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Applications of Cognitive Radio Networks

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The term *cognitive radio* (CR), originally coined in the late 1990s, envisaged a radio that is aware of its operational environment so that it can dynamically and autonomously adjust its radio-operating parameters to accordingly adapt to the different situations. Cognition is achieved through the so-called cognitive cycle, consisting of the observation of the environment, the orientation and planning that leads to making appropriate decisions in accordance with specific operation goals, and finally, the execution of these decisions (e.g., access to the appropriate channel). Decisions can be reinforced by learning procedures based on the past observations and the corresponding results of prior actuations.

More than a decade after the CR concept was developed, researchers all over the world have devoted significant efforts to address different technical challenges of CR networks, mainly covering the fundamental problems associated with cognitive procedures as well as technology enablers of CR concepts. Research has also focused on the potential offered by CR networks for making dynamic spectrum access (DSA) a reality, thanks to the ability to identify spatial and temporal spectrum gaps that are not occupied by primary users, and to place secondary/unlicensed transmissions within these gaps.

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The objective of this special issue is to build on the foundations of CR and to provide the state of the art in CR networks from an application-oriented perspective. The purpose of this special issue is to contribute to the exploitation of CR concepts and techniques to drive them toward practical applications and usage scenarios. In this context, a total of 38 articles were submitted. As a result of two rounds of reviews, a total of 11 articles have been selected, covering a wide variety of application areas in the field.

The first article in this special issue, "Smart Radios for Smart Vehicles" by Di Felice et al., focuses on the application of CR concepts to vehicular network environments. It provides a taxonomy of the existing literature in the area, highlighting the key research problems and identifying how spectrum management functions can take into account the characteristics of the vehicular environment. The article "Spectrum-Aware Underwater Networks" by Bicen et al. covers another relatively unexplored application of CR technologies to enable underwater acoustic communications. In particular, dynamic spectrum sharing mechanisms are applied, which take into account the characteristics of the underwater channel. The article also provides an analysis of the capacity gain achievable via spectrum sharing.

The applicability of CR networks as a promising technology to address the next-generation power grid (i.e., the smart grid) is addressed in the article "Cognitive Radio Networks for Smart Grid Applications" by Gungor and Şahin. It presents the main smart grid characteristics, the associated CR-based smart grid applications, and the architectures to support them. The article also provides the major challenges and open research problems in the field.

The area of CR networks applied to emergency networks and public safety communications is covered by two articles in this issue. In particular, the article "TV White Space Technology" by Villardi et al. focuses on the interference between portable cognitive emergency wireless networks deployed in emergency areas, for example, a catastrophic event. The article presents a stochastic-geometric model to capture the reduction of effective service area when adjacent networks share the TV white space spectrum and defines the fractional service area as a metric to evaluate the capability of providing services in different scenarios. The article "Public Safety Communications" by Ferrús et al. discusses the role of spectrum sharing in increasing the capacity of public safety networks in emergency and disaster relief situations. It presents

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a taxonomy of five possible spectrum sharing models to provide sufficient bandwidth for emergency communications based on their operational demands. The principles behind each model are presented together with associated applicability and illustrative examples.

The application of CR networks in the area of DSA is covered by different articles of the special issue. The article "Opportunistic Spectrum Access" by Khattab et al. addresses the experimental performance evaluation of opportunistic DSA. It presents an implementation of a CR network environment using low-complexity transceivers and demonstrates the performance of distributed spectrum access schemes. The article "Dynamic Spectrum Access Networks" by Tallon et al. focuses on the application of CR technologies and DSA to deploy small independent service providers networks that form coalitions with each other to offer coverage in larger areas. The article proposes the use of cyclostationary signatures both to identify coalitions and to enable the handover process between providers. The article "Cognitive Radio Systems Evaluation" by Tandur et al. presents an approach to evaluate the performance of CR systems based on the integration of measurements, models, and emulation. This enables the reproduction of the radio environment in laboratory conditions. The article overviews the state of the art in each of the three considered elements and discusses different aspects thereof.

The role of learning in CR networks is covered by two articles of the special issue. The article "Impact of Cognitive Radio" by Macaluso et al. discusses learning in CR from a more systematic approach and develops some guidelines for when to learn. More specifically, it recommends some metrics that can be used to characterize occupancy data to determine whether it is worthwhile looking for an occupancy pattern in the data. The article "Knowledge Management Toolbox" by Stavroulaki et al. addresses how CR networks can benefit from learning functionalities that help in the identification and processing of information leading to exploitable knowledge. It presents different scenarios of applicability, discusses the basic learning functionalities and requirements, and provides an overview of the potential implementation approaches.

Finally, the article "Cognitive Resource Management" by Marojevic et al. presents a novel perspective on CR systems that embraces all wireless access layers such as spectrum, service, application, infrastructure, and hardware environments. It proposes a distributed resource management methodology that considers the resources and optimization targets in different environments.

We hope that the readers will find this issue interesting and valuable for their research and development efforts. We would like to thank all the contributors who submitted their articles to this special issue and all the anonymous reviewers who helped us in the review process. We would also like to express our gratitude to the editor-in-chief, the mobile radio senior editor, and the publishing staff of the magazine for their help.

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