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# A Survey on Spectrum Sensing and Quality of Services in Wireless Sensor Network

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**ABSTRACT**
Cognitive networks offer the promise of significantly improving both spectrum efficiency and utilization. In the last few years, significant research progresses has been made in supporting the key functions needed in a cognitive network and in the development of cognitive radios but many challenges remain. This report identifies several critical research areas including cognitive networking as a system, the interactions between technology and policy, and cognitive networking. Meeting this huge demand for bandwidth is a challenge since most easily usable spectrum bands have been allocated. Many studies have however shown that more than 90% of the allocated spectrum is unused or underutilized.

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

## 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].

The definitions of Cognitive Radio (CR) are still being developed by industry and academia. At one extreme, a CR is assumed to be a fully re-configurable radio device that can "cognitively" adapt itself to the users' needs and the local environment. For example, mobile handset may automatically change from being a cellular radio to a PMR radio, or it may automatically power down when in a sensitive (hospital, cinema, airport) environment.

Cognitive Radio Network (CRN) is a network comprising of CR devices that are equipped with cognitive capability and re-configurability, and can change their transmitter parameters based on interactions with the environment in which they operate . In a CRN, there are two types of users: primary and secondary. Primary users (PUs) are the licensed/legitimate/ authorized users, which have the license to operate in a prescribed spectrum band accessing the primary base station. Secondary users (SUs), which are also referred to as "CR users," or as "CRs" for brevity, are unlicensed users without a spectrum license. These CR users need additional functionalities to share the licensed spectrum band. SUs look for opportunistic access to both licensed and unlicensed spectrum and are allowed to operate only if no interference is caused for licensed PUs.

There are four major functions for cognitive radios: 1) Spectrum sensing, i.e., detecting unused spectrum a.k.a spectrum holes or white spaces and the presence of the PUs; 2) Spectrum management which is the selection of the best available channels in terms of the received signal strength, interference, energy efficiency, transmission power, number of users, QoS, and security requirements; 3) Spectrum mobility maintains seamless communication and vacates the channel when a licensed PU is detected through a spectrum handoff, i.e., changing the physical regions traversed by the existing path or switching to a new unused spectrum band; 4) Spectrum sharing coordinates access by several CRs and focuses on power allocation [15].

Energy aware routing is a variant of directed diffusion and is intended to increase the lifetime of the network. It differs from directed diffusion in that it maintains a set of sub-optimal paths instead of maintaining or enforcing one optimal path at a higher rate. These paths are maintained and chosen by a certain probability. The value of this probability is determined by how low an energy consumption each path can achieve. Always using the minimum energy path all the time will deplete the energy of the nodes on that path. Hence, by having multiple paths that are chosen at different times, the energy of any single path will not be depleted quickly.

A cognitive radio is a radio frequency transmitter/receiver that is designed to intelligently detect whether a particular segment of the radio spectrum is currently in use, and to jump into the temporarily-unused spectrum very rapidly, without interfering with the transmissions of other authorized users. Main functions of cognitive radio are: Spectrum sensing, spectrum management, spectrum mobility and spectrum sharing. Spectrum sensing detects the unused spectrum and shares it without harmful interference with other licensed users. Spectrum Management is the task of selecting the best available spectrum to get user communication requirements. Spectrum Mobility is defined as the process when a cognitive radio user exchanges its frequency of operation. Spectrum Sharing decides which secondary user can use the spectrum hole at some particular time. One of the major challenges in open spectrum usage is the spectrum sharing, which is also known as Dynamic Spectrum Sharing problem.

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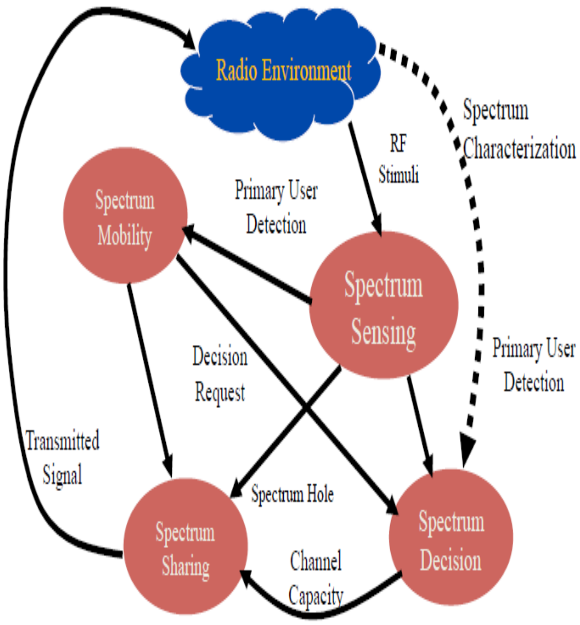


**Figure 1:** Cognitive radio cycle.

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 wired and wireless Network model. In section III we discuss about the functions of Cognitive Radio Sensor Networks. In section IV we discuss about 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 WIRED V/S WIRELESS NETWORKS

