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Editorial

Cognitive Communications

Future radio communication networks will be heterogeneous in nature and will need to dynamically adapt to changing needs. This will require networks, sub-systems and devices to be increasingly intelligent, i.e. cognitive. This Special Issue deals with the subject of cognitive communications – the application of cognition to wireless systems in the most general sense, a field which incorporates techniques from several disciplines, including distributed artificial intelligence, electromagnetics, regulatory policy and economics, in addition to wireless communications. Thus, cognitive communications encompasses more than just the standard areas of cognitive radio and cognitive networks, including more speculative areas such as cognitive environments (incorporating frequency selective surfaces), and cognitive acoustics.

In this Special Issue we received a total of 55 original submissions, out of which we accepted 25, with several other papers transferred over to regular issues due to space and time constraints. The original impetus of this call came from the Worldwide Universities Network Cognitive Communications Consortium (WUN CogCom, www.wun-cogcom.org), which has members from over 90 organisations worldwide. The consortium was established to play a leading role in Cognitive Communications research through global collaboration by organising meetings, conferences and other dissemination activities such as this Special Issue. The papers, while not covering the vast breadth of the Consortium, fall into the following broad areas: spectrum sensing, spectrum access, spectrum management and power control, cognitive radio physical layers, cognitive radio joint physical layers and MAC, learning applied to cognitive communications, security for cognitive radio, and applications of cognition.

The first six papers of the Special Issue deal with spectrum sensing aspects and different methods to improve its performance, including improved energy detection, optimal opportunistic sensing, feature detection, and analytical methods to assess the fundamentals of spectrum sensing.

The next nine papers, and by far the largest group in the Special Issue investigate spectrum access & management, and power control. Issues are considered such as low complexity spectrum access, opportunistic access, distributed spectrum access for ad hoc networking, coverage improvement, power assignment, as well as fundamentals.

The following four papers deal with physical layer aspects of cognitive radio. Papers investigate antenna selection for MISO systems, cooperative relaying scaling laws in a cognitive radio context, as well as code properties of a convolutional encoder. The final paper in this set also combines physical layer aspects of distributed beamforming with a novel opportunistic scheduling protocol.

Our only paper dealing with machine learning aspects of cognitive radio appears next. Here manifold learning is used to improve automatic signal detection. The lack of papers in this category is quite surprising given that it was really the application of machine learning to radio communications by Joseph Mitola III that established the field of cognitive radio. A possible explanation is that the 'first wave' of research in cognitive communications, has been for a large extent dominated by research on the sensing aspect of Mitola's 'cognitive cycle'. However, with research in sensing reaching maturity, as also evident from the papers in this issue, we could expect a much larger focus on machine learning in the 'second wave' of research in cognitive communications.

The next three papers deal with the very important area of cognitive radio security. The level of autonomy, learning and adaptivity foreseen in the cognitive communications area makes devices and systems highly prone to cyber-attack. Here we have papers dealing with a primary user emulation attack, use of distributed consensus security mechanisms, and a simulation framework to assess security threats.

The final two papers in the Special Issue deal with applications of cognition. The first paper considers how a voice service can be delivered over a cognitive network using spatially unused TV spectrum, also known as TV white spaces The second paper deals with how smart indoor environments can be created and controlled, using intelligent frequency selective surfaces embedded in walls to better control frequency selectivity and spectrum availability.

The guest editors would like to thank the authors for their contributions, and also the reviewers who have provided useful feedback in the form of suggestions and corrections to help improve the quality of the manuscripts. We would also like to thank Professor Habib Rashvand, the Editor-in-Chief, for giving us this opportunity to put together this Special Issue. Finally, we hope that IET Communications readers will find the articles inspiring and helpful to their future research.

