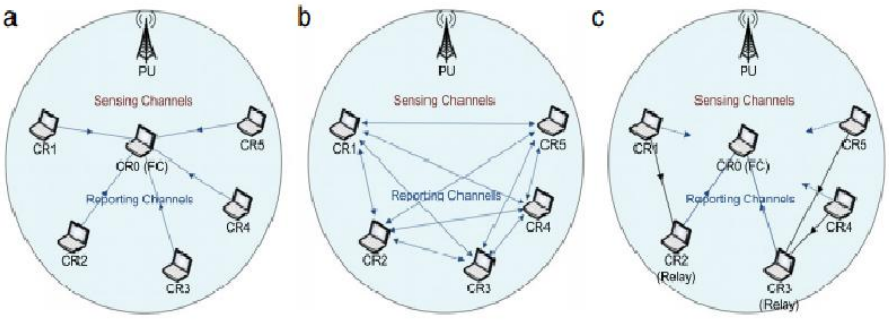

Figure3.(a)Centralized sensing (b) Distributed sensing (c)Relay assisted[13]

III. Non-Cooperative Sensing :

In non-cooperative sensing, each cognitive radio works independently. In this technique, each CR user takes its own judgement and does not take the support of other CRs.

(a) Matched filter detection

According to this method, SNR (signal to noise ratio) of the obtained signal is increased. The basic requirement for best possible performance is that cognitive radio needs to have prior knowledge of primary signal transmitted by primary user. It needs less detection time as compared to other techniques. In CR, such knowledge is not readily available to secondary user therefore; the complexity of this method becomes high. So this method is not used practically. In figure 4, the output signal is obtained by passing through the Band Pass Filter (BPF)and the matched filter. The signalis convolved here and an impulse response is generated by the matched filter. This output is compared with the threshold value.[9]

H_1= Hypothesis for presence of primary user…..(1)

H_0=Hypothesis for absence of primary user…..(2)

H_1: x (t) =s (t) +w (t)

H_0: x (t) = w (t)

Where S (t) is the signal transmitted

X (t) is the signal received

W (t) is the white Gaussian noise with variance

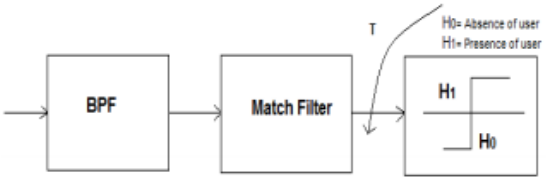

Figure 4. Matched filter detection based spectrum sensing

(b) Cyclostationary detection

In this technique, a cyclostationary signal can vary periodically with time and this periodicity is used to detect presence or absence of PU. Due to presence of this periodicity, these cyclostationary signal exhibit spectral relationship which is absent in stationary noise. This method is tough to noise uncertainties and perform better than energy detection. This method has another good advantage that it is competent of differentiate between CR transmissions from various types of PU signal. It improves the overall CR throughput.

Energy detector is the most popular method. If CR have no information about primary signal then energy detection can be used for spectrum sensing unlike other models energy detection does not require any other

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information about PU and strong to unidentifiedfading. In figure 6 the input signal is passed into band pass filter then signal is fed into square law device and then into integrator which calculate the moderate energy. The output value or energy is compared with threshold λ ,if the result is higher than the threshold value then primary signal is present, and if result is below threshold value is then primary signal is absent as depicted in equation (1) and (2).

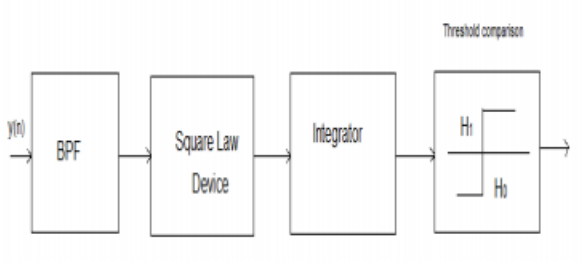

Figure 5.Block diagram of energy detector [11]

IV. Elements of Cooperative Spectrum Sensing

The cooperative spectrum sensing contains seven elements (1) Cooperation Model (2) Sensing Technique (3) Hypothesis Testing (4) Control Channel (5) Data Fusion (6) User Selection (7) Knowledge Base

These elements are briefly explained below [13]

