

Preface

The radio spectrum is one of the most precious resources which must be managed to ensure efficient access for the wireless communication services which use it. The allocation and management of spectrum are administered by the regulatory authorities. Traditionally, spectrum allocation is carried out exclusively of its use in large geographic areas and assigning frequency bands to specific users or service providers is proved to be inefficient. Recently, substantial knowledge about dynamic spectrum access scheme has been accumulated to enable efficient spectrum sharing. The cognitive radio based on dynamic spectrum access has emerged as a new technology to enhance the efficiency of spectrum usage. The key characteristics of cognitive radio system is to sense their environment and dynamically adapt their transmission parameters (e.g., modulation waveform, channel access method, spectrum use, and networking protocol) as needed for reliable communication and efficient utilization of radio spectrum. The main objective of this book is to treat some of the core functionalities related to cognitive radios and provide an in-depth and wide range of knowledge in spectrum access and management for enabling the technology.

Chapter “[Introduction](#)” is the introductory chapter which is devoted to kick-start with the topic. It provides the preliminaries for understanding the rest of the chapters on spectrum access and management.

Chapter “[Spectrum Sensing for Half and Full-Duplex Cognitive Radio](#)” explores the spectrum sensing approaches in cognitive radio networks for half duplex (HD) and full duplex (FD) mode of transmission. FD techniques can achieve the simultaneous spectrum sensing and data transmission in cognitive radio networks. Two spectrum sensing algorithms are developed based on the Cumulative Power Spectral Density (CPSD) of the received signal, dealing with the HD mode. These algorithms outperform the traditional Energy Detector (ED), the well-known Cyclostationary Detector (CSD) based on the Generalized Likelihood Ratio Test (GLRT) and the Autocorrelation Detector (ACD). Furthermore, these algorithms are robust against the noise variance, so that the dependence on Noise Uncertainty (NU) presented in ED is avoided. In addition, the proposed algorithms are blind as

they do not require any prior information on the PU's signal, contrary to Cyclostationary or Waveform detectors. The material in this chapter covers the main trends on the state of the art.

Chapter “[Dynamic Spectrum Access Algorithms Without Common Control Channels](#)” presents the most recent Dynamic Spectrum Access (DSA) algorithms, the metrics of the algorithms, and the mathematical background. These algorithms are classified into Homogeneous Role Algorithms, Heterogeneous Role Algorithms, Symmetric Available Channel Model, and Asymmetric Available Channel Model. The algorithms have bounded Maximum Time-to-Rendezvous (MTTR) to avoid long-time delay in CRNs. State of the art have nearly optimal MTTR. This kind of dynamic spectrum access algorithms is one of the key MAC layer functions in the cognitive radio networks (CRNs).

Chapter “[Quantified Dynamic Spectrum Access Paradigm](#)” introduces a quantified approach of QDSA which enables easier understanding and interpretation of the outcomes to spectrum sharing. The quantified approach transforms spectrum into a commodity that can be exchanged with service providers, and a resource that can be precisely controlled for making an efficient use. It facilitates easier interpretation and requires less skill of its users. Furthermore, quantified dynamic spectrum sharing enables spatial overlap of multiple RF systems while protecting their spectrum rights.

Chapter “[A Case Study of Cognitive Radio Networks: Secure Spectrum Management for Positive Train Control Operations](#)” presents a multi-tiered cognitive radio network architecture that is being developed to address the spectrum allocation for Positive Train Control (PTC) operations. In addition to efficient spectrum sharing, this cognitive radio will also detect spectrum abuse, any potential cyber threats to PTC operations and improve security of radio communication between the PTC nodes.

Chapter “[Centralized and Distributed Algorithms for Stable Communication Topologies in Cognitive Radio Ad hoc Networks](#)” presents two algorithms for stable communication topologies in CRAHN—the first one is generic benchmarking algorithm that determines a sequence of stable communication topologies spanning all of the SU nodes such that the number of transitions from one instance of the topology to another is the global minimum. The second one is distributed local spectrum knowledge-based stable path routing protocol called the Maximum Common Primary User channel-based Routing (MCPUR) protocol that prefers to choose an SU-SU source-destination (s-d) path with the largest value for the sum of the number of common PU channels available for use across each of its constituent SU-SU edges.

Chapter “[Cognitive Radio Testbeds: State of the Art and an Implementation](#)” summarizes various software defined radio (SDR) implementations of CR systems in the literature. Most popular SDR tools are GNU Radio, LabVIEW and USRP hardware. The authors present a prototype implementation of an energy-based wideband spectrum sensing testbed by using SDR tool, LabVIEW, and NI USRP-2921 hardware in real time.

Chapter “Visible Light Based Throughput Downlink Connectivity for the Cognitive Radio Networks” presents a visible light (VL)-based throughput downlink connectivity scheme for the CR network, by exploiting both CR and VL technologies in IoT communication scenario.

Chapter “Reconfigurable MIMO Antennas for Cognitive Radios” will shine some light on the most recent CR front ends focusing on MIMO-based integrated architecture. The front end of a CR consists of a sensing antenna for spectrum scanning and a reconfigurable antenna or reconfigurable multiple-input multiple-output (MIMO) antenna system for communication over several frequency bands.

Chapter “Cognitive Radio and the New Spectrum Paradigm for 5G” focuses on the introduction and access management of new spectral resources to support the substantial traffic increase in 5G. An extensive review on the current state of cognitive radio techniques as well as possible applications of cognitive radio in 5G wireless communications is presented in this chapter.

This book attempts to present current and emerging trends in research and development of spectrum access techniques and management of cognitive radio networks featuring a structured approach. Features include the following:

- Reviews the current state of the art as well as offering an in-depth treatment of spectrum sensing and management of cognitive radio networks.
- Provides up-to-date materials for cognitive radio networks and practical design information and extensive discussion through case studies and descriptions of cognitive radio platforms and testbeds.
- The chapters are written by several experts; highlight current design and engineering practices, emphasizing challenging issues of cognitive radio networks together with implementation details.
- Supplements its content with extensive references to enable researchers for further investigation of spectrum and access and management of cognitive radio networks.

It is hoped that this book will serve as a reference book for graduate level course in believing that it would be a useful resource for readers who want to understand this emerging technology, as well as those who wish to enhance their knowledge conducting research and development in this field.

Bandar Seri Begawan, Brunei Darussalam

Mohammad A. Matin

Spectrum Access and Management for Cognitive Radio
Networks

Matin, M.A. (Ed.)

2017, IX, 286 p. 125 illus., 92 illus. in color., Hardcover

ISBN: 978-981-10-2253-1