

IEEE INTERNATIONAL DYNAMIC SPECTRUM  
ACCESS NETWORKS SYMPOSIUM

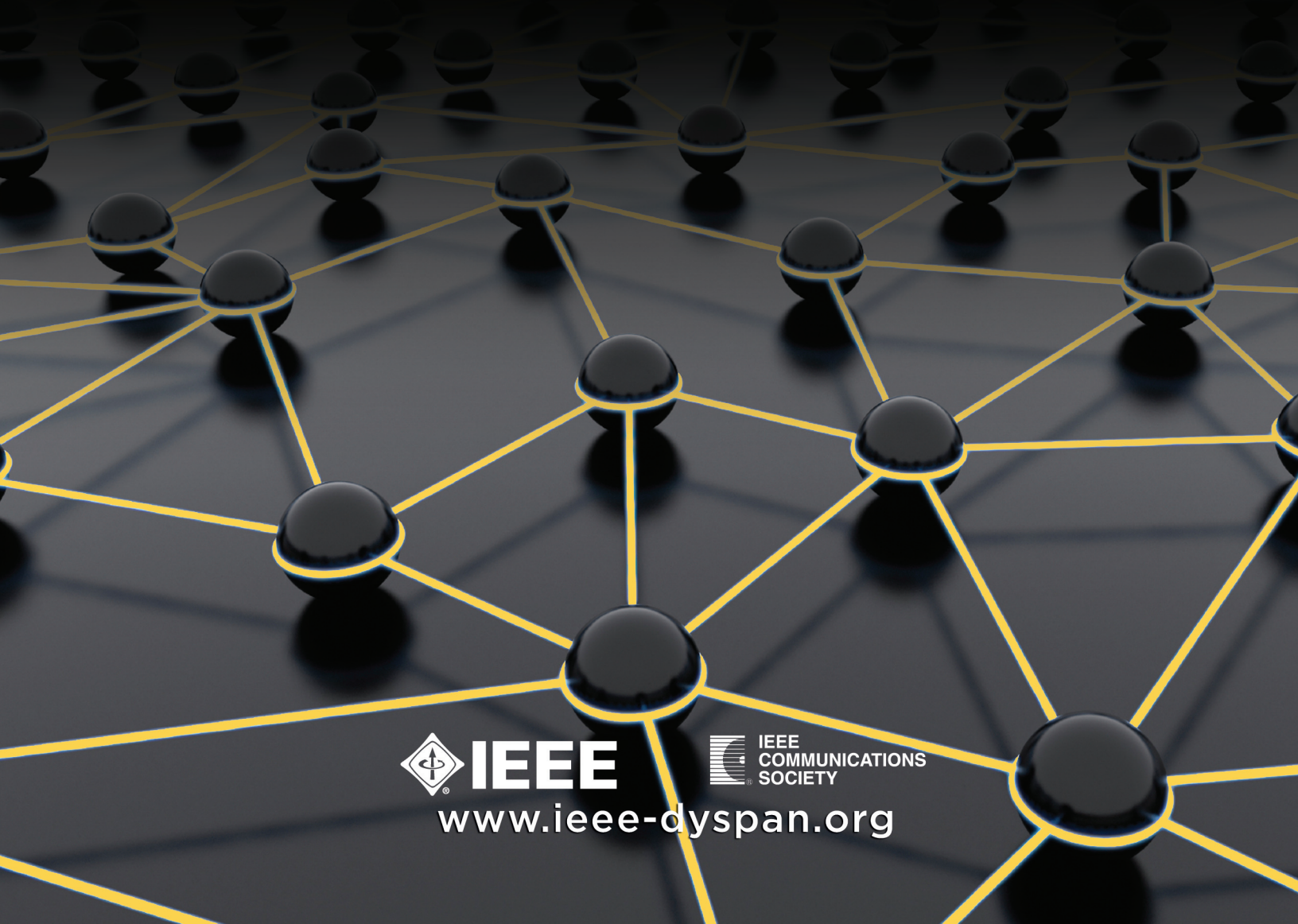


# DySPAN2011

Dynamic Spectrum Access Networks

AACHEN, GERMANY 3-6 MAY 2011

## FINAL PROGRAM



**IEEE**



IEEE  
COMMUNICATIONS  
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# GENERAL INFORMATION

**IEEE DySPAN 2011 Badges** must be worn at all times and are necessary for entrance into all IEEE DySPAN events.

## Registration

All attendees must register and receive a conference badge in order to participate in conference activities.

