Maria Gabriella di Benedetto,
Yingbo Hua, Thomas Kaiser, and
Xiaodong Wang

Cognitive Radio Technology

Cognitive radio is an exciting and new way of thinking and researching about wireless communications. Indeed, it is already being considered as one of the key candidate technologies for the fourth-generation (4G) wireless systems. There are several drivers for the development of cognitive radio. Perhaps the most pressing of them is improved utilization of the electromagnetic radio spectrum: a highly valuable natural resource. Careful studies of the current usage of the radio spectrum by several agencies have already revealed that a large fraction of the radio spectrum is inadequately utilized. This basic finding has led to numerous research initiatives. For instance, five European projects addressing a multitude of cognitive radio topics were recently approved with a total budget of more than €50 million. They are:

- Adaptive Reconfigurable Access and Generic Interfaces for Optimization in Radio Networks (ARAGORN) (www.ict-aragorn.eu)
- European Research on Ultra-Wideband (EUWB) (www.euwb.eu)
- Physical Layer for Dynamic Spectrum Access and Cognitve Radio (PHYDYAS) (www.ict-phydyas.org)
- End-to-End Efficiency (E3) (www.ict-e3.eu)
- Sensor Network for Dynamic and Cognitive Radio Access (SENDORA) (www.sendora.eu).

Moreover, there are emerging companies who apply cognitive radio principles for sensing the environment, (e.g., self-organizing femtocells) in order to efficiently exploit the bandwidth resources and also to minimize interference (see, for example, www.ubiquisys.co, www.adaptrum.com). Several cognitive radio test trials were created by the United States Federal Communications Commission (FCC) to investigate the impact of cognitive radios in white spaces (i.e., the underutilized TV frequencies). Even a white space coalition, consisting of eight large companies, was founded in order to promote the usefulness of the not yet publicly available analog television broadcast frequency bands (http://en.wikipedia.org/wiki/White_Spaces_Coalition).

THE OBJECTIVE OF THIS SPECIAL ISSUE IS TO PROVIDE THE BROAD TUTORIAL COVERAGE ON THE EXCITING TECHNOLOGIES FOR COGNITIVE RADIO NETWORKS, DYNAMIC SPECTRUM MANAGEMENT, AND COGNITIVE NETWORK OPERATION PRINCIPLES AND MODELS.

Cognition can also be extended to network rules of operation. A cognitive network integrates cognitive principles in the rules of interaction between nodes, that is, the set of wireless nodes forms a social network that must be modeled and analyzed as one entity in order to optimize the design. Cognitive principles must reflect in the rules that govern the coexistence and interoperability of different wireless systems. Needless to say, signal processing is destined to play a significant role in the development of cognitive radio networks, hence the need for this *IEEE Signal Processing Magazine* special issue focusing on this very topic. The objective of this special issue is to provide the broad tutorial coverage on the exciting technologies for cognitive radio networks, dynamic spectrum management, and cognitive network operation principles and models.

Seven articles make up this issue. The first article by Devroye et al., presents some recent results on the fundamental information and communication theoretic limits of cognitive networks. In such a theoretic setting, the notion of cognition is modeled in the form of nodes having side information about the wireless environment in which they transmit.

In the article by Budiarjo et al., the issue of coexistence of licensed and unlicensed users is addressed, and it also analyzes spectral shaping based on orthogonal frequency division multiplexing (OFDM), including sidelobes mitigation techniques such as windowing, adjacent carriers deactivation, and cancellation.

Next, Yue offers an overview of antijamming coding techniques that are suitable for the purpose of link maintenance in cognitive radio systems, i.e., to protect the secondary transmission from being corrupted by the reactivated primary user.

Scutari et al. describe in their article a decentralized approach to opportunistic underlay/interweave resource allocation in hierarchical cognitive networks, and provides conditions for the existence and uniqueness of Nash equilibrium points in a game where secondary users compete against each other to maximize their performance, under the constraint on the maximum (or null) interference induced to the primary users.

(continued on page 198)

Digital Object Identifier 10.1109/MSP.2008.930499