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David Grace is Head of Communications Research Group and Senior Research Fellow within the Department of Electronics at the University of York. He is also a Co-Director of the York – Zhejiang Lab on Cognitive Radio and Green Communications, and a Guest Professor at Zhejiang University. He received his PhD from University of York in 1999, with the subject of his thesis being 'Distributed Dynamic Channel Assignment for the Wireless Environment'. Current research interests include cognitive green radio, particularly applying distributed artificial intelligence to resource and topology management to improve overall energy efficiency; architectures for beyond 4G wireless networks; dynamic spectrum access and interference management. He is a co-investigator of the FP7 BuNGee project dealing with broadband next generation access, and recently he was the principal investigator of a UK MOD project on 'Cognitive Routing for Tactical Ad Hoc Networks'. From 2003–7 he was the technical lead for the 14-partner FP6 CAPANINA project. He is an author of over 160 papers, and author/editor of 2 books. He currently chairs the Worldwide Universities Network Cognitive Communications Consortium (WUN CogCom), which has members from 90+ organisations worldwide, and is a member of COST IC0902. He is the WUN CogCom Liaison Chair for IEEE Committee on Cognitive Networks, and is a founding member of the new IEEE Technical Sub-Committee on Green Communications and Computing (GCC). In 2013, he will be an IEEE ICC Symposium Co-Chair: Cognitive Networks Track. From 2005–9 he was COST 297 WG1 chair which dealt with radio communications for high altitude platforms. In 2000, he jointly founded SkyLARC Technologies Ltd, and was one of its directors.

Honggang Zhang is a Full Professor of Department of Information Science and Electronic Engineering as well as the Co-Director of York-Zhejiang Lab for Cognitive Radio and Green Communications at the Zhejiang University, China. He is an Honorary Visiting Professor of the University of York, UK. He received the Ph.D. degree in Electrical Engineering from Kagoshima University, Japan, in March 1999. From October 1999 to March 2002, he was with the Telecommunications Advancement Organisation (TAO) of Japan, as a TAO Research Fellow. From April 2002 to November 2002, he joined the TOYOTA IT Centre. From December 2002 to August 2004, he has been with the UWB Research Consortium, Communications Research Laboratory (CRL) and National Institute of Information and Communications Technology (NICT) of Japan. He was the principle author and contributor for proposing DS-UWB in IEEE 802.15 WPAN standardisation task group. From September 2004 to February 2008, he has been with CREATE-NET (Italy), where he leaded its wireless teams in exploring Cognitive Radio and UWB technologies while participated the European FP6/FP7 projects (EUWB, PULSERS 2). Dr. Honggang Zhang serves as the Chair of the Technical Committee on Cognitive Networks (TCCN) of the IEEE Communications Society (ComSoc). He was the Co-Chairs of IEEE Globecom 2008 Symposium. He was the founding TPC Co-Chairs of CrownCom 2006 as well as the Steering Committee Member of CrownCom 2006–2009. In the area of cognitive green communications and computing, Dr. Honggang Zhang was the Lead Guest Editor of the IEEE Communications Magazine Special Issues on 'Green Communications'. He was the General Chair of IEEE/ACM GreenCom 2010 (2010 IEEE/ACM International Conference on Green Computing and Communications) and the Co-Chairs of the IEEE International Workshop on Green Communications (GreenComm 2010–2011) in conjunction with IEEE ICC/Globecom. He is the co-author/editor of the forthcoming two books with the titles of 'Cognitive Communications – Distributed Artificial Intelligence (DAI), Regulatory Policy & Economics, Implementation' (John Wiley & Sons) and 'Green Communications: Theoretical Fundamentals, Algorithms and Applications' (CRC Press), respectively.

Maziar Nekovee is a pioneer in research and development of cognitive radio and white space networking technologies, and has been instrumental in establishing these areas as a major R&D activity at British Telecom (BT). He is also very actively involved in international and national regulation and standardisation of cognitive radio technology, and in leading a number of large EU and international collaborative projects in this field, involving major industry, universities and radio spectrum regulators.

Prior to joining BT in 2001 he held academic posts at Imperial College and Queen Mary College, and is currently an honorary senior fellow at University College London. He has a PhD in quantum physics and a first degree and MSc in electrical engineering (cum laude) both obtained in the Netherlands.

Dr Nekovee has published over 80 technical papers and 7 patents. He has edited a book entitled 'Cognitive Radio Communication and Networks: Principle and Practice' (2010) which was selected by the IEEE Communications Society as 'a best read' in cognitive radio, and has given numerous keynotes, invited lectures, and tutorials in leading IEEE and IET conferences around the world. He was awarded a Royal Society Industry Fellowship in 2006, and was nominated for the 2011 BT Innovation Award for his pioneering work on cognitive radio access to TV White Spaces.

His current research focuses on performance modelling, simulation and algorithm development for wireless and mobile systems, including co-existence and spectrum sharing in emerging cognitive radio and white space networks, dynamic spectrum access for wireless communications in smart energy grids and intelligent transportation, and networks security solutions against wireless worm and virus attacks.

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