

# Preface

The concept of Cognitive Radio (CR) appeared as a new paradigm in 1999, with the potential of its application to Software Defined Radio (SDR) and reconfigurable radio over wireless networks. It describes the situation in which intelligent radio devices and associated network entities communicate in such a manner that they are able to adjust their operating parameters according to the needs of the user/network, while learning from the experience at the same time. Such a concept that attempts to mimic human cognition and reasoning has created a huge excitement in the wireless community, igniting discussions that lead to a plethora of theoretical and practical research work together with standardization and regulation activities.

Since 2002, various (radio spectrum) regulation authorities, including the US Federal Communications Committee (FCC), have started to point out at more flexible and efficient ways of allocating and using the spectrum. For instance, between 2002 and 2010, FCC has issued a series of rules and regulations which authorize unlicensed devices to use some portion of the terrestrial TV broadcast band in an opportunistic manner, widely known as the *TV White-Space*. Encouraged by this initiative, an avalanche of spectrum measurement campaigns has swept all over the world, trying to provide evidence for the acclaimed underutilization of the spectrum.

With the advent of 4G wireless networks, technological areas like orthogonal frequency division multiplexing (OFDM), multiple input multiple output (MIMO) system, co-operative communications, dirty radio frequency (RF) coding, multi-hop communications have taken centre-stage. However, as the telecommunication domain moves on, there has been a renewed focus on new intelligent technologies. In this context, CR represents an emerging and innovative area in wireless communications, wherein, not only the wireless network, but also the different wireless devices including relays, gateways and at time even mobile nodes keep track of other surrounding devices and help adapt the entire communication mechanism in an agile manner, without changing the hardware itself. CR, along with its interdependent yet newly developed technologies of SDR, network coding, cooperative communication, etc., will have enormous applications in next

generation wireless and cellular networks. The CR could be used in conjunction with SDR for enhanced spectrum utilization to promote efficient use of the spectrum by exploiting the existence of spectrum holes. In addition, an adaptive cross-layer design could be implemented and a multi-hop based architecture could be designed for cellular networks. This could be done using intelligent environment-aware nodes that increase system capacity.

Over the last 12 years CR has been found to be a path-breaking technology and many fundamental/mathematical studies in this domain have been published. However, there has been lack of material on specific aspects of communication networks. In fact, to the best knowledge of the authors, there has not been any book published with specific focus on the technological impact of CR on cellular and general wireless networks yet.

Importantly, there are several research concerns and challenges, while considering CR in next generation wireless systems. The primary research concerns of CR are in the area of spectrum sensing and spectrum allocation, particularly in opportunistic/secondary use. Further, CR brings in significant challenges and research issues in the cellular and wireless networks that need to be addressed, in order to incorporate it into real world wireless networks. Moreover, CR necessitates changes in the hardware, especially in the digital signal processing (DSP) boards and field programmable gate arrays (FPGA) that have not been considered in depth so far in the literature. Keeping these different aspects in mind, this book is divided into two major sections.

In the first section, the focus is mainly on the radio spectrum. [Chapter 1](#) introduces the basic concepts of CR in details, presenting different spectrum access schemes, different broad research areas and regulations. Notably, this chapter is written by a leading technical expert in the areas and provides a comprehensive outlook onto the different issues in the CR-based wireless networks. [Chapter 2](#) describes the spectrum use models for the analysis, design and simulation of CR networks and [Chap. 3](#) describes how bandwidth efficient co-operative spectrum sensing could be carried out in these networks. [Chapter 4](#) discusses the challenges of emergency networking using licensed spectrum, while [Chap. 5](#) details the signature detection for context awareness in CR networks. Subsequently, [Chap. 6](#) delves into generalized Eigen-value-based spectrum sensing for CR networks.

The second section deals with applications of CR in wireless and cellular networks. The section begins with [Chap. 7](#) that describes in simple terms how the cellular network operators make use of the cognitive network paradigm, in all types of networks - from self-organizing networks to cellular networks. Further, [Chap. 8](#) talks about signal separation in cognitive wireless communications and [Chap. 9](#) provides details about automatic wireless network recognition based on MAC feature detection. [Chapter 10](#) describes evolutionary algorithms for spectrum allocation in CR networks, while [Chap. 11](#) explains different radio resource allocation mechanisms for CR-based *ad hoc* wireless networks. [Chapters 12, 13](#) and [14](#) detail different aspects of CR, specifically with regard to cellular networks. Particularly, [Chap. 12](#) describes the next generation cognitive cellular networks, especially for LTE, WiMAX and wireless broadband access. [Chapter 13](#) talks

about cognitive capabilities for femto-cell networks and [Chap. 14](#) details the interference modeling, shaping and avoidance for cognitive cellular networks. The last chapter, [Chap. 15](#) introduces FPGA for cognitive radio and describes the system design and FPGA implementation for a CR wireless device.

It is expected that this book will serve as the main reference book for post-graduate level students and professional researchers, who work in the ICT domain, especially on mobile devices and wireless networks. The book provides significant technical and practical insights in different CR aspects, starting from basic background, principles behind the technology, inter-related technologies and applications to cellular and wireless networks, technical challenges, implementation issues and future development trends.

This book is published by Springer-Verlag, the well known and prestigious book publisher world-wide. The editors wish the readers a pleasant reading and welcome any comments/feedback to the Editors that might help improve the content and presentation of different future related publications.

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