Doubly Cognitive Architecture Based Cognitive Wireless Sensor Networks

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ABSTRACT

Scarcity of spectrum is increasing not only in cellular communication but also in wireless sensor networks. Adding cognition to the existing wireless sensor network (WSN) infrastructure has helped. As sensor nodes in WSN are limited with constraints like power, efforts are required to increase the lifetime and other performance measures of the network. In this article, the authors propose Doubly Cognitive WSN, which works by progressively allocating the sensing resources only to the most promising areas of the spectrum and is based on pattern analysis and learning. As the load of sensing resource is reduced significantly, this approach saves the energy of the nodes and reduces the sensing time dramatically. The proposed method can be enhanced by periodic pattern analysis to review the strategy of sensing. Finally the ongoing research work and contribution on cognitive wireless sensor networks in Communication Research Centre (IIIT-H) is discussed.

Keywords: Cognitive Networks, Cognitive Wireless Sensor Network (WSN), Doubly Cognitive WSN, Pattern Recognition and Analysis, Spectrum Sensing

1. INTRODUCTION AND MOTIVATION

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). A unit of Cognitive networking system i.e., Cognitive radios dynamically selects spectrum, 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 (Fette, 2006; Mahmoud, 2007). 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 (Raghavendra, 2007; Sohraby, Minoli, & Znati, 2007). 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. Traditionally all the WSN works in ISM band (2.4 GHz), but in the same band we have many competing technologies working simultaneously like WLAN 802.11 a/b/g and ZigBee 802.15.4, Wi-Fi, Bluetooth. Hence in such an environment where all these competing technologies are working simultaneously, it becomes difficult to find免费 spectrum and transmit without an error. Also at the same time the licensed mobile communication bands are almost free for 85% of the time (Akyildiz, Lee, Vuran, & Mohanty, 2006; Cavalcanti, Das, Wang, & Challapali, 2008). Hence there are two motives: either to find a free channel in the unlicensed band and do wireless transmission or to find a free channel in the licensed band and do communication over that. Also it will be strictly required that whenever the licensed user comes back in the licensed band, the cognitive user backs-off from the channel and switch to another free channel without creating any difficulty to the primary user. Several other things are also important such as selecting the most suitable channel among the free channels and fair allocation of free channels among several competing nodes.

Adding cognition to the existing WSN infrastructure brings several benefits. A Cognitive Wireless Sensor Network (CWSN) enables current WSN to overcome the spectrum scarcity as well as node energy problem. A relatively better propagation characteristic is an added advantage. By adaptively changing the systems parameters like transmitted power, operating frequency, modulation, pulse shape, symbol rate, coding technique and constellation size a wide variety of data rates and QoS can be achieved which improves the power consumption and network life time in a WSN (Rondeau & Bostian, 2009).

There are two similar looking terms in the context of cognitive radio: cognitive radio 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 has cognitive capabilities in the physical layers only. But this does not fulfill our purpose as the WSN demands cognitive radio capabilities with cognitive networking among them which can take benefit from this cognition. Hence the concept for cognitive WSN which involves cognition not only in the physical layer but a cross layered approach. Intuitively this cross layered approach is more beneficial for the WSN.

2. DOUBLY COGNITIVE APPROACH FOR CWSN

During continuous research in the area of cognitive radio and wireless sensor networks we came up with an idea which is based on pattern recognition as well as multi-objective optimization for cognitive WSN. The basic idea of doubly cognitive WSN is explained in Figure 1. Underlying notion of our idea is to progressively allocate the spectrum sensing resources to only the most promising areas of the spectrum. This translates in a reduction of energy consumption in sensing resources and time needed to accurately identify spectrum holes, in contrast with the conventional approaches that allocate the sensing budget over the entire spectrum uniformly all the time. This conventional approach is very energy and time consuming in a cognitive WSN where there is very hard constraint for energy as well as sensing time. Doing sensing only in the most promising area can not only save the energy of
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