



# SPAWC 2015

The 16th IEEE International Workshop on  
Signal Processing Advances in Wireless Communications

June 28 – July 1, 2015, Stockholm, Sweden

## Workshop Program





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# Program Overview

## Sunday June 28

18:00 - 20:00 City Hall Welcome Reception

## Monday June 29

08:30 - 09:00 Registration

09:00 - 10:30 **Tutorial 1.1** - Millimeter Wave Wireless Communications (Heath)

**Tutorial 2.1** - Massive MIMO for 5G (Larsson, Björnsson)

**Tutorial 3.1** - MIMO Broadcast and Interference Channels  
Towards 5G (Elia, Slock)

10:30 - 11:00 Coffee break

11:00 - 12:30 **Tutorial 1.2** - Millimeter Wave Wireless Communications (Heath)

**Tutorial 2.2** - Massive MIMO for 5G (Larsson, Björnsson)

**Tutorial 3.2** - MIMO Broadcast and Interference Channels  
Towards 5G (Elia, Slock)

12:30 - 13:45 Lunch

13:45 - 14:15 Opening Ceremony

14:15 - 15:15 **Plenary 1** - 5G for the Networked Society (Mazur)

15:15 - 16:30 **R1** - Energy Efficiency and Energy Harvesting

**S1** - 5G Waveforms

16:30 - 16:45 Coffee break

16:45 - 18:00 **R2** - Coding and Modulation

**S2** - Signal Processing for Millimetre Wave Communication Systems

## Tuesday June 30

08:30 - 09:00 Registration

09:00 - 10:00 **Plenary 2** - On Pilot Contamination in Massive MIMO (Utschick)

10:00 - 11:15 **R3** - Network Design and Performance

**S3** - Massive MIMO

11:15 - 11:30 Coffee break

11:30 - 12:45 **R4** - Large-scale MIMO

**S4** - Recent Advances in Signal Processing for Inband Full-Duplex Radio

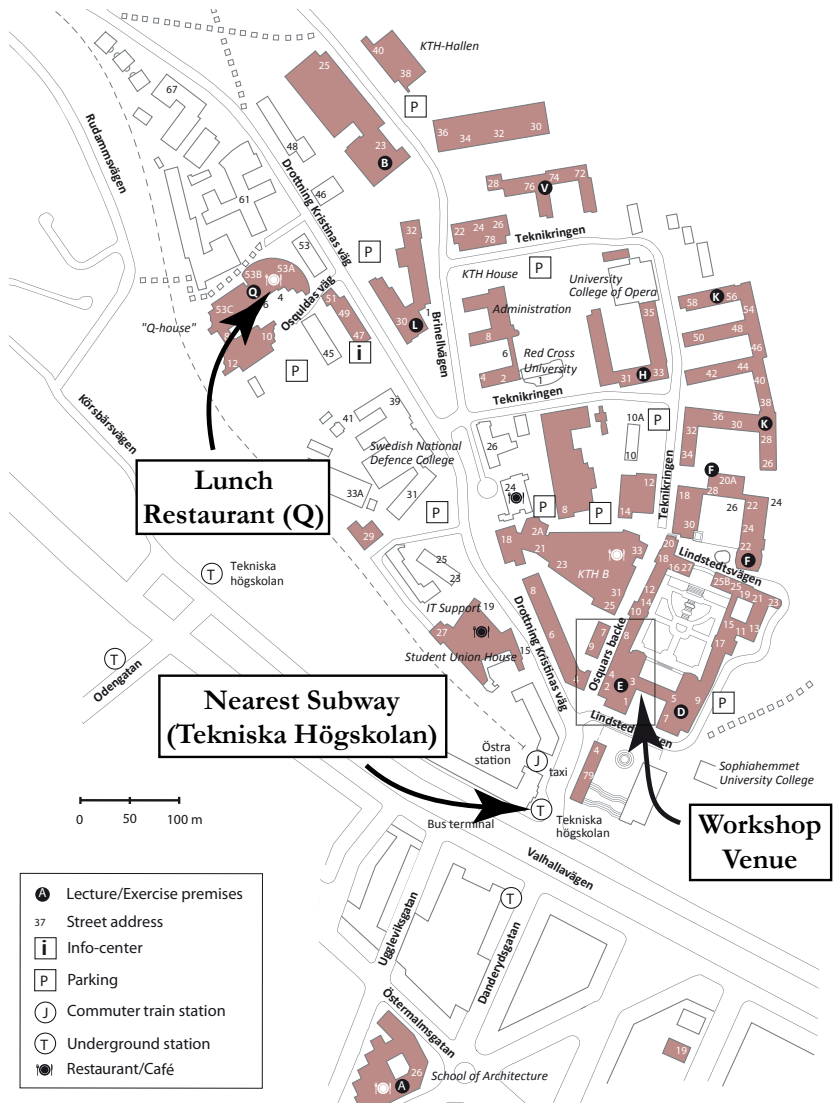
- 12:45 - 14:00 Lunch
- 14:00 - 15:00 **Plenary 3** - One Decade of ‘Sensorless Sensing’: Wireless Networks as Human Context Sensors (Patwari)
- 15:00 - 16:15 **R5** - Detection and Receiver Design  
**S5** - Security, Privacy, and Trust
- 16:15 - 16:30 Coffee break
- 16:30 - 17:45 **R6** - Transmitter Optimization  
**S6** - Signal Processing, Coding, and Information Theory for Optical Communications
- 19:00 - 00:00 Vasa Museum Workshop Banquet

### Wednesday July 1

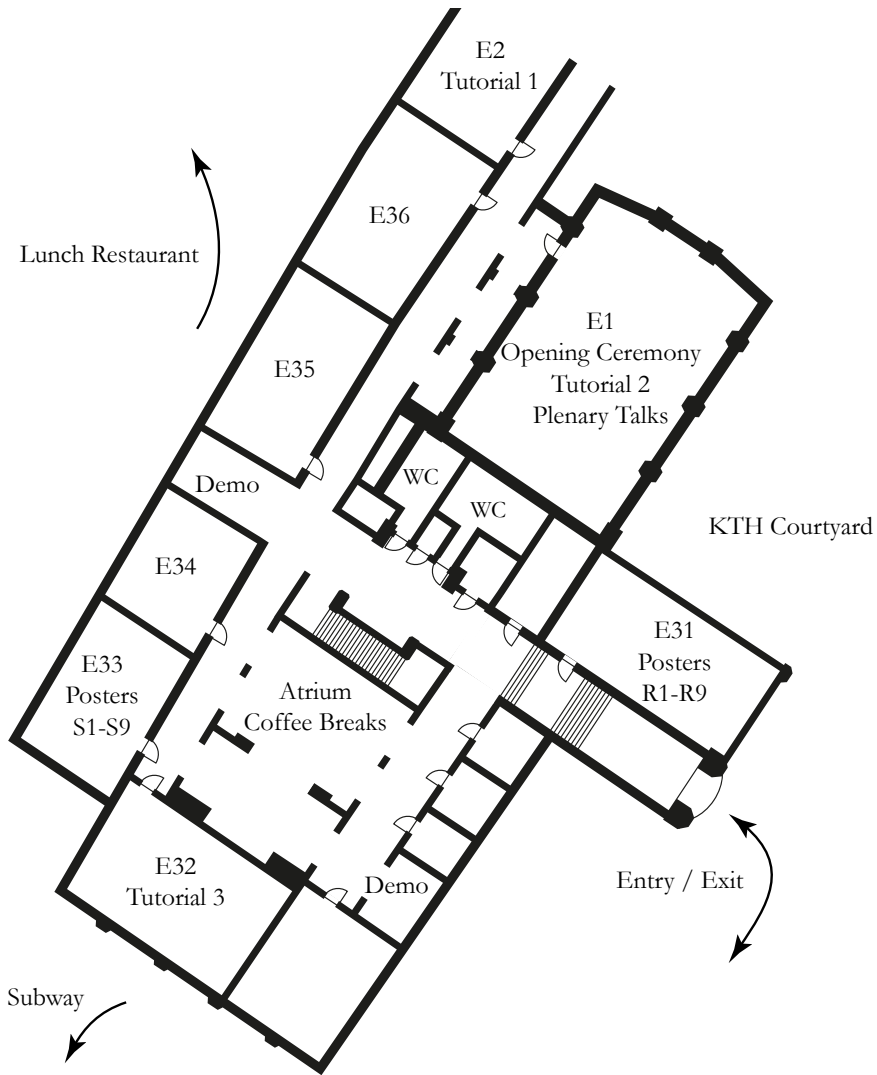
- 08:30 - 09:00 Registration
- 09:00 - 10:00 **Plenary 4** - Cooperative Radar and Communications Signaling (Bliss)
- 10:00 - 11:15 **R7** - Estimation  
**S7** - Satellite Communications
- 11:15 - 11:30 Coffee break
- 11:30 - 12:45 **R8** - Cooperative Communications and Multi-user Networks  
**S8** - Joint Analog Source-Channel Coding
- 12:45 - 14:00 Lunch
- 14:00 - 15:00 **Plenary 5** - 5G The Ultimate Wireless Platform (Doppler)
- 15:00 - 16:15 **R9** - Interference Modeling and Management  
**S9** - Proximal Communications for 5G: D2D Caching and Contextualization

# Maps

## KTH Campus



# Workshop Venue





# A Letter from the Chairs

**Dear SPAWC 2015 participant,**

On behalf of the organization committee, it is our great pleasure to welcome you to KTH Royal Institute of Technology, in Stockholm Sweden, for the 16th IEEE International Workshop on Signal Processing Advances in Wireless Communications, SPAWC 2015. We are looking forward to hosting the world's leading expertise in signal processing for communications and networking and to have the opportunity to share recent research advances with you during the event.

Building on the tradition and success of previous SPAWCs, the workshop features an exciting three-day program of poster presentations and plenary talks, started off by three tutorials on timely topics. The workshop program spans a diverse set of topics related to signal processing for communications. However, as a sign of the times, the clearest trend in this year's program is, perhaps not surprisingly, 5G and 5G enabling technologies. This trend is reflected in the plenary talks, in the tutorials, in the special sessions as well as in the regular sessions.

