# Book Reviews

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## Cooperative Cognitive Radio Networks: The Complete Spectrum Cycle, Mohamed Ibnkahla; CRC Press; 1st Edition; January, 2013; ISBN-13: 978-1-4665-7078-8; hardcover, 349 pages

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Cognitive radio technologies are fast becoming an important enabling technology for allowing wireless devices to efficiently utilize the scarce wireless spectrum. The spectrum occasionally used by primary users, such as several TV stations, can be shared with several secondary users that sense the spectrum and only utilize it if the primary users are not communicating. The secondary users vacate the medium as soon as the primary users start communicating. Effective execution of this process requires several things to happen at the same time: cooperative sensing, learning, planning, and decision making, considering not only the engineering aspects of the coordination but also the economic aspects. A cognitive radio (CR) transceiver on each secondary mobile device helps perform several of these tasks.

This book discusses the complete spectrum cycle for cognitive radios starting with an introduction on cognitive radios, presenting spectrum sensing in single-band and multi-bands, routing and medium access considerations, spectrum handoff, and the economics and security considerations that need to be addressed to make cognitive radios successful. This book is a good source for a beginner in the research area of cognitive radios. The author aims to bridge the isolated work in cognitive radios to present a view of the complete spectrum cycle.

In Chapter 1 the author provides an overview of cognitive radio systems. The chapter includes the definition of cognitive radio, specifications of a cognitive radio framework, and different paradigms of organization of a cognitive radio network. Chapter 2 discusses spectrum sensing in detail. In particular, it investigates the major spectrum sensing techniques in both single-band and multi-band setups. Coherent, energy, and featured detection in single-band is discussed. In multi-band, serial sensing, parallel sensing, wavelet, and compressed sensing are discussed in detail. In Chapter 3, cooperative spectrum sensing and acquisition is discussed in detail. External cooperative spectrum sensing, which is done by entities that are external to the communicating network and internal corporative spectrum sensing, which involves the communicating secondary devices, done centrally or in a distributed fashion, are discussed. This chapter also discusses cooperative diversity with the help of the relay nodes. Chapter 4 deals with cooperative spectrum acquisition in the presence of interference from concurrently communicating nodes. The interference could be caused by transmitting-receiving SU pairs, PU pairs, or other sources of interference. The chapter discusses the use of relaying stations to enhance performance in the face of the potentially debilitating interference.

Chapter 5 discusses the different performance variables for measuring spectrum-sensing performance. The variables include sampling cost, sensing time, transmission time, throughput, and probability of false alarms, power control, and fairness. This chapter discusses the trade-offs that need to be accounted for during the design/operative phases that account for these performance variables. Chapter 6 discusses the spectrum handoff that happens when a primary transmitter comes online and needs to transmit on the channel that the secondary user is currently accessing. In such a case, the secondary user (transmitter) either goes silent (stops transmitting) or hops to a different frequency so that it can transmit concurrently with the primary transmitter without collisions. The latter has two different categories: proactive or reactive handoffs. The chapter provides a few mathematical tools to perform analysis of the handoff strategies and their performances.

In Chapter 7 the author discusses medium access control protocols (MAC) in cognitive radio networks. In particular, the chapter discusses cooperative and non-cooperative MAC layer protocols that can be used in the absence of a common control channel. The author discusses centralized versus distributed MAC architectures and the challenges for the design of MAC protocols when there is no common control channel among communicating entities.

Chapter 8 discusses cognitive radio ad hoc and sensor networks (CRAHSN). In a CRAHSN, both the PUs and the SUs are mobile, which makes the problem of spectrum sensing and acquisition even more challenging. This chapter discusses the differences between a CRAHSN and a standard CR network, the spectrum sensing problem in a CRAHSN, the MAC protocols proposed for CRAHSNs, and local control and fairness schemes for spectrum sharing. Chapter 9 discusses medium access in CRAHSN. Several MAC protocols for CRAHSNs, such as CM-MAC (a CSMA/CA based protocol), opportunistic multi-radio MAC, and an algorithm based on statistical channel allocation were also presented. Chapter 10 discusses routing in multi-hop cognitive radio networks. The routing in multi-hop CR networks has to account for multiple paths between SU transmitters and receivers and the presence of relays in the route optimization decision. This chapter covers several relevant issues relating to mobility routing in multihop CRNs, such as mobility, spectrum awareness, network topology changes, and scalability. The design challenges and several routing protocols are discussed in this chapter.

Chapter 11 discusses the economics of cognitive radio. The cognitive radio spectrum sharing model lends itself to several economic models for sharing resources, such as leasing, sharing, and using the channel anonymously and individually. Spectrum access rights are categorized into commons, shared use, and exclusive use. This chapter discusses the nature of different markets: fixed-price markets, single auctions, and double auctions.

Chapter 12 discusses the security concerns for the CR networks. CR networks are prime candidates for jamming by malicious users, as in the cooperative spectrum sharing (the more throughput efficient scheme) the PUs inform the SUs of their schedule, which is available to an active jammer. Malicious users can hold the channel and not release it, fake having access to a channel, effectively zeroing throughput, and masquerade as a fake PU. These are a few of the basic security concerns. The chapter proposes the concept of trust for the CR nodes and presents the entropy-based and probability-based trust models. The chapter also contains the path disruption and jamming attack descriptions and some descriptions of the PU emulation attacks.

The author does a very good job of providing a broad overview of the spectrum cycle of CR networks from a basic introduction to a discussion of security issues. The chapters are written well and have a good combination of explanations and mathematical formulations. The exhaustive references at the end of the chapters will also aid in follow-up reading.