Chapter 9
QoS Support in the Cognitive Radio Networks

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ABSTRACT

Wireless Mesh Networks (WMNs) are communications networks made up of radio nodes organized in a mesh topology. As a direct evolution from WMNs, the Cognitive Radio Networks (CRN) are similar to the WMNs in many ways. Correspondingly, CRNs are also expected to support delay sensitive and/or high bandwidth real-time streaming multimedia applications like live video streaming, VoIP (Voice-over-IP), video conferencing, online gaming, and so on. However, Quality-of-Service (QoS) provisioning in CRNs is very challenging due to various issues. In this chapter, issues that take place on different network layers, chiefly the physical, MAC (Medium Access Control), and network layer are examined. This chapter also studies and reviews existing proposals to tackle the challenging issue of QoS provisioning in CRNs. Based on these reviews, gaps are identified in existing proposals and some possible solutions are suggested. In the second part of the chapter, the authors look into how greater QoS provisioning capabilities are provided by two proposed routing protocols for CRNs utilizing a variety of techniques. A conclusion is provided at the last part of the chapter together with possible future research directions.

INTRODUCTION

The objective of this chapter is to examine existing medium access schemes and routing protocols that were proposed to meet the QoS requirements of broadband applications in CRNs. The motivation comes from the belief that even though it may not be possible to eliminate interference totally, performance improvement can be achieved by minimizing the effects of interference through the use of appropriate MAC layer, network layer or cross-layer protocols. We examine the different
techniques that were utilized in existing schemes. These includes power control, rate control, multiple communication channels, cognitive radio and routing/cross-layer protocols that considers multiple network metrics like network topology, traffic level, noise level etc. By reviewing existing research literature, the chapter identifies inadequacy in terms of medium access control (MAC) and network layer solutions for QoS provisioning in CRNs. To address these gaps, the last part of the chapter look at two cognitive routing protocols that has the potential to tackle the challenging issue of QoS provisioning in CRNs through a cross-layer interaction across the three different networking layers, physical, MAC and network layer. These cognitive routing protocols are able to provide superior performance compared to existing protocols by considering a combination of different metrics like spectrum information, network topology, traffic pattern, interference and transmission properties like transmission power, modulation, rate etc.

BACKGROUND

The radio spectrum is a scarce and valuable resource. Due to the proliferation of diverse wireless communication systems, the unlicensed spectrum is becoming increasingly crowded.

Correspondingly, WMNs are also expected to have QoS support for delay sensitive and/or high bandwidth applications like live streaming multimedia, interactive video conferencing, online gaming, Internet TV and so on. In this chapter, QoS is defined as the ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow. The performance of a data flow can be measured in terms of delay, throughput and packet loss. However, QoS provisioning in WMNs is very challenging due to various issues. These include physical layer issues such as fading or attenuation of a transmitted signal over the wireless medium which results in a loss of signal power at the receiver. Other factors include the dynamical changing of topology, capacity limitations, link variability and multi-hop communications. On the network layer, many existing dynamic routing protocols select paths based on only one criteria (shortest hops, delay etc), which do not take into account topology, interference or traffic pattern. This causes the traffic to flow through nodes that experience high interference and thus increases the occurrences of dropped packets and retransmissions.

Despite on-going research efforts, one key limitation to the performance of the WMNs is the interfering nature of wireless transmissions which degrades the network capacity. This is made worse, especially for the case of devices operating in the unlicensed spectrum where it is becoming increasingly crowded due to the proliferation of diverse wireless communication systems. The popularity of mobile wireless devices has also contributed to the increased utilisation of the unlicensed wireless spectrum. It is very commonplace nowadays to see people accessing popular Internet Websites or applications on the move. Popular examples of these applications include YouTube, Skype and Maple Story and so on.

The overcrowding of the unlicensed spectrum aggravates the interference issues which further reduces the performances of wireless devices. The interference is further exacerbated in CRNs where traffic takes multiple hops to reach the destination.

On the other hand, surveys (FCC Spectrum Policy Task Force, FCC Report of the Spectrum Efficiency Working Group, 2002) have shown that vast portions of the licensed spectrum remain underutilized across frequency, space and time. This development has presented new opportunities for improving the performance of WMNs as the underutilized spectrum can either be used to carry existing traffic, thus alleviating the interference problem on existing communication channels, or can be used to admit new traffic flows to increase network capacity.