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A Survey of Cooperative Spectrum Sensing in Cognitive Radio Networks

Navpreet Kaur
Student, Department of IT
UIET, PANJAB UNIVERSITY
Chandigarh, UT
nvprtkr7@gmail.com

Mrs.Inderdeep Kaur Aulakh
Head of the Department
UIET, PANJAB UNIVERSITY
Chandigarh, UT
ikaulakh@yahoo.com

Abstract- The spectrum sensing is the base line on which the whole process of cognitive radio works. It has raised new facets for cognitive radio and many opportunistic spectrum access approaches. To avoid the interference with the licensed users and determining the accessible spectrum for increasing the spectrum's usage is its pivotal task of cognitive radio. Generally detection performance is compromised with receiver uncertainty, multipath fading and shadowing issues and an effective method to alleviate the effect of these issues is the cooperative spectrum sensing. This paper provides the introduction to spectrum sensing, its techniques, cooperative spectrum sensing, and System requisites for cooperative sensing, its advantages and disadvantages, and elements of cooperative spectrum sensing and further describes various research area. Finally, this paper concludes that cooperative sensing becomes crucial if the network all together is to prevent interference with each primary user.

Keywords- *spectrum holes, cognitive radio cooperation, spectrum sensing, cooperative sensing, non-cooperative sensing.*

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1. Introduction

The accessible radio spectrum is restricted natural resource and the demands of growing number of high data rate gadgets can not be accommodated by the present static spectrum allocation schemes [1], [2]. The static allocation of spectrum leads to underutilization of radio spectrum. Also, the traditional approach to spectrum allocation is immutable as individually each wireless operant is given an exclusive license of certain frequency band [1],[3]. For long duration of time the licensed frequency bands are not used by operators and the entire spectrum is not used completely. Spaces that are not used in the allotted frequency band are called as "*spectrum holes*". Cognitive radio is a new area emerged to control and manages the radio spectrum deficiency [3]. Fig (1) denotes the spectrum holes.

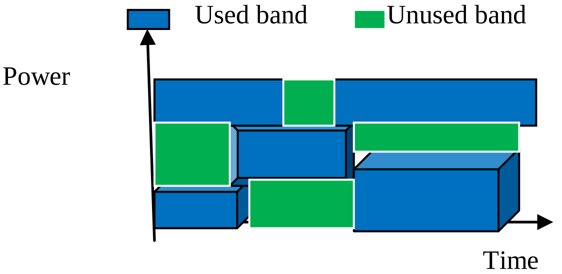

Fig (1) Spectrum hole

The main function of each secondary users (SUs) or unlicensed users in cognitive network is to observe the primary users (PUs) or the licensed users, if they are present and if they are absent, the task is to identify the unused frequency band [4]. Federal Communications Commission defines cognitive radio as, "*Cognitive radio: A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system operation, such as maximize throughput, mitigate interference, facilitate interoperability, access secondary markets*" [5]. Hence, the significance of cognitive radio is to identify the new paths to access the unused frequency bands.

A process where cognitive radio audits its radio spectrum and geographical surroundings, detects the usage statistics of other primary and secondary users and moreover determines the possible spectrum space holes is called as *Spectrum Sensing* [6].

2. Non-Cooperative and Cooperative Sensing Techniques

Fig (2) depicts two types of approaches to sense the available spectrum: non cooperative approach and cooperative approach. In this paper we mainly emphasize on cooperative approach and briefly describe the non-cooperative approach.