The community has shown great interest to contribute to SPAWC 2015 with a total of 154 submitted papers to the open track, of which 88 have been accepted into the program, along with 52 invited special session papers. We wish to especially express our gratitude to our Technical Co-Chairs Mats Bengtsson and Visa Koivunen, for their

hard work in putting together a high quality technical program, naturally with help from the Special Session Chairs and the many Special Session Organizers, the Plenary Chair and the Plenary Speakers, the Tutorial Chair and the Tutorial Speakers, and the many authors that have contributed to the program. We also wish to acknowledge the reviewing work by the SPCOM Technical Committee members, facilitated by the highly sophisticated review assignment algorithm designed by Efthymios Tsakonas and Nikos Sidiropoulos, and the hard work by all the organizing committee members.

At the time of writing, we have a total of 163 registered participants joining us to make this a successful event. Several people and organizations have stepped up to support this year's SPAWC. We are very grateful to our Gold Sponsors, Qamcom and Ericsson, and to our Silver Sponsor ACCESS. A special thanks goes to the City of Stockholm, who very generously offered to host the welcome reception in the City Hall. Finally, we wish to thank our student volunteers (Marie, Pol, Arash, Arun, Efthymios, and Hadi) for their help, Cecilia Ljunglöf at KTH Meetings and Events for all her helpful advice and for managing most of the local arrangements at KTH, Clary Rapp of Visit Stockholm for her input to the workshop proposal, Raine Tiivel for her financial administrative support, and Tim Davidson and Min Dong for generously sharing their experience gained during SPAWC 2014.

The weeks following midsummer are normally the best days of the year to experience Sweden, and we hope that you will take the time to also enjoy Stockholm and Sweden during your stay.

Joakim Jaldén and Björn Ottersten, General Chairs



# Organizing Committee

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Magnus Jansson (KTH Royal Institute of Technology, Sweden)

KTH Meetings and Events

### **Technical Program Committee**

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Shi Jin (Southeast University, China)  
Yindy Jing (University of Alberta, Canada)  
Erik Larsson (Linköping University, Sweden)  
Amir Leshem (Bar-Ilan University, Israel)  
David Love (Purdue University, IN, USA)  
Wing-Kin (Ken) Ma (The Chinese University of Hong Kong, Hong Kong)  
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# Sponsors

## Organizers and Technical Sponsors



## Welcome Reception Sponsor



## Gold Sponsors



## Silver Sponsor



## Host University



# Tutorials and Plenary Talks

# Tutorial 1



## Millimeter Wave Wireless Communications

Robert W. Heath Jr. (The University of Texas at Austin, USA)

Monday June 29, 09:00-12:30, Room E2

### Summary

Communication at millimeter wave (mmWave) frequencies is defining a new era of wireless communication. The mmWave band relieves spectral gridlock at lower frequencies by offering much higher bandwidth communication channels than presently used in commercial wireless systems. The next generation of wireless local area networks is exploiting the mmWave unlicensed band at 60 GHz to provide multi-gigabit-per-second data rates. There is also growing interest in using mmWave licensed spectrum for 5G cellular systems at other mmWave frequencies. The potential for mmWave is immense.

Signal processing is critical for enabling the next generation of mmWave communication. Because of the wide bandwidth, overall complexity and mixed signal power consumption are significant concerns. This motivates developing MIMO signal processing techniques for example that operate with few high resolution or many low-resolution analog-to-digital converters. The propagation channel characteristics lead to sparsity in the channel, which can be exploited in channel estimation, signal detection, and equalization. System analysis of mmWave wireless systems is more complicated due to the use of compact antennas, sensitivity to blockages, and distance dependent propagation effects. Because of the higher carrier frequencies, supporting mobility becomes a significant challenge requirement the development of time-varying signal processing techniques such as rapid beam adaptation.

This tutorial will provide an overview of mmWave wireless communication from a signal processing perspective. Note that this will not be a review of contents from the author's book, which has a lot of background on propagation and circuits. Rather it will emphasize more specific lines of research inquiry of interest to signal processing researchers especially those working on MIMO communication and array processing.

### Biography

**Robert W. Heath Jr.** (IEEE Fellow) received the B.S. and M.S. degrees from the University of Virginia, Charlottesville, VA, in 1996 and 1997 respectively, and the Ph.D. from Stanford University, Stanford, CA, in 2002, all in electrical engineering. From 1998 to 2001, he was a Senior Member of the Technical Staff then a Senior Consultant at Iospan Wireless Inc, San Jose, CA where he worked on the design and implementation of the physical and link layers of the first commercial MIMO-OFDM communication system. Since January 2002, he has been with the Department of

Electrical and Computer Engineering at The University of Texas at Austin where he is a Cullen Trust for Higher Education Endowed Professor, and is a Member of the Wireless Networking and Communications Group. He is also President and CEO of MIMO Wireless Inc. and Chief Innovation Officer at Kuma Signals LLC. His research interests include several aspects of wireless communication and signal processing: limited feedback techniques, multihop networking, multiuser and multicell MIMO, interference alignment, adaptive video transmission, manifold signal processing, and millimeter wave communication techniques. He is a co-author of the book “Millimeter Wave Wireless Communications” published by Prentice Hall in 2014.

Dr. Heath has been an Editor for the IEEE Transactions on Communication, an Associate Editor for the IEEE Transactions on Vehicular Technology, lead guest editor for an IEEE Journal on Selected Areas in Communications special issue on limited feedback communication, lead guest editor for an IEEE Journal on Selected Topics in Signal Processing special issue on Heterogeneous Networks, and lead guest editor for an IEEE Journal on Selected Topics in Signal Processing special issue on Millimeter Wave Wireless Communication. He currently serves on the steering committee for the IEEE Transactions on Wireless Communications. He was a member of the Signal Processing for Communications Technical Committee in the IEEE Signal Processing Society and is a former Chair of the IEEE COMSOC Communications Technical Theory Committee. He was a technical co-chair for the 2007 Fall Vehicular Technology Conference, general chair of the 2008 Communication Theory Workshop, general co-chair, technical co-chair and co-organizer of the 2009 IEEE Signal Processing for Wireless Communications Workshop, local co-organizer for the 2009 IEEE CAMS-AP Conference, technical co-chair for the 2010 IEEE International Symposium on Information Theory, the technical chair for the 2011 Asilomar Conference on Signals, Systems, and Computers, general chair for the 2013 Asilomar Conference on Signals, Systems, and Computers, founding general co-chair for the 2013 IEEE GlobalSIP conference, and was technical co-chair for the 2014 IEEE GLOBECOM conference.

Dr. Heath was a co-author of best student paper awards at IEEE VTC 2006 Spring, WPMC 2006, IEEE GLOBECOM 2006, IEEE VTC 2007 Spring, and IEEE RWS 2009, as well as co-recipient of the Grand Prize in the 2008 WinTech WinCool Demo Contest. He was co-recipient of the 2010 and 2013 EURASIP Journal on Wireless Communications and Networking best paper awards, the 2012 Signal Processing Magazine best paper award, a 2013 Signal Processing Society best paper award, the 2014 EURASIP Journal on Advances in Signal Processing best paper award, and the 2014 Journal of Communications and Networks best paper award. He was a 2003 Frontiers in Education New Faculty Fellow. He is also a licensed Amateur Radio Operator and is a registered Professional Engineer in Texas.

# Tutorial 2



## Massive MIMO for 5G: Fundamentals and Recent Theory

Erik G. Larsson (Linköping University, Sweden)

Emil Björnson (Linköping University, Sweden)

Monday June 29, 09:00-12:30, Room E1

### Summary

The next generation wireless networks need to accommodate 1000x more data traffic than contemporary networks. Since the spectrum is scarce in the bands suitable for coverage, the main improvements need to come from spatial reuse of spectrum; many concurrent transmissions per area unit. This is made possible by the massive MIMO technology, where the access points are equipped with hundreds of antennas. These antennas are phase-synchronized and can thus radiate the data signals to multiple users such that each signal only adds up coherently at its intended user.

Over the last the couple of years, massive MIMO has gone from being a theoretical concept to becoming one of the most promising ingredients of the emerging 5G technology. This is because it provides a way to improve the area spectral efficiency (bit/s/Hz/area) under realistic conditions, by upgrading existing base stations. In other words, massive MIMO is a commercially attractive solution since 100x higher efficiency is possible without installing 100x more base stations.

This tutorial introduces the basic communication theory and motivation behind massive MIMO, as well as recent theoretical results on power control, energy efficiency, and impact of hardware impairments.

### Biographies

**Erik G. Larsson** is Professor and Head of the Division for Communication Systems in the Department of Electrical Engineering (ISY) at Linköping University (LiU) in Linköping, Sweden. He joined LiU in September 2007. He has previously held positions at the Royal Institute of Technology (KTH) in Stockholm, University of Florida, George Washington University (USA), and Ericsson Research (Stockholm). He received his Ph.D. from Uppsala University in 2002.

His main professional interests are within the areas of wireless communications and signal processing. He has published some 100 journal papers on these topics, he is co-author of the textbook *Space-Time Block Coding for Wireless Communications* (Cambridge Univ. Press, 2003) and he holds 10 issued and many pending patents on wireless technology.

He is Associate Editor for the IEEE Transactions on Communications and he has previously been Associate Editor for several other IEEE journals. He serves as vice chair of the IEEE Signal Processing Society SPCOM technical committee in 2014. He also serves as chair of the steering committee for the IEEE Wireless Communications Letters in 2014-2015. He is active in conference organization, most recently as the General Chair of the Asilomar Conference on Signals, Systems and Computers 2015 (he was Technical Chair in 2012).

**Emil Björnson** is Assistant Professor at the Division of Communication Systems at Linköping University, Sweden. He received the M.S. degree in Engineering Mathematics from Lund University, Sweden, in 2007. He received the Ph.D. degree in Telecommunications from the Department of Signal Processing at KTH Royal Institute of Technology, Stockholm, Sweden, in 2011. From 2012 to July 2014, he was a joint postdoc at the Alcatel-Lucent Chair on Flexible Radio, Supélec, Paris, France, and the Department of Signal Processing at KTH Royal Institute of Technology.

His research interests include multi-antenna cellular communications, massive MIMO techniques, radio resource allocation, green energy efficient systems, and network topology design. He is the first author of the book “Optimal Resource Allocation in Coordinated Multi-Cell Systems” published in Foundations and Trends in Communications and Information Theory, 2013. He is also dedicated to reproducible research and has made a large amount of simulation code publicly available.

Dr. Björnson has received 4 best paper awards (as first author or co-author) for novel research on optimization and design of multi-cell multi-antenna communications: IEEE WCNC 2014, IEEE SAM 2014, IEEE CAMSAP 2011, and WCSP 2009.



