

IEEE Workshop on **5G & Beyond - Enabling Technologies and Applications**
In conjunction with **IEEE ICC 2015**, June 8, London, UK
<http://www.ctr.kcl.ac.uk/5G2015/>



Workshop Chairs

Gerhard Fettweis - Technical University of Dresden, Germany
Mischa Dohler - King's College London, UK.

Ted Rappaport - NYU, USA
Ralf Irmer - Vodafone, Germany
Toktam Mahmoodi - King's College London, UK

Workshop Programme – June 8, 9:00 – 18:00

09.00 – 09.05 Opening & Welcome by Chairs

09.00 – 10.30 Keynote Talks

Session chair: Gerhard Fettweis (Technische Universität Dresden, Germany)

09.05 – 09.30 **Keynote 1:** “What if? Some Disruptive Design Approaches for Cellular” by Mischa Dohler & Toktam Mahmoodi, King's College London

We will outline and summarize some of the more disruptive ideas around 5G designs which surface in recent months. Notably, we will discuss possible fundamental changes related to technology, standards and business models. We will discuss the impact of these developments onto the current research and innovation ecosystem.

09.30 – 10.00 **Keynote 2:** “5G Connectivity, IoT and Big Data - What it means to Rolls-Royce and Industry Verticals” by Paul Stein, CSO Rolls-Royce

This keynote exposes the requirements and drivers for an all-connected vertical industry like the one represented by Rolls-Royce. The real-time and big data capabilities of the industrial Internet of Things will be discussed and some surprising findings exposed which may impact 5G research and innovation.

10.00 – 10.30 **Keynote 3: “5G Controversies”** by
Dan Warren (former GSMA, now Capita)

Is 5G an evolution, a revolution? Should we follow the traditional path of cellular designs, or are fundamental changes really required? This keynote summarizes the findings of the previous keynote speakers, and adds the experience and insights from a wider cellular community, including the GSMA.

10.30 – 11.00 Networking Break (and time to upload posters)

11.00 – 12.00 Panel “Government, Governance & Business”

This panel will examine the 5G design from a government and business perspective. Notably, we will examine if there is a strong business case or a strong societal utility which requires 5G innovation to be accelerated.

Panel Chair: Dan Warren, Capita, UK
Panellists: Joe Buttler, Ofcom, UK
John Cunliffe, CTO Ericsson, UK
Andy Sutton, Principle Network Architect, EE

Dr Dan Warren: As Senior Director of Technology at the GSMA, Dan Warren is a technology subject matter expert across all of the GSMA’s Project and Working Groups and key spokesperson for the GSMA. Dan currently leads the GSMA’s definition of Voice over LTE (VoLTE) for the global industry, as well as being a lead technology expert on Rich Communications and all IMS-based projects, Embedded Mobile and Wi-Fi Roaming.

Dan is a recognised industry expert on the Mobile Broadband market and all aspects of technical implementation, and is a regular spokesperson at conferences including Mobile World Congress, CTIA and the LTE World Series. Dan has written columns for Connected Planet and RCR Wireless, is regularly quoted in Tier 1 and industry press, and was listed in Global Telecoms Business ‘Top 40 Under 40’ for 2009, 2010 and 2012.

Since joining the GSMA in 2007, Dan has led projects and initiatives on IP-based Interconnect, Application Awareness and Quality of Service, and was also the GSMA lead standards delegate, regularly attending 3GPP and tracking activity across other industry groups, until the end of 2011.

Prior to the GSMA, Dan worked as a network architect and standards engineer at Vodafone and in standards, technical marketing and product management roles at Nortel. Dan holds a PhD in Applied Mathematics and a degree in Mathematics.

Dr Joe Butler: Joe is the Technical Director in Ofcom’s Spectrum Policy group where he is responsible for the group’s technical work and technology policy. Joe is an engineer with 20 years of experience in the field of radio engineering, technology and software.

