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Guest Editorial

Special Issue on Signal Processing for Large Scale 5G Wireless Networks

The increasing demand for any-time any-where wireless connectivity has posed a formidable '1000 × data challenge' for service providers. With the envisioned 1000 × explosion in mobile data traffic by the end of year 2020, wireless network architecture needs to rapidly evolve. In particular, the evolution trajectory should be charted such that exponential gains can be realised in network wide resource efficiency. This requires a clean slate design for future 5G wireless networks while provisioning interoperability with the legacy deployment. Both operators and technology providers realise that 5G will not merely be a newer version of 4G simply provisioning faster data transfers. These 5G networks are expected to be more dynamic due to heterogeneity in terms of devices, technologies, spectral bands and deployment models. Heterogeneity is indeed the intrinsic and central feature of the evolving networking paradigm.

Now several potential solutions have recently been proposed to meet the aforementioned challenges and all address both network architecture and technologies. On the architectural front, concepts such as (i) cloudification & softwarisation of radio access networks; (ii) split-plane deployment; (iii) licensed shared access; (iv) decoupled uplink and downlink transmissions; and (v) information/content centric networking are all being considered as the enabling candidates. In terms of new technologies: (i) mmWave communications; (ii) massive MIMO; (iii) D2D communications; (iv) small cell deployment; and (v) low power IoT communication technologies (such as Bluetooth Low Energy, 802.11ah WiFi, LoRA, SIGFOX) are all vital design tools for future 5G HetNets. In addition, the so-called concept of 'tactile internet', which has a wide spectrum of requirements ranging from ultra-low latency to ultra-high throughput via deployment of HetNets, cannot be realised without significant advances in signal processing algorithms. Thus, the main objective of this Special Issue is to provide a platform for the dissemination of important results in those signal processing techniques necessary for enabling large scale, heterogeneous, 5G wireless networks.

The first part of this Special Issue presents four contributions. In the first paper, Mumtaz et al. present an energy efficient algorithm for D2D users in the presence of other cellular users (CUs). The authors employ Lagrangian duality theory for optimising both the power and rate of the D2D users while guaranteeing an acceptable quality-of-service (QoS) for the CUs. Finally, the solution of the proposed algorithm is then employed to achieve proportional fairness between the D2D and the CU users.

The second paper (Butt et al.) reflects a growing interest in the area of green communication. It has recently been accepted that opportunistic exploitation of ambient energy sources is going to be the cornerstone of future wireless networks. The authors discuss relay selection schemes with the objective of minimising outage probability for a network consisting of a single source, multiple relays and a single destination. The relays are powered by radio frequency (RF) signals from the source and the authors present an optimal relay selection strategy to minimise outage probability for the system. Finally, a numerical solution is developed to determine the optimal number of relays.

In the third paper, Gurjar et al. examine the significance of wireless channel estimation error on the performance of an analogue network coding (ANC)-based MIMO two-way relay system employing zero-forcing (ZF) transceivers in a Rayleigh fading environment. An analytical framework has been developed to study the overall outage analysis and some interesting (exact) expressions have been derived for special cases such as when the relay is equipped with less than two antennas. Some of the important contributions of this work are: a) exact expressions for the overall outage probability and the ergodic sum-rate have been derived within the context of channel estimation error; b) the authors have shown that system diversity may reduce to zero in the presence of channel estimation error due to imperfect self-interference cancellation; c) they conclude that a low complexity solution can be further

derived by exploiting channel estimation error with ZF transmission/reception for an ANC based MIMO two-way relay system.

In the final paper, Li et al. propose a hierarchical precoding approach for multi-cell, multi-user systems with any number of base stations and users, which is suitable for any number of data streams. The key feature of this approach is to align the inter-user interferences within the same cell to the room spanned by the inter-cell interferences, by which both the inter-cell and inter-user interferences are cancelled simultaneously. The effectiveness of this proposed method is demonstrated with an extensive set of simulations.

In summary, this Special Issue presents some important recent advances in D2D and relay assisted communication networks with a special focus on energy efficiency. Moreover, some of the state-of-the-art methods in multiuser MIMO systems have also been studied. For those interested in future 5G wireless networks, these articles will serve as a good springboard to appreciate further developments in this important topic.

