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IET Editorial

Special Issue on

Green Wireless Internet Technology

In the future communications will be pervasive in nature, allowing users access at the "touch of button" to attain any service, at any time, on any device. The future device design process requires both a reconfigurable RF front end and back end with high tuning speed, energy efficiency, excellent linearity and intelligence to maximise the "greenness" of the network. But energy efficiency and excellent linearity are the main topics that are driving the designs of future transceivers, including their efforts to minimise network contributions to climate changes such as the effect of CO_2 emissions: the minimisation of these is a requirement for information and communication technology (ICT) as much as for other technologies. Recently, information and communication technologies were shown to account for 3% of global power consumption and 2% of global CO_2 emissions, and hence far from insignificant. The approach towards energy conservation and CO_2 reduction in future communications will require a gret deal of effort which should be targeted both at the design of energy efficient, low-complexity physical, MAC and network layers, while maintaining the required Quality of Service (QoS). There is also a need, in infrastructures, networks and user terminals, to take a more holistic approach to improving or achieving green communications, from radio operation, through functionality, up to implementation. The increasing demand for data and voice services is not the only cause for concern since energy management and conservation are now at the forefront of the political agenda. The vision of Europe 2020 is to become a smart, sustainable and inclusive economy, and as part of these priorities the EU have set forth the 20:20:20 targets, whereby greenhouse gas emissions and energy consumption should be reduced by 20% while energy from renewables should be increased by 20%.

To support the proposed multi-standard flexible radio transceivers and system networks at the base station and at the user terminal, this special issue targets some leading research and practical case studies in the very active field of green wireless internet technology and reconfigurable transceivers, to provide design requirements and recommendations for the key components for tomorrow's ICT networks that will support a whole host of future services, internet of things (IoT) and e-applications with minimised energy cost. The scientific works presented here provide a step further toward overcoming the so-called energy trap, which is seen by many as the next stumbling block in the migration towards 5G systems. We present eleven leading works that will allow the readership to go beyond state-of-the-art on these topics, and perhaps establish new concepts towards further innovation in green communications.

The first article by Alimenti et al., entitled "24-GHz Patch Antenna Array on Cellulose-Based Materials for Green Wireless Internet Applications", reports exploitation of cellulose-based paper substrate to fabricate a patch array antenna at 24GHz. The authors also adopt microstrip circuitry and copper adhesive laminate shaped by a photo-lithographic process and transferred to the hosting substrate using a sacrificial

layer. The proposed design shows the feasibility of low-cost antenna systems for green wireless Internet technology and applications up to the boundary between microwaves and millimeter-waves.

The contribution by Chen et al., “Analysis of Collaborative Spectrum Sensing With BPSK Signal Power Estimation Errors” proposes novel iterative and non-iterative blind estimation methods for binary phase shift keying modulated primary user signal power using the maximum likelihood principle for collaborative spectrum sensing. The authors explore the effect of the primary user traffic on these methods. The proposed blind estimation methods offer an excellent trade-off between reliability and complexity.

“Compact and Closely Spaced Tuneable Printed F-Slot MIMO Antenna System for Mobile and Wireless Applications with Efficient Diversity”, by Elfergani et al., proposes a miniaturized tunable two-antenna MIMO system composed of printed F-slot shapes that is designed to operate in the GPS, PCS, DCS and UMTS bands. The approach makes use of two sets of antennas loaded with varactors to simultaneously achieve miniaturization and tunability. To assess its effectiveness, the channel capacity of the proposed antenna was investigated and found to be close to that of an un-correlated system with efficient diversity, in which the mutual coupling across the full bandwidth was better than -13dB. The proposed antennas can be a promising solution for adaptive MIMO systems in handheld devices.

A fundamental theme in this special issue considers reconfigurability, a design attribute that will accommodate several radio technologies. To address this topic, the contribution by Cheng et al., “A Practical Realisation of a Novel Software Defined Radio Based Aeronautical Communications System”, considers an innovative architectural design for a software implementation, followed by the validation and flight trial results of an aeronautical communications system developed to accommodate several radio technologies. This can drastically reduce the size, weight and cost in avionics with respect to current radio systems implemented as standalone equipment. In addition, the modular approach ensures the possibility to dynamically reconfigure each radio element to operate on a specific type of radio link. A radio resource management (RRM) framework is developed in the IMR, consisting of a communication manager for the resource allocation and management of the different radio links and a radio adaptation manager to ensure protocol convergence through IP.

Olwal et al. contribute the work entitled “Bio-inspired Energy and Channel Management in Distributed Wireless Multi-Radio Networks” that proposes a biological behaviour-based network resource management method, in order to address the existing inefficient energy and frequency channel utilisation problems. The research was inspired by a well-established optimal foraging theory, whereby a solitary biological forager in a random ecosystem makes optimal decisions that maximize its own nutrients consumption, survival probability and lifetime, while minimising possible risks associated with its own behaviour. The paper has applied this natural principle and developed a Bio-inspired Energy and Channel (BEACH) management method. The BEACH method is aimed at achieving both efficient communication energy and frequency channel utilisation in the distributed wireless multi-radio network considered. The efficacy of the developed BEACH method has been extensively validated through

computer simulations and shown to yield improved energy-efficiency and throughput performance.