The network that uses wires is known as a wired network. Initially the networks were mostly wired networks. When there is a use of wire in a network, definitely it also requires network adapters, routers, hubs, switches if there are more than two computers in a network. The installation of a wired network has been a big issue because the Ethernet cable should be connected to each and every computer that makes a network. Definitely this kind of connection takes time, in fact more time than expected, because when we connect wires with computers we have to take care of lot of things like wire should not come under the feet, it should be under ground or it should be under the carpet if computers are in more than one room. However in new homes nowadays, the wiring is being done in such a way that it will look like as it is a wireless connection, greatly simplifying the process of cables. Similarly the wiring of a wired network depends on lot of things like what kind of devices are being used in a wired network, whether the network is using external modem or is it internal, the type of internet connection and many other issues. As we know making a wired network is not an easy task, but still there are many other tasks that are more difficult than making a wired network, but we are not going to discuss these tasks here. In configuring the wired network, the hardware implementation is a main task. Once the hardware implementation is finished in a wired network, the remaining steps in a wired network do not differ so much from the steps in a wireless network [6].

There are some advantages of wired network that include cost, reliability and performance. While making a wired network, Ethernet cable is the most reliable one because the makers of Ethernet cable continuously improving its technology and always produces a new Ethernet cable by removing the drawbacks of previous one. That is why Ethernet cable is the most preferable in making a wired network, as its reliability is kept on growing from the past few years. In terms of performance, wired networks can provide good results. In the category of Ethernet, there is Fast Ethernet too, that provides enormous performance if a wired network is built in home for some features like data sharing, playing games and for the sake of high speed internet access.

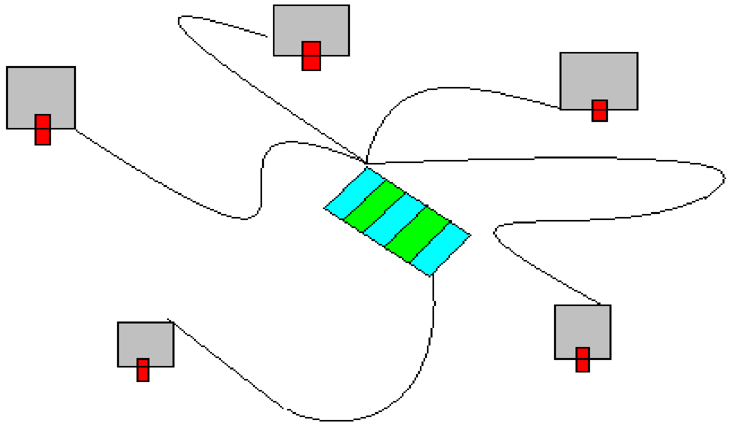

**Figure 2:** Wired Network.

The nodes of wired network does require power, as they get that power from the alternating current (AC) source that is present in that particular network.

On the other hand, wireless network is such kind of network that does not use wires to build a network. It uses radio waves to send data from one node to other node. Wireless networks lie under the category of telecommunications field. It is also known as wireless local area network (WLAN). It uses the Wi-Fi as a standard of communication among different nodes or computers. There are three types of Wi-Fi communication standard.

- 802.11b
- 802.11a
- 802.11g

Wireless LAN costs more than the wired network as it requires wireless adapters, access points that makes it three or four times expensive than Ethernet cables, hubs/switches for wired network. Wireless network faces reliability problem also as compared to wired networks, because while installing the wireless network it may encounter the interference that can come from the household products like microwave ovens, cordless phone etc. Wi-Fi communication standard's performance is inversely proportional to the distance between the computers and the access points. Larger the distance between the computers and access point, smaller will be Wi-Fi performance and hence smaller will be performance of wireless network.

Similarly, security wise it is less secure than the wired network because in wireless communication data is sent through the air and hence there are more chances that data can be intercepted [7].