Hours for the Registration Desk:  
 Tuesday, 3 May 8:00 – 19:00  
 Wednesday, 4 May 8:00 – 17:00  
 Thursday, 5 May 8:00 – 17:00  
 Friday, 6 May 8:00 – 12:00

## Conference Meals

Included in the price of the full registration are the Welcome Reception, Three Lunches, Networking Breaks and the Evening Banquet.

## A Friendly Reminder

Please turn off anything that chirps, beeps, buzzes or rings which includes but not limited to pagers, beepers, cell phones, PDA and laptops during the conference. The speakers and audience thank you for your consideration and cooperation.

## Dress Attire

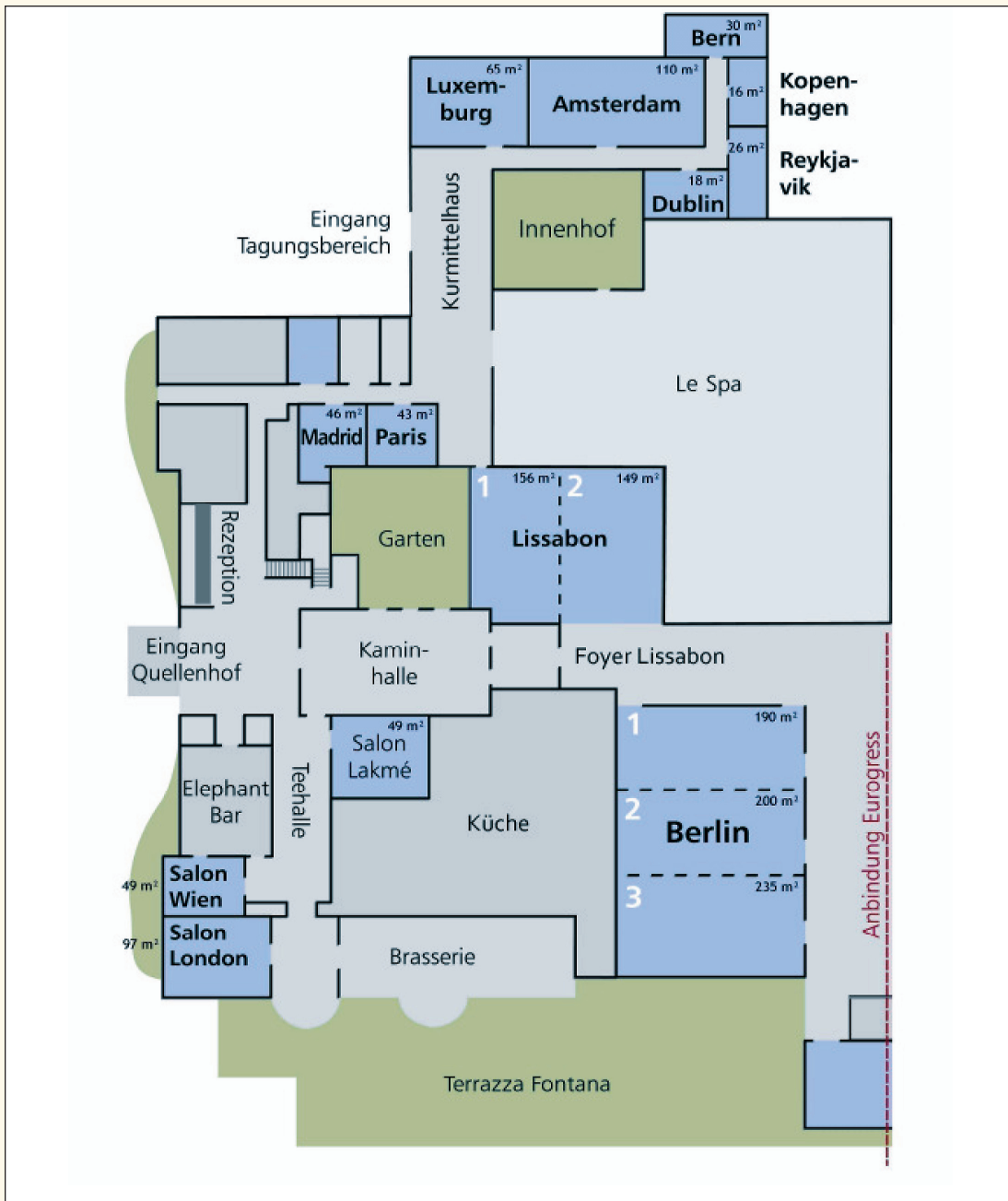
Business casual is recommended for all daytime and evening IEEE DySPAN 2011 events.

