Chapter 118
Radio Resource Management in Cognitive Radio Sensor Networks

Ayaz Ahmad
COMSATS Institute of Information Technology, Pakistan

Sadiq Ahmad
COMSATS Institute of Information Technology, Pakistan

ABSTRACT

Wireless Sensor Networks (WSNs) use the unlicensed Industrial, Scientific, and Medical (ISM) band for transmissions. However, with the increasing usage of these networks for diverse applications, the currently available ISM band does not suffice for their transmissions and a new challenge appears before the WSNs' research community. One of the candidate approaches to tackle this spectrum insufficiency problem is to incorporate the opportunistic spectrum access capability of Cognitive Radio (CR) into the existing WSN, thus giving birth to Cognitive Radio Sensor Network (CRSN). Efficient spectrum utilization is another approach to overcome this challenging problem. Another challenge associated to WSN operation is the dependability of sensor nodes on battery supplied power where the batteries in general are not replaceable. Therefore, advanced and intelligent radio resource management schemes are very essential to perform dynamic and efficient spectrum allocation among multiple sensor nodes and to optimize the power consumption of each individual node in the network. Radio resource management enables the sensor nodes to efficiently utilize the available spectrum and power, which in turn ensures QoS transmissions, maximizes the network lifetime, and reduces the inter-node and inter-network interferences. In this chapter, the authors present a comprehensive overview of the recent advances in radio resource management for CRSN. Radio resource management in CRSN has been reviewed in various scenarios (i.e., centralized, cluster-based, and distributed). The related issues and challenges are discussed, and future research directions are highlighted.

DOI: 10.4018/978-1-5225-0196-1.ch118

INTRODUCTION

Wireless spectrum is a scarce communication resource that necessitates the design of spectrum efficient wireless technologies. One of these technologies is Cognitive Radio (CR) technology that has recently attracted worldwide attention due to its capability to detect and exploit the underutilized spectrum opportunistically (Zhao & Sadler,, 2007; Haykin, 2005). The existing wireless networks may benefit from the potential advantages of dynamic spectrum access capability of cognitive radio by integrating cognitive radio technology into the existing infrastructure of these networks.

Wireless Sensor Networks (WSNs) can also utilize cognitive radio technology for dynamic spectrum access. A wireless sensor network consists of a large number of power-constrained sensor nodes deployed in an area for monitoring and reporting a specific physical phenomenon (Akyildiz, Sankarasubramaniam & Cayirci, 2002). Operating in the unlicensed Industrial, Scientific, and Medical (ISM) band, these sensor nodes are application specific which monitors the physical phenomena, and accumulates and reports useful data to the sink nodes. It may occur that due to large number of sensor nodes in an area (e.g., areas of healthcare and telemedicine); the available ISM band does not suffice to support all the transmissions. This may result in loss of useful data from some sensor nodes. Dynamic spectrum access may address the aforementioned spectrum insufficiency issue if sensor nodes are equipped with cognitive radio technology. Utilizing cognitive radio technology, sensor nodes may dynamically and opportunistically access, and utilize the idle licensed radio spectrum for their transmissions (Akan, Karli, & Ergul, 2009). This emerging technology that incorporates the opportunistic spectrum access capability of cognitive radio into the existing WSN is named Cognitive Radio Sensor Network (CRSN).

Similar to other wireless networks, radio resource management in CRSN is also essential. Radio resource management is necessary for fair and efficient utilization of spectrum among multiple sensor nodes and energy-efficient transmissions. Energy-efficient transmissions not only results in extended battery life but also ensures a tolerable level of interference to licensed nodes/users. The principal objectives of radio resource management in the context of CRSN can be summarized as follows:

1. Minimal energy utilization.
2. Faire spectrum allocation among multiple sensor nodes.
3. Utilization of spectrum efficiently.
4. Accounting for the priority among sensor nodes and data.
5. Meeting Quality-of-Service (QoS) requirements.
6. Avoiding interference to licensed/primary nodes.
7. Reduction of spectrum hand-offs.

In this chapter, a review of radio resource management in CRSN in various scenarios has been presented. A separate section is dedicated to each of these scenarios. Through out this chapter, the terms "radio resource management," radio resource allocation, and "resource allocation" are used interchangeably.

MOTIVATION AND BACKGROUND

In this section, we provide in detail introduction and background of the topics covered in order to highlight the importance of this chapter.