# Tutorial 3



## MIMO Broadcast and Interference Channels Towards 5G: Feedback, Performance and Topological Considerations

Petros Elia (EURECOM, France)

Dirk Slock (EURECOM, France)

Monday June 29, 09:00-12:30, Room E32

### Summary

There is general consensus that any attempt to meaningfully improve the current performance of wireless communications, must surpass two fundamental challenges; the challenge of inventing communication schemes that properly manage interference, and the challenge of efficiently disseminating and utilizing feedback that may be delayed and imperfect. In the center of this effort, are revolutionary new algorithms that employ multiple antennas; an approach that continues to offer paradigm shifts in wireless communications and penetrate its standards.

The tutorial will provide an overview of the latest efforts to design such new schemes that manage to handle multiuser interference, as well as the latest efforts in understanding and meeting the fundamental learning-vs-using tradeoff; i.e., the latest efforts on finding ways to manage interference in the presence of reduced and delayed feedback. In the process, the tutorial will touch upon many new methods used over many different settings relating to multi-user (MU) MIMO in single and multiple cells, and hetnets. We elaborate on the design of spatial(-temporal) communication schemes, the concepts of signal space/scale Interference Alignment (IA), (Delayed) Channel State Information at the Transmitter (D-CSIT), channel training and feedback overhead, ergodic and retrospective IA, as well as summarize the latest results on topological interference networks, where we will consider the effect of imperfect CSI in topological interference networks where link strengths are affected by many topological factors.

This tutorial will focus on providing an insightful exposition of the latest exciting findings, as well as will place heavy emphasis on exposing new challenges and open questions on the role of feedback in modern and envisioned multiuser wireless communications, focusing on broadcast and interference channels.

### Biographies

**Petros Elia** received the B.Sc. degree from the Illinois Institute of Technology, and the M.Sc. and Ph.D. degrees in electrical engineering from the University of Southern California (USC), Los Angeles, in 2001 and 2006 respectively. Since February 2008 he has been an Assistant Professor with the Department of Mobile Communications at EURECOM in Sophia Antipolis, France.

His latest research deals with the role of feedback and complexity in multiuser communications, MIMO, cooperative and multiple access protocols and transceivers, complexity of communication, as well as with isolation and connectivity in dense networks, queueing theory and cross-layer design, coding theory, information theoretic limits in cooperative communications, and surveillance networks. He is a Fulbright scholar, the co-recipient of the SPAWC-2011 best student paper award on the topic of reduced complexity bidirectional communication with limited feedback, and of the NEWCOM++ distinguished achievement award 2008-2011 for a sequence of publications on the topic of reduced complexity multimode communications in the presence of little or no feedback.

**Dirk T. M. Slock** received an engineering degree from the University of Gent, Belgium in 1982. In 1984 he was awarded a Fulbright scholarship for Stanford University, USA, where he received the MSEE, MS in Statistics, and PhD in EE in 1986, 1989 and 1989 resp. While at Stanford, he developed new fast recursive least-squares algorithms for adaptive filtering. In 1989-91, he was a researcher at the Philips Research Laboratory Belgium. In 1991, he joined EURECOM where he is now professor. At EURECOM, he teaches statistical signal processing (SSP) and signal processing techniques for wireless communications. He invented semi-blind channel estimation, the chip equalizer-correlator receiver used by 3G HSDPA mobile terminals, spatial multiplexing cyclic delay diversity (MIMO-CDD) now part of LTE, and his work led to the Single Antenna Interference Cancellation (SAIC) concept used in GSM terminals. In 2000, he cofounded SigTone, a start-up developing music signal processing products. He has also been active as a consultant on xDSL, DVB-T and 3G systems. He is the (co)author of over 400 technical papers. He received one best journal paper award from IEEE-SP and one from EURASIP in 1992. He is the coauthor of two IEEE Globecom'98, one IEEE SIU'04 and one IEEE SPAWC'05 best student paper award, and a honorary mention (finalist in best student paper contest) at IEEE SSP'05, IWAENC'06 and IEEE Asilomar'06. He was an associate editor for the IEEE-SP Transactions in 1994-96 and the IEEE Signal Processing Letters and EURASIP Signal Processing in 2009-10. He is an editor for the EURASIP Journal on Advances in Signal Processing (JASP). He was a member of the IEEE-SPS Awards Board 2011-13 and currently of the EURASIP JWCN Awards Committee. He was the General Chair of the IEEE-SPS SPAWC'06 and IWAENC'14 workshops, and the upcoming EUSIPCO'15. He is a Fellow of the IEEE and of EURASIP.

# Plenary 1



## 5G for the Networked Society

Sara Mazur (Ericsson, Sweden)

Monday June 29, 14:15-15:15, Room E1

### Abstract

The digitalization and mobility provided by ICT are key enablers for the transformation of industries and society. It is essential to provide efficient and highly capable solutions for the connectivity requirements that we anticipate in the coming years. The development of the 5G concept is done in parallel with design of test beds and the key technology components are identified.

### Biography

**Sara Mazur** is Vice President and Head of Research at Ericsson.

Prior to taking up this position, Mazur was Head of System Management within Ericsson's Business Unit Networks, focusing on unit-wide technology and research coordination and strategic management of technologies, a post she held since 2007. Mazur has worked throughout her career on advanced technology to strengthen Ericsson's technical excellence. She started at Ericsson Research in 1995 and has since held many management positions in the group that have kept her very close to the development of the telecommunications industry.

Mazur holds a Master's degree in science and a Ph.D. in electrical engineering from the KTH Royal Institute of Technology in Sweden. She is also an appointed Associate Professor in Fusion Plasma Physics in the same institute.

Mazur is the inventor of 69 granted patents and has authored several journal articles in international physics journals and conference papers on international conferences. She is the co-author of the book Handbook of antennas in wireless communication. She maintains close ties with several universities and is a member of the strategic advisory board of the School of Electrical Engineering in the KTH Royal Institute of Technology in Sweden and member of Royal Swedish Academy of Engineering Sciences (IVA) on Education and Research. Mazur is since 2013 a member of the Board of Directors of Saab AB.



## On Pilot Contamination in Massive MIMO

Wolfgang Utschick (Technische Universität München, Germany)

Tuesday June 30, 09:00-10:00, Room E1

### Abstract

Massive MIMO is a promising technology for the next generation of cellular wireless networks. The idea is basically to deploy a large number of antennas at each base station such that the number of antennas is at least an order of magnitude larger than the number of simultaneously served users. As a desired consequence the resulting array gain leads to an increased energy efficiency and, more importantly, for a typical wireless channel, the large number of antennas leads to approximately orthogonal channel vectors for two different users due to the law of large numbers. This enables robust spatial multiplexing with simple signal processing methods. For perfect channel state information, the typical interference phenomena are negligible due to the mentioned mutual orthogonality of channel vectors. However, for a block fading channel model with limited coherence time and frequency, the limited number of available channel accesses per channel realization results in a dimensionality bottleneck. This dimensionality bottleneck gives rise to the pilot contamination effect which has been observed in the classical massive MIMO setup. Pilot contamination describes the interference in the channel estimates obtained in the uplink that is caused by the fact that the number of channel accesses in one coherence block is too small to give every user an orthogonal training sequence. The interference in the channel estimates in turn leads to interference during data transmission, which ultimately limits the performance of a massive MIMO system even for an unlimited number of antennas at each base station. Fortunately, this is not the final word on massive MIMO, however, since the typical rich channel structure in massive MIMO scenarios can be taken into account to mitigate the undesired consequences of pilot contamination. In this talk, we discuss two directions how to suppress or at least to lessen the detrimental effects of pilot contamination. To this end, we firstly introduce novel blind and semi-blind channel estimation methods for cellular time-division duplexing systems. The methods are based on the maximum a-posteriori principle given a prior for the distribution of the channel vectors and the received signals from the uplink training and data phases. Contrary to the state-of-the-art massive MIMO channel estimators, the proposed se-

*Continued on page 20*

mi-blind method efficiently suppresses most of the interference caused by pilot-contamination. In the second part of the talk, we show how to push the limits of massive MIMO systems by exploiting the statistical properties of the channels. We propose a novel precoding approach for massive MIMO systems, which extends the conventional pilot contamination precoding idea. To this end, we introduce an additional precoding stage, which is independent of the instantaneous CSI, but depends solely on channel distribution information. The proposed technique completely removes the interference caused by pilot contamination. Simulations results will show the effectiveness of this technique for a pilot contamination limited massive MIMO systems.

### **Biography**

**Wolfgang Karl Utschick** completed several accredited industrial training programs in electronics before he received the diploma and doctoral degrees in electrical engineering, both with honors, from Technische Universität München (TUM). In 2002 he has been appointed Professor at TUM where he is director of the Fachgebiet Methoden der Signalverarbeitung (Signal Processing). Wolfgang teaches courses on Signal Processing, Stochastic Processes, and Optimization Theory in the field of Wireless Communications and Signal Processing applications. Since 2011 he is serving as a regular guest professor at Singapore's new autonomous university, Singapore Institute of Technology (SIT). He holds some 20 patents in the field of multiantenna signal processing and has authored and co-authored more than 300 technical articles in international journals and conference proceedings. He edited several books and is founder and editor of the Springer book series "Foundations in Signal Processing, Communications and Networking". Dr. Utschick has been Principal Investigator in multiple research projects funded by the German Research Fund (DFG). He is currently the coordinator and spokesman of the national DFG priority program "Communications over Interference limited Networks" (COIN) which is dedicated to topics as cooperative communications, crosslayer design, ad-hoc wireless networks, etc. He is a member of the VDE and senior member of the IEEE, where he serves as an elected member for the IEEE Signal Processing Society Technical Committee on Signal Processing for Communications and Networking since 2010 during his second term. He has been serving a full term as chairman of the deans of study affairs at TUM, and since 2011 he is member of the steering committee of the Department for Electrical and Computer Engineering at TUM.



## **One Decade of 'Sensorless Sensing': Wireless Networks as Human Context Sensors**

Neal Patwari (University of Utah, USA)

Tuesday June 30, 14:00-15:00, Room E1

### **Abstract**

Standard radio transceivers make radio channel measurements which change due to the movements of people; thus a deployed wireless network can be used as a “sensorless sensor” to estimate the locations, activities, and gestures of people in the area in which the devices are deployed. The term was coined in 2006 by Woyach, Puccinelli, and Haenggi to describe how a wireless sensor network serves as a sensor even if no specific sensors are attached to the wireless devices. The area is also referred to as “device-free” because the people being sensed carry no radio device. In the past decade of sensorless sensing, a variety of experimental research has shown that people can be located with sub-meter accuracies, their activities, poses, and gestures they are performing can be distinguished from each other, and their breathing rate estimated. The results have application in health care, security, logistics, and in general in context aware computing. We describe the progress that has been made in exploiting channel measurements for human context sensing and the significant open challenges that remain.