## Conference Hotel

### Pullman Aachen Quellenhof

Monheimsallee 52  
 52062 Aachen  
 Germany  
 Tel: +49 241 – 913 2 945  
 Fax: +49 241 – 913 100

# HOTEL FLOOR PLAN



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## PROGRAM AT A GLANCE

### Tuesday, 3 May 2011

8:30 – 17:00	Full Day Tutorial (T1: Institute for Networked Systems, RWTH Aachen University)
9:00 – 12:30	AM Tutorials (T2: Berlin 1 • T3: Berlin 2 • T4: Berlin 3)
12:30 – 13:30	Lunch (Kaminhalle)
13:30 – 17:00	PM Tutorials (T5: Berlin 1 • T6: Berlin 3)
19:00 – 21:00	Welcome Reception (Kaminhalle)

### Wednesday, 4 May 2011

8:30 – 10:30	Opening & Keynote Session: M. Kurth, D. Sicker, D. Cleevly (Berlin)
10:30 – 11:00	Networking Coffee Break (Kaminhalle)
11:00 – 11:30	Demonstration Talks (Berlin)
11:30 – 12:30	Plenary Session I (Berlin)
12:30 – 13:30	Lunch (Kaminhalle)
12:30 – 13:30	Demonstrations (Lissabon)
13:30 – 15:00	Technology & Policy Sessions - TS1: Measurements and Models (Berlin 3) - PS1: Usage Rights and Regulatory Models (Berlin 1)
15:00 – 15:30	Networking Coffee Break (Kaminhalle)
15:00 – 15:30	Demonstrations (Lissabon)
15:30 – 17:00	Technology & Policy Sessions - TS2: Spectrum Sensing I (Berlin 3) - Joint Tech & Policy Session I (Berlin 1)
17:15 & 18:00	Cathedral Tours

### Thursday, 5 May 2011

8:30 – 9:30	Keynote Session: P. O'Donohue & J. Peha (Berlin)
9:30 – 10:30	Plenary Session II (Berlin)
10:30 – 11:00	Networking Coffee Break (Kaminhalle)
11:00 – 11:30	Poster Talks (Berlin)
11:30 – 12:30	Panel: Regulatory Perspectives on Next Generation Radio Systems (Berlin)
12:30 – 13:30	Lunch (Kaminhalle)
12:30 – 13:30	Posters & Demonstrations (Lissabon)
13:30 – 15:00	Technology & Policy Sessions - TS3: TV White Space (Berlin 3) - PS2: Business Cases (Berlin 1)
15:00 – 15:30	Networking Coffee Break (Kaminhalle)
15:30 – 16:30	Posters & Demonstrations (Lissabon)
16:30 – 18:00	Technology & Policy Sessions - TS4: Secondary Spectrum Access (Berlin 3) - PS3: Policy & Engineering (Berlin 1)
19:00 – 22:00	Conference Banquet (Aachen City/Town Hall)

