A Survey on Energy Efficiency using Spectrum Sensing in Wireless Sensor Network

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ABSTRACT
A Wireless sensor network (WSN) consists of wireless sensor nodes or motes, which are devices equipped with a processor, a radio interface, an analog-to- digital converter, sensors, memory and a power supply. Cognitive radio technology can significantly improve spectrum utilization efficiency via enabling secondary users to access licensed spectrum dynamically without harmful interference to primary users.

Keywords: Cognitive Radio, Cognitive Radio Sensor Networks, Quality of services, Wireless sensor networks, Spectrum sensing.

INTRODUCTION
In recent years there has been a world-wide interest in Wireless Sensor Networks (WSNs). It will not be an exaggeration to consider WSNs as one of the most researched areas in the last decade. Here is a sampling from the literature as summarized in. With several applications and business opportunities arising every day, the WSN market is forecast to rise from $0.45 billion in 2012 to $2 billion in 2022 [3].

WSN technology offers numerous advantages over conventional networking solutions, such as, lower costs, scalability, reliability, accuracy, flexibility, and ease of deployment that enable their use in a wide range of diverse applications. With advancements in technology and sensors getting smarter, smaller, and cheaper, billions of wireless sensors are being deployed in numerous applications. Some of the potential application domains are military, environment, healthcare, and security. In military, sensor nodes can be used to detect, locate or track enemy movements. In case of natural disasters, sensor nodes can sense and detect the environment to forecast disasters in advance. In health care, sensor nodes can help in monitoring a patient’s health. In security, sensors can offer vigilant surveillance and increase alertness to potential terrorist attacks.

Cognitive Radio (CR) has emerged as a promising technology to improve the spectrum utilization by enabling opportunistic access to the licensed spectrum bands [2]. This technology can also be applied to WSNs, which leads to Cognitive Radio Sensor Networks (CRSNs). Sensor nodes in CRSNs can sense the availability of licensed channels and adjust the operation parameters to access the idle ones, when the condition of the licensed-free channel degrades. However, since the energy consumption for supporting the CR functionalities, e.g., channel sensing and switching, is considerable for battery-powered sensor nodes, the opportunistic channel access should be carefully studied to improve the energy efficiency in CRSNs.

Cognitive radio technology has emerged in a concept of dynamic spectrum access (DSA), where users can intelligently and efficiently share the spectrum resources [4]. Compared to traditional static spectrum allocation schemes, DSA has been corroborated as an effective approach to mitigating the problem of scarce spectrum resources. The essence of DSA technology lies in the fact that devices with cognitive capability, called secondary users (SUs), can dynamically scan and utilize the licensed spectrum resources not occupied by the licensed users, usually called primary users (PUs). In addition to the spectrum constraint, the energy constraint has recently drawn a great deal of attention from both industry and academia.

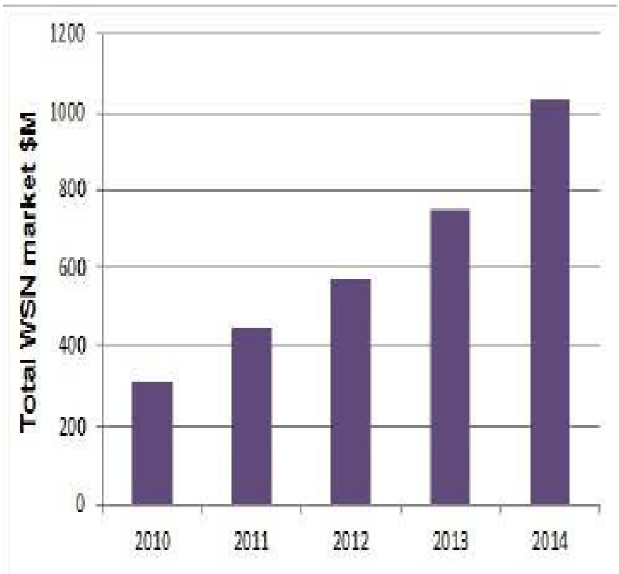

Figure 1: WSN market 2010-2014 [3].

Cognitive radio (CR) features, such as the opportunistic spectrum (white space) usage, the introduction of secondary users in licensed bands, and the ability to learn the environment through sensing, present themselves as a mean to overcome spectrum shortage. Enabling such CR characteristics over "traditional" WSNs allows them to change their transmission parameters according to the radio environment and possibly enhance the reliability of WSNs in areas densely populated by wireless devices. These cognitive radio-imbued WSNs (CWSNs) can have access to new spectrum bands with better propagation characteristics. By adaptively changing system parameters like the modulation schemes, transmit power, carrier frequency, channel coding schemes, and constellation size, a wider variety of data rates can be achieved, especially when CWSNs operate on software-defined radios. This can improve device energy efficiency, network lifetime, and communication reliability [5].