### **Biography**

**Neal Patwari** received the B.S. (1997) and M.S. (1999) degrees from Virginia Tech, and the Ph.D. from the University of Michigan, Ann Arbor (2005), all in Electrical Engineering. He was a research engineer in Motorola Labs, Florida, between 1999 and 2001. Since 2006, he has been at the University of Utah, where he is an Associate Professor in the Department of Electrical and Computer Engineering, with an adjunct appointment in the School of Computing. He directs the Sensing and Processing Across Networks (SPAN) Lab, which performs research at the intersection of statistical signal processing and wireless networking. Neal is the Director of Research at Xandem, a RF sensing technology company. His research interests are in radio channel signal processing, in which radio channel measurements are used to benefit security, networking, and localization applications. He received the NSF CAREER Award in 2008, the 2009 IEEE Signal Processing Society Best Magazine Paper Award, the 2011 University of Utah Early Career Teaching Award, and best paper awards at SenseApp 2012 and IPSN 2014.

# Plenary 4



## Cooperative Radar and Communications Signaling

Daniel W. Bliss (Arizona State University, USA)

Wednesday July 1, 09:00-10:00, Room E1

### Abstract

Historically, radar and radio operations have been adversarial. Because each system typically considers the other to be a source of unacceptable interference, the systems are traditionally allocated independent spectrum in any given region of space. Consequently, these systems compete for scarce spectral resources. As the demand for wireless communications has increased, the competition between the systems has become more raucous.

Fundamentally, we challenge the premise that these systems should be adversarial. By blurring the line between radar and communications systems, the performance of both systems can be improved potentially. One simple example is the parasitic radar, which is sometimes denoted a passive or “green” radar. In this example, a communications broadcast signal is employed as a radar illuminator. There are a variety of limits to this approach. First, the “radar” receiver has to construct a reference of the broadcast signal. Second, the communications system parameters may not have the most desirable characteristics for radar performance. Despite these concerns, this limited approach is a useful example of significant potential performance improvements as a radar capability is enabled in a spectral allocation where none existed previously.

We suggest a more fundamental level of cooperation for which the distinction between nodes traditionally identified as radar and radio is removed. A simple example, is using the “radar” as a communication relay. We suggest a joint estimation and communication RF energy employment that is cognitive in a more general sense than is used typically. This suggestion invites the investigation of the fundamental limits of performance for these joint systems.

Immediately, the question of specific metrics for joint performance presents itself. Communications systems can be characterized by a number of metrics, including latency and data rate. Radar systems are often characterized by detection and estimation performance. Combining these metrics to produce a joint performance metric is an open area of research.

In our research, we investigate system concepts and the fundamental bounds on joint radio and radar performance by using an analogy to the communications multiple-access channel. We propose a novel joint estimation and information theoretic bound

formulation for a receiver that observes communications and radar return in the same frequency allocation. To enable this joint bound, we construct a novel metric, which we denote estimation rate. The joint performance bound is presented in terms of bounding surfaces for the communications rate and estimation rate of the system.

In this talk, we present an overview of the current state of research for joint communications and radar operation with an emphasis on joint performance bounds. We also identify opportunities for future research directions.

## Biography

**Daniel W. Bliss** is an Associate Professor in the School of Electrical, Computer and Energy Engineering at Arizona State University. Dan received his Ph.D. and M.S. in Physics from the University of California at San Diego (1997 and 1995), and his B.S. in Electrical Engineering from Arizona State University (1989). His current research topics include statistical signal processing, multiple-input multiple-output (MIMO) wireless communications, MIMO radar, cognitive radio and radar systems, radio network performance bounds, geolocation techniques, channel phenomenology, and signal processing and machine learning for anticipatory physiological monitoring. Dan has been the principal investigator on numerous programs with applications to radio, radar, and medical monitoring. He has made significant contributions to robust multiple-antenna communications including important theoretical results, multiple patents, and the development of advanced fieldable prototype systems. He is responsible for some of the foundational MIMO radar literature, and was the principal investigator on an airborne ground moving target indicator (GMTI) MIMO radar program that demonstrated experimentally the validity of the theoretical results.

Before moving to ASU, Dan was a senior member of the technical staff at MIT Lincoln Laboratory (1997-2012) in the Advanced Sensor Techniques group, where he performed research in the areas of communications, radar, and anticipatory physiological monitoring. Between his undergraduate and graduate degrees Dan was employed by General Dynamics (1989-1991), where he designed avionics for the Atlas-Centaur launch vehicle, and performed research and development of fault-tolerant avionics. As a member of the superconducting magnet group at General Dynamics (1991-1993), he performed magnetic field calculations and optimization for high-energy particle-accelerator superconducting magnets. His doctoral work (1993-1997) was in the area of high-energy particle physics, searching for bound states of gluons, studying the two-photon production of hadronic final states, and investigating innovative techniques for lattice-gauge-theory calculations. He has published a graduate-level textbook on adaptive wireless communications, has published over 80 technical articles and conference papers, and he received the Best Lecture Award for his 2008 Tri-Service Radar paper that discussed MIMO radar. He is a Fellow of the IEEE.



# Plenary 5



## 5G The Ultimate Wireless Platform

Klaus Doppler (Nokia Research Center, USA)

Wednesday July 1, 09:00-10:00, Room E1

### Abstract

Cellular networks have evolved from a voice centric design to a wireless platform for a diverse set of applications. The evolution of 4G/LTE will support operation in licensed as well as unlicensed band, direct communications between devices and machine type communication with up to 10 years of battery life. 5G will be the next major wireless standard extending the success story of 4G/LTE. It will power 50bn+ connected devices and enable for example extreme mobile broadband, tactile internet experience and mission critical communication to autonomous vehicles. Key performance targets include peak data rates beyond 10Gbps and latency below 1ms. In this plenary talk we will introduce the motivation for 5G, example use cases and the main design parameters. We will also present key technology enablers, the 5G ecosystem and its expected timeline. We will put a special emphasize on Device-to-Device communications.

### Biography

**Klaus Doppler** is heading the Radio Communications research in Nokia LABS, part of Nokia Technologies. His team is responsible for the 3GPP LTE, WLAN and 5G research and standardization of Nokia Technologies and explores new opportunities in radio implementation. In the past he has been leading the Wireless Systems team at Nokia Research Center in Berkeley, CA which contributed to IEEE802.11ah standardization and to the establishment of a new business line in Nokia Technologies. He led and contributed to several research activities on the design and integration of novel radio concepts into wireless systems, including device-to-device communication, (cooperative) relaying and multiband operation. He received several inventor awards at Nokia between 2007 and 2011. Klaus received his PhD. from Helsinki University of Technology, Finland in 2010 and his MSc. in Electrical Engineering from Graz University of Technology, Austria in 2003. He has more than 75 pending and granted patent applications and he has published 30 journal and conference publications and book chapters.

# Poster Sessions

# Regular Session R1

## Energy Efficiency and Energy Harvesting

Monday June 29, 15:15-16:30, Room E31

- R1.1 **Budget Constrained Small Cell Deployment Planning for Heterogeneous LTE Networks**  
Florian Bahlke (TU Darmstadt, Germany); Oscar Dario Ramos-Cantor (Technische Universität Darmstadt & Telekom Innovation Laboratories, Germany); Marius Pesavento (Technische Universität Darmstadt, Germany)
- R1.2 **Online Power Control Strategy for Wireless Transmission with Energy Harvesting**  
Fatemeh Amirnavaei and Min Dong (University of Ontario Institute of Technology, Canada)
- R1.3 **Competitive Design of Energy Harvesting Communications in Wireless Fading Channels**  
Jesús Gómez-Vilardebò (CTTC, Spain)
- R1.4 **Energy Efficient Precoding for MIMO Cyclic Prefixed Single Carrier Communications**  
Jeevan Shrestha and Ivan Stupia (Université Catholique de Louvain, Belgium); Luc Vandendorpe (University of Louvain, Belgium)
- R1.5 **Secrecy Energy Efficiency Optimization for MISO and SISO Communication Networks**  
Ashkan Kalantari (University of Luxembourg, The Interdisciplinary Centre for Security, Reliability and Trust (SnT), Luxembourg); Sina Maleki (University of Luxembourg & The Interdisciplinary Centre for Security, Reliability and Trust (SnT), Luxembourg); Symeon Chatzinotas (University of Luxembourg, Luxembourg); Björn Ottersten (University of Luxembourg, Luxembourg)
- R1.6 **Time-Dependent Analysis of Transmission Process in a Wireless Sensor Network with Energy Saving Mechanism Based on Threshold Waking Up**  
Wojciech M. Kempa (Silesian University of Technology, Poland)
- R1.7 **Optimal Design of Energy-Efficient Cooperative WSNs: How many sensors are needed?**  
Stefan Mijovic (University of Bologna, Italy); Luca Sanguinetti (University of Pisa & SUPELEC, Italy); Chiara Buratti (University of Bologna, Italy); Mérouane Debbah (Supelec, France)

- R1.8     **Energy efficient symbol-level precoding in multiuser MISO channels**  
Maha Alodeh (SnT, Luxemburg); Symeon Chatzinotas (University of Luxembourg, Luxemburg); Björn Ottersten (University of Luxembourg, Luxemburg)
- R1.9     **Opportunistic D2D Communication in Energy Harvesting Heterogeneous Cellular Network**  
Howard Yang (Singapore University of Technology and Design, Singapore); Jemin Lee (Singapore University of Technology and Design (SUTD), Singapore); Tony Q. S. Quek (Singapore University of Technology and Design, Singapore)
- R1.10    **On the Feasibility of Wireless Energy Transfer Using Massive Antenna Arrays in Rician Channels**  
Salil Kashyap, Emil Björnson and Erik G. Larsson (Linköping University, Sweden)

# Special Session S1

## 5G Waveforms

Monday June 29, 15:15-16:30, Room E33

### Session Organizers

Xavier Mestre (Centre Tecnologic de Telecomunicacions de Catalunya, Spain)

Elefterios Kofidis (University of Piraeus, Greece)

