

Extending the Lifetime of Multichannel Sensing Wireless Cognitive Sensor Networks Using Sensor Selection

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Abstract: Wireless Cognitive Sensor Networks (WCSNs) consist of a combination of small, less energy and economical sensors. One of the major functions of these WCSNs is to sense the channels properly. The primary issue is that the sensors cannot sense the multiple channels simultaneously. So, to select cooperative sensors for sensing multiple channels simultaneously is a challenging issue. The focus should also be laid on extending the lifetime of WCSNs.

In this paper, for sensing different channels within different sensing periods tunable receiver is proposed and to extend the lifetime of the sensors, systematic node selection is suggested. With node selection, adequate nodes sense the channel while all the quality restrictions are to be maintained. A subset of nodes to sense every channel is chosen in a way that the remaining energy of the sensor is balanced properly which results in extending the lifetime of the network. Simulation results are obtained to discuss the benefits of the proposed process with other sensor choosing schemes.

Keywords: Energy efficient, Lifetime maximization, Multichannel sensing.

I. INTRODUCTION

One of the functionality of the cognitive system is spectrum sensing, through which white spaces are determined [1]. The primary issue in this process is that the Secondary User (SU) cannot perform the function of a transmitter and a receiver at the same time. Further, it is also possible that one of the SU might fail the whole of the sensing area because of an unperfected location. So, WCSNs having small, less energy and economical frequency sensors, can be a probable solution when sensors are used for sensing [2]. A situation may arise when a feeble PU

signal is to be discovered but due to fading effects, the sensor fails to do so. Hence, to overcome this situation Cooperative Spectrum Sensing (CSS) is proposed. In CSS energy consumption is an area of concern especially for WCSNs with large overhead and large message size is discussed in [4]. The energy utilization mechanism empathically affects the lifetime of the network. So, to encounter this condition reducing the number of sensing nodes is a feasible option [4]. In [5], for reducing the communication overhead the number of SU is determined. In [6], the node selection is done by observing the historical behavior of the SUs and the receiving strength of the PU is also considered. In [7], a process of relay node selection is considered for developing an efficient CSS. In [8], a numerical method is adopted for determining the number of SU for CSS. In [9], the cooperative nodes for CSS are discussed. In [10], for extending the lifetime of WCSNs for CSS is discussed. In [11], future cognitive radio networks that can operate over a broad spectrum are discussed. Researchers have also proposed multichannel joint sensing design [12,13]. The multichannel selection assignment is presented for throughput maximization during the transmission [14]. The energy harvesting technique is also discussed to increase the lifetime of the sensor networks [15].

The lifetime of multichannel CSS can be optimized by the precise selection of channels and sensors. So, energy can be saved as a small number of sensors precisely selected perform the sensing. The lifetime optimization problem discussed in [10] is elaborated in his paper.

II. SYSTEM MODEL

The work considers CWSNs consisting of N sensors dispersed unvaryingly in a square or rectangular region and fusion center is situated at the center. The frequency spectrum to be

monitored consists of M channels which are preferred by the MPUs. It is taken for granted that a PU can be assigned only a single channel and Fusion Center (FC) knows the location of the sensors, PUs, an implemented WCSN is shown in Fig. 1.

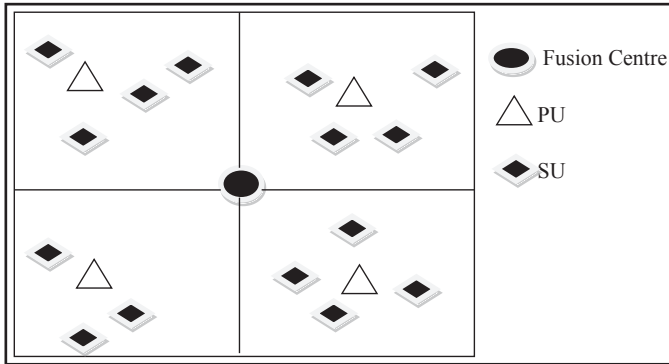


Fig. 1: System Model

The sensors are small and equipped with low complexity circuits. A small sensor would not be able to sense multiple channels simultaneously. In Fig. 2 a sensor receiver block diagram is shown.

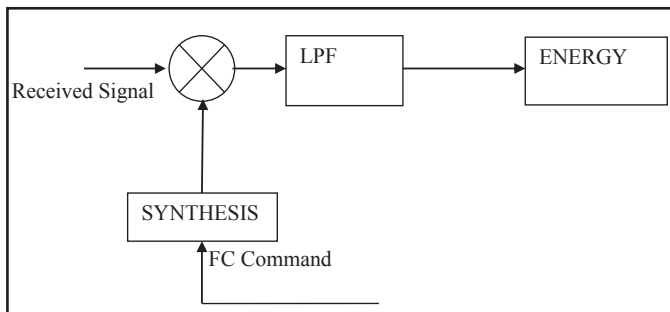


Fig. 2: Receiver Circuit

III. PROBLEM FORMULATION

To increase the lifetime is a challenge in WCSNs along with maintaining high Global Detection Probability (GDP) and Global False Alarm Probability (GFP) to detect the channels effectively. The higher GDP decreases the interference with PU and better GFP enhances the utilization of free channels. The aim is to select the most suitable sensors of collaborative nature for sensing every channel. So, that the WCSN lifetime is maximized in the presence of constraints of GDP and GFP.