Finally, we would like to thank (i) all the submitting authors for considering this Special Issue as a potential journal in which to publicise their research work; (ii) the reviewers for their high quality evaluations; and (iii) the Editorial team of the IET Signal Processing journal for their professional support.

Guest Editor Biographies



Syed Ali Raza Zaidi is currently University Academic Fellow (Assistant Professor) at the University of Leeds, UK. Prior to this, he was a Research Fellow in SPCOM Research Group at Leeds. He received his B. Eng. degree in information and communication system engineering from the School of Electronics and Electrical Engineering, NUST, Pakistan in 2008. He was awarded the NUST's most prestigious Rector's gold medal for his final year project. From September 2007 till August 2008, he served as a Research Assistant in Wireless Sensor Network Lab on a collaborative research project between NUST, Pakistan and Ajou University, South Korea. In 2008, he was awarded overseas research student scholarship along with Tetley Lupton and Excellence Scholarships to pursue his PhD at the School of Electronics and Electrical Engineering, the University of Leeds, U.K. He was also awarded with COST IC0902, DAAD and Royal Academy of Engineering grants to promote his research. In 2013, he was conferred with the prestigious F. W. Carter Prize for outstanding Doctoral thesis by the University of Leeds. Dr. Ali was a visiting Research Scientist at Qatar Innovations and Mobility Centre from October to December 2013. He has served as an invited reviewer for IEEE flagship journals and conferences. Dr. Ali is also UK Liaison for the European Association for Signal Processing (EURASIP). He is currently serving as an editor for IEEE Communication Letters and Lead Guest Editor for IET Signal Processing Special Issues on 5G Wireless Networks. He is also the general secretary for IEEE Technical Committee on 5G Networks. He has published more than 60 papers in leading IEEE journals and conferences and has chaired several IEEE workshops/conferences. His current research interests are in the area of design and implementation of large scale networks for machine-to-machine communication (including robotics and autonomous systems).

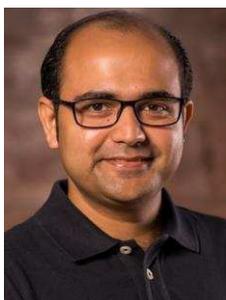


Des McLernon received his B.Sc in electronic and electrical engineering and his MSc in electronics, both from the Queen's University of Belfast, N. Ireland. He then worked in industry on radar systems research and development with Ferranti

Ltd in Edinburgh, Scotland and later joined Imperial College, University of London, where he took his PhD in signal processing. After first lecturing at South Bank University, London, UK, he moved to the School of Electronic and Electrical Engineering, at the University of Leeds, UK, where he is a Reader in Signal Processing. His research interests are broadly within the domain of signal processing for wireless communications (in which area he has published over 285 journal and conference papers). He has supervised over 35 PhD students, given many invited talks in the UK and abroad and is Associate Editor of the IET Signal Processing journal. He has been a member of various international conference TPC's and conference organisation committees - recent conference organisation includes IEEE SPAWC 2010, European Signal Processing Conference (EUSIPCO) 2013, IET Conference on Intelligent Signal Processing (London, 2013/2015) and IEEE Globecom 2014/2015 (2nd/3rd Workshops on Trusted Communications with Physical Layer Security). His current research projects include distributed sensing, PHY layer security, caching and energy efficiency in heterogeneous networks, energy harvesting, robotic and drone communications, intrusion detection in software defined networks, compressive sensing and time-frequency analysis.