### FRIDAY, 6 May 2011

8:30 – 9:30	Keynote Session: K. Sabnani & V. Bahl (Berlin)
9:30 – 10:30	Panel: Perspectives on Cognitive Radios: The Past and Next 10 Years (Berlin)
10:30 – 11:00	Networking Coffee Break (Kaminhalle)
11:00 – 12:30	Panel: Business Perspectives on Dynamic Spectrum Access (Berlin)
12:30 – 13:30	Lunch (Kaminhalle)
13:30 – 15:00	Technology & Policy Sessions - TS5: Spectrum Sharing and Protocols (Berlin 3) - Joint Tech & Policy Session II: (Berlin 2) - PS4: Regulatory Engineering (Berlin 1)
15:00 – 15:30	Networking Coffee Break (Kaminhalle)
15:30 – 17:00	Technology & Policy Sessions - TS4: PHY Issues and Experimental Studies (Berlin 3) - T6: Close up with A. Sahai (Berlin 2) - TS7: Spectrum Sensing II (Berlin 1)

## ORGANIZING COMMITTEE

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**Milind Buddhikot**, Alcatel-Lucent, USA

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# MESSAGE FROM THE GENERAL CHAIRS



Petri Mähönen



Milind Buddhikot

On behalf of the IEEE DySPAN 2011 Organizing Committee, we are pleased to welcome you to the 5th International Dynamic Spectrum Access Symposium (DySPAN). IEEE DySPAN has grown to be a premier conference on all communications aspects that are relevant not only for Dynamic Spectrum Access and Cognitive Radios but covering also other radical and novel approaches and technologies towards more efficient spectrum use.

IEEE DySPAN 2011, like its predecessors, is a unique symposium that gathers the technology, policy, and regulatory communities together. This year's program is tailored to encourage discussion, information exchange and debate also in cross-disciplinary fashion. The conference includes 15 different technical and policy

sessions, 3 panels, a number of high-level keynote presentations and 6 tutorials. Practical demonstrations and posters will add spice to the program, and demonstration and poster presenters provide excitement through "2-minute madness" talks. The conference received papers from 36 different countries, and the authors represent academic, industry, policy makers and regulators.

The competition for accepted papers was particularly strong this year and the selected papers are of highest quality. The acceptance process was very thorough. Reviews were done almost exclusively by TPC and PPC program committee members, and both program committee meetings and shepherding processes were used efficiently. Overall, the acceptance ratio this year was only slightly over 25%, which also reflects the increased competition among IEEE DySPAN technical submissions.

It is our pleasure to welcome you to Aachen, which itself is in the very middle of "old Europe." The city has a very long history, which hopefully also provides you a good background for informal discussions and debates.

Setting up such a comprehensive and high-quality program is not possible without the hard work, cooperation and devotion of a very large number of individuals. This year we had a number of patrons, who provided not only monetary but also logistics help. Without their generous support the conference would have been unable to reach its quality level. There would be no program without keynote speakers, tutorial and demonstration presenters, and naturally the paper authors. We extend our deepest appreciation for their support and participation. Finally, we would like to express our sincere thanks to the technical and policy program chairs and volunteers, including all the unnamed local organizers, who have been working unbelievably hard and volunteered their efforts.

We hope that you will enjoy the conference, and have time also to sample some of the city attractions!

## IEEE DySPAN 2011 General Co-Chairs

**Petri Mähönen,**  
RWTH Aachen University, Germany

**Milind Buddhikot,**  
Alcatel-Lucent, Bell Labs, USA

## MESSAGE FROM THE TECHNICAL PROGRAM CO-CHAIRS



Heather Zheng



Marina Petrova

Welcome to IEEE DySPAN 2011, the Fifth International Symposium on Dynamic Spectrum Access Networks, in Aachen Germany. This year's IEEE DySPAN carries on the tradition as the preeminent event attracting engineers, network architects, researchers and academics together to discuss state of the art research on emerging wireless networks. As the vision of dynamic spectrum networks draws closer to wide-scale deployment, this year's strong technical program includes a particularly deep selection of papers on real world studies, including several on whitespace technologies.

