An Effective Channel Access Mechanism for Data Transmission in Heterogeneous Cognitive Radio Sensor Networks

V. Noel Jeygar Robert
Department of Information Science and Technology
College of Engineering, Guindy, Anna University
Chennai, India
noel.jey89@auist.net

K.Vidya
Department of Information Science and Technology
College of Engineering, Guindy, Anna University
Chennai,India
vidyak@auist.net

Abstract**—Wireless sensor networks (WSN) function in ISM (Industrial Scientific and Medical) band undergoes unlimited interference problem due to overcrowded sensor nodes and also, it consumes large amount of energy to transmit data. To make an effective use of the spectrum more efficiently Cognitive Radio technology is integrated to Wireless Sensor Networks. The so-called cognitive radio and wireless sensor networks together form a new terminology known as cognitive radio sensor networks, thereby utilizes the spectrum more efficiently by accessing licensed channels. However, in order to support cognitive radio (CR) such as channel discovery, switching and accessing licensed channel in wireless sensor networks makes the task more complex since CRSN utilizes more energy. In pursuance of a solution to the existing, this work has devised a new mechanism by effectively accessing the channel in CRSNs, to improve the energy utilization. Based on the cognitive radio functions and capability, this work has further investigated that when the nodes should shift the channel i.e. from licensed band to ISM band for improving the energy efficiency, in accordance with the packet drop measure of the license-free channel. This work has proposed the effective channel accessing and switching mechanism for data transmission within a cluster and outside cluster in CRSN. The simulation results of the proposed algorithms show that reduction of energy utilization in CRSNs.**

Keywords- ISM(Industrial Scientific and Medical) Band, Cognitive Radio Sensor Networks Spectrum, Licensed Channel

I. INTRODUCTION

Wireless sensor network (WSN)are highly scattered networks of wireless nodes that has been widely applied in different fields of application which includes military observation,environmental sensing and industrial applications. A Wireless Sensor Network are group of numerous sensor nodes which is used to sense a particular area and the results are send to the sink node[1]. Generally, these sensor nodes are highly dependent on their battery power. Hence a sensor nodes life time is calculated on its battery power, and the sensor nodes are deployed in a remote environment. As a result energy constraint has becomes a major problem in WSNs.

Adopting Cognitive Method in WSN

Cognitive Radio (CR) is an Software Defined Radio that authorizes cognitive users or the secondary users to operate on the spectrum hole or the available spectrum allocated to primary users[2].CR can be integrated with WSN to overcome the limitations in conventional WSN. CR knows the available spectrum in a license and ISM band and makes use of the spectrum available in an efficient manner. Maintaining the Integrity of the Specifications. In today's world spectrum bands are becoming crowded as number of sensor's trying to access the spectrum band causing severe interference. By enabling cognitive radio properties in a sensor node makes an effective solution by selecting and accessing licensed band channel based on the availability. Hence, Cognitive Radio Sensor Networks are implemented in the cluster for data transmission, respectively.

Primary User:Primary User's are those who own the licensed band spectrum. Base station monitors the licensed channel and primary user and make sure that the primary user operations are not interrupted by any unauthorized user.

Base-Station: Licensed spectrum is a utility function of Base-station. In general, base-station or otherwise called as sink nodes does not have any capability for sharing or aceesing the avilable spectrum hole with other users. In order to provide cognitive capability to secondary users, base-station must inherit the properties of a cognitive radio.

Cognitive Radio User: Cognitive radio user is a user who adopts the cognitive radio properties which obtain the unlicensed spectrum [3]. Hence, the spectrum is approached only in a timeserving manner. Spectrum handoff, Spectrum decision, spectrum sensing are certain capabilities which together form a cycle and play an important role in sensing and sharing the available spectrum hole. This cycle makes the CRSN to take intelligent decision in sharing accessing and allocating the spectrum available to other users who lack in bandwidth and makes good use of the spectrum which is left free for those nodes in need.

II. CR-WSN CAPABILITIES

- Self-configuring - A new node is set into its position in order to fine tune its functions such as inter-cell interference,transmission power, automatically by configuring, testing and authenticating itself.
- Energy constrained - Much more energy efficient such that it can successfully transmit more with the existing energy constraints in WSNs.
- Self-Aware nodes –Self Aware nodes are those with few functionalities framed to provide an application service.

