



Cognitive Radio In Wireless Sensor Network

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Abstract- *Cognitive radio is an emerging wireless communications concept in which a network or a wireless node is able to sense its environment, and especially spectrum holes, and change its transmission and reception chains to communicate in an opportunistic manner, without interfering with licensed users. Cognitive radio thus aims to improve the way the scarce radio spectrum is utilized. Indeed today's approach is based on dividing the spectrum into small pieces, each for a specific purpose. Since the applications use their spectrum to a limited extent, this leads to the unwanted situation of under-utilization of this scarce radio resource. While radio communications grow constantly, regulation authorities recognize that the current approach is reaching its limits and are planning to open some bands for cognitive use. Consequently, cognitive radio and dynamic spectrum allocation are becoming key technologies and key research activities in the field of wireless communications. In this survey intrinsic properties and current research challenges of spectrum management in CR networks are presented.*

Keywords— *Cognitive Radio, WSN, CWSN*

I. INTRODUCTION

Cognitive networking speaks for an intelligent communication system, consisting of both the wire-line and/or the wireless connections, that is aware of its transmission environment, both internal and external, and acts adaptively and autonomously to attain its intended goal(s) [1]. A unit of Cognitive networking system i.e., Cognitive waveform design, time diversity, and spatial diversity options. It can even make changes at higher layers, for example, by modifying the medium access protocols or changing its routing behavior based on the network topology [2]. This implies that all the network nodes and the end devices with cognitive capabilities are self-aware and context-aware all of the time. The interest in cognitive networking is mainly driven from the need to manage the increasing complexity and the efficient utilization of available resources to deliver applications and services as economically as possible. A wireless sensor network (WSN) is one of the areas where there is very high demand for cognitive networking.

Wireless Sensor Network is a collection of sensor nodes working in a co-operative manner. Each node has certain processing capability, RF transceiver, power source apart from sensing and actuating units [3]. There are several constraints among which the constraint of resources (spectrum and power) is the most appealing one in a WSN. Although in WSN the nodes are constraint in resources mainly in terms of battery power but these days there is scarcity increasing in terms of spectrum availability also.

These features are exploited in association with cognitive radio for improving utilization of radio spectrum [4].

A "Cognitive Radio" is a radio that can change its transmitter parameters based on interaction with the environment in which it operates [5]. The cognitive radio transceiver consists of the radio front-end and the baseband processing unit. The RF technology observes the spectrum and indicates the spectrum holes. In cognitive radio there is a co-existence of licensed and unlicensed wireless users in a common area. There are special measures taken so that the usage of licensed user is not interrupted. To improve spectrum utilization by facilitating spectrum sensing in the concept of "cognitive radio based wireless sensor" has been introduced. In a cognitive system the sensing of the spectrum is also done by the sensor networks and forwarded to the base stations. Further the collected information is processed and sent to another network where further spectrum utilization takes place. The entire process is carried out without interfering with the licensed users [4].

There are two important terms in this regard, Cognitive Radio based WSN and Cognitive WSN, which appear similar but are quite different from each other. A Cognitive Radio WSN is a WSN with each node having cognitive radio capability and nothing more than that. This means it will have cognitive capabilities in the physical layers only. But this will not fulfil our purpose as the WSN demands cognitive radio capabilities with networking among them which can take benefit from this cognition. Because contemporary protocols for layers above the physical layer are written for a fixed channel/bandwidth/QoS assignment schemes. Changing the physical layer parameter frequently will also affect the upper layer function. Hence for a scenario where the channel frequency as well as the allotted bandwidth will be changing too frequently a more flexible protocol will be required. Hence the concept for Cognitive WSN which involves cognition not only in the physical layer but will be a cross layered approach [1].

The increasing demand for spectrum in wireless communication has made efficient spectrum utilization a big challenge [6]. To address important requirement, cognitive radio(CR) has emerged as the key technology. A CR is an intelligent wireless communication system that is aware of its surrounding environment and adapts its internal parameters

to achieve reliable and efficient communication and optimum utilization of the resources [7]. With the advent of CR technology, we have a different perspective of the traditional WSNs. In the current cognitive wireless sensor networks (CWSNs), the nodes change their transmission and reception parameters according to the radio environment. Cognitive capabilities are based on four activities: (i) monitoring of spectrum sensing, (ii) analysis and characterization of the environment, (iii) optimization of the best communication strategy based on different constraints such as reliability, power, security and privacy issues etc., and (iv) adaptation and collaboration strategy. The cognitive technology will not only enable access to new spectrum but it will also provide better propagation characteristics leading to reduction in power consumption, network life-time and reliability in a WSN. With cognitive capabilities, WSNs will be capable of finding a free channel in the unlicensed band to transmit or could find a free channel in the licensed band for communication. A CWSN, therefore, will be able to provide access not only to new spectrum bands in addition to the available 2.4 GHz band, but also to the spectrum band that has better propagation characteristics. If a channel in a lower frequency band is accessed, it will certainly allow communications with higher transmission range in a CWSN, and hence fewer sensor nodes will be required to provide coverage in a specific area with a higher network life-time due to lower energy consumption in the nodes. CWNs will also provide better propagation characteristics by adaptively changing system parameters like modulation schemes, transmit power, carrier frequency and constellation size. The result will be a more reliable communication with reduced power consumption, increased network life-time and higher reliability and enhanced quality of service(QoS) guarantee to applications [6].