- S1.1     **Dual Polarized Modulation and Receivers for Mobile Communications in Urban Areas**  
Pol Henarejos (Centre Tecnologic de Telecomunicacions de Catalunya (CTTC), Spain); Ana Pérez-Neira (CTTC, Spain)
- S1.2     **Subcarrier spacing - a neglected degree of freedom?**  
Frank Schaich (Bell Labs, Alcatel-Lucent AG, Germany); Thorsten Wild (Alcatel-Lucent Bell Labs, Germany)
- S1.3     **Make-It-Real-And-Anticirculating Orthogonal Space-Time Coding for MIMO OFDM/OQAM**  
Dinh-Thuy Phan-Huy (Orange-France Telecom, France); Pierre Siohan (Orange Labs, France); Maryline H elard (INSA Rennes & IETR Institute of Electronics and Telecommunications of Rennes, France)
- S1.4     **Filtered OFDM: A New Waveform for Future Wireless Systems**  
Javad Abdoli and Ming Jia (Huawei Technologies Canada Co., Ltd., Canada); Jianglei Ma (Huawei, Canada)
- S1.5     **Optimized Burst Truncation in Fast-Convolution Filter Bank Based Waveform Generation**  
Juha Yli-Kaakinen and Markku K. Renfors (Tampere University of Technology, Finland)
- S1.6     **Waveform Optimization Using Trapezoidal Pulses for 5G Random Access with Short Message Support**  
Gerhard Wunder (Heinrich-Hertz-Institut, Germany); Saeed Afrasiabi Gorgani (Technical University of Berlin, Germany); Sofiane Sid Ahmed (Heinrich-Hertz-Institut, Germany)

# Regular Session R2

## Coding and Modulation

Monday June 29, 16:45-18:00, Room E31

- R2.1     **Turbo-FSK: a New Uplink Scheme for Low Power Wide Area Networks**  
Yoann Roth (CEA-Leti, France); Jean-Baptiste Doré (CEA, France); Laurent Ros (GIPSA-lab & INPG & CNRS organisation, France); Vincent Berg (CEA LETI, France)
- R2.2     **Compressed Sensing Using Sparse Binary Measurements: A Rateless Coding Perspective**  
Dejan Vukobratović (University of Novi Sad, Serbia); Dino Sejdinovic (University of Oxford, United Kingdom); Aleksandra Pižurica (Ghent University, Belgium)
- R2.3     **Modulation and Coding Schemes Selection for Type-II HARQ in Time-Correlated Fading Channels**  
Nassar Ksairi (Huawei Technologies Co. Ltd., France); Philippe Ciblat (Telecom ParisTech, France)
- R2.4     **Outage Probability of Correlated Binary Source Transmission over Fading Multiple Access Channels**  
Xiaobo Zhou (University of Oulu, Finland); Xin He (Japan Advanced Institute of Science and Technology & University of Oulu, Japan); Markku Juntti (University of Oulu, Finland); Tad Matsumoto (Japan Advanced Institute of Science and Technology, Japan)
- R2.5     **On the Time-Frequency Localisation of 5G Candidate Waveforms**  
Christopher Boyd, Renaud-Alexandre Pitaval and Olav Tirkkonen (Aalto University, Finland); Risto Wichman (Aalto University School of Electrical Engineering, Finland)
- R2.6     **A General Analysis of Cyclic Block Transmultiplexers with Cyclic Convolution**  
Didier Pinchon (Institute of Mathematics, France); Pierre Siohan (Orange Labs, France)
- R2.7     **Are Side-Band Tones Beneficial for PAPR Reduction in FBMC?**  
Khalil Hariss (Lebanese University, Lebanon); Youssef Nasser (American University of Beirut, Lebanon); Haidar ELMokdad (Lebanese University, Lebanon); Karim Youssef Kabalan and Youssef Jaffal (American University of Beirut, Lebanon)

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- R2.8     **A New Waveform Enabling Enhanced QAM-FBMC Systems**  
Yeo Hun Yun (Samsung Electronics, Korea); Chanhong Kim (Samsung Electronics, Co. Ltd., Korea); Kyeongyeon Kim, Zuleita Ka Ming Ho, Byunghwan Lee and Ji-Yun Seol (Samsung Electronics, Korea)
- R2.9     **Adaptive Interlaced Space-Time Transmission**  
Majid Nasiri Khormuji (Huawei Technologies Sweden, Sweden)
- R2.10    **Separability of Parallel Gaussian MIMO Broadcast Channels with Shaping Constraints**  
Christoph Hellings and Wolfgang Utschick (Technische Universität München, Germany)

# Special Session S2

## Signal Processing for Millimeter Wave Communication Systems

Monday June 29, 16:45-18:00, Room E33

### Session Organizers

Robert Heath (The University of Texas, USA)

Nuria Gonzalez Prelcic (Universidade Vigo, Spain)

- S2.1 **Spectral mask filling for PAPR reduction in large bandwidth mmWave systems**  
Sridhar Rajagopal (Samsung Research America - Dallas, USA); Shadi Abu-Surra (Samsung Research America – Dallas, USA); Jianzhong Zhang (Samsung, USA)
- S2.2 **Hybrid Beamforming with Finite-Resolution Phase Shifters for Large-Scale MIMO Systems**  
Foad Sahrabi and Wei Yu (University of Toronto, Canada)
- S2.3 **On the Performance of Randomly Directional Beamforming Between Line-of-Sight and Rich Scattering Channels**  
Gilwon Lee and Youngchul Sung (KAIST, Korea); Marios Kountouris (Huawei Technologies, France)
- S2.4 **Virtual AoA and AoD Estimation for Sparse Millimeter Wave MIMO Channels**  
Taejoon Kim (City University of Hong Kong, Hong Kong); David Love (Purdue University, USA)
- S2.5 **Dictionary-free Hybrid Precoders and Combiners for mmWave MIMO Systems**  
Roi Méndez-Rial and Cristian Rusu (University of Vigo, Spain); Nuria González-Prelcic (Universidad de Vigo, Spain); Robert Heath (The University of Texas at Austin, USA)





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# Regular Session R3

## Network Design and Performance

Tuesday June 30, 10:00-11:15, Room E31

- R3.1     **Cross-Layer Design of Network-Coded Transmission with a Delay Constraint**  
Jinfeng Du (MIT & KTH (Sweden), USA); David Adams and Muriel Médard (MIT, USA)
- R3.2     **K-Best Branch and Bound Technique for the MINLP Resource Allocation in Multi-User OFDM Systems**  
Youssef Jaffal and Youssef Nasser (American University of Beirut, Lebanon); Yoann Corre (SIRADEL, France); Yves Lostanlen (SIRADEL & University of Toronto, Canada)
- R3.3     **Performance of Rateless Codes in ALOHA WANETs**  
Amogh Rajanna (University of Minnesota, Twin Cities, USA); Itsik Bergel (Bar Ilan University, Israel); Mostafa Kaveh (University of Minnesota, USA)

- R3.4     **Distributed Caching in 5G Networks: An Alternating Direction Method of Multipliers Approach**  
Azary Abboud (Supelec, France); Ejder Baştuğ (CentraleSupélec, France); Kenza Hamidouche and Mériouane Debbah (Supelec, France)
- R3.5     **Delay Analysis of Heterogeneous Cellular Networks**  
Gongzheng Zhang and Aiping Huang (Zhejiang University, P.R. China); Tony Q. S. Quek (Singapore University of Technology and Design, Singapore); Hangguan Shan (Zhejiang University, P.R. China)
- R3.6     **Time and Power Allocation for the Gaussian Wiretap Channel with Feedback of Secret Keys**  
Javier Vía (University of Cantabria, Spain)
- R3.7     **A Semidefinite Relaxation Approach to Mobile Cloud Offloading with Computing Access Point**  
Meng-Hsi Chen and Ben Liang (University of Toronto, Canada); Min Dong (University of Ontario Institute of Technology, Canada)
- R3.8     **Optimal and Suboptimal Routing Based on Partial CSI in Wireless Ad-hoc Networks**  
Yiftach Richter (Bar - Ilan, Israel); Itsik Bergel (Bar-Ilan, Israel)
- R3.9     **Uplink Capacity and User Association for Cooperative Heterogeneous Cellular Networks**  
Zeina Mheich (CEA, France); Antonio De Domenico (CEA-LETI Minatec, France); Valentin Savin (CEA LETI, France)

# Special Session S3

## Massive MIMO

Tuesday June 30, 10:00-11:15, Room E33

### Session Organizer

Wolfgang Utschick (Technische Universität München,, Germany)

- S3.1      **Cell-Free Massive MIMO: Uniformly Great Service For Everyone**  
Hien Quoc Ngo (Linköping University, Sweden); Alexei Ashikhmin (Bell Labs, Alcatel-Lucent, USA); Hong Yang (Bell Labs & Alcatel-Lucent, USA); Erik G. Larsson (Linköping University, Sweden); Tom Marzetta (Bell Labs, USA)
- S3.2      **Adjustable Phase Shift Pilots for Sparse Massive MIMO-OFDM Channels**  
Li You and Xiqi Gao (Southeast University, P.R. China); Lee Swindlehurst (University of California at Irvine, USA); Wen Zhong (Southeast University, P.R. China)
- S3.3      **Energy-Efficient Future Wireless Networks: A Marriage between Massive MIMO and Small Cells**  
Emil Björnson (Linköping University, Sweden); Luca Sanguinetti (University of Pisa & SUPELEC, Italy); Marios Kountouris (Huawei Technologies, France)
- S3.4      **Pilot decontamination using combined angular and amplitude based projections in massive MIMO systems**  
Haifan Yin and Laura Cottatellucci (EURECOM, France); David Gesbert (Eurecom Institute, France); Ralf R. Müller (FAU Erlangen-Nürnberg, Germany); Gaoning He (Huawei Technologies, P.R. China)
- S3.5      **Global EE Optimization of Massive MIMO Systems**  
Wenjia Liu (Beihang University, P.R. China); Alessio Zappone (TU Dresden, Germany); Chenyang Yang (Beihang University, P.R. China); Eduard Jorswieck (TU Dresden, Germany)
- S3.6      **Rate-balancing in Massive MIMO using Statistical Precoding**  
David Neumann, Andreas Gründinger, Michael Joham and Wolfgang Utschick (Technische Universität München, Germany)