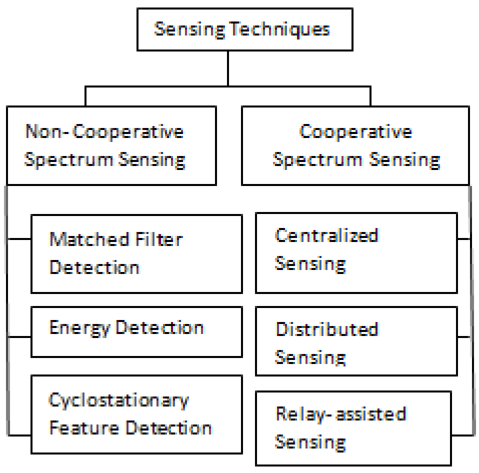

Fig (2). Spectrum Sensing Techniques

In non-cooperative approach, each radio operates separately within the network to execute its work of measuring and analyzing the spectrum utilization. The non-cooperative

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approach is further classified as matched filter detection, cyclostationary feature detection and energy detection. *Matched filter Detection* is the optimum linear filter constructed to increase the signal to noise ratio for the given input signal [1]. This filter is used only when the secondary user has preliminary information about the primary user. Matched filter operates similar to correlation which convolves the unknown signal with the filter having impulse response same as the reference signal. Following are the equation [7] and block diagram of matched filter operation:

$$y[n] = \sum_{k=-\infty}^{\infty} h[n-k]x[k \quad - (1)$$

Where 'x' is the anonymous signal convolved with 'h' which is the impulse response of the filter matched to the referenced signal for increasing the signal to noise ratio [1].

Fig (3). Block Diagram of matched filter

Noisy signal is made as input to the matched filter and the output of the filter is the signal having maximum SNR.

Energy Detection is a non coherent detection method that detects the primary signal based on sensed energy [8]. It is well known sensing approach as it does not require the prior information of primary user and is independent of the pattern of the signal.

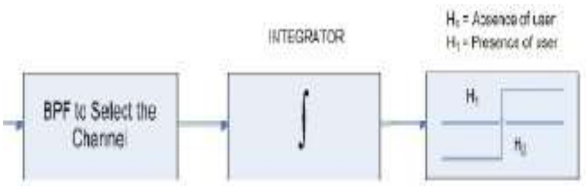

Fig (4). Energy Detector block diagram [8]

In this approach, the signal is first passed from the band pass filter with bandwidth 'w' and then the filtered signal is integrated and finally the integrated output is compared with known threshold 'v' to determine the absence or presence of licensed user. The threshold value is determined from the stats of the noise.

Cyclostationary feature detection approach executes better than the energy detection in low SNR regions [1]. It has the ability to differentiate transmissions from various types of licensed users. In this it requires the prior information of traits of the signal.

In cooperative approach, each CR user shares the knowledge they acquire. In this technique, number of secondary users collectively gathers the information concerning channel utilization and spectrum map is used to store this information. Secondary user after regular intervals forwards it to the Central Coordinator as a section of control message and then the group of Ultra high frequency channels present at each node, bitwise-or of all spectrum maps is taken. The best accessible channel is then selected by coordinator and transmitted back to the secondary user. [9]

Broadly cooperative sensing is further classified as centralized sensing, distributed sensing and relay assisted sensing. *Centralized approach* has a master node in the network that amasses from each radio or CR user, the sensing information. Each CR user independently detects the channels and then analyses the collected information and decides upon the spectrum band that can be used or not. The master node has the ability to instruct the various CR users to perform different measures at different time.

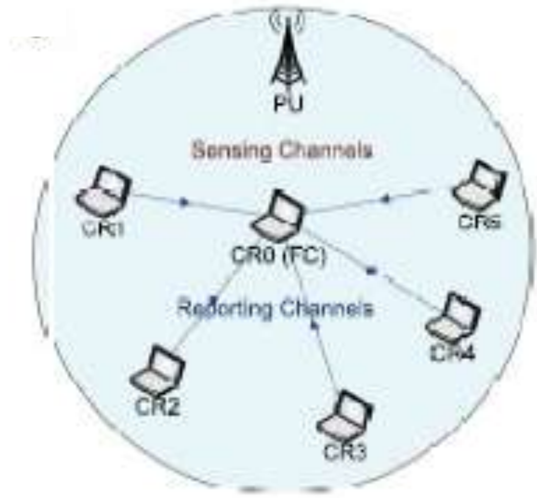

Fig (5) Centralized technique [4], [11]

Distributed technique has no master node; instead the sense information is shared among various nodes. In this technique of spectrum sensing each node has some amount of overhead of being highly independent so that they could possibly set themselves as faster and easier network.