Muhammad Ali Imran received his M.Sc. (Distinction) and Ph.D. degrees from Imperial College London, UK, in 2002 and 2007, respectively. He is currently a Reader in Communications in the Institute for Communication Systems (ICS - formerly known as CCSR) at the University of Surrey, UK and an adjunct Associate Professor at the University of Oklahoma, USA. He has lead a number of multimillion-funded international research projects encompassing the areas of energy efficiency, fundamental performance limits, sensor networks and self-organising cellular networks. He is also leading the new physical layer work area for 5G innovation centre at Surrey. He has a global collaborative research network spanning both academia and key industrial players in the field of wireless communications. He has supervised 21 successful PhD graduates and published over 200 peer-reviewed research papers including more than 20 IEEE Transaction papers. He has been giving a series of expert tutorials on emerging Green 5G technologies and networks at IEEE flagship conferences such as WCNC, PIMRC and ICC. Recently, he has been appointed as an area Chair for IEEE ComSoc Technical Committee on Backhaul/Fronthaul Networking and Communications (TCBNC). He secured first rank in his B.Sc. and a distinction in his M.Sc. degree along with an award of excellence in recognition of his academic achievements conferred by the President of Pakistan. He has been awarded IEEE ComSoc's Fred Ellersick award 2014 and FEPS Learning and Teaching award 2014 and twice nominated for Tony Jean's Inspirational Teaching award. He is a shortlisted finalist for The Wharton-QS Stars Awards 2014 for innovative teaching and VC's learning and teaching award in University of Surrey. He is a senior member of IEEE and a Senior Fellow of Higher Education Academy (SFHEA), UK.



Muhammad Zeeshan Shakir is a Senior Research Fellow at Carleton University, Canada. In recent years, he has been involved in several joint R&D initiatives with Telus, DragonWave, University of Surrey, KAUST, and TAMUQ. His research interests include design and deployment of diverse wireless communication systems, including hyper-dense heterogeneous networks and related 5G technologies. He has published more than 75 technical journal and conference papers and has contributed to seven books, all in reputable venues. He is an author of three research monographs including one authored book. He earned his PhD degree in electronic and electrical engineering from University of Strathclyde, Glasgow, UK in 2010. He is an Associate Technical Editor of IEEE Communications Magazine and has served as a Lead Guest Editor for IEEE Communications and IEEE Wireless Communications Magazines. He has been serving as Chair/Co-chair of several

workshops/symposia in IEEE flagship conferences, such as ICC and GlobalSIP. He has been giving a series of expert tutorials on emerging Green 5G technologies and networks at IEEE flagship conferences such as Globecom, ICUWB, PIMRC and ICC. Recently, he has been appointed as a Chair to IEEE ComSoc Technical Committee on Backhaul/Fronthaul Networking and Communications (TCBNC). He is an active member of IEEE, IEEE ComSoc and IEEE Standard Association.



Mounir Ghogho received his MSc degree in 1993 and PhD degree in 1997 from the National Polytechnic Institute of Toulouse, France. He was an EPSRC Research Fellow with the University of Strathclyde, Glasgow (Scotland), from September 1997 to November 2001. Since December 2001, he has been a faculty member with the school of Electronic and Electrical Engineering at the University of Leeds, UK, where he currently holds a Chair in Signal Processing and Communications. Since 2010, he has also been a Research Director at the International University of Rabat (Morocco). He was awarded the UK Royal Academy of Engineering Research Fellowship in September 2000. He is one of the recipients of the 2013 IBM Faculty award. He is currently an Associate Editor of the IEEE Signal Processing magazine. He served as an Associate Editor of the IEEE Transactions on Signal Processing from 2005 to 2008, the IEEE Signal Processing Letters from 2001 to 2004, and the Elsevier's Digital Signal Processing journal from 2011 to 2012. He is currently a member of the IEEE Signal Processing Society SAM Technical Committee. He served as a member of the IEEE Signal Processing Society SPCOM Technical Committee from 2005 to 2010 and a member of IEEE Signal Processing Society SPTM Technical Committee from 2006 to 2011. He was the General Chair of the 11th IEEE workshop on Signal Processing for Advanced Wireless Communications (SPAWC2010) and the 21st edition of the European Signal Processing Conference (EUSIPCO 2013), and the Technical co-Chair of the MIMO symposium of IWCMC 2007 and IWCMC 2008. His research interests are in signal processing and communication networks. He has published over 260 journal and conferences papers. He was awarded the UK Royal Academy of Engineering Research Fellowship in September 2000. He is also one of the recipients of the 2013 IBM Faculty award and is the EURASIP Liaison in Morocco.