# Regular Session R4

## Large-scale MIMO

Tuesday June 30, 11:30-12:45, Room E31

- R4.1 **Pilot Clustering in Asymmetric Massive MIMO Networks**  
Rami Mochaourab (KTH Royal Institute of Technology, Sweden); Emil Björnson (Linköping University, Sweden); Mats Bengtsson (KTH Royal Institute of Technology, Sweden)
- R4.2 **Pilot Beam Sequence Design for Channel Estimation in Millimeter-Wave MIMO Systems: A POMDP Framework**  
Junyeong Seo, Youngchul Sung, Gilwon Lee and Donggun Kim (KAIST, Korea)
- R4.3 **Massive MIMO for Decentralized Estimation over Coherent Multiple Access Channels**  
Amirpasha Shirazinia (Signals & Systems Division, Uppsala University, Sweden); Subhrakanti Dey (Uppsala University, Sweden); Domenico Ciuonzo (University of Naples Federico II, Italy); Pierluigi Salvo Rossi (Norwegian University of Science and Technology, Norway)
- R4.4 **1-Bit Direction of Arrival Estimation based on Compressed Sensing**  
Christoph Stöckle (Munich University of Technology, Germany); Jawad Munir (Technische Universität München, Germany); Amine Mezghani and Josef A. Nossek (TU Munich, Germany)
- R4.5 **Low-complexity Detector for Very Large and Massive MIMO Transmission**  
Yasser Fadlallah (INRIA, France); Abdeldjalil Aïssa-El-Bey (TELECOM Bretagne, France); Karine Amis (Institut Mines Telecom, Telecom Bretagne & Lab-STICC CNRS UMR 6285, France); Dominique Pastor (Ecole Nationale Supérieure des Télécommunications de Bretagne, France)
- R4.6 **The Pathwise MIMO Interfering Broadcast Channel**  
Wassim Tabikh and Dirk Slock (EURECOM, France); Yi Yuan-Wu (Orange Labs, France)
- R4.7 **Multuser MIMO Precoding with Per-Antenna Continuous-Time Constant-Envelope Constraints**  
Christopher Mollén (Linköpings Universitet, Sweden); Erik G. Larsson (Linköping University, Sweden)
- R4.8 **Joint Beamforming and Broadcasting in Massive MIMO**  
Erik G. Larsson (Linköping University, Sweden)

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**R4.9 Multicast Multigroup Beamforming for Per-antenna Power Constrained Large-scale Arrays**

Dimitrios Christopoulos (University of Luxembourg & SnT, Luxemburg); Symeon Chatzinotas (University of Luxembourg, Luxemburg); Björn Ottersten (University of Luxembourg, Luxemburg)

**R4.10 Power-Efficient Beam Sweeping for Initial Synchronization in mm-Wave Wireless Networks**

Igor M Guerreiro (Federal University of Ceara - UFC & Wireless Telecommunications Research Group - GTEL, Brazil); Johan Axnäs (Ericsson Research, Sweden); Dennis Hui (Ericsson Research, USA); Charles Casimiro Cavalcante (Wireless Telecom Research Group - Federal University of Ceará, Brazil)

# Special Session S4

## Recent Advances in Signal Processing for Inband Full-Duplex Radio

Tuesday June 30, 11:30-12:45, Room E33

### Session Organizers

Mikko Valkama (Tampere University of Technology, Finland)

Francisco Monteiro (Instituto de Telecomunicações, Portugal)

- S4.1      **Subspace-Constrained SINR Optimization in MIMO Full-Duplex Relays under Limited Dynamic Range**  
Emilio Antonio-Rodríguez (Aalto University, Finland); Roberto López-Valcarce (Universidad de Vigo, Spain); Taneli Riihonen (Aalto University School of Electrical Engineering, Finland); Stefan Werner (Aalto University, Finland); Risto Wichman (Aalto University School of Electrical Engineering, Finland)
- S4.2      **Digital Self-Interference Cancellation under Nonideal RF Components: Advanced Algorithms and Measured Performance**  
Dani Korpi and Timo Huusari (Tampere University of Technology, Finland); Yang-Seok Choi (Intel, USA); Lauri Anttila (Tampere University of Technology, Finland); Shilpa Talwar (Intel, USA); Mikko Valkama (Tampere University of Technology, Finland)
- S4.3      **Passive Loop Interference Suppression in Large-Scale Full-Duplex Cellular Networks**  
Constantinos Psomas and Ioannis Krikidis (University of Cyprus, Cyprus)
- S4.4      **Full-Duplex MIMO Relaying Powered by Wireless Energy Transfer**  
Mohammadali Mohammadi (Shahrekord University, Iran); Himal A Suraweera (University of Peradeniya, Sri Lanka); Gan Zheng (University of Essex & University of Luxembourg, United Kingdom); Caijun Zhong (Zhejiang University, P.R. China); Ioannis Krikidis (University of Cyprus, Cyprus)
- S4.5      **MU-MIMO Beamforming with Full-duplex Open-loop Training**  
Xu Du and John Tadrous (Rice University, USA); Chris Dick (Xilinx, USA); Ashutosh Sabharwal (Rice University, USA)

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S4.6 **Massive MIMO Full-Duplex Relaying with Optimal Power Allocation for Independent Multipairs**

Francisco A. Monteiro (Instituto de Telecomunicações & ISCTE - University Institute of Lisbon, Portugal); Francisco Rosário (IST, University of Lisbon, Portugal); João S Lemos (Instituto de Telecomunicações/Instituto Superior Técnico, Portugal); António J. Rodrigues (IT / Instituto Superior Técnico, Portugal); João Xavier (I.S.T. - Technical U. Lisbon / I.S.R. Lisbon, Portugal)

# Regular Session R5

## Detection and Receiver Design

Tuesday June 30, 15:00-16:15, Room E31

- R5.1     **Distortion Analysis in OQAM/FBMC-based OFDMA**  
David Gregoratti (Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain); Xavier Mestre (CTTC, Spain)
- R5.2     **On Quantization of Log-Likelihood Ratios for Maximum Mutual Information**  
Andreas Winkelbauer and Gerald Matz (Vienna University of Technology, Austria)
- R5.3     **Detection and Mitigation of False Data Injection Attack in Cooperative Communications**  
Sang Wu Kim (Iowa State University, USA)
- R5.4     **Angle-Of-Arrival-Based Detection of Underwater Acoustic OFDM Signals**  
Alon Amar (RAFAEL, Israel); Yaakov Buchris (Rafael, Israel); Milica Stojanovic (Northeastern University, USA)
- R5.5     **Joint Spectrum Sensing and Direction of Arrival Recovery from sub-Nyquist Samples**  
Shahar Stein, Or Yair and Deborah Cohen (Technion - Israel Institute of Technology, Israel); Yonina C. Eldar (Technion-Israel Institute of Technology, Israel)
- R5.6     **Distributed Cooperative Spectrum Sensing from Sub-Nyquist Samples for Cognitive Radios**  
Deborah Cohen, Alon Akiva and Barak Avraham (Technion - Israel Institute of Technology, Israel); Stacy Patterson (Rensselaer Polytechnic Institute, USA); Yonina C. Eldar (Technion-Israel Institute of Technology, Israel)
- R5.7     **Rate Allocation for Decentralized Detection in Wireless Sensor Networks**  
Alla Tarighati and Joakim Jaldén (KTH Royal Institute of Technology, Sweden)
- R5.8     **Impulsive Noise Mitigation for Wireless OFDM**  
Paolo Banelli (University of Perugia & Università degli Studi di Perugia, Italy); Luca Rugini (University of Perugia, Italy)

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**R5.9 MIMO-based Multitaper Detection over Nakagami Channels for Dynamic Spectrum Access Devices**

Ebtihal H. G. Yousif (Edinburgh University, United Kingdom); Tharmalingam Ratnarajah (The University of Edinburgh, United Kingdom); Mathini Sellathurai (Heriot-Watt University, United Kingdom)

**R5.10 DS-SS Quasi-Optimal Detection under Interference Generated by Computer Platforms**

Pedro A. Roncagliolo (Universidad Nacional de La Plata, Argentina); Javier G García (National University of La Plata, Argentina); Carlos H Muravchik (Universidad Nacional de La Plata, Argentina)

# Special Session S5

## Security, Privacy, and Trust

Tuesday June 30, 15:00-16:15, Room E33

### Session Organizers

Deniz Gunduz (Imperial College London, UK)

Tobias Oechtering (KTH Royal Institute of Technology, Sweden)

- S5.1 **Relay Selection in Wireless Networks for Optimal Delay Anonymity Tradeoff**  
Omid Javidbakht and Parv Venkitasubramaniam (Lehigh University, USA)
- S5.2 **The Individual Secrecy Capacity of the Gaussian SISO and Degraded Gaussian MIMO Multi-Receiver Wiretap Channel**  
Ahmed Mansour (Technische Universität München, Germany); Rafael F. Schaefer (Princeton University, USA); Holger Boche (Technical University Munich, Germany)
- S5.3 **Optimal Privacy-Cost Trade-off in Demand-Side Management with Storage**  
Onur Tan (Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain); Deniz Gündüz (Imperial College London, United Kingdom); Jesús Gómez-Vilardebò (CTTC, Spain)
- S5.4 **Structure of Optimal Privacy-Preserving Policies in Smart-Metered Systems with a Rechargeable Battery**  
Simon Li and Ashish Khisti (University of Toronto, Canada); Aditya Mahajan (McGill University, Canada)
- S5.5 **Secrecy and Energy Efficiency in MIMO-ME Systems**  
Alessio Zappone, Pin-Hsun Lin and Eduard Jorswieck (TU Dresden, Germany)
- S5.6 **Biometrics in Claim-Based Authentication Framework**  
Tanya Ignatenko (Eindhoven University of Technology, The Netherlands)