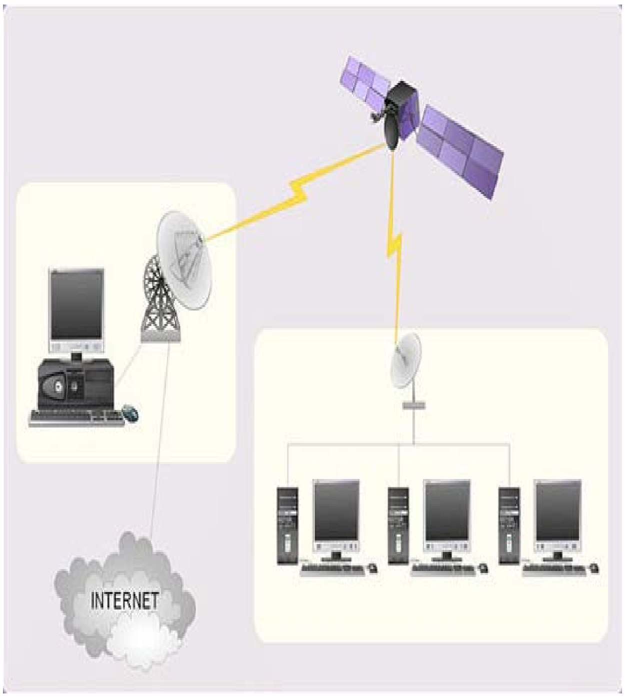


**Figure 3:** Wireless Network.

**III FUNCTIONS OF COGNITIVE RADIO**

The main goal of cognitive radio is to provide adaptability to wireless transmission through dynamic spectrum access so that the performance of wireless transmission can be optimized, as well as enhancing the utilization of the frequency spectrum. The major functionalities of a cognitive radio system include spectrum sensing, spectrum management, and spectrum mobility. Through spectrum sensing, the information of the target radio spectrum (e.g. the type and current activity of the licensed user) has to be obtained so that it can be utilized by the cognitive radio user. The spectrum sensing information is exploited by the spectrum management function to analyze the spectrum opportunities and make decisions on spectrum access. If the status of the target spectrum changes, the spectrum mobility function will control the change of operational frequency bands for the cognitive radio users.

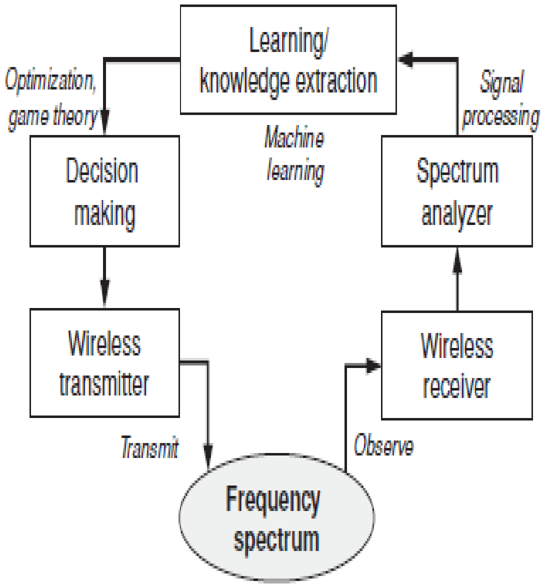


**Figure 4:** Components in a cognitive radio node [9].

**IV 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] 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.

[3] 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.

[4] 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.

[5] In this paper they provide a comprehensive survey on the smart grid-driven approaches in energy-efficient communications and data centers, and the interaction between smart grid and information and communication infrastructures. Although the studies on smart grid, energy-efficient communications, and green data centers have been separately surveyed in previous studies, to this end, research that falls in the intersection of those fields has not been properly classified and surveyed yet. They start our survey by providing background information on the smart grid and continue with surveying smart grid-driven approaches in energy-efficient communication systems, followed by energy, cost and emission minimizing approaches in data centers, and the corresponding cloud network infrastructure.

[6] In this paper they presented the survey on CB schemes for cellular networks, WLANs, WSNs and CRNs. The classification of CB schemes has been performed depending upon the type of network and for each network, discussion on CB has been made with respect to performance metrics. From the literature review, they noticed that considerable work has been done on channel bonding schemes for cellular networks, WLANs, WSNs and CRNs.

[7] We propose a multi-objective optimization framework for the design of a Pareto optimal resource allocation algorithm based on the weighted Tchebycheff approach. In particular, the algorithm design incorporates three important system design objectives: total transmit power minimization, energy harvesting efficiency maximization, and interference power leakage-to transmit power ratio minimization. The proposed framework takes into account a quality of service (QoS) requirement regarding communication secrecy in the secondary system and the imperfection of the channel state information (CSI) of potential eavesdroppers (idle secondary receivers and primary receivers) at the secondary transmitter. The proposed framework includes total harvested power maximization and interference power leakage minimization as special cases. The adopted multi objective optimization problem is non-convex and is recast as a convex optimization problem via semi definite programming (SDP) relaxation.

[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] 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.

[10] 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 test beds 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.

[11] 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.

[12] 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.

[13] 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.

[14] 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.

[15] They provide in this paper a comprehensive survey on the CRN communication paradigm in SGs, including the system architecture, communication network compositions, applications, and CR-based communication technologies. They highlight potential applications of CR-based SG systems.
They survey CR-based spectrum sensing approaches with their major classifications. They also provide a survey on CR-based routing and MAC protocols, and describe interference mitigation schemes. They furthermore present open issues and research
challenges faced by CR-based SG networks along with future directions.

**V CONCLUSIONS**

Most of today's radio systems are not aware of their radio spectrum environment: they are designed to operate in a specific frequency band using a specific spectrum access system. Furthermore, investigations of spectrum utilisation indicate that not all the spectrum is in use all of the time. CR-WSNs differ from conventional WSNs in many aspects. Because protecting the right of PUs is the main concern in CR-WSN, it has many new challenges including the challenges in the conventional WSNs. This section discusses the challenges affecting the design of a CR-WSN. The detection probability is a metric used for correct detection by CRWS regarding the absence of PUs on the channel.

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