A key function of CR consists in the capability of acquiring the knowledge of the instantaneous spectrum status. Such capability can be accomplished by using geo-location techniques, by receiving control and management information or by performing spectrum sensing. Geo-location methods require a central database, self-locating capability and frequently updates of the database by license holders. Likewise, control and management information techniques require both infrastructure elements and a database. On the other hand, spectrum sensing is considered the most promising solution for spectrum awareness [10].

The rest of this paper is organized as follows in the first section we describe an introduction of about the Cognitive Radio Sensor Networks. In section II we discuss about the Network model. In section III we discuss about the rich literature for the Spectrum sensing in Cognitive Radio Sensor Networks. In section IV we discuss about the problem statement as we getting from the rich literature survey, finally in section V we conclude the about our paper which is based on the literature survey and specify the future scope.

II NETWORK MODEL

Consider a CRSN application in a crowded area, where S cognitive sensor nodes are deployed to periodically transmit the sensed data, e.g., temperature or traffic information, to a sink node (or access point). The network operation can be divided into a sequence of time periods. There are also a number of overlapping wireless systems in this area, such as, WiFi and ad hoc networks, causing significant and uncontrollable interference over the unlicensed channel. To guarantee the performance of data transmission, the sink node coordinates sensor nodes to perform spectrum sensing over licensed channels and opportunistically access the idle ones for data transmission, when the unlicensed channel is suffering from significant interference. Since we aim to study the performance of spectrum sensing, we only focus on the time periods wherein spectrum sensing is required for licensed channel access. There are a number of orthogonal licensed channels owned by PUs in the primary network coexisting with the CRSN. At the beginning of each time period, a number of sensor nodes are randomly selected to sense the licensed channels and report their local binary decisions to the sink. Then, the sink makes global decisions based on the local reports and schedule sensor nodes to access the idle channels for data transmission.

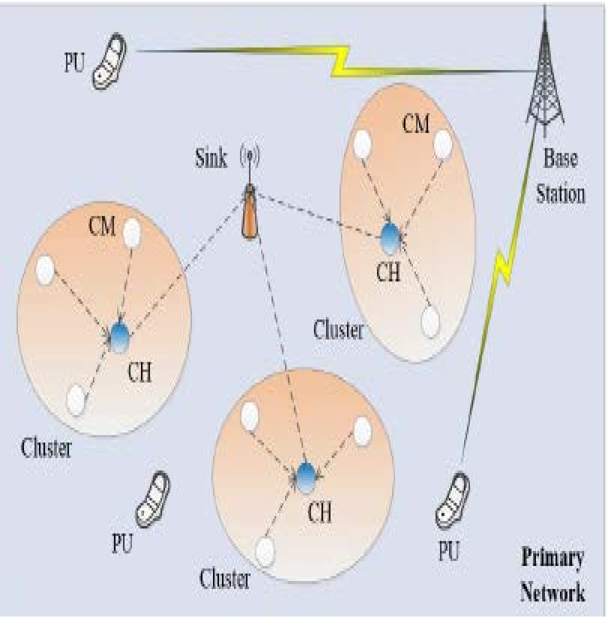

Figure 2: The architecture of CRSN.

III RELATED WORK

In this section we discuss about the rich literature survey for the Cognitive Radio Sensor Networks the field of wireless sensor networks**.**

[1] They propose a secure and energy-efficient collaborative spectrum sensing scheme to resist SSDF attacks and enhance the energy efficiency in CRSNs. Specifically, we theoretically analyze the impacts of two types of attacks, i.e., independent and collaborative SSDF attacks, on the accuracy of collaborative spectrum sensing in a probabilistic way. To maximize the energy efficiency of spectrum sensing, we calculate the minimum number of sensor nodes needed for spectrum sensing to guarantee the desired accuracy of sensing results.

[2] They investigate the dynamic channel accessing problem to improve the energy efficiency for a clustered CRSN. Under the primary users' protection requirement, we study the resource allocation issues to maximize the energy efficiency of utilizing a licensed channel for intra-cluster and inter-cluster data transmission, respectively. Moreover, with the consideration of the energy consumption in channel sensing and switching, they further determine the condition when sensor nodes should sense and switch to a licensed channel for improving the energy efficiency, according to the packet loss rate of the license-free channel.

[3] In this survey, they give an overview of wireless sensor networks and their application domains including the challenges that should be addressed in order to push the technology further. Then they review the recent technologies and testbeds for WSNs. Finally, they identify several open research issues that need to be investigated in future. Our survey is different from existing surveys in that we focus on recent developments in wireless sensor network technologies.

