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Editorial
Cognitive Radio and Dynamic Spectrum Sharing Systems

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The vision behind software radio (SR) is to realize the communication specific signal processing of a radio as far as possible on programmable hardware. An ideal SR samples the received signal directly at the antenna, and its hardware consists of a general purpose processor that is connected with analog-to-digital and with digital-to-analog converters. A radio that uses an analog radio frontend for signal conditioning and employs digital signal processors as well as field programmable gate arrays is referred to as software defined radios (SDRs). Cognitive radios (CRs) are self-learning, intelligent SDRs that are able to monitor their environment and to adapt to actual conditions like available base stations (standards) or channel properties. Most important CR properties are, for example, self-location, spectrum awareness, transmission power control, or radio signal analysis. By extending cognitive radio principles to a network layer, a concept of cognitive networks arises. Cognitive networks can adapt their topology and parameters in self-configurable and dynamic manner according to the any sort of relevant changes.

With an increased demand for mobile communications and new wireless applications, the efficient usage of the available spectrum resources gains importance. Due to the currently practiced static assignment of spectrum to specific users by regulatory bodies, the actual demand for transmission resources often exceeds the available bandwidth. Promising approaches to overcome static spectrum assignments are given by dynamic spectrum sharing systems. Important examples of these technologies are overlay systems in which the spectral resources left idle by the primary (licensed) users are offered to secondary users. Obviously, the terminals in the secondary systems must be able to detect an emerging primary user immediately as well as reliably. At this point, the strong connection between cognitive radio and dynamic spectrum sharing systems becomes apparent. With this relation in mind, the present special issue presents twelve papers written by well-known experts from academia and industry.

The first (invited) paper "Achievable rates and scaling laws for cognitive radio channels," by N. Devroye et al. outlines recent information theoretic results on the limits of possible primary and cognitive user communication in single and multiple cognitive user scenarios. The authors first consider the achievable rate and capacity regions of single user cognitive channels and then consider a different information theoretic measure: the multiplexing gain. Furthermore, a cognitive network setting with a single primary user and multiple cognitive users is studied and it is shown that, with single-hop transmission, the sum capacity of the cognitive users scales linearly with the number of users.

In the second paper "Maximising the system spectral efficiency in a decentralised 2-link wireless network," S. Sinanovic et al. analyze the system spectral efficiency of a 2-link wireless network. The authors analytically show that transmitting with maximum power always maximizes the system spectral efficiency; either both links transmit simultaneously, or only the link with the better channel conditions transmits. The impact of the scheduling policy on the system spectral efficiency is also studied. It is shown that in terms of spectral efficiency per Watt, sequential transmission is always preferable to simultaneous transmission for power-constrained wireless networks. Furthermore, a scenario that reflects a situation with multiple links and one dominant interferer is studied.

The third paper “Interference mitigation technique for coexistence of pulse based UWB and OFDM,” by K. Ohno and T. Ikegami studies the effect of interference from pulse-based ultra wideband (UWB) on orthogonal frequency division multiplexing (OFDM) signals. To mitigate this interference, the authors propose to set the pulse repetition interval of UWB the same or half the period of the OFDM symbol excluding the guard interval. Furthermore, this interference mitigation technique is expanded for direct sequence UWB (DS-UWB) systems by considering how the symbol repetition interval in DS-UWB can be set to mitigate interference on OFDM and to reduce the UWB peak power.

An overlay system in which narrowband AM signals interfere with a broadband multicarrier system is considered in the fourth paper “Narrowband AM interference cancellation for broadband multicarrier systems,” by D. Van Welden and H. Steendam. The authors propose two AM signal estimators, that is, the sliding window estimator and the successive interference cancellation algorithm, to reduce the effect of the AM interference in an overlay multicarrier system. It is shown that the proposed estimators are able to produce accurate estimates of the frequencies, and track the time-varying amplitudes of the AM signals significantly reducing interfering impact of AM signal on multicarrier system.