His recent work at Ofcom has included being technical director for the UK 4G spectrum auction, leading Ofcom’s work on Public Sector Spectrum Release & TV White Spaces dynamic spectrum access. He has also worked in Ofcom’s Technology Strategy team where he managed a programme of technology research.

Prior to Ofcom Joe worked in radar system design and also in a number of technology start-up companies in the UK and New Zealand. Joe has a PhD in Electrical Engineering from UCL.

John Cunliffe: At Ericsson John works with customers, research, partners, governments and regulators across 16 countries of Western and Central Europe. John's strategy work includes business development and mergers & acquisitions.

John started his career in R&D and has worked on most aspects fixed and mobile networks.

John is a Chartered Engineer, a Fellow of the Institute of Engineering and Technology (IET) and a board member at the UK ICT trade association, techUK. He is also a member of the Advisory Council of the UK's Broadband Stakeholder Group.

Professor Andy Sutton: Andy is EE's Principal Network Architect with responsibilities for RAN architecture evolution and mobile backhaul strategy and architecture. He has 30 years of experience within the telecommunications industry, mainly in radio access, transmission and transport network strategy, architecture and design. Andy's research interests include; distributed and centralised RAN architectures and protocols, radio access network dimensioning and QoS, mobile backhaul including microwave and millimetre-wave radio systems along with synchronisation and time distribution in telecommunications networks. During his career Andy has worked for Mercury Communications Ltd, Orange, France Telecom Group, H3G and EE. Andy is a Visiting Professor with the Department of Computing, Science and Engineering at the University of Salford where he delivers 6 annual lectures, also works with the University on collaborative research projects. He is a research mentor with the 5G Innovation Centre at the University of Surrey and industrial partner of the H2020 Tweether project at Lancaster University. Andy is a Chartered Engineer, Fellow of the Institution of Engineering and Technology, Member of the Institute of Telecommunications Professionals and Fellow of the British Computer Society. Andy contributes to International telecommunications standardisation activities and several industry forums.

12.00 – 12.30 Poster Session #11

Session chair: Toktam Mahmoodi (King's College London, United Kingdom)

1. "Rainfall Effect on the Performance of Millimeter-wave Point-to-Point Link"
Yong-Ping Zhang (Huawei Technologies, China); Peng Wang (The University of Sydney, Australia); Shulan Feng (Huawei Technologies, P.R. China); Philipp Zhang (Hisilicon Technologies, Huawei, P.R. China)
2. "Digitally Assisted Analog Beamforming for Millimeter-Wave Communication"
Andre Kokkeler and Gerard Smit (University of Twente, The Netherlands)
3. "Single carrier filtering system architecture for flexible frequency domain multiplexing uplink"
Ying Chen and Linda M. Davis (University of South Australia, Australia)
4. "Fractional Pilot Reuse in Massive MIMO Systems"
Italo Atzeni (Mathematical and Algorithmic Sciences Lab, France Research Center, Huawei Technologies, France); Jesús Arnau (Huawei Technologies & Mathematical and Algorithmic Sciences Lab, France Research Center, France); Mérouane Debbah (Supelec, France)
5. "Differentially Encoded Blind Multicell Multiuser Massive MIMO"
Mahdi Fozi (Sharif University of Technology & Tarbiat Modares University, Iran); Babak Hossein Khalaj (Sharif University of Technology, Iran); Marius Pesavento (Technische Universität Darmstadt, Germany)
6. "Wideband Communication with High-Dimensional Arrays: New Results and Transceiver Architectures"
John Brady and Akbar Sayeed (University of Wisconsin-Madison, USA)
7. "Channel Estimation via Oblique Matching Pursuit for FDD Massive MIMO Downlink"

Minhyun Kim, Junho Lee, Gye-Tae Gil and Yong H. Lee (KAIST, Korea)

8. "Resource Allocation for Co-Primary Spectrum Sharing in MIMO Networks"

Tachporn Sanguanpuak (University of Oulu & Asian Institute of Technology (AIT), Finland); Sudarshan Guruacharya (Nanyang Technological University, Singapore); Nandana Rajatheva (University of Oulu, Finland); Matti Latva-aho (UoOulu, Finland)