# Regular Session R6

## Transmitter Optimization

Tuesday June 30, 16:30-17:45, Room E31

- R6.1     **Backhaul-aware Base Station Association in Two-tier Heterogeneous Cellular Networks**  
Gongzheng Zhang (Zhejiang University, P.R. China); Tony Q. S. Quek (Singapore University of Technology and Design, Singapore); Aiping Huang (Zhejiang University, P.R. China); Marios Kountouris (Huawei Technologies, France); Hangguan Shan (Zhejiang University, P.R. China)
- R6.2     **Subspace Estimation and Decomposition for Hybrid Analog-Digital Millimetre-Wave MIMO systems**  
Hadi Ghauch (Royal Institute of Technology (KTH), Sweden); Mats Bengtsson (KTH Royal Institute of Technology, Sweden); Taejoon Kim (City University of Hong Kong, Hong Kong); Mikael Skoglund (KTH Royal Institute of Technology, Sweden)
- R6.3     **Channel Gain Prediction in Wireless Networks Based on Spatial-Temporal Correlation**  
Qi Liao (Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institute, Germany); Stefan Valentin (Bell Labs, Alcatel-Lucent, Germany, France); Slawomir Stanczak (Fraunhofer Heinrich Hertz Institute & Technische Universität Berlin, Germany)
- R6.4     **Weighted LS multiuser channel estimation for LTE**  
Yuriy Zakharov (University of York, United Kingdom); Delai Zheng (Shanghai R&D Institute, Huawei Technologies Co. Ltd, P.R. China)
- R6.5     **On the Distributed Approaches with Imperfect Channel Estimation for MIMO Interference Channel**  
Sinda Smirani (Orange, France); Ahmed Saadani and Yi Yuan-Wu (Orange Labs, France)
- R6.6     **Energy-Efficient Transmit Beamforming for MISO Downlink via Sequential Convex Approximation**  
Oskari Tervo (University of Oulu, Finland); Le-Nam Tran (Maynooth University, Ireland); Markku Juntti (University of Oulu, Finland)

- R6.7     **Precoding Design and User Selection for Multibeam Satellite Channel**  
Ahmad Gharanjik (KTH/ University of Luxembourg & SnT Center, Luxembourg);  
Bhavani Shankar Mysore R (Interdisciplinary Centre for Security, Reliability and  
Trust & University of Luxembourg, Luxembourg); Pantelis-Daniel Arapoglou  
(National Technical University of Athens, Greece); Mats Bengtsson (KTH Royal  
Institute of Technology, Sweden); Björn Ottersten (University of Luxembourg,  
Luxembourg)
- R6.8     **Optimal Power Allocation in Device-to-Device Communication with SIMO  
Uplink Beamforming**  
Ali Ramezani-Kebrya (University of Toronto, Canada); Min Dong (University  
of Ontario Institute of Technology, Canada); Ben Liang (University of Toronto,  
Canada); Gary Boudreau and S. Hossein Seyedmehdi (Ericsson, Canada)
- R6.9     **Linear Transceiver Optimization in Multicell MIMO Based on the  
Generalized Benders Decomposition**  
Rami Mochaourab and Mats Bengtsson (KTH Royal Institute of Technology,  
Sweden)
- R6.10    **WMMSE-based Multiuser MIMO Beamforming: A Practice-Oriented  
Design and LTE System Performance Evaluation**  
Jiaxian Pan and Wing-Kin Ma (The Chinese University of Hong Kong, Hong  
Kong); Xin Xia and Yuan Tian (Huawei Technologies Co., P.R. China)

# Special Session S6

## Signal Processing, Coding, and Information Theory for Optical Communications

Tuesday June 30, 16:30-17:45, Room E33

### Session Organizers

Gerhard Kramer (Technical University of Munich, Germany)

Mansoor Isvand Yousefi (Technical University of Munich, Germany)

Ragnar Thobaben (KTH Royal Institute of Technology, Sweden)

- S6.1     **MIMO Channel Statistics and Signal Processing in Mode-Division Multiplexing Systems**  
Joseph Kahn and Sercan Arik (Stanford University, USA); Keang-Po Ho (SiBEAM, Sunnyvale, CA, USA)
- S6.2     **Digital Backpropagation in the Nonlinear Fourier Domain**  
Sander Wahls (TU Delft, The Netherlands); Son Le (Aston University, United Kingdom); Yaroslav Prylepkiy (Aston University & Aston Institute of Photonic Technologies, United Kingdom); H. Vincent Poor (Princeton University, USA); Sergei Turitsyn (Aston University, United Kingdom)
- S6.3     **Backward Particle Message Passing**  
Henk Wymeersch (Chalmers University of Technology, Sweden); Naga VishnuKanth Irukulapati (Chalmers University of Technology (CTH), Sweden); Isaac Sackey, Pontus Johannisson and Erik Agrell (Chalmers University of Technology, Sweden)
- S6.4     **A Gaussian Noise Model of Spectral Amplitudes in Soliton Communication Systems**  
Qun Zhang and Terence H. Chan (University of South Australia, Australia)
- S6.5     **Spatially Coupled Codes and Optical Fiber Communications: An Ideal Match?**  
Laurent Schmalen (Alcatel-Lucent, Bell Laboratories, Germany); Detlef Suikat and Detlef Rösener (Alcatel-Lucent, Germany); Vahid Aref (Bell Laboratories, Alcatel-Lucent, Germany); Andreas Leven (Alcatel-Lucent, Germany); Stephan ten Brink (University of Stuttgart, Germany)

# Regular Session R7

## Estimation

Wednesday July 1, 10:00-11:15, Room E31

- R7.1     **Uplink-Downlink Channel Transformation Using an Adaptive Kalman filter for Multicarrier Systems**  
Behailu Y. Shikur (University of Rostock, Germany); Tobias Weber (Uni Rostock, Germany)
- R7.2     **Fast Variational Bayesian Learning for Channel Estimation with Prior Statistical Information**  
Evrpidis Karseras (Imperial College London, United Kingdom); Wei Dai (Imperial College, United Kingdom); Linglong Dai and Zhaocheng Wang (Tsinghua University, P.R. China)
- R7.3     **Direction Finding by Complex L1-Principal-Component Analysis**  
Nikolaos Tsagkarakis (The State University of New York at Buffalo, USA); Panos P. Markopoulos (State University of New York at Buffalo, USA); Dimitris A. Pados (The State University of New York at Buffalo, USA)
- R7.4     **A Blind Timing and Frequency Synchronization Method Based on the Correlation Characteristics of an OFDM Signal**  
Youssef El Hajj Shehadeh and Sebastian Baumgartner (Chemnitz University of Technology, Germany); Gangolf Hirtz (Chemnitz University, Germany)
- R7.5     **Direction-of-Arrival Estimation with Single-RF ESPAR Antennas via Sparse Signal Reconstruction**  
Rongrong Qian and Mathini Sellathurai (Heriot-Watt University, United Kingdom); Jonathon A Chambers (Loughborough University, United Kingdom)
- R7.6     **Performance Limitations of Localization Based on Ranging, Speed, and Orientation**  
Carlo Fischione (KTH, Sweden); Alessio De Angelis (University of Perugia, Italy)
- R7.7     **Robust Censoring For Linear Inverse Problems**  
Georg Kail (Delft University of Technology, Austria); Sundeep Prabhakar Chepuri and Geert Leus (Delft University of Technology, The Netherlands)
- R7.8     **DOA Estimation and Array Registration with Joint Sparse Reconstruction Methods**  
Thomas Wiese, Lorenz Weiland and Wolfgang Utschick (Technische Universität München, Germany)

*Continued on page 46*

*Continued from page 45*

**R7.9 Data and Error Rate Bounds for Binary Data Gathering Wireless Sensor Networks**

Xin He (Japan Advanced Institute of Science and Technology & University of Oulu, Japan); Xiaobo Zhou and Markku Juntti (University of Oulu, Finland); Tad Matsumoto (Japan Advanced Institute of Science and Technology, Japan)

**R7.10 Quantization of Compressed Sensing Measurements using Analysis-by-Synthesis with Bayesian-Optimal Approximate Message Passing**

Osman Musa and Norbert Goertz (Vienna University of Technology, Austria)

# Special Session S7

## Satellite Communications

Wednesday July 1, 10:00-11:15, Room E33

### Session Organizers

Bhavani Shankar (University of Luxembourg, Luxembourg)

Sina Maleki (University of Luxembourg, Luxembourg)

- S7.1 **An innovative interference mitigation approach for high throughput satellite systems**  
Màrius Caus (Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain); Ana Perez-Neira (UPC, Spain); Martina Angelone (European Space Agency, The Netherlands); Alberto Ginesi (ESA/ESTEC, The Netherlands)
- S7.2 **A comparison of iterative receivers for the non linear satellite channel**  
Bouchra Benammar (Technological Research Institute (Saint-Exupery), Toulouse, France); Nathalie Thomas (University of Toulouse, France); Charly Poulliat (INP - ENSEEIHT Toulouse, France); Marie-Laure Boucheret (University of Toulouse IRIT Enseeiht, France); Mathieu Dervin (Thales Alenia Space, France)
- S7.3 **Multiuser Detection in Multibeam Satellite Systems: Theoretical Analysis and Practical Schemes**  
Giulio Colavolpe (University of Parma, Italy); Andrea Modenini (European Space Agency, The Netherlands); Amina Piemontese and Alessandro Ugolini (University of Parma, Italy)
- S7.4 **Robust Adaptive Coding and Modulation Scheme for the Mobile Satellite Forward Link**  
Alberto Rico-Alvariño, Anxo Tato and Carlos Mosquera (University of Vigo, Spain)
- S7.5 **On-board Signal Predistortion for Digital Transparent Satellites**  
Nicolò Mazzali (University of Luxembourg, Luxembourg); Bhavani Shankar Mysore R (Interdisciplinary Centre for Security, Reliability and Trust & University of Luxembourg, Luxembourg); Björn Ottersten (University of Luxembourg, Luxembourg)





*Photo: Henrik Trygg / mediabank.visitstockholm.com*

# Regular Session R8

## Cooperative Communications and Multi-user Networks

Wednesday July 1, 11:30-12:45, Room E31

### Papers

- R8.1      **Bi-directional Signaling Strategies for Dynamic TDD Networks**  
Laddu Praneeth Roshan Jayasinghe and Antti Tölli (University of Oulu, Finland); Matti Latva-aho (UoOulu, Finland)
- R8.2      **Stochastic Amplify-and-Forward Schemes for Multigroup Multicast Transmission in a Distributed Relay Network**  
Sissi Xiaoxiao Wu (The Chinese University of Hong Kong, Hong Kong); Qiang Li (University of Electronic Science and Technology of China, P.R. China); Wing-Kin Ma and Anthony Man-Cho So (The Chinese University of Hong Kong, Hong Kong)
- R8.3      **Improving the Degrees of Freedom in MIMO Relay Networks via PHY Caching**  
Wei Han, An Liu and Vincent Lau (Hong Kong University of Science and Technology, Hong Kong)