A. Existing System

Existing system works on minimizing the data transmission delay or increasing the network capacity for CRSNs. But it does not concentrate on improving the energy efficiency for CRSNs[4]. The most crucial thing is to conclude when the energy consumption during transmission of data can be reduced by using the licensed channel. It depends on several distinct factors, number of licensed channels packet drop rate of the available license-free channel. Eventhough there is are number of available spectrum holes, when a node senses an available channel, in a spectrum hole another difficulty occurs in selecting the best available channel.

B. Proposed System

An effective channel access mechanism is put forward for transmission of data in hetrogeneous cognitive radio sensor networks by sensing and accessing licensed channels. Energy utilization for channel discovery and accessing for transmission of data in a hetrogeneous cluster is analyzed thoroughly. Looking into the timeserving channel discovery and shifting problem and to improve the power factor in a hetrogeneous CRSNs,sensor nodes transmit their sensed data to the sink node via routing by accessing the licensed channel at idle state. In order to encapsule the PUs, the channel occupancy duration (COD) for each licensed channel is limited. After the end of COD the channel becomes free. During interference between primary and secondary user, licensed channel should be hand-over to the primary user and secondary user access next available licensed channel, Otherwise secondary user should access default license-free channel.

III. System Framework Description

A. Determination Of Free Channel

For the purpose of efficient data transmission, the most energy efficient channel in the set of available channels must be selected. For that, a expected energy consumption must be calculated for each channel and with that the best channel is selected. Normal WSN uses the license-free channel for data

Transmission and it is not a productive method. So, CR uses the licensed channels for data transmission but it does not select the best of the licensed channels. So it becomes essential for the node to discover the best channel in the available channel set.

B. Accessing the Free Channel

Usually, from the sensed channels the best channel is opportunistically accessed. Channel Available Duration (CAD) plays a major role in the channel accessing a Cognitive Radio (CR) sensor node. If CAD of a channel expires, it becomes essential for the sensor node to look out for the next best channel to continue the data transmission without any packet loss. If the data transmission is complete, the secondary user must drop the channel and make it idle so that it can be used by any other node present in the cluster.

C. Primary User Interference

When a cognitive user currently uses the channel which belongs to the non-cognitive user and the non-cognitive user is ready for data transmission, interference occurs hence immediate handover of the channel must take place from the secondary or cognitive user to primary user or non-cognitive user and the next channel which is available for data transmission is sensed. As soon as the interference occurs, the node must calculate the residual data which must be transmitted and that data alone should be transmitted..

D. Cluster Head Selection

Clusters are group of nodes which are organized together so that the energy of the nodes are balanced during transmission of data. Clustering also improves the scalability of sensor nodes. Data transmission in a heterogeneous cognitive radio sensor networks involves data transmission within the nodes inside the cluster and between clusters members present in two different clusters. The data is transmitted from cluster head to cluster monitor and then to the members of the cluster of the other cluster. So it becomes essential to select the optimal node as the cluster monitor.

IV. Performance Evaluation

A. Free Channel Identification

Due to traffic in unlicensed band, free channels in licensed band spectrum is determined by Cognitive Radio Sensor Network using efficient channel access scheme. From the list of expected set of accessible licensed channels CL, the best channel is selected. Using this, it becomes easier for the node to transmit data instead of searching for free channels every time it wants to transfer the data. From the channel set reorder the channels according to increasing order of energy consumption. Then one has to check the channels whether they are busy or idle and the channel is selected and data transmission is done by channel access algorithm

Fig.1. Indicates the flow of channel sensing algorithm. First, the energy consumption via license-free channel is calculated.