The fifth paper “Non-parametric interference suppression using cyclic Wiener filtering: pulse shape design and performance evaluation,” by A. Benjebbour et al. investigates a flexible spectrum sharing scenario where a wideband single-carrier modulated signal is jammed by unknown narrowband interference (NBI). The authors utilize a cyclic Wiener filter to exploit the cyclostationarity property of the wideband signal for nonparametric suppression of NBI. To improve the NBI suppression capability of cyclic Wiener filter, pulse shape designs that outperform existing raised cosine pulse shaping schemes even for the same amount of excess bandwidth are proposed.

P. Jallon proposes a DVB-T signal detection algorithm based on a cost function that tests the cyclostationary property of the OFDM signals in the sixth paper “An algorithm for detection of DVB-T signals based on their second order statistics.” Furthermore, a theoretical analysis is used to evaluate the impact of the noise and multipath channel on the proposed cost function. The author exploits the obtained asymptotic results to propose a detection test based on the false alarm probability.

In the seventh paper “Cyclostationarity-inducing transmission methods for recognition among OFDM-based systems,” K. Maeda et al. present two cyclostationarity-inducing transmission methods that enable the receiver to distinguish among different systems that use a common OFDM-based air interface. In the first method, a specific preamble is inserted in which only a selected subset of subcarriers is used for transmission. In the second method, a few subcarriers in the OFDM frame are dedicated to transmit specific signals designed so that the whole frame exhibits cyclostationarity at certain cycle frequencies.

Challenges unique to the design of programmable wireless radio (PWR) unit of a dynamic spectrum access capable CR are focused in the eight paper “Efficient design of OFDMA based programmable wireless radios,” by S. F. Shah and A. H. Tewfik. The authors provide complete design architecture of OFDMA-based PWR that includes RF/analog frontend with data converters and digital baseband processor. Also, efficient IFFT/FFT modules based on a modified Cooley-Tukey decomposition, data recovery during filter transition bands, and a specific example of low-complexity PWR based on the IEEE 802.22 draft standard are considered.

The ninth paper “Opportunistic scheduling for OFDM systems with fairness constraints,” by Z. Zhang et al. deals with the opportunistic scheduling for downlink multiuser OFDM systems. The authors derive optimal opportunistic scheduling policies under three QoS/fairness constraints for multiuser OFDM systems: temporal fairness, utilitarian fairness, and minimum-performance guarantees. To address the implementation complexity of the optimal policies, a modified Hungarian algorithm and a simple suboptimal algorithm are applied.

A. Motamedi and A. Bahai investigate the problem of optimal channel selection for spectrum-agile low-powered wireless networks in unlicensed bands in the tenth paper “Optimal channel selection for spectrum-agile low-power wireless packet switched networks in unlicensed band.” In the paper, the channel selection problem is formulated as a reinforcement learning problem and further reduced to a multiarmed bandit problem enabling to derive the optimal selection rules. Such problem formulation allows spectrum agile node to achieve the optimal tradeoff between determination of interference patterns in each channel and use of channel that is optimal so far. By using traffic measurement of an 802.11-based network, as an example of a packet-switched network in the unlicensed band, the authors show validity of the underlying assumptions on the interfering traffic model.

The eleventh paper “Resource distribution approaches in spectrum sharing systems,” by T. Yamada et al. considers a centralized and a decentralized resource allocation approach. The proposed centralized approach is based on hierarchical spectrum trading model that associates each level of hierarchy with a trading occurrence frequency and a set of nonoverlapping spatial areas, whereas trading occurrence frequency and area size depend on the hierarchy level. The proposed decentralized approach is based on a game-theoretical framework in which operators act aversely to unequal payoffs. The authors also consider a hybrid of centralized and decentralized approach that exploits the benefits of both.

In the twelfth paper “Examining the viability of broadband wireless access under alternative licensing models in the TV broadcast bands,” T. Brown and D. C. Sicker focus on viability of broadband wireless access (BWA) transmission in the licensed TV bands on a secondary access basis. The authors develop a general BWA efficiency and economic analysis tool and provide examples corresponding to different demographic (urban, rural) and licensing regimes (unlicensed, nonexclusive licensed, exclusive licensed). It is shown that significant differences in considered regimes exist, for example, in rural areas an unlicensed model is the most viable, whereas in the densest urban areas no model is economically viable.

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