Although there are several advantages and benefits that can be achieved by deploying CWSNs [8], guaranteeing security poses a significant challenge. Unless these challenges are solved to an effective level, deployment of CWSNs in real-world applications may face a serious impediment. As observed in [9], the CR nature of a system introduces an entirely new gamut of threats and vulnerabilities that cannot be easily mitigated.

The three salient characteristics of CR are its environmental awareness, learning and acting capabilities. Considering these characteristics from an attacker's perspective, a CWSN will provide much more capability to an attacker to launch attacks that are long-lasting and catastrophic in nature and those which can be triggered by simple spectral manipulations[10].

A. Two main characteristics of cognitive radio can be defined [12]

1) Cognitive capability

Through real-time interaction with the radio environment, the portions of the spectrum that are unused at a specific time or location can be identified. CR enables the usage of temporally unused spectrum, referred to as spectrum hole or white space. Consequently, the best spectrum can be selected, shared with other users, and exploited without interference with the licensed user [11].

2) Reconfigurability

A CR can be programmed to transmit and receive on a variety of frequencies, and use different access technologies supported by its hardware design [13]. Through this capability, the best spectrum band and the most appropriate operating parameters can be selected and reconfigured [11].

II. CRSN ARCHITECTURE

Cognitive radio sensor nodes form a wireless communication architecture of CRSN as shown Figure:1 over which the information obtained from the field is conveyed to the sink in multiple hops. The main duty of the sensor nodes is to perform sensing on the environment. In addition to this conventional sensing duty, CRSN nodes also perform sensing on the spectrum. Depending on the spectrum availability, sensor nodes transmit their readings in an opportunistic manner to their next hop cognitive radio sensor nodes, and ultimately, to the sink. The sink may be also equipped with cognitive radio capability, i.e., cognitive radio sink [14].

In addition to the event readings, sensors may exchange additional information with the sink including control data for group formation, spectrum allocation, spectrum handoff-aware route determination depending on the specific topology. A typical sensor field contains resource-constrained CRSN nodes and CRSN sink. However, in certain application scenarios, special nodes with high power sources, i.e., actors, which act upon the sensed event, may be part of the architecture as well [15].

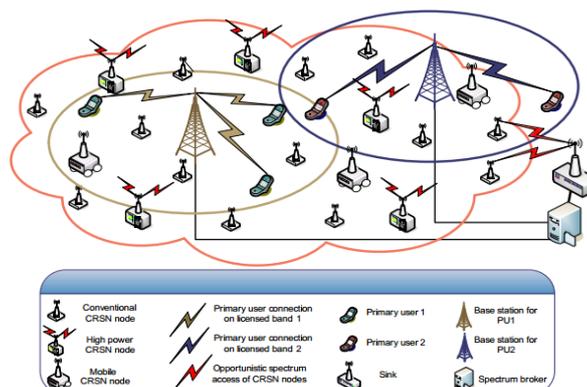


Figure 1: A typical cognitive radio sensor network (CRSN) architecture.[14]

These nodes perform additional tasks like local spectrum bargaining, or acting as a spectrum broker. Therefore, they may be actively part of the network topology. It is assumed that the sink has unlimited power and a number of cognitive transceivers, enabling it to transmit and receive multiple data flows concurrently.

A. CRSN Node Structure

CRSN node hardware structure is mainly composed of sensing unit, processor unit, memory unit, power unit, and cognitive radio transceiver unit as abstracted in Figure 2. In specific applications, CRSN nodes may have mobilization and localization units as well. The main difference between the hardware structure of classical sensor nodes [14] and CRSN nodes is the cognitive radio transceiver of CRSN nodes. As discussed in Section V-A, cognitive radio unit enables the sensor nodes to dynamically adapt their communication parameters such as carrier frequency, transmission power, and modulation.

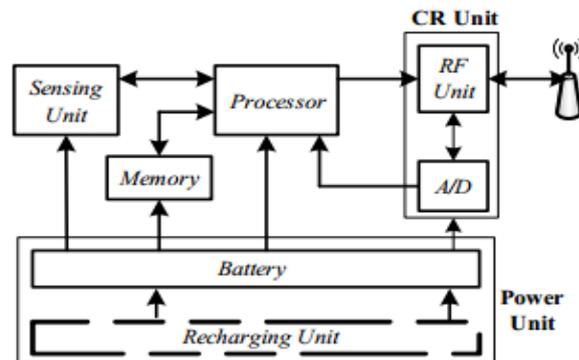


Figure 2: Hardware structure of a cognitive radio sensor node[14]

CRSN nodes also inherit the limitations of conventional sensor nodes in terms of power, communication, processing and memory resources. These limitations impose restrictions on the features of cognitive radio as well. CRSN nodes may perform spectrum sensing over a limited band of the spectrum due to processing, power, and antenna size constraints. Consequently, CRSN nodes are generally constrained in terms of the degree of freedom provided by the cognitive radio capability as well.

III. CONCLUSIONS

Cognitive radio systems offer the opportunity to improve spectrum utilization by detecting unoccupied spectrum bands and adapting the transmission or reception to those bands while avoiding the interference to high priority users. CR is aware of its surrounding environment, tracks changes and reacts upon what it found. Based on that, nodes in cognitive wireless sensor network (CWSN) change their transmission parameters according to the radio environment, to communicate efficiently, and coexist well with others. This is the main difference between WSN and new CWSN. We hope that this paper will provide better understanding of the security challenges for CWSN.

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