Guest Editorial Spectrum and Energy Efficient Design of Wireless Communication Networks: Part II

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SPECTRUM efficiency (SE) and energy efficiency (EE) are among the most important venues for technological advances in current and emerging wireless communication networks. The past decade has witnessed tremendous efforts and progress made by both the industry and academia for improving SE. We foresee that the emerging cognitive and self-organizing networks will further increase SE. In recent years, energy and power efficiencies of wireless networks have become more crucial because of the steadily rising energy cost and environmental concerns. While there has been a paradigm shift from improving SE to reducing energy consumption, a dilemma also arises as some EE criteria are in conflict with the SE objectives. Thus, there is an urgent need to address key challenges and state-of-the-art solutions for joint spectrum and energy efficient design (SEED) and optimization of wireless communication networks.

With the above vision, a Call for Papers for a special issue in the IEEE Journal on Selected Areas in Communications, was published in October 2011. The invited topics included system modeling, spectrum and energy efficient architectures and topologies for wireless networks, self-organization and self-optimization techniques for spectrum and energy efficient wireless networks, spectrum and energy efficient link adaptation and resource allocation, multiuser/single-user MIMO techniques for spectrum and energy efficiencies, and signal processing challenges for spectrum and energy efficient wireless networks. By the deadline in April 2012, we received 82 manuscripts, out of which 26 were accepted after a thorough and rigorous review process and 4 were suggested to accept if room.[1] Unfortunately, due to space constraints, several high-quality manuscripts could not be accommodated in this JSAC issue. Further, due to the page limit, we will publish two JSAC volumes (May 2013 and Feb 2014) each containing 15 papers.

The second volume published in Feb 2014 covers three subfields: (i) Performance evaluation and analysis techniques for joint spectrum and energy efficiencies of wireless networks, (ii) Cognitive and cooperative communication technologies for effective spectrum access, and (iii) Spectrum and energy efficient link adaptation and resource allocation.

The first three papers deal with performance evaluation and analysis techniques for joint spectrum and energy efficiencies of wireless networks. The paper by Liu, Zheng, Xiang and Zhao, entitled, "Design and Performance Analysis of An Energy-Efficient Uplink Carrier Aggregation Scheme," proposes a new dynamic carrier aggregation (DCA) scheduling scheme to improve the energy efficiency of uplink communications. The proposed scheme is analyzed in terms of both the data rate and energy conservation. The authors also build an ideally balanced system (IBS) to investigate the upper bound of the DCA scheme performance, and derive closed-form expressions.

The paper by Joung, Ho and Sun, entitled, "Spectral Efficiency and Energy Efficiency of OFDM Systems: Impact of Power Amplifiers and Countermeasures," analyzes the impact of power amplifier (PA) on the EE and SE tradeoff of OFDM systems. For the SE-EE tradeoff improvement, the authors propose a PA switching (PAS) technique. In a PAS transmitter, one or more PAs are switched on intermittently to maximize the EE and deliver an overall required SE. As a consequence, a high EE over a wide range SE can be achieved.

The paper by Rappaport and Murdock, entitled, "Consumption Factor and Power-Efficiency Factor: A Theory for Evaluating the Energy Efficiency of Cascaded Communication Systems," presents a new theory, called the consumption factor theory, that comprises a set of equations to provide new methods for analyzing and comparing the power efficiency of communication systems. One of the key concepts of the consumption factor theory is the power efficiency factor, which has implications for network design. The consumption factor theory has implications for the minimum energy consumption per bit required to achieve error-free communication, and may be used to extend Shannons fundamental limit theory.

The next five papers relate to cognitive and cooperative communication technologies for effective spectrum access. The paper by Ren, Wang and Du, entitled, "CAD-MAC: A Channel-Aggregation Diversity Based MAC Protocol for Spectrum and Energy Efficient Cognitive Ad Hoc Networks," proposes a diversity technology named Channel-Aggregation

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[1]Papers coauthored by Guest Editors were handled independently by Senior Editors.

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Diversity (CAD), through which each node can utilize multiple channels simultaneously and efficiently allocate the upper-bounded power resource with only one data radio. Based on the CAD technology, the authors also develop a CAD-based MAC (CAD-MAC) protocol, which enables the secondary nodes to sufficiently use available channel resources under the upper-bounded transmit power and transmit multiple data packets in one transmission process subject to the transmission-time fairness constraint.

The paper by Chen and Liu, entitled, "Spectrum-Efficient Coded Modulation Design for Two-Way Relay Channels," presents and analyzes spectrum and energy efficient coded modulation schemes for two-way relay channels. The authors propose a new constellation mapping for JMR. The proposed constellation mapping is a many-to-one function and can be considered as a new form of network coding operation, in which the network coding is performed on the redundancy labeling of each constellation point. They also establish the corresponding asymptotic optimal constellation labeling criterion by formulating the constellation constrained capacity with side information and develop a novel transceiver structure based on systematic low-density parity-check (LDPC) codes.

The paper by Li, Guo, Zhuang and Ye, entitled, "On Efficient Resource Allocation for Cognitive and Cooperative Communications," studys the problem of maximizing the minimum transmission rate among multiple source-destination pairs using cooperative communication (CC) in a cognitive radio network (CRN). In order to improve the spectrum efficiency, the author exploits the network coding opportunities existing in CC that can further increase the capacity. Moreover, the authors apply the reformulation and linearization techniques to the original optimization problems with nonlinear and nonconvex objective functions to produce high competitive solutions in a timely manner.

