ENERGY-EFFICIENT COGNITIVE RADIO NETWORKS


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Spectrum efficiency and energy efficiency are two critical issues for wireless communication networks. As a promising paradigm to improve spectrum usage efficiency, much attention has been paid to cognitive radio (CR) in both academia and industry since it was introduced more than 10 years ago. On the other hand, fast growing wireless applications are consuming more and more energy, and pose big challenges to operators in terms of energy footprint. However, few discussions were held on the energy efficiency issue in CR networks (CRNs) until recently. Actually, energy efficiency is of crucial importance for a CR scenario compared to non-CR ones because it not only involves the greenhouse problem and operational expenditure, but is a prerequisite to achieve high utilization of the limited transmission power consumed to support additional signal processing requirements for the CR system, such as spectrum sensing and signal overhead. Optimizing the energy efficiency of CRNs not only reduces the environmental impact, but also cuts deployment costs to enable economical green wireless networks.

The objective of this Feature Topic is to provide a collection of survey/tutorial content focusing on the recent advances in the development of energy-efficient CRNs. Our Call for Papers attracted many submissions worldwide. After a rigorous review process, six papers that best fit the theme of this Feature Topic and cover a broad spectrum of research topics including user association, the trade-off between spectrum and energy efficiency, and device-to-device wireless regional area networks, were selected for publication.

In the first article, "Energy-Efficient Non-Cooperative Cognitive Radio Networks: Micro, Meso, and Macro Views" by Chunxiao Jiang *et al.*, the authors investigate three important issues in energy-efficient non-cooperative cognitive radio networks: a spectrum sensing algorithm (micro view), a spectrum sharing algorithm (meso view), and energy-efficient CRN deployment (macro view). The energy-efficient spectrum sensing and access issues are discussed with a survey of existing solutions, as well as proposals for new algorithms. Regarding the network deployment issue, the authors discuss the advantages and disadvantages of two existing schemes, and propose a mixed solution by integrating them, which can enhance the energy efficiency of the CRN.

In the second article, "Energy-Efficient User Association in Cognitive Heterogeneous Networks" by Agapi Mesodiakaki *et al.*, the authors introduce a concept of cognitive heterogeneous networks (HetNets) and investigate the user association issue in cognitive HetNets. The main technical challenges in this field are discussed, as well as several existing user association solutions. The authors evaluate existing approaches under two different simulation scenarios, and show the potential of exploiting the available context-aware information to associate users in an energy-efficient way while maintaining high spectrum efficiency.

The third article, "Energy Efficiency Is a Subtle Concept: Fundamental Trade-offs for Cognitive Radio Networks" by Salim Eryigit *et al.*, investigates five fundamental trade-offs for energy efficiency in CRNs: quality of service, fairness, primary user interference, network architecture, and security. How these factors affect each other and their relationships with energy efficiency are also studied. Furthermore, the authors present the perspective of future directions for improving the energy efficiency of CRNs. Social networks, user behavior, and energy harvesting, which integrate CR with other networking paradigms, are introduced.

The fourth article, "Spectrum- and Energy-Efficient D2DWRAN" by Huaizhou Shi *et al.*, discusses energy-efficient spectrum sharing in a device-to-device wireless regional area network (D2DWRAN). The authors give an overview of D2DWRAN, including the main ideas, use cases, characteristics, and requirements of the D2DWRAN. To enhance the energy efficiency of an OFDMA-based D2DWRAN, a greedy energy-efficient

spectrum sharing algorithm is proposed. Along with energy, channel utilization and fairness are also considered. Thus, significant improvement in both network capacity and energy efficiency can be achieved, as can be seen from simulation results.

The fifth article, "Cognitive Radio in 5G: A Perspective on Energy-Spectral Efficiency Trade-Off" by Xuemin Hong *et al.*, introduces the concept of a cognitive cellular network, and provides an overview on recent advances in this field from the perspective of energy and spectral efficiency trade-offs. Different architectures, usage scenarios, levels of analysis, and capacity metrics are discussed to show how such a trade-off can be performed systematically in the cognitive cellular network. Three representative examples are given to illustrate that trade-off analysis can lead to important insights and useful design guidelines for future cognitive cellular networks.

In the sixth article, "Energy-Efficient NC-OFDM/OQAM-Based Cognitive Radio Networks" by Tao Jiang *et al.*, the authors investigate how to make an energy-efficient physical layer design for the non-contiguous (NC) OQAM-OFDM based CRNs. A criterion of joint peak-to-average power ratio reduction and sidelobe suppression is proposed. The main feature of the criterion is that it not only reduces the peak-to-average power ratio of NC-OFDM/OQAM signals, but also keeps the sidelobe at an acceptable level. Extensive simulation results verify the effectiveness of the criterion, which can result in prominent improvement of the energy efficiency in NC-OFDM/OQAM-based CRNs.

In conclusion, the Guest Editors would like to thank all the authors who submitted their papers for this Feature Topic, and all the reviewers for their time and effort. Their careful reviews and valuable comments helped us select the appropriate papers and improve the quality of this Feature Topic. Finally, we hope that this will serve as a useful and informative reference for interested readers, and stimulate further research and development activities on energy-efficient cognitive radio networks. We acknowledge the support of Sean Moore, Editor-in-Chief, who has guided us in this endeavor, S. Charis Scoggins, Joseph Milizzo, Cathy Kemelmacher, and Jennifer Porcello for their editorial support.

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