IV. SENSOR AND CHANNEL SELECTION

During the process of sensor selection for multiple channel CSS, the major issue that is to be tackled first is the determination of the order of the channels. The process of determination of the order of the channel has been discussed in [13], but the complexity of this method is very high as well as the method is not compatible with the network having a large number of sensors. In this paper, a distance-based approach is proposed

which reduces the complexity. In distance-based approach, there is a probability that only a few sensors are located around the PUs which are far from the center. To determine the sensor for the all nodes simultaneously sensors are selected for all the channels and saved in the matrix. For the matrix coordination, two methods are proposed. In the first method, we try to select enough sensors for almost every channel, based on the order of the channel and then save the sensors in the required row of the matrix. Then the sensor from the next channel is selected. In the second method, a single sensor for every channel is selected and then stored in the desired matrix. Then the restriction of the GDP is checked. The first method is also discussed by selecting the channels randomly. This method is discussed only to show that the lifetime based sensor selection is far better than other assumptions. For obtaining the optimum lifetime of the network along with maintaining the constraints on the Global False Alarm Probability. A Lifetime Based Sensor Selection (LBSS) based on the method 1 will be referred as LBSS 1 and a Lifetime Based Sensor Selection (LBSS) based on the method 2 will be referred to as LBSS 2. When the first method is adopted by random selection for the channels then a Lifetime Based Sensor Selection (LBSS) based on method 1 with random channel selection will be referred to as LBSSR 1.

V. SIMULATION AND COMPARISON RESULTS

To evaluate the proposed scheme simulations are done in MATLAB. Few assumptions are made before the start of the simulation such as a square region is considered of length L meters and a fusion center is located at the center. N sensors are assumed and M , PUs are seen. IEEE 802.15.4 protocol compatible sensors are used. In Fig. 3, the success percentage of the proposed scheme LBSS 1 and LBSS 2 are compared, we have also plotted the success percentage of the LBSSR 1. It can be said that distance based channel selection causes to improve the success percentage. On observing the performance of LBSS 2 it can be said that LBSS 2 performs far better than LBSS 1 because it selects sensors one at a time.

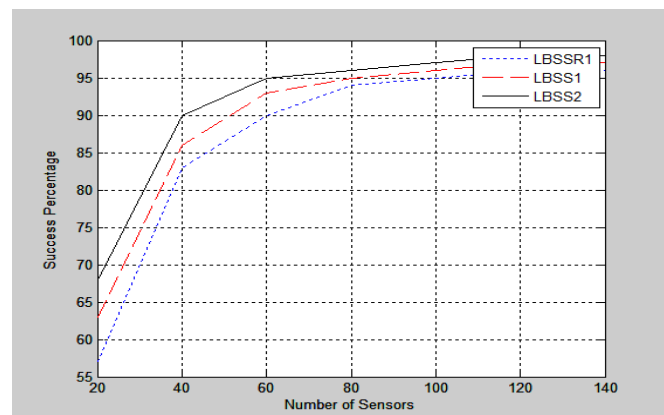


Fig. 3: Success Percentage of Schemes

The lifetime of the proposed approaches was also compared for a different number of sensors. This is shown in Fig. 4.

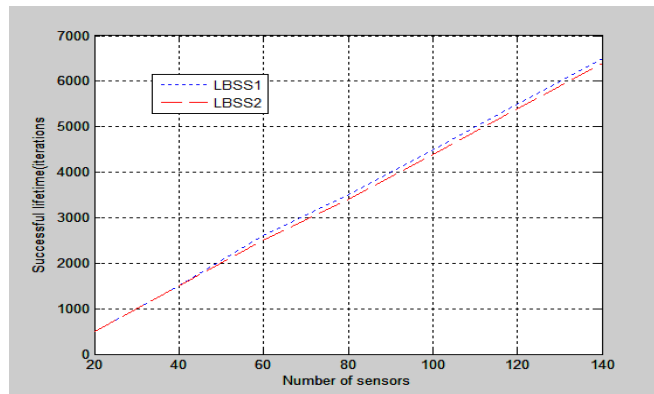


Fig. 4: Success Percentage for the Multi-Channel CSS Lifetime

VI. CONCLUSION

For improving the performance of WCSNs, energy efficiency and lifetime optimization are observed. The multi-channel CSS lifetime optimization problem is discussed. In this paper, a lifetime-based sensor selection approach is proposed. Simulation results were obtained and compared for lifetime-based sensor selection approach when a single sensor for every channel is selected, when multiple sensors for every channel is selected and when the single sensor for every channel which was selected randomly is selected.

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