The technical program includes a wide range of papers organized into 9 sessions, including joint sessions with the policy track, over three days. In addition, we are hosting separate sessions for system demonstrations and research posters, both of which were chosen using independent, highly selective processes. We believe that these projects represent cutting edge research on dynamic spectrum networks, and hope they will spur discussions and generate new research directions.

This year's conference is made possible by the dedicated efforts of many members of the IEEE DySPAN community. We would like to give special thanks to the IEEE DySPAN 2011 technology track TPC for generously giving their time and energy to provide detailed, high quality paper reviews. The final program was chosen through lengthy discussions and animated debates during the TPC teleconference meeting held in January 2011.

We thank the Policy Program Co-Chairs Martin Weiss and Pierre de Vries, Poster Chair Allen MacKenzie, and Demo Co-Chairs Przemyslaw Pawelczak and Ranveer Chandra for their assistance in the technical program selection. Finally, we thank the General Co-Chairs, Petri Mähönen and Milind Buddhikot for their help and trust, and the Steering Committee for the opportunity to serve as TPC Co-Chairs.

### IEEE DySPAN 2011 Technical Program Co-Chairs

**Heather Zheng,**  
UC Santa Barbara, USA

**Marina Petrova,**  
RWTH Aachen University, Germany

## MESSAGE FROM THE POLICY PROGRAM CO-CHAIRS



Martin Weiss



Pierre de Vries

DSA technologies have the potential to restructure the global wireless ecosystem by delivering expanded capabilities and thus new opportunities and threats for all stakeholders. The new products and services, new business/service models, and new spectrum management frameworks that will emerge to leverage these new capabilities, will pose new challenges for regulators. The policy program has been an integral part of IEEE DySPAN from its inception since the economic, legal and social aspects of DSA need to be addressed explicitly in conjunction with the technical challenges.

The IEEE DySPAN conference offers a unique opportunity for researchers to address the inherently multidisciplinary research challenge of bringing DSA from the lab to practice. Every year, the IEEE research community reaches out to non-engineering colleagues to address the important business and policy issues that are essential to the realization of next generation wireless systems. The policy program chairs and committee are proud to once again have the opportunity to present policy and economic research that bridges the disciplinary divides,

offering technically-informed policy perspectives and policy-aware commentary on technical issues. With panels offering expert insight on topics such as regulatory perspectives from around the world and the outlook for radio systems in 2020, and research sessions reporting on business models, economic analysis, usage rights and regulatory engineering, we have sought to advance understanding of a cross section of the many business/economic/public policy issues that need to be addressed.

A conference like this is a community effort. We would like to thank the IEEE, our colleagues on the IEEE DySPAN organizing committees, our corporate sponsors, and all of the participants who will be joining us in Aachen for providing a forum for building a global cross-disciplinary research community. Our special thanks go to the policy program committee for the time and effort they devoted to encouraging submissions and providing thoughtful paper reviews.

### IEEE DySPAN 2011 Policy Program Co-Chairs

**Martin Weiss,**  
University of Pittsburgh, USA

**Pierre de Vries,**  
Silicon Flatirons Centre, USA



Wednesday, 4 May 2011 • 9:00 – 9:30 • Room: Berlin

## Matthias Kurth

President, Federal Network Agency, Germany

### Cornerstones of a Forward-looking Regulatory Framework – How to Foster Investment and Innovation

**Abstract:** Liberalization in the extremely dynamic telecommunications sector took place against the background of the conclusion that competitive systems are more easily capable of adapting and innovating than monopolies. Companies that need to fear competition are also facing cost pressure, requiring them to be more efficient. Thus telecommunications liberalization was founded from the start not only on allocative but also on dynamic advantages.

Considering the development of productivity, prices and diversity of services since the telecommunications sectors liberalization, these assumptions have proven themselves as correