

DYNAMIC SPECTRUM MANAGEMENT FOR 5G



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In the last decade global mobile data traffic has approximately doubled each year, growth that is projected to continue unabated, due mainly to the introduction of new services and features specified by standards bodies. Thus, the wireless industry is asked to fulfill an increase in mobile data demand by a factor of 1000 \times , which is one of the most challenging requirements that the 5G system design has to address. There are various opportunities to enhance the network capacity, for example, by exploiting advanced receiver techniques, novel cooperative multipoint transmissions schemes, innovative multi-antenna solutions, and finally, an effective and broad deployment of heterogeneous networks. Unfortunately, these foreseen technical innovations on small cells and macrocells seem insufficient to reach the 1000 \times target. One of the key enablers that can allow supporting the required data traffic is to exploit additional bands, and to guarantee access to as much licensed and unlicensed spectrum as possible. Therefore, the wireless research community has to focus much more on enhanced, more effective, and also completely new spectrum management techniques. That is the reason this Special Issue focuses on highlighting some recent and promising results in the area of dynamic spectrum management for 5G and beyond systems. Among the 35 submitted papers, only 16 were selected for this Special Issue, and in the following a very short introduction of each of them is provided.

In “Multi-RAT Dynamic Spectrum Access for 5G Heterogeneous Networks: The SPEED-5G Approach” by Ioannis Prodrinos *et al.*, a new spectrum management solution is presented to address traffic allocation over heterogeneous wireless technologies. In “Spectrum and Network Density Management in 5G Ultra-Dense Networks” by George Koudouridis *et al.*, a framework for spectrum and network access density management in ultra-dense networks is introduced. In “Toward Context-Aware Dynamic Spectrum Management for 5G” by Giuseppe Caso *et al.*, the authors suggest that context-aware interoperability and interference control may be crucial to comply with spectrum efficiency in 5G systems. In “Hybrid Resource Allocation for Millimeter-Wave NOMA” by António Morgado *et al.*, a hybrid orthogonal and non-orthogonal resource allocation technique is presented. In “A Survey of Advanced Techniques for Spectrum Sharing in 5G Networks” by Lin Zhang *et al.*, a

survey is given of advanced techniques for spectrum sharing. In “Dynamic Reuse of Unlicensed Spectrum: An Inter-Working of LTE and WiFi” by Youjia Chen *et al.*, a comprehensive survey on spectrum sharing technologies and a novel analytical framework are presented. In “Grid Modernization Enabled by SDN Controllers: Leveraging Interoperability for Accessing Unlicensed Band” by Saba Al-Rubaye *et al.*, the authors provide new algorithms for a centralized SDN controller that governs transmissions of utility information over licensed/unlicensed bands through an LTE-LAA model infrastructure. In “How and How Much Sparsity Can Be Exploited to Overcome IoT Challenges in 5G” by Bassem Khalfi *et al.*, challenges facing the support of IoT through 5G systems are discussed. In “Advanced Dynamic Channel Access Strategy in Spectrum Sharing 5G System” by Siyu Lin *et al.*, a spectrum sharing framework for the 5G system is designed. In “Cooperation in 5G HetNets: Advanced Spectrum Access and D2D Assisted Communications” by Georgios I. Tsiropoulos *et al.*, a heterogeneous networking architecture, where cells of different sizes and radio access technologies coexist, is presented. In “Dynamic Shared Spectrum Allocation for Underlying Device-to-Device Communications” by Berna Ozbek *et al.*, an overview on spectrum sharing in D2D underlying communications for 5G and beyond applications is given. In “Unlicensed Spectrum Sharing: From Coexistence to Convergence” by Zhenyu Zhou *et al.*, the authors develop a converged framework for multiple access that helps explore the integration of wireless communication and computer networking. In “Channel Hopping Protocols for Dynamic Spectrum Management in 5G Technology” by Aohan Li *et al.*, the authors analyze the latest channel hopping protocols for dynamic spectrum management. In “Radio Resource Management in Future Terrestrial-Satellite Communication Networks” by Linling Kuang, *et al.*, the authors introduce three technical challenges in radio resource management of terrestrial-satellite communication networks. In “Multi-Tenant Slicing for Spectrum Management on the Road to 5G” by Matteo Vincenzi *et al.*, the authors take into account some radical changes foreseen for next generation networks. In “Data Delivery in Wireless Multimedia Sensor Networks: Challenging and Defying in the IoT Era” by Fadi Al-Turjman *et al.*, best effort and real-time multipath routing protocols for wireless multimedia sensor networks are surveyed.

The articles of this Special Issue cover different topics and propose interesting innovations to enable 5G and beyond networks. We hope that you enjoy reading the issue and will find it interesting and useful. Finally, we would like to thank those who submitted the papers, the reviewers for the time spent selecting them, the SPEED-5G project (H2020-ICT-2014-2, Project ID: 671705) for nurturing the idea of this Special Issue, Professor Hamid Gharavi for effectively guiding us, and Jennifer Porcello for her editorial support.