9. "Multipacket Reception Performance in the Presence of In-Band Full Duplex Communication"

Tiago Bento (FCT - Universidade Nova de Lisboa, Portugal); Luis Bernardo (Universidade Nova de Lisboa, Portugal); Rui Dinis (Faculdade de Ciências e Tecnologia, University Nova de Lisboa, Portugal); Rodolfo Oliveira (Nova University of Lisbon, Portugal); Paulo F Pinto and Pedro Amaral (Universidade Nova de Lisboa, Portugal)

10. "Adaptive Searching and Tracking Algorithm for AoA Estimation in Localized Hybrid Array"

Jian A. Zhang (CSIRO, Australia); Xiaojing Huang and Y. Jay Guo (University of Technology, Sydney, Australia)

11. "Filter Bank OFDM: A New Way of Looking at FBMC"

Hao Lin (France Telecom, France)

12. "TCGTR-based Channel Estimation for Cooperative Multi-cell Large Scale Antenna Systems"

Tianhang Yu, Minjian Zhao, Yunlong Cai and Jie Zhong (Zhejiang University, P.R. China)

13. "Electrical Balance Isolation for Flexible Duplexing in 5G Mobile Devices"

Leo Laughlin, Mark Beach and Kevin A Morris (University of Bristol, UK); John Haine (U-blox, UK)

12.30 – 13.00 Poster Session #12

Session chair: Mischa Dohler (King's College London, United Kingdom)

1. "Bandwidth Compressed Carrier Aggregation"

Tongyang Xu and Izzat Darwazeh (University College London, UK)

2. "How to Calibrate Massive MIMO?"

Xiliang Luo (ShanghaiTech University, China); Xin Wang (Fudan University, China)

3. "Uplink Sum-Throughput Evaluation of Sectorized Multi-cell Massive MIMO System"

Jiahui Li, Qiang He, Limin Xiao, Xibin Xu and Shidong Zhou (Tsinghua University, China)

4. "Modelling Machine Type Communication in IEEE 802.11ah networks"

Evgeny Khorov (IITP RAS & MIPT, Russia); Alexander Krotov (The Institute for Information Transmission Problems, Russia); Andrey Lyakhov (IITP RAS, Russia)

5. "Millimeter Wave Beamforming Based on WiFi Fingerprinting in Indoor Environment"

Ehab Mahmoud Mohamed (Osaka University, Japan); Kei Sakaguchi (Osaka University & Tokyo Institute of Technology, Japan); Seiichi Sampei (Osaka University, Japan)

6. "Uplink Achievable Rate of Full-Duplex Multi-Cell Massive MIMO Systems"

Yan Huang (Beijing University of Posts and Telecommunications, China); Shaodan Ma (University of Macau, China); Ying Wang (Beijing University of Posts and Telecommunications, China)

7. "Performance and Design of SIC Receiver for Downlink NOMA With Open-Loop SU-MIMO"

Keisuke Saito, Anass Benjebbour, Yoshihisa Kishiyama, Yukihiro Okumura and Takehiro Nakamura (NTT DOCOMO, INC., Japan)

8. "On Rate Region Analysis Of Full-Duplex Cellular System With Inter-User Interference Cancellation"

Wenping Bi, Xin Su and Limin Xiao (Tsinghua University, China); Shidong Zhou (Tsinghua University, Canada)

9. "Large-Scale Analysis of Linear Massive MIMO Precoders in the Presence of Phase Noise"

Rajet Krishnan and Mohammad Reza Khanzadi (Chalmers University of Technology, Sweden); Narayanan Krishnan (Qualcomm, USA); Yongpeng Wu (University of Erlangen-Nuremberg, Germany); Alexandre i Amat (Chalmers University of Technology, Mexico); Thomas Eriksson (Chalmers University

of Technology, Sweden); Robert Schober (Universität Erlangen-Nürnberg, Germany)