The article “Cooperative Transmission Schemes for Energy Efficient Collaborative Wireless Sensor Networks” by Naeem et al. investigates collaborative wireless sensor networks. Energy conservation is one of the prime concerns that is leading researchers to investigate collaborative wireless sensor networks with some application-specific challenges. Such challenges include combining distributed data synchronously, performing power-aware signal processing, defining communication methods that can provide progressive accuracy and optimizing processing and communication for signal transmission. A cooperative resource selection and transmission scheme is proposed to improve the performance of collaborative wireless sensor networks in terms of maintaining link reliability. A measure of Channel Quality Index (CQI) is also proposed to obtain dynamic adaptivity and to optimize resource usage within wireless sensor networks according to environment conditions. Based on CQI, a subset of nodes is proposed to be chosen to perform cooperative transmission by exploiting collaboration between wireless sensing nodes. As part of the proposed cooperative nature of transmission, the recently proposed transmit-receive antenna selection scheme and lattice reduction algorithm have also been considered. It is assumed that channel state information (CSI) is estimated at the receiver and also that there is a feedback link between the wireless sensing nodes and the fusion centre receiver. From the simulation results it is observed that for 99.99% detection reliability, the proposed adaptive transmission scheme and proposed hybrid scheme consume only 15% and 18% of energy respectively as compared to the conventional cooperative transmission.

The next contribution, by Antonopoulos et al., “ANC-aided Game Theoretic MAC Protocol for Energy Efficient Data Dissemination” targets a novel medium access scheme based on Analog Network Coding (ANC) for data dissemination in wireless networks. The authors propose a Medium Access Control (MAC) protocol that exploits to the maximum the recent advances in the Network Coding (NC) domain to enhance the system performance. In particular, ZigZag decoding techniques are applied to resolve the data packet collisions, while Random Linear NC (RLNC) is employed to eliminate the need of exchanging control packets. The proposed protocol, evaluated by both analytical and simulation results, is proven to improve the energy efficiency in the network without compromising the provided Quality of Service.

The contribution by Ajibesin et al., on “DEA Envelopment with Slacks Model for Energy Efficient Multicast Over Coded Packet Wireless Networks”, proposes novel approaches that are based on Data Envelopment Analysis (DEA) to further optimize energy consumption in wireless multicast networks. They develop the input-oriented VRS envelopment with slacks models for energy-efficiency in ad hoc wireless multicast networks. The authors explored random linear network coding (RLNC) based on a simulation approach and compared the results with the input-oriented VRS DEA envelopment with slacks approach. The results show the DEA approach substantially saves energy compared to the RLNC. Furthermore, it is shown that the DEA method has the capability to identify which ad hoc network is inefficient and to project it towards the efficient frontier.

The next article, “Energy Efficient Transmission Techniques for Wireless Sensor Networks” by Haleem et al., studies power versus rate performance of a class of transmission techniques. The study arises in the context of a wireless sensor network in which multiple nodes equipped with single or multiple antennas cooperatively send simultaneous and distinct signals to multiple receiving nodes, each equipped with a single receiving antenna. The criterion in deriving the techniques is to eliminate or minimize the mutual interference, so maximizing received signal to interference plus noise ratio (SINR). It is shown that, for low bit rates, time-shared transmission can achieve the performance of the optimal power shared technique operating in spatially uncoupled (ideal) channels. As the bit rate increases, time shared transmission becomes suboptimal. In this context Best Linear Optimization (BLO), Dirty Paper Coding (DPC) and Zero Forcing (ZF) are promising.

The work of Fouad et al. entitled “Adaptive Control of Solar Tracking System” studies two tracker systems based on open- and closed-loop control strategies. The designed control system objective is to keep the tracker perpendicular to sunlight at all times during the day and to eliminate modelling errors such as sun position data deviations, friction and environmental changes. System performance is verified through computer simulation, where the controller is corrected for modeling errors and date changes from the date used for algorithm design.

Ghani et al. contribute the work entitled “A Step Forward to Map Fully Parallel Energy Efficient Cortical Columns on Field Programmable Gate Arrays (FPGAs)” that proposes an area-efficient architecture at the system level and benchmarked with a speech recognition application. The authors present energy and area-efficient hardware architectures to map fully parallel cortical columns on a reconfigurable platform – Field Programmable Gate Arrays (FPGAs). Due to the spatio-temporal nature of spiking neurons it is more appropriate to map such architectures on FPGAs, where signals can be represented in binary form and communication can be performed through the use of spikes. The viability of implementing multiple recurrent neural reservoirs is demonstrated with novel multiplier-less reconfigurable architectures and a design strategy is devised for its implementation.

The final article, by Behjati et al., entitled “Self-Organizing Comprehensive Handover Strategy for Multi-Tier LTE-Advanced Heterogeneous Networks ”, proposes a comprehensive handover algorithm. The authors investigate handover between the different layers of a heterogeneous LTE-Advanced system as a critical attribute to plan the best way of interactive coordination within the network for the proposed HetNet. The algorithm takes into account multiple factors in both handover sensing and decision stages, based on signal power reception, resource availability and handover optimization, as well as prioritization among macro and femto stations, to obtain maximum signal quality while avoiding unnecessary handovers.

Overall, the papers presented here represent a cross-section of leading-edge work across a range of topics relevant to the theme of the special issue, drawn from a broad spread of international contributors, and giving clear indicators of the way in which work to address the green communications agenda is progressing. We would like to thank all authors who submitted manuscripts to this special issue and for the reviewers that

assisted the guest editors to select the best articles for publication. Our gratitude also extends to the members of the organising committee, drawn from the School of Engineering and Informatics, University of Bradford, UK, to the 4TELL Research Group, Instituto de Telecomunicações, Aveiro, Portugal, to the School of Engineering & Engineering Technology, Modibbo Adama University of Technology, Yola, Nigeria, to the School of Information Technology & Computing, American University of Nigeria, and to the Commonwealth ITU group, UK, that provided the launch pad for this special issue.

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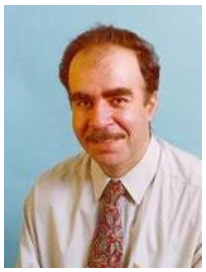

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