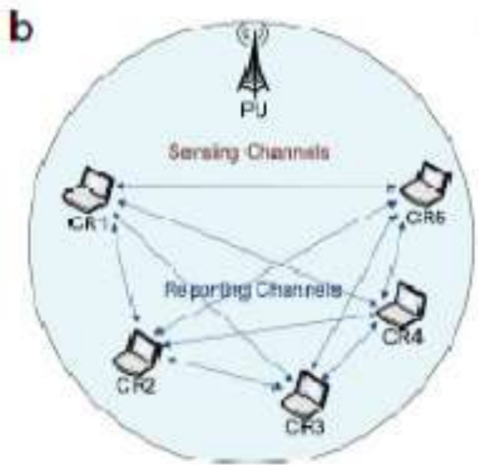

Fig (6). Distributed Technique [4,], [11] *Relay assisted technique* allows each user to independently sense the channel and if the primary user is detected by the CR node, the particular channel being sensed is vac1ated without notifying the other CR nodes. Moreover, when the sensing information needs to be communicated to the receive node it travels through multiple hops and all these hops are said to be relays.

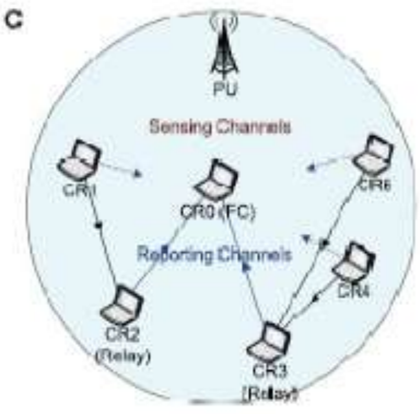

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Fig (7). Relay assisted technique [4], [11]

3. System Requisites for Cooperative Sensing

Applications using cooperative sensing techniques provide number of advantages and these advantages need to satisfy different requirements of system. Following are the system requirements: [10]

a) **System Synchronization:**
Synchronization between each node in cooperative sensing is necessary to keep channel vacant from communications while sensing is ongoing. Synchronization is necessary where the sense periods are used to increase channel throughput.

b) **Appropriate geographical arrangement of cooperating nodes:**
To obtain optimal sensing from cooperative nodes and to reduce hidden node syndrome, it is mandatory to arrange the nodes in the best suitable manner.

c) **Control Channel:**
To allow transmission between cooperating nodes, a control channel is needed which acquires a part of overall bandwidth of the system.

4. Advantages and Disadvantages of Cooperative Spectrum Sensing

Advantages:

- The sensitivity requirements for employing cooperation within the nodes can intensely decrease the sensitivity requisites approximately to -25 dBm [1].
- Sensitivity Threshold is achieved.
- Detection time is decreased using cooperative networks.

Disadvantages:

- Sensing in this is performed at regular intervals as the acquired

Sensing information becomes outdated fast due to issues like channel impairments, receiver uncertainty etc.

5. Elements of Cooperative sensing

Cooperative sensing has seven elements namely (i) cooperation models, (ii) sensing techniques, (iii) control channel and reporting, (iv) data fusion, (v) hypothesis testing, (vi) user selection, and (vii) knowledge base [4]. Fig (8) shows these elements and following is the brief introduction to these elements:[4]

Fig (8). Elements of cooperative spectrum sensing. [4]

- *Sensing Techniques* are used to monitor spectrum band to detect the licensed user and or the unused frequency band. Cooperation within the CR nodes effect the choice of the technique to be used.
- *Cooperation Models* deal with how licensed users cooperate with each other to perform spectrum sensing.
- *Knowledge Base* supports the process of cooperative sensing to boost the detection performance. Licensed and unlicensed user locations, prior knowledge etc is stored in this.
- *User Selection* considers how to effectively gather the information regarding coordinated CR nodes and recognize the way to increase the cooperative throughput and reduce the cooperation overhead.
- *Data Fusion* is a method of integrating the results of shared sensing to make a cooperative decision.
- *Control Channel and Reporting* deals with how the gained sensed information is communicated to control coordinator or

other CR nodes using limited bandwidth channel or channel susceptible to fading.