10. "Radio Access Sharing Strategies for Multiple Operators in Cellular Networks"

Andrijana Popovska Avramova (Technical University of Denmark, Denmark)

11. "Cooperative Content Distribution for 5G Systems Based on Distributed Cloud Service Network"

Lirong Jiang, Gang Feng and Shuang Qin (University of Electronic Science and Technology of China, China)

12. "Interference in LoS Massive MIMO is Well Approximated by a Beta-Mixture"

Yeqing Hu, Yi Hong and Jamie Evans (Monash University, Australia)

13.00 – 14.30 Lunch Break

14.30 – 16.00 Technical Session #01 "5G Designs I"

Session chair: Simone Redana (Nokia Siemens Networks, Germany)

1. "Area Energy and Area Spectrum Efficiency Tradeoff in 5G Heterogeneous Networks"

Haris Pervaiz, Leila Musavian and Qiang Ni (Lancaster University, UK)

2. "Radio Access for Ultra-Reliable and Low-Latency 5G Communications"

Niklas A Johansson and Y.-P. Eric Wang (Ericsson Research, USA); Erik Eriksson and Martin Hessler (Ericsson AB, Sweden)

3. "Analysis of Ultra-Reliable and Low-Latency 5G Communication for a Factory Automation Use Case"

Osman N. C. Yilmaz (Ericsson Research, Finland); Y.-P. Eric Wang and Niklas A Johansson (Ericsson Research, USA); Nadia Brahmi and Shehzad Ali Ashraf (Ericsson Research, Germany); Joachim Sachs (Ericsson Research & Ericsson AB, Sweden)

4. "Full-Duplex Opportunistic Relay Selection in Future Spectrum-Sharing Networks"

Mohammad Galal Khafagy and Mohamed-Slim Alouini (King Abdullah University of Science and Technology (KAUST), Saudi Arabia); Sonia Aïssa (INRS, University of Quebec, Canada)

5. "On Feasibility of Coding-based 3GPP LTE Coverage Enhancements for MTC"

Anastasiia Voropaeva, Alexander Pyattaev, Mikhail Gerasimenko, Sergey Andreev and Yevgeni Koucheryavy (Tampere University of Technology, Finland)

6. "On Prospects of Positioning in 5G"

Armin Dammann, Ronald Raulefs and Siwei Zhang (German Aerospace Center (DLR), Germany)

14.30 – 16.00 Technical Session #02 "5G Millimeter-Wave"

Session chair: Gerhard Fettweis (Technische Universität Dresden, Germany)

1. "Millimeter Wave Channel Model and System Design Considerations"

Qian (Clara) Li and Hooman Shirani-Mehr (Intel Corporation, USA); Tommaso Balercia (Technische Universitaet Braunschweig & Intel Mobile Communications GmbH, Germany); Huaning Niu, Apostolos Papathanassiou and Geng Wu (Intel Corporation, USA)

2. "3-Dimensional Large-Scale Channel Model for Urban Environments in mmWave Frequency"

Sangkyu Baek, Youngbin Chang, Sooyoung Hur and June Hwang and Byungchul Kim (Samsung Electronics, Korea)

3. "Effective RF Codebook Design and Channel Estimation for Millimeter Wave Communication Systems"

Sohail Payami, Mehrdad Shariat, Mir Ghorraishi and Mehrdad Dianati (University of Surrey, UK)

4. "Achievable Rates of Multi-User Millimeter Wave Systems with Hybrid Precoding"

Ahmed Alkhateeb and Robert Heath (The University of Texas at Austin, USA); Geert Leus (Delft University of Technology, Netherlands)

5. "73 GHz Wideband Millimeter-Wave Foliage and Ground Reflection Measurements and Models"
Theodore Rappaport and Sijia Deng (New York University & NYU WIRELESS, USA)

6. "8 GHz and 73 GHz Millimeter-Wave Indoor Propagation Measurements and Path Loss Models"
Sijia Deng, Mathew Samimi, Theodore Rappaport (New York University & NYU WIRELESS, USA)