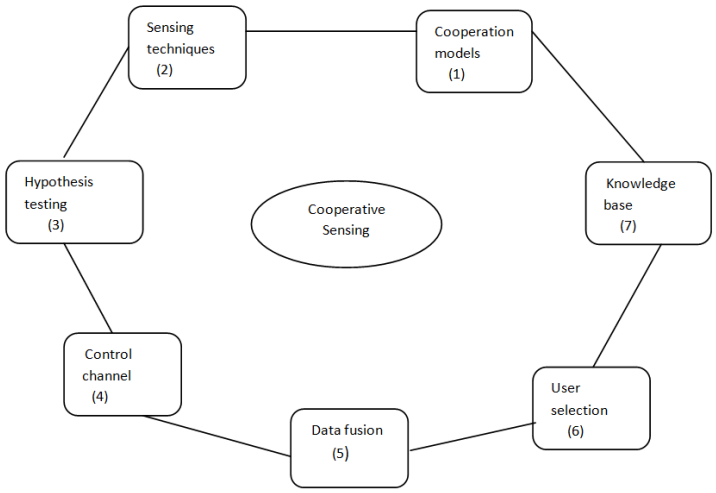

Figure 6.Elements of cooperative sensing technique

*Cooperation model*emphasis on how CR users assist with each other. There are two approaches in cooperating model: parallel fusion, data fusion. In parallel fusion cooperating sensing consist of three steps: data fusion, local sensing and data reporting. All the secondary users collect data and report to fusion centre. The fusion centre combines all the data and makes a cooperative decision and then this decision is broadcast to all cooperating users.

Sensing technique is used to sense the absence or presence of PU signal or availability of spectrum. In sensing technique energy detection is most popular method due to its simplicity. All the sensing techniques are discussed in earlier sections of this paper.

Hypothesis testing is a numerical test used to determine the presence or absence of PU. In this testing the comparison is made between null hypothesis and alternative hypothesis. There are many testing for example the generalized likelihood ratio test (GLRT) and sequential testing.

Control channel is used for CR user to report local sensing data to fusion centre. It can be employ as a dedicated channel in licensed or unlicensed band. There are three major requirements for control channel: bandwidth security and reliability.

Data fusion is the process of combining all the data received at fusion centre. There are two rules used in data fusion that is hard combining and soft combining or quantized decision. The sensing result received at fusion centre through CR can be combined in three different ways.(a) Hard decision combining: In this method CR make a local decision based on reported data and then this result is transmit the single bit decision for hard combining. It gives the better performance as compared to soft combining in terms of cost and reliability. There are three common fusion rules AND, OR, Majority rules. *Logical OR* rule: It declares that presence of primary signal if at leastone of the CR reports that same result.*Logical AND rule:* It declares presence of primary signal if total number of CR reports the same result.*Majority rule*: It declares presence of primary signal if more than half of secondary user or CR reports the same result.(b)Soft decision combining: In this method, secondary user forward its local perception to the FC to make soft decision. The accumulated value is compared with threshold value by FC.[3]

*User selection*plays important role in control theperformance of cooperative sensing because it is used for cooperative gain. It removes issues like shadowing and fading and reduces the cooperation overhead. There are various user selection schemes like centralized and cluster based.*Centralized selection:* It is performed at fusion centre to take benefit of all gathered information collected from cooperating CR.There are many problems arises like high overhead such as control channel bandwidth and energy efficiency.*Cluster based selection:*Clustering is used to improve the detection performance through reporting channel under Rayleigh fading. There are four clustering methods which depends on availability of location information (a) Random clustering (b) Statistical clustering (c) Distance based clustering (d) Reference based clustering

Knowledge base is a database that stores all information related to primary user. It serves two roles in cooperative sensing. It improves detection performance. Also, it reduces the burden of cooperative sensing by extract the spectrum information.

V. Conclusion

In this paper, various cooperative and non cooperative schemes have been reviewed. Based on different methods, energy detection is considered to be best solution for problems like interference and hidden primary user. Cooperative sensing is an active technique to avoid interference with any primary user while sensing. In this paper, various fundamental elements used in cooperative sensing are discussed.Studies have shown that there are many unlicensed spectrum which is under utilized in time and space domain. Cooperative spectrum sensing can use spectrum efficiently. This will improve the overall performance of spectrum and also the increase data rate.

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