- *Hypothesis Testing* is a test to know the absence or presence of a licensed user. This can be carried out individually by the control coordinator or by each CR user to obtain a cooperative decision.

6. Conclusion

Cooperative sensing is essential to avoid interference with any primary user while sensing of frequency band is ongoing. In this paper we described the system requisites to carry out the spectrum sensing task followed by its advantages and disadvantages. We further sliced the problem of cooperative sensing into its key elements. Hence, we concluded that cooperative sensing is not appropriate in all the applications but wherever applied, considerable gain in system and network performance is obtained.

It helps to reduce hidden node problem where the licensed users are not detected but the receivers facing interference are able to detect both the licensed and the transmissions of the cognitive radio system. Cooperative sensing helps to acquire accurate sensing information which further reduces the number of false alarms. It also provides precise signal detection and maximizes the system reliability.

References

[1] Subhedar, Mansi, and Gajanan Birajdar. "Spectrum sensing techniques in cognitive radio networks: a survey." *International Journal of Next-Generation Networks* 3.2 (2011): 37-51.

[2] Yücek, Tevfik, and Hüseyin Arslan. "A survey of spectrum sensing algorithms for cognitive radio applications." *Communications Surveys & Tutorials, IEEE*11.1 (2009): 116-130.

[3] International Journal of Innovative Research in Science, Engineering and Technology
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Cooperative Sensing Approach in Cognitive Radio Network-A Review Paper
Yasir Abdelfatah Merghani Ahmed 1, Dr. Khalid Hamid Bilal 2, Dr.Amin Babiker A\elnabi Mustafa 3
Department of Communication, Faculty Post Graduate Studies / El Neelain University, Khartoum, Sudan1
Department of Communication, Faculty Engineering / Science & Technology University, Khartoum, Sudan 2
Department of Communication, Faculty Engineering / El Neelain University, Khartoum, Sudan 3.

[4] Akyildiz, Ian F., Brandon F. Lo, and Ravikumar Balakrishnan. "Cooperative spectrum sensing in cognitive radio networks: A survey." *Physical communication* 4.1 (2011): 40-62.

[5] Federal Communications Commission. "Notice of proposed rule making and order: Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies." *ET docket* 03-108 (2005): 73.

[6] Tabakovic, Zeljko. "A Survey of Cognitive Radio Systems." *Post and Electronic Communications Agency, Jurisiceva* 13 (2013).

[7] http://en.wikipedia.org/wiki/Matched_filter

[8] Malik, Shahzad A., et al. "Comparative analysis of primary transmitter detection based spectrum sensing techniques in cognitive radio systems."*Australian journal of basic and applied sciences* 4.9 (2010): 4522-4531.

[9] Imam, MOHD Sajid, Sheetal Ingle, and Shabnam Ara. "A Review paper based on spectrum sensing techniques in Cognitive Radio Networks." *Network and Complex Systems* 3.9 (2013): 14-20.

[10] http://www.radio-electronics.com/info/rf-technology-design/cognitive-radio-cr/cooperative-spectrum-sensing.php

[11] Min, Alexander W., and Kang G. Shin. "An optimal sensing framework based on spatial rss-profile in cognitive radio networks." *Sensor, Mesh and Ad Hoc Communications and Networks, 2009. SECON'09. 6th Annual IEEE Communications Society Conference on*. IEEE, 2009.