16.00 – 16.30 Networking Break

16.30 – 18.00 Technical Session #03 "5G Designs II"

Session chair: Toktam Mahmoodi (King's College London, United Kingdom)

1. "When Pilots Should Not Be Reused Across Interfering Cells in Massive MIMO "

Ji Yong Sohn, Sung Whan Yoon and Jaekyun Moon (Korea Advanced Institute of Science and Technology, Korea)

2. "Location-Based Channel Estimation and Pilot Assignment for Massive MIMO Systems"

Zhaocheng Wang, Chen Qian and Linglong Dai (Tsinghua University, China); Jinhui Chen and Chen Sun (Sony China Research Lab, China); Sheng Chen (University of Southampton, UK)

3. "Flexible Fast-Convolution Implementation of Single-Carrier Waveform Processing for 5G"

Juha Yli-Kaakinen and Markku K. Renfors (Tampere University of Technology, Finland)

4. "Uplink Rate Distribution in Heterogeneous Cellular Networks with Power Control and Load Balancing"

Sarabjot Singh (Nokia Technologies, USA); Xincheng Zhang (The University of Texas at Austin & Qualcomm, USA); Jeffrey Andrews (The University of Texas at Austin, USA)

5. "Exploiting the Elevation Dimension of MIMO System For Boosting Handset Capacity"

Reham Almesaeed (University Of Bristol, UK); Araz Sabir Ameen (University of Bristol & University of Sulaimani, UK); Angela Doufexi and Andrew Nix (University of Bristol, UK)

6. "Taming the Complexity of mm-Wave Massive MIMO Systems: Efficient Channel Estimation and Beamforming"

Stefano Montagner and Nevio Benvenuto (University of Padova, Italy); Stefano Tomasin (Mathematical and Algorithmic Sciences Lab France Research Center & Huawei Technologies, France)

16.30 – 18.00 Technical Session #04 "5G Massive MIMO"

Session chair: Mischa Dohler (King's College London, United Kingdom)

1. "Coordinated Optimization of EVD-Based Channel Estimators in Multi-Cell Massive MIMO Networks"

Umut Ugurlu and Risto Wichman (Aalto University, Finland); Cassio Barboza Ribeiro and Carl Wijting (Nokia Research Center, Finland)

2. "Frequency Spreading Equalization in Multicarrier Massive MIMO"

Amir Aminjavaheri (University of Utah, USA); Arman Farhang, Nicola Marchetti and Linda Doyle (Trinity College Dublin, Ireland); Behrouz Farhang-Boroujeny (University of Utah, USA)

3. "Deployment Issues for Massive MIMO Systems"

Callum Neil (Victoria University of Wellington, New Zealand); Mansoor Shafi (Spark New Zealand Ltd & Victoria University of Wellington, New Zealand); Peter J Smith and Pawel A. Dmochowski (Victoria University of Wellington, New Zealand)

4. "One-Bit Massive MIMO: Channel Estimation and High-Order Modulations"

Sven Jacobsson (Ericsson Research & Chalmers University of Technology, Sweden); Giuseppe Durisi (Chalmers University of Technology, Sweden); Mikael Coldrey (Ericsson Research & Ericsson AB, Sweden); Ulf Gustavsson (Ericsson AB, Sweden); Christoph Studer (Cornell University, USA)

5. "A Scalable Massive MIMO Array Architecture Based on Common Modules "

Antonio Puglielli, Nathan Narevsky, Pengpeng Lu and Thomas Courtade (UC Berkeley, USA); Gregory Wright (Alcatel-Lucent Bell Labs, USA); Borivoje Nikolic and Elad Alon (UC Berkeley, USA)

6. "Low Complexity Detection for Massive MIMO under Multipath Fading with Limited Storage Resources"

Ting Li, Sujeet Patole and Murat Torlak (The University of Texas at Dallas, USA)

18.00 Closing of Workshop