Chapter 2
Cooperative Spectrum Sensing with Censoring of Cognitive Radios and MRC-Based Fusion in Fading and Shadowing Channels

Srinivas Nallagonda
National Institute of Technology – Durgapur, India
Sanjay Dhar Roy
National Institute of Technology – Durgapur, India
Gianluigi Ferrari
University of Parma, Italy
Riccardo Raheli
University of Parma, Italy

ABSTRACT
In this chapter, the authors study the performance of Cooperative Spectrum Sensing (CSS) with soft data fusion, given by Maximal Ratio Combining (MRC)-based fusion with Weibull faded channels, and Log-normal shadowed channels. More precisely, they evaluate the performance of a MRC-based CSS with Cognitive Radios (CRs) censored on the basis of the quality of the reporting channels. The performance of CSS with two censoring schemes, namely rank-based and threshold-based, is studied in the presence of Weibull fading, Rayleigh fading, and Log-normal shadowing in the reporting channels, considering MRC fusion. The performance is compared with those of schemes based on hard decision fusion rules. Furthermore, depending on perfect or imperfect Minimum Mean Square Error (MMSE) channel estimation, the authors analyze the impact of channel estimation strategy on the censoring schemes. The performance is studied in terms of missed detection probability as a function of several network, fading, and shadowing parameters.

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INTRODUCTION

There is huge demand of spectrum in this decade due to increase in internet traffic and other new services. However, good part of the spectrum has already been licensed/leased to different government, semi-government and private organizations. Although, it can be noticed that the licensed and leased spectrums are not efficiently used and hence efficient spectrum allocation and utilization policies are required from spectrum traders and researchers. In order to deal with this conflict between spectrum scarcity and spectrum under-utilization, cognitive radio (CR) has been proposed as a revolutionary technology for the next generation of wireless communication networks (Mitola, 1999), (Haykin, 2005). In order to guarantee that the operation of the primary users (PUs) is not affected, the secondary users (SUs) need to sense the presence of active PUs: this process is referred to as spectrum sensing.

It is necessary to detect the presence of PUs accurately and quickly in order to find available unused spectrum, which is called spectrum holes. This is done by “Spectrum sensing” an important feature of CR technology. Accurate sensing of spectrum holes is a hard task because of the time-varying nature of wireless channels (Cabric, 2004), including fading and shadowing. Presence of multi-path fading or shadowing in the sensing (S) channel (S-channel) between a PU and a SU, may limit the successful detection of the PU by a single SU (Digham, 2003). The detection/sensing performance can be improved, by limiting the negative impact of fading, if different SUs are allowed to cooperate by sharing their local sensing information on the activity status of PUs: this is the essence of cooperative spectrum sensing (CSS) (Akyildiz, 2006), (Ghasemi, 2005), (Zhang, 2008). More precisely, CR systems allow the CR users to sense the spectrum of PUs opportunistically without creating any intolerable interference to PUs. In many wireless applications, it is of great interest to check the presence and availability of an active communication link when the PU signal is unknown. In such scenarios, one appropriate choice consists in using an energy detector (ED) which measures the energy in the received waveform over a proper observation time window (Urkowitz, 1967), (Digham, 2003). Therefore, CSS using EDs improves the detection performance when all CR users sense the PU individually and send their sensing information via reporting (R) channels (R-channels) to a fusion center (FC). In CSS systems, the sensing information on the PUs’s activity status sent by several CR users is combined at the FC to obtain a global decision. In general, the sensing information reported to the FC by several CR users can be combined in two different ways: through (i) soft combining (Teguig, 2012), (Sun, 2011), (Nallagonda, 2013a) or (ii) hard combining (Choudhari, 2012(a)), (Choudhari, 2012(b)), (Choudhari, 2013), (Nallagonda, 2011b), (Nallagonda, 2012). In this book chapter, we focus on soft combining of spectrum sensing decisions from several CR users when the S- and R-channels are affected by fading and shadowing. Specifically, we study the impact of Weibull fading as well as Lognormal shadowing in the R-channels and the benefits of censoring the CR users on the basis of quality of the R-channels.

The rest of the chapter is organized as follows. Initially, we discuss on the background of this chapter: in particular, the motivation of the present work and the basics of CSS, along with existing works, are introduced. Next, we evaluate performance of CSS in faded environments (Rayleigh fading, Weibull fading, and Log-normal shadowing) under several hard and soft data fusion rules. We introduce the concept of censoring on the basis of the quality of R-channels, which is then incorporated into CSS systems. Specifically, two different censoring methods, such as rank-based and threshold-based censoring, have been analyzed under both perfect and imperfect channel estimation schemes. Finally, we conclude this chapter. The logical structure of the work presented in this chapter is shown in Figure 1.
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