[4] In this article, they overview energy efficient non-cooperative cognitive radio networks from the micro, meso, and macro perspectives, where the micro view means how to design energy-efficient spectrum sensing algorithms for each individual secondary user, the meso view means how to coordinate non-cooperative secondary users to share spectrum efficiently, and the macro view means how to deploy cognitive radio networks in an energy-efficient approach. As for the macro-scale deployment issue of secondary networks,

[5] In this context, the WSNs will be playing a significant role in the everyday life of people, and thus their security is of great importance. This explosion in the number of wireless sensing and actuating devices in city areas together with the continuous installation of many (public and private) wireless access networks in these areas has resulted in congestion in the unlicensed spectrum bands (ISM bands around 2.4GHz) that are used for both WSNs And Wi-Fi.

[6] In this paper, an efficient spectrum sensing system is developed where each cognitive radio (CR) user senses the spectrum multiple times within an allocated sensing period. Each CR user quantizes its decision to predefined levels so as to

achieve a tradeoff between bandwidth utilization and decision reporting accuracy. The reports for all the CR users are compared at the fusion center using Smith–Waterman algorithm, an optimal algorithm for aligning biological sequences used in bioinformatics, and similarity indices are computed.

[7] In this paper, they first propose an asynchronous cooperative sensing scheme in which each SVU provides an energy information (EI) that is tagged with location and time information. The sensing decision will be made on account of the EI. Considering the temporal and spatial diversities of each SVU, we assign different weights to each EI and formulate the probabilities of detection and false alarm as the optimization problems to find the optimal weight of each EI. Then, based on the asynchronous sensing, the specifications of the opportunistic spectrum access mechanism are elaborated in both centralized and decentralized CVNs for the sake of practical implementation.

[8] In this article, they present a brief overview of energy management and challenges in smart cities. They then provide a unifying framework for energy-efficient optimization and scheduling of IoT-based smart cities. We also discuss the energy harvesting in smart cities, which is a promising solution for extending the lifetime of low-power devices and its related challenges. They detail two case studies. The first one targets energy-efficient scheduling in smart homes, and the second covers wireless power transfer for IoT devices in smart cities.

[9] The objective of this paper is to present an overview of how intelligent device-to-device (D2D) communication can be achieved in the IoT. In particular, we focus on an analysis of state-of-the-art routing algorithms that will enable intelligent D2D communications and identify major challenges of intelligent D2D communication in the IoT. D2D communication is an integral part of the IoT environment to design, deploy, and maintain a sustainable IoT ecosystem.

[10] In this article, they provide an overview of state-of-the-art research that addresses this problem. Furthermore, they suggest important design guidelines of an energy efficient framework for cooperative spectrum sensing. Cognitive radio has been proposed as a promising technology to resolve the spectrum scarcity problem by dynamically exploiting underutilized spectrum bands. Cognitive radio technology allows unlicensed users to exploit the spectrum vacancies at any time with no or limited extra interference at the licensed users.

[11] This article proposes a hierarchical cloud computing architecture to enhance performance by adding a mobile dynamic cloud formed by powerful mobile devices to a traditional general static cloud. A mobile dynamic cloud is based on heterogeneous wireless architecture where device-to-device communication is used for data transmission between user devices. The main advantage of the proposed architecture is an increase in overall capacity of a mobile network through improved channel utilization and traffic offloading from Long Term Evolution-Advanced to device-to-device communication links.

IV PROBLEM STATEMENT

Existing works provide a comprehensive and in-depth investigation on optimizing the quality-of-service (QoS) performances for CRSNs, such as reducing the transmission delay or increasing the network capacity. However, few of them have paid attention to improving the energy efficiency for CRSNs, with a delicate consideration of the energy consumption in channel sensing and switching. In order to enhance energy efficiency, the key issue is to determine when the energy consumption of transmitting a fixed amount of data can be reduced by sensing and accessing a licensed channel, compared with the energy consumption when only using the default license-free channel. It is very challenging since the decision depends on different factors, including the packet loss rate of the license-free channel, the probabilities for accessing licensed channels, as well as the protection for primary users (PUs). Moreover, due to the dynamic availability of licensed channels, when sensor nodes decide to sense and access a licensed channel, another challenge lies in identifying the best licensed channel to sense and access to optimize the energy efficiency for data transmission.

V CONCLUSIONS AND FUTURE WORK

WSNs have attracted a lot of attention in industrial automation, defense applications, utility metering and home automation, just to name a few. A WSN has event-driven communication patterns and generally yields a 'bursty' type of traffic when deployed in a multi-hop topology i.e. where information is relayed through multiple intermediate nodes. In this paper, we presented the survey on CRSN for cellular networks, WLANs, WSNs.

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