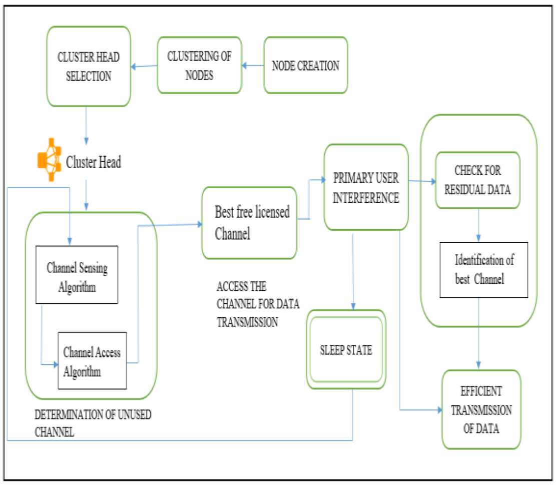

Fig. 1. Flow of Effective Channel Access Algorithm

B. Flow of Channel Access Algorithm for Data Transmission between clusters

1. C_L indicates any Licensed Band
2. C_U indicates any Unlicensed Band or ISM Band
3. L_A indicates any Licensed User or non-cognitive user
4. L_U indicates any Unlicensed User or cognitive user
5. L_A operates in C_L
6. L_U operates in C_U
7. C_L=1 indicates channel is being used by any L_A
8. C_L=0 indicates channel is free i.e. L_A is in idle or sleep state
9. When C_L=0,L_U switch to C_L for transmission of data
10. Hence $|C_L|$==C_U;(C_U € C_Z) and transmits data D_J
11. When an interference occurs by a primary user L_A
12. Packet Drop occurs C_L=0 moves to C_L=1.
13. The Residual data D_R is then remains in C_U
14. Residual Data D_R is transmitted via C_U

Calculate the energy utilization for transmission of data over C_L for the available set of clusters and determine the expected energy consumption over the channel for all channels in a channel set C_Z.

C. Interference

In Cognitive Radio WSNs, the Secondary User uses the idle Primary User's licensed channel for the purpose of data transmission. In case of primary user's entry to the licensed channel, the following must happen. The secondary user must drop the channel C_K as soon as the primary user enters the channel. The next best channel must be selected from the available set of channels for transmission. The switching must be in a fashion such that data packets which are being transmitted are not lost. The residual data is devised in case of primary user interference for further transmission. If no free channel is available then residual data is transmitted in the default channel C_0.

D. Cluster Head Selection

Clustering, is a process, where nodes are organized into groups called clusters in order to facilitate a performance improvement in a network. A cluster groups the sensor nodes into clusters each monitored by a cluster monitor. Each and every node in a cluster are directly involved in exchanging messages with neighbours inside a cluster and between clusters. Because of its inherent data transmission a clustered organization is considered to improve balanced power factor in a sensor networks.

V. RESULTS AND DISCUSSIONS

TABLE I. INPUT PARAMETERS TABLE

Scope	Settings
CM power for transmission of data within a cluster	20 mW
CH power for transmission of data between clusters	40 mW
CH maximum adjustable power over licensed channels	200 mW
Power Amplifier efficiency	0.9
Single node energy consumption for sensing	0.000131 J
Single node energy consumed for channel switching	0.00001 J
False Alarm probability	0.05

A. Energy Consumption

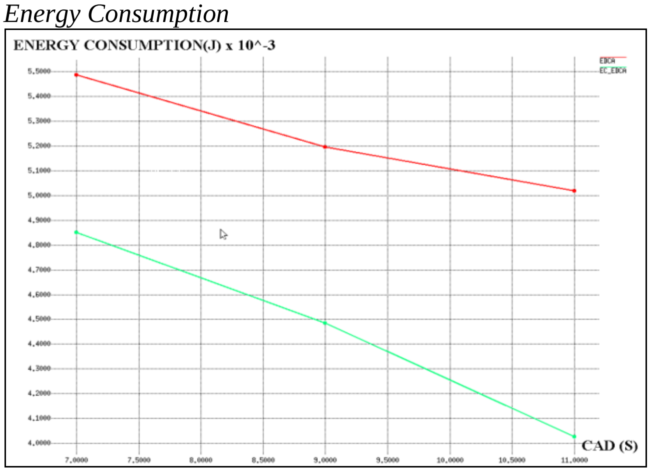

Fig.2. Energy Consumption Obtained by Random CH vs. Methodized CH Selection

As shown in Fig. 2, the graph of energy consumption in existing method vs. proposed method is created. The red line indicates the energy utilization in existing method and the green line indicates the energy utilization in proposed method. In the existing method the cluster head selection is random and in proposed method the cluster head selection is methodized and then selected.

TABLE II. ENERGY CONSUMPTION TABLE

CAD (in secs)	Existing Energy Consumption (in J)	Proposed Energy Consumption (in J)
7	0.005485729945818 J	0.004851054945818 J
9	0.005194142445814 J	0.004484992445773 J
11	0.005017742445813 J	0.004026592445827 J

Table.II represents the existing energy consumption values and the energy consumption value of the proposed method with respect to the Channel Occupancy Duration (COD).