The paper by Zhou, Liu, Pan, Tian, Shi, and Yang, entitled, "Two-Stage Cooperative Multicast Transmission with Optimized Power Consumption and Guaranteed Coverage," focuses on energy efficient two-stage cooperative multicast transmissions, aiming to minimize the total transmission power while ensuring a practical coverage ratio. The authors assume a selective combining based on average received signal strength (SCA) at the receiver and the user density is supposed to be sufficiently high. Then they propose a mobile relay (MR) arrangement based on sector ring structures for the second stage transmission, followed by an analytical derivation of the optimal BS power conditioned on a desired coverage ratio.

The paper by Han, Yang and Molisch, entitled, "Spectrum and Energy Efficient Cooperative Base Station Doze," introduces a traffic-aware mechanism, named cooperative base station (BS) doze. The key idea is to allow BS idling by exploiting the delay tolerance of some users as well as the short-term spatiotemporal traffic fluctuations in the network, and to increase the opportunity of the idling by using coordinated multi-point (CoMP) transmission. And then the authors propose a hierarchical iterative algorithm to solve the optimization problem.

The last seven papers are related to spectrum and energy efficient link adaptation and resource allocation. The paper by Holtkamp, Auer, Bazzi and Haas, entitled, "Minimizing Base Station Power Consumption," proposes a new radio resource management algorithm which aims at minimizing the base station supply power consumption for multi-user MIMO-OFDM. The proposed algorithm finds the number of transmit antennas, the radio frequency (RF) transmission power per resource unit and spatial channel, the number of discontinuous transmission time slots, and the multi-user resource allocation, such that supply power consumption is minimized.

The paper by Macaluso, Özgül, Forde, Sutton and Doyle, entitled, "Spectrum and Energy Efficient Block Edge Mask-Compliant Waveforms for Dynamic Environments," shows how networks can generate waveforms which comply with the energy limits of the Block Edge Mask (BEM) and at the same time make best use of the spectral resources available to them. The authors focus on OFDM waveforms. The spectrum- and energy-efficient BEM-compliant waveforms are generated using a process that optimally combines symbol shaping and subcarrier-power loading to create a waveform that minimizes the difference between the transmitted wave and BEM. Practical considerations relating to peak-to-average-power-ratio reduction and time and frequency synchronization issues are explored to ensure the BEM-compliant waveforms can be transmitted with minimal changes to the transceiver.

The paper by Xu and Zhang, entitled, "Throughput Optimal Policies for Energy Harvesting Wireless Transmitters with Non-Ideal Circuit Power," addresses tradeoff between EE and SE problem for a point-to-point additive white Gaussian noise (AWGN) channel with the transmitter powered solely via energy harvesting from the environment. The authors study the optimal transmit power allocation to maximize the average throughput over a finite horizon, subject to the time-varying energy constraint and the non-ideal circuit power consumption. Finally, inspired by the off-line optimal solution, the authors propose a new online algorithm under the practical setup with only the past and present energy state information (ESI) known at the transmitter.

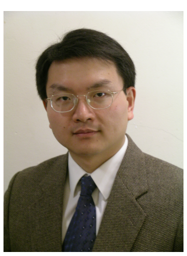
The paper by López-Pérez, Chu, Vasilakos and Claussen, entitled, "Power Minimization Based Resource Allocation for Interference Mitigation in OFDMA Femtocell Networks," introduces a simple self-organization rule, based on minimizing cell transmit power, following which a distributed cellular network is able to converge into an efficient resource reuse pattern. Based on such self-organization rule and taking realistic resource allocation constraints into account, the authors also propose two novel resource allocation algorithms, being autonomous and coordinated, respectively.

The paper by Cai, Liu, Luan, Shen, Mark and Poor, entitled, "Sustainability Analysis and Resource Management for Wireless Mesh Networks with Renewable Energy Supplies," studys the sustainable performance of a wireless mesh network powered by renewable energy sources, and proposes adaptive resource management and admission control schemes to address the random availability and capacity of the energy supply. To balance traffic loads across the mesh network according to the energy adequacy at different mesh APs, the authors propose an adaptive resource management scheme. And the authors also present a distributed admission control strategy to guarantee high resource utilization and to improve energy sustainability.

The paper by Wu, Wang, and Zheng, entitled, "Energy Efficiency and Spectral Efficiency Tradeoff in Type-I ARQ Systems," studys the optimum energy efficient and spectral efficient designs for type-I automatic-repeat-request (ARQ) systems in Rayleigh flat fading channels. The authors consider three optimum designs: the first scheme maximizes the EE, or equivalently, minimizes the total energy per information bit without considering the SE; the second scheme minimizes a new metric, the energy per information bit normalized by the SE; and the third scheme maximizes the EE under the constraint of a minimum SE.

The paper by Zhu and Wang, entitled, "Performance Analysis of Chunk-Based Resource Allocation in Multi-Cell OFDMA Systems," studys performance analysis of chunk-based resource allocation in the multi-cell OFDMA environment. The authors analytically evaluate how spectral efficiency performance is affected by parameters, such as radius ratio of the central area to the whole cell, transmit signal to noise ratio (SNR), number of users, number of subcarriers per chunk, and coherence bandwidth.

Finally, the guest editorial team would like to express their appreciation to all the authors of the papers submitted to this special issue. Moreover, we are grateful to all the anonymous reviewers involved in the review process, for delivering high-quality review reports. We would also like to express our gratitude to the JSAC team: the Editor-in-Chief Dr. Martha Steenstrup, the Senior Editor Prof. Wayne Stark, the Executive Editor Laurel Greenidge and the IEEE publications staff (Sue Lange in particular) for their fantastic support and input, which made this issue successful.



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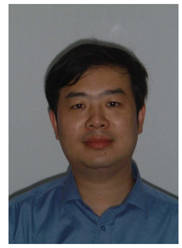

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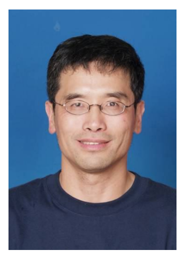

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