Chapter 9
Performance Evaluation of GSM Traffic Transmission over Cognitive Radio Networks under Opportunistic Spectrum Sharing Collisions

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ABSTRACT

Cognitive Radio networks and channel sharing are emerging as a new paradigm of communication in multimedia and wireless networks. In this chapter, the authors consider a secondary use application that consists of carrying TDMA traffic between the mobile and the base station for GSM networks over a Cognitive Radio network. Therefore, packets are not only lost by reason of Primary traffic interruptions, but the authors consider the opportunistic spectrum sharing which is the cornerstone of the Cognitive Radio concept as the major cause of collisions between several Secondary Users. The authors introduce their specific collision model, and they propose a solution consisting of the creation of many secondary user links with high reliability using a specific algorithm introduced here to alleviate traffic collisions. The authors evaluate the secondary traffic transmission performance in view of the Spectral Efficiency, and they outline the achieved gains of using the proposed solution. Finally, the authors highlight the recent trend in CR literature, which consists of leveraging the TV white spaces to deploy and enhance next generation cellular networks such as LTE.

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1. INTRODUCTION

Mobile and multimedia communication services have experienced a great evolution over the last decades. Increasing demand for the frequency spectrum resource makes the radio spectrum more precious. On the other hand, actual observations of the spectrum occupancy taken on some bands reveal the low and discontinuous usage of the licensed spectrum in time and space (Shared Spectrum Company, 2009; NTIA, 2003). Hence, the emergence of the Cognitive Radio (CR) (Mitola, 2000) as a new paradigm to find strategies for enhancing and sustaining the growth of multimedia and wireless networks with limited spectrum.

This spectral coexistence concept has been proposed with the objective of enabling devices to occupy the spectrum that has been left vacant by licensed users. Therefore, the proposed telecommunication system will be divided into two networks: a primary network called Primary Users (PUs), which holds the spectrum license and has primary rights to it, and a secondary network called Secondary Users (SUs), which is allowed to use the primary network's bandwidth in case of PU absence. For this reason, Cognitive Radio devices will incorporate more self management capabilities and autonomous functions.

The cognitive radio systems employ opportunistic spectrum sharing (Cabric, Mishra, Willkomm, Broderson, & Wolisz, 2005) which is a well regarded way to exploit the temporarily unused spectral resources. The cognitive radio must obtain a complete picture of the primary network in order to fill the spectrum holes and avoid the eventual interferences. That is, the licensed spectrum bands are continuously sensed except some bands where the primary signal could be undetectable, this situation is often referred to as the "hidden node" problem. The "hidden node" concept is one of the chief problems in CR systems and is still an open research issue (Kamil & Khider, 2008). The use of a cooperative sensing system should render this event infrequent and reduces its probability of occurrence (Akyildiz, Lee, Vuran, & Mohanty, 2006; Cabric, Mishra, & Brodersen, 2004). In our analysis, the functionality of cooperative sensing is assumed to be incorporated into CR devices and sensing measurements performed by multiple devices are combined to improve the sensing reliability. As described in Willkomm, Gross and Wolisz (2005), secondary users may use a dedicated control channel, called Group Control Channel (GCC), for exchanging the sensing measurements. Resulting local sensing decisions are forwarded to a common receiver, referred to as a centralized scheduler, to infer a final overall decision. Based on that sensing-derived information, Secondary User Links (SULs) can be formed from a composition of multiple subchannels (SCs) that are currently not occupied by licensed users. While using a certain band of spectrum, the secondary user must avoid disturbing and interfering with the corresponding primary user. The SU is required to vacate the subchannel as soon as the corresponding PU becomes active and claims its spectral resource. Therefore, the secondary user loses some packets on those subchannels and, as a consequence, needs to restructure its communication link. Accordingly, SU link maintenance is seen as a means of ensuring reliability in CR context.

The SUL maintenance mechanism deals with two main crucial aspects. The first one is to minimize the effect of PU arrival on the established SU link by adopting a suitable link structure. In this article we propose to make use of the Spectrum Pooling Concept (Weiss & Jondral, 2004) i.e. subchannels selected to create a SUL should be scattered over multiple PU frequencies. The major advantages of this principle are twofold:

1. It limits performance degradation due to the interference caused by primary user reappearance.
2. It reduces the number of jammed subchannels once the primary user appears during the lifetime of a Secondary User path.