Chapter 18
Transport Layer for Cognitive Radio Sensor Networks

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ABSTRACT

The transport layer is responsible for reliable and energy-efficient delivery of packets from source to destination. Since Cognitive Radio Sensor Network (CRSN) is an emerging technology, there is a need to develop efficient transport layer protocols for it. Therefore, the main goal of this chapter is to provide design guidelines and highlight design issues and challenges of transport protocols for cognitive radio sensor networks. In this chapter, the authors provide a foundation for development of new transport protocols for cognitive radio sensor networks by presenting characteristics and major existing schemes of traditional transport protocols. Additionally, they provide design guidelines and challenges for the development of transport protocols for cognitive radio sensor networks including a guideline on simulation ground for transport protocols. In summary, this chapter is an initial step towards new directions of research and development of transport protocols for cognitive radio sensor networks.

1. INTRODUCTION

Wireless networks follow fixed spectrum assignment policy which is regulated by the government. The spectrum is assigned to licensed holders who pay for the spectrum according to their usage and needs. This fixed spectrum assignment policy worked well in the past. But now, as much of the spectrum has been assigned to licensed holders and also there is high emergence of new portable devices such as laptops, smart phones, tablets, PDAs etc. which operate on unlicensed spectrum. This rapid emergence of new devices resulted in a dramatic increase in the usage of spectrum due to which, there is scarcity in the spectrum. Also, licensed users do not use their spectrum all the time, they use the spectrum in sporadic manner and the spectrum usage is concentrated on some portions while considerable portion of the spectrum remains unutilized (Akyildiz et al., 2006). Also according to Federal Communication Commission (FCC, 2003), the range of temporal

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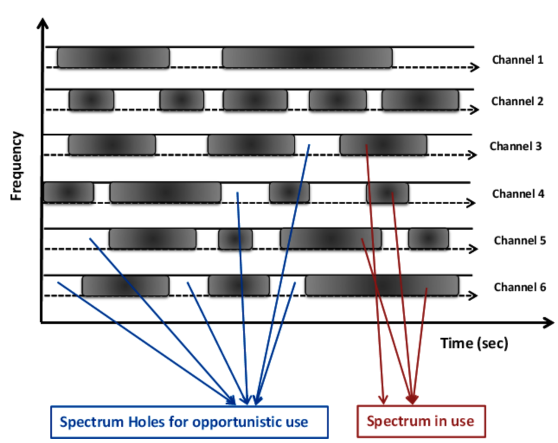
and geographic variations in assigned spectrum utilization is from 15% to 85%. Thus spectrum usage is also very inefficient and large portion of spectrum is wasting.

Therefore a new communication paradigm is required for solving the problem of spectrum scarcity and inefficient spectrum utilization so that existing spectrum can be utilized opportunistically (Akyildiz et al., 2009). In order to solve this problem, FCC (FCC, 2003) has approved the usage of unlicensed devices on licensed spectrum band subject to the condition that licensed user (Primary Radio user) will not be interfered. On the other hand, Dynamic Spectrum Access (DSA) techniques are proposed to solve the problems of spectrum scarcity and inefficient spectrum usage. The key enabling technology for dynamic spectrum access is Cognitive Radio (CR) (Haykin, 2005; Zhao & Sadler, 2007; Wyglinski et al., 2009) which utilizes spectrum holes opportunistically. Spectrum holes are temporally unused spectrum which is currently not utilizing by PR users. The concept of spectrum holes is also illustrated in Figure 1.

Cognitive Radio (CR) devices are intelligent devices which are capable of adapting their transmission parameters based on the interaction with environment in which they operate (Akyildiz et al., 2009). The concept of CR technology is introduced by J. Mitola (Mitola et al., 1999; Mitola 2000). It is based on Software Defined Networking (SDR) which was proposed in order to mitigate dependency of radio networks on hardware characteristics (e.g. channel coding, bandwidth, frequency bands etc.) (Ramachandran et al., 2006). SDRs increase the flexibility of radio devices to operate on different spectrum bands by adding programming feature to them. This capability allows the device to operate on any spectrum band instead of specific spectrum bands like current radio devices such as 3G, GSM, 802.11 etc. (Tragos et al., 2013). CR devices have capability to sense the spectrum and find vacant spectrum bands. CR then utilizes these vacant/available spectrum bands opportunistically and solves the problem of spectrum scarcity and inefficient spectrum utilization caused by fixed spectrum assignment policy. In licensed bands, primary radio (PR) users, to whom spectrum is allocated, have higher priority to use the spectrum. Therefore CR users must detect the presence of PR users while accessing the spectrum and only use the current spectrum if PR user is not utilizing it at the current time. It is also possible that PR user arrives on its spectrum while CR user is utilizing it. In this case, CR user has to vacate the spectrum so that PR user should not be interfered and has to select another available idle spectrum band.

Figure 1. The concept of spectrum holes



In CRNs, significant amount of work has been carried on spectrum utilization efficiency and spectrum sharing (Chowdhury et al., 2008; Chowdhury et al., 2009; Shi et al., 2010), channel assignment (Saleem et al., 2012; Ahmed et al., 2013a; Ahmed et al., 2013b), data dissemination (Rehmani et al., 2013), routing (Chowdhury et al., 2011; How et al., 2011; Chowdhury et al., 2009) and transport layer as well. In section 3, we discuss various transport protocols for CRNs in order to get insights for developing transport protocols for CRSNs. CRN is also used in wide range of applications. Some of them are emergency and public safety applications (Gorcin et al., 2008), consumer applications (Ball et al., 2005), medical applications (Phunchongharn et al., 2010), mili-

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