- R8.4        **Selection Combining, and Opportunistic Relaying, with Many Diversity Branches: Switching Rates for Most Common Fading Types**  
David B Smith (National ICT Australia, Australia)
- R8.5        **Feasibility Study of Full-duplex Relaying in Satellite Networks**  
Bhavani Shankar Mysore R (Interdisciplinary Centre for Security, Reliability and Trust & University of Luxembourg, Luxembourg); Gan Zheng (University of Essex & University of Luxembourg, United Kingdom); Sina Maleki (University of Luxembourg & The Interdisciplinary Centre for Security, Reliability and Trust (SnT), Luxembourg); Björn Ottersten (University of Luxembourg, Luxembourg)
- R8.6        **Partial Zero Forcing for Multi-Way Relay Networks**  
Wuhua Zhang, Moslem Noori, Yindi Jing and Masoud Ardakani (University of Alberta, Canada)
- R8.7        **Velocity-assisted Multidimensional Scaling**  
Sandeep Kumar (IIT Kanpur, India); Ketan Rajawat (Indian Institute of Technology Kanpur, India)
- R8.8        **A Scalable Performance-Complexity Tradeoff for Vector Precoding by Partial Perturbation**  
Christos Masouros (University College London, United Kingdom); Tharmalingam Ratnarajah (The University of Edinburgh, United Kingdom); Mathini Sellathurai (Heriot-Watt University, United Kingdom)
- R8.9        **Robust MISO Downlink Precoder Design With Per-Antenna Power Constraints**  
Mostafa Medra and Timothy N. Davidson (McMaster University, Canada)

# Special Session S8

## Joint Analog Source-channel Coding

Wednesday July 1, 11:30-12:45, Room E33

### Session Organizer

Luis Castedo (Universidade da Coruña, Spain)

- S8.1      **On the Physical Layer Security of Analog Joint Source Channel Coding Schemes**  
Eduardo Hodgson, Glauber Brante and Richard Demo Souza (Federal University of Technology - Paraná (UTFPR), Brazil); João Luiz Rebelatto (Federal University of Technology - Parana, Brazil)
- S8.2      **Hybrid Digital-Analog Transmission Taking Into Account D/A and A/D Conversion**  
Matthias Rüngeler (RWTH Aachen University, Germany); Peter Vary (RWTH Aachen, Germany)
- S8.3      **Design of Analog Joint Source-Channel Coding Systems for Broadcast Channels with MSE Balancing**  
Óscar Fresnedo, José P González-Coma and Luis Castedo (University of A Coruña, Spain)
- S8.4      **Analog Coding for Gaussian Source and State Interference Estimation**  
Ahmad Abou Saleh, Fady Alajaji and Wai-Yip Geoffrey Chan (Queen's University, Canada)
- S8.5      **Sending Gaussian Multiterminal Sources over the Gaussian MAC with Bandwidth Expansion**  
Nan Jiang and Yang Yang (Texas A&M University, USA); Anders Høst-Madsen (University of Hawaii, USA); Zixiang Xiong (Texas A&M University, USA)
- S8.6      **Application of analog joint source-channel coding to broadcast channels**  
Mohamed Hassanin, Bo Lu and Javier Garcia-Frias (University of Delaware, USA)
- S8.7      **Multiple Description Analog Joint Source Channel Coding with side information at the ML decoders**  
Aitziber Saez and Xabier Insausti (CEIT, Spain); Pedro M. Crespo (CEIT and TECNUN (University of Navarra), Spain); Iker Alustiza (CEIT, Spain)

# Regular Session R9

## Interference Modeling and Management

Wednesday July 1, 15:00-16:15, Room E31

- R9.1     **Asymptotic SINR for Millimeter Wave Massive MIMO Cellular Networks**  
Tianyang Bai and Robert Heath (The University of Texas at Austin, USA)
- R9.2     **Minimizing the Routing Delay in Cognitive Radios Using Potential Fields**  
Jan Oksanen (Aalto University, Finland); Brett Kaufman (Rice University, USA);  
Visa Koivunen (Aalto University, Finland); H. Vincent Poor (Princeton University,  
USA)
- R9.3     **A Novel Relay-Based Interference Alignment Strategy for Multi-User  
Networks**  
Yue Tian (MVB, Woodland Road, University of Bristol, United Kingdom); Mark  
Beach and Andy Nix (University of Bristol (UoB), United Kingdom)
- R9.4     **Mixed Norm Minimization for MIMO Cellular Interference Channel**  
Huiqin Du (Jinan University, P.R. China); Tharmalingam Ratnarajah (The  
University of Edinburgh, United Kingdom); Mathini Sellathurai (Heriot-Watt  
University, United Kingdom); Jonathon A Chambers (Loughborough University,  
United Kingdom)
- R9.5     **Interference Alignment via Feasible Point Pursuit**  
Aritra Konar and Ruoyu Sun (University of Minnesota, USA); Nicholas  
Sidiropoulos (University of Minnesota, USA); Zhi-Quan Luo (University of  
Minnesota, USA)
- R9.6     **Near-Optimum Power Control for Two-Tier SIMO Uplink Under Power  
and Interference Constraints**  
Baris Yuksekkaya (Hacettepe University & Electrical & Electronics Engineering,  
Turkey); Hazer Inaltekin (Antalya International University, Turkey); Cenk Toker  
(Hacettepe University, Turkey); Halim Yanikomeroglu (Carleton University,  
Canada)
- R9.7     **Distributed Learning of Equilibria for a Stochastic Game on Interference  
Channels**  
Krishna Chaitanya A (Indian Institute Science, India); Vinod Sharma and Utpal  
Mukherji (Indian Institute of Science, India)
- R9.8     **On the benefits of Edge Caching for MIMO Interference Alignment**  
Matha Deghel, Ejder Baştuğ, Mohamad Assaad and Mérouane Debbah  
(CentraleSupélec, France)

*Continued on page 52*

- R9.9     **Nonlinear Spatiotemporal Channel Gain Map Tracking in Mobile Cooperative Networks**  
Dionysios Kalogieras and Athina Petropulu (Rutgers, The State University of New Jersey, USA)
- R9.10    **Optimal Jammer Placement in Wireless Localization Networks**  
Sinan Gezici (Bilkent University, Turkey); Suat Bayram (Turgut Ozal University, Turkey); Mohammad Reza Gholami (Postdoc at KTH, Sweden); Magnus Jansson (KTH Royal Institute of Technology, Sweden)

# Special Session S9

## Proximal Communications for 5G: D2D, Caching and Contextualization

Wednesday July 1, 15:00-16:15, Room E33

### Session Organizer

Angeliki Alexiou (University of Piraeus, Greece)

Giuseppe Caire (Technical University Berlin, Germany)

- S9.1 **Network Coding Schemes for Device-to-Device Communications Based Relaying for Cellular Coverage Extension**  
Gabor Fodor (Ericsson Research & Royal Institute of Technology (KTH), Sweden); Andrea Abrardo and Besmir Tola (University of Siena, Italy)
- S9.2 **Towards a Mobile Content Marketplace**  
Sameh Hosny, Faisal Alotaibi and Hesham ELGAMAL (The Ohio State University, USA); Atilla Eryilmaz (The Ohio State University, USA)
- S9.3 **Cache-enabled Small Cell Networks with Local User Interest Correlation**  
Zheng Chen (CentraleSupélec - CNRS - Université Paris Sud, France); Marios Kountouris (Huawei Technologies, France)
- S9.4 **CEO Problem based Analysis of D2D Cooperative User Pairing**  
Xin He (Japan Advanced Institute of Science and Technology & University of Oulu, Japan); Markku Juntti and Xiaobo Zhou (University of Oulu, Finland); Petri Komulainen (MediaTek, Finland); Tadashi Matsumoto (CWC - Oulu, Finland)
- S9.5 **Probabilistic Handshake in All-to-all Broadcast Coded Slotted ALOHA**  
Mikhail Ivanov (Chalmers University of Technology, Sweden); Petar Popovski (Aalborg University, Denmark); Fredrik Brännström and Alexandre Graell i Amat (Chalmers University of Technology, Sweden); Čedomir Stefanović (Aalborg University & University of Novi Sad, Denmark)
- S9.6 **On the Fundamental Limits of Caching in Combination Networks**  
Mingyue Ji (University of Southern California, USA); Ming Fai Wong (California Institute of Technology, USA); Antonia Tulino (Bell Labs, USA); Jaime Llorca (Bell Labs, Alcatel-Lucent, USA); Giuseppe Caire (Technische Universität Berlin, Germany); Michelle Effros (California Institute of Technology, USA); Michael Langberg (State University of New York at Buffalo, USA)



*Photo: Anneli Karlsson, the Swedish National Maritime Museums.*

# Social Program

## **Welcome Reception**

Sunday June 28, 18:00-20:00, Stockholm City Hall

By invitation of the City of Stockholm, the participants of SPAWC are welcomed to a reception at the Stockholm City Hall. Located at the center of the city, the City Hall is perhaps most well known internationally from the coverage of the Nobel banquet, which has been held annually in the City Hall since 1934. A representative of the City of Stockholm and a representative of the SPAWC organizing committee will greet you to the City Hall. After this you will be served a light dinner buffet.

It is important to be on time at the start of the reception in order to ensure entrance into the City Hall.



**Stockholms  
stad**

## **Workshop Banquet**

Tuesday June 30, 19:00-00:00, Vasa Museum

The SPAWC 2015 workshop banquet will be held in the Vasa museum, home to the fully restored Swedish warship that sank on its maiden voyage in 1628 and that was raised from the depths in 1961. In addition to dining in the ship hall, with the magnificent warship Vasa at your side, the banquet will also feature a welcome drink and a tour of the museum.

The Vasa museum is most easily reached by taking bus 67 from in front of KTH, or by a 30-minute stroll through beautiful Östermalm. Please note that the Vasa Museum's Ship Hall maintains a constant temperature of 18 degrees Celsius (64.4 degrees Fahrenheit). We therefore recommend appropriate clothing.

## **Lunches**

Monday-Wednesday, Restaurant Q, Osquldas väg 4

Lunches are included in all conference registrations, and will be served in a KTH campus restaurant, restaurant Q. The restaurant provides a meat, a fish, and a vegetarian option, including salad, (unbottled) drink and coffee, every day. Lunch tickets are included in the conference package. The location of the restaurant is marked on the campus map included in the program.

## **Coffee Breaks**

Monday-Wednesday, Atrium

Coffee breaks will be held in an atrium in the historical main buildings of KTH, where also the plenary talks, the tutorials, and the poster sessions will take place. Weather permitting, your coffee and snacks can also be enjoyed in the main courtyard of KTH, seen on page 1, only a few meters away from the conference halls.



# Notes

## Organizers



## Host University



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