B. Delay

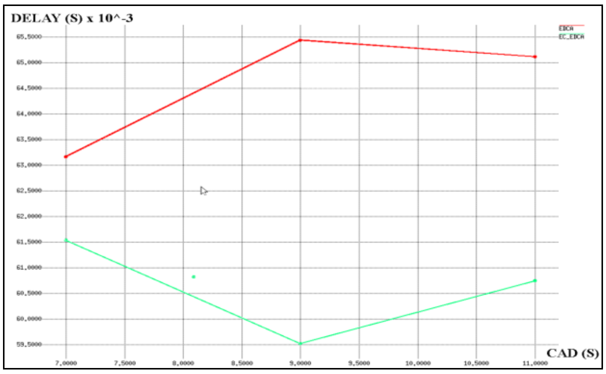

Fig..3. Delay Obtained by Random CH vs Methodized CH Selection

As shown in Fig. 3, the graph of delay in time is created with respect to existing method vs. proposed method. The red line indicates the energy consumption in existing method and the green line indicates the energy consumption in proposed method. Since there occurs difference in CH selection, there is a variation in the delay vs COD and our proposed method consumes least amount of delay in comparison with other methods.

TABLE III. END TO END DELAY TABLE

CAD (in secs)	Existing Delay (in secs)	Proposed Delay (in secs)
7	0.0631633s	0.0615383s
9	0.0654339s	0.0595261s
11	0.0651148s	0.0607493s

C. Throughput

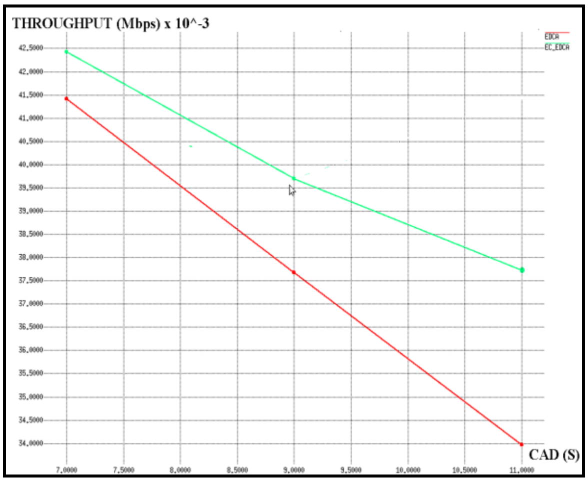

Fig.4. Throughput Obtained by Random CH vs Methodized CH Selection

As shown in Fig. 4, the graph of data transmission throughput is plotted with respect to existing method vs. proposed method. The red line indicates the energy consumption in existing method and the green line indicates the energy consumption in proposed method. Since cluster head is responsible for transmission of data, the throughput increases when the optimal cluster head is selected.

TABLE IV. THROUGHPUT TABLE

CAD (in secs)	Existing Throughput (in MB/S) Proposed Throughput (in MB/S)	Existing Throughput (in MB/S) Proposed Throughput (in MB/S)
7	0.0414144 MB/s	0.0424208 MB/s
9	0.0376735 MB/s	0.0397048 MB/s
11	0.0339733 MB/s	0.0414208 MB/s

The analysis of throughput is done with the use of values tabulated in Table IV. Hence, cluster head selection plays a major role in the throughput and so our method has higher throughput than any other methods.

VI. CONCLUSION AND FUTURE WORK

An effective channel sensing and accessing mechanisms has been put forward for transmission of data in heterogeneous cognitive radio sensor networks, respectively, which forms a thorough answer to control the usage of available spectrum hole and achieving optimal power factor. By taking into consideration the fact of energy utilization in channel discovery and accessing, the conditions of discovery and accessing licensed channels for potential energy utilization reduction was determined. Simulation results indicates the proposed model can significantly bring down the energy utilization of heterogeneous CRSN nodes during transmission of data.

In the future, revocable CRSNs can be investigated, where the power factor can be balanced and spectrum allocation channel switching can be done using Game Theoretic approach to avoid unlimited interference in accessing the channel Due to continuous channel sensing node energy depletes constantly. So, a table can be deployed to track the state of channels constantly to make CR more efficient.

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