BIOGRAPHIES

SHAHID MUMTAZ (smumtaz@av.it.pt) has more than 10 years of wireless industry experience and is currently working as a senior research scientist at Instituto de Telecomunicações Portugal. He received his M.Sc. and Ph.D. degrees in electrical and electronic engineering from Blekinge Institute of Technology, Sweden, and the University of Aveiro, Portugal, in 2006 and 2011, respectively. He has more than 100 publications in international conferences, journal papers, and book chapters. His research interests are in the area of RRM, small cells, and the Internet of Things.

ANWER AL-DULAIMI received his Ph.D. degree in electrical and computer engineering from Brunel University, London, United Kingdom. Currently, he is a senior systems engineer in the R&D department at EXFO Inc., Toronto, Canada. He is recognized

as an Associate Fellow of the British Higher Education Academy and registered as a Chartered Engineer by the British Engineering Council. He is the Chair of IEEE 1932.1, “Standard for Licensed/Unlicensed Spectrum Interoperability in Wireless Mobile Networks,” as part of IEEE 5G initiatives.

VALERIO FRASCOLLA has an M.S. and a Ph.D. in electronic engineering from Ancona University, Italy. In 2006 he moved to Germany to work for Comneon, Infineon, and finally Intel, where he is currently director of research and innovation. He is a mentor and technology coach in wearable and IoT actions (Fashion Fusion, WEARSustain), is active in several international research projects, and contributes to 5G system design, standardization, and prototyping. His research interests are wireless systems design, with focus on spectrum management, mmWave, and MEC technologies.

DUSIT NIYATO [M’09, SM’15, F’17] is currently an associate professor in the School of Computer Science and Engineering, at Nanyang Technological University, Singapore. He received his B.Eng. from King Mongkuts Institute of Technology Ladkrabang, Thailand, in 1999, and his Ph.D. in electrical and computer engineering from the University of Manitoba, Canada, in 2008. His research interests are in the area of energy harvesting for wireless communication, the Internet of Things, and sensor networks.

KEITH BRIGGS has a Ph.D. in applied mathematics from Melbourne University, and is a Fellow of the Institute of Mathematics and its Applications. He has published over 100 papers in the areas of dynamical systems, computational number theory, biostatistics, statistical mechanics, graph theory, and communications systems. He has worked in the last 15 years on mathematical and statistical modeling of communications systems in the BT research department.

CALL FOR PAPERS

IEEE WIRELESS COMMUNICATIONS MAGAZINE

5G TESTING AND FIELD TRIALS

BACKGROUND

The coming 5G era will boost both the personal broadband mobile communications and the industry utilizations greatly. According to the time table defined in ITU, the proposals for 5G systems must be submitted in 2019, and they will be then evaluated to make a final IMT-2020 specifications by the end of 2020. The evaluation will be based on certain evaluation criteria including key performance indicators (KPIs). The different usage scenarios of 5G will set different priorities for the KPIs. Also, the key new features brought by the 5G systems, such as mmWave and 5G New Radio, will highly impact those KPIs. Testing and field trials are essentially demanding to evaluate the KPIs, and the related technologies have attracted more and more attention from both the academia and industry. To reflect recent research advances on the 5G testing and field trials, this special issue calls for original papers with contributions in, but not limit to, the following topics:

- Testing and field trials environment building for 5G, including testing network architecture and deployment, wireless propagation modeling and measurements.
- Development of testing tools and algorithms for 5G, including testing instruments design, software development, programming languages and models, trouble shooting tools, and various algorithms for testing and field trials.
- Testing and field trial cases design for 5G, including new KPIs and metrics defining to meet the challenges such as the massive scalability and the ultra-reliability, methodologies for measurement and calculation of the new KPIs and metrics.
- Vertical business use cases of 5G testing and field trials, including spectrum management, policy control and charging, security and privacy, services and applications, and techno-economic analysis.
- Testing and field trials of 5G with other wireless networks, including converged broadcasting and mobile networks, and other various heterogeneous networks.
- Progresses in standardization (including ITU, 3GPP, IEEE, ETSI, ONF and etc.), related to 5G testing and field trials.

SUBMISSION GUIDELINES

Prospective authors should prepare their submissions in accordance with the rules specified in the Information for Authors section of the *IEEE Wireless Communications* guidelines (<http://www.comsoc.org/wirelessmag/paper-submission-guidelines>). Authors should submit a PDF version of their complete manuscript to <http://mc.manuscriptcentral.com/ieee-wcm>. Select “October 2018-Special Issue-5G Testing and Field Trials” from the drop-down menu.

IMPORTANT DATES

- Manuscript Submission Deadline: February 1, 2018
- Initial Decision: April 10, 2018
- Revised Manuscript Due: May 15, 2018
- Final Decision: June 15, 2018
- Final Manuscript Due: July 10, 2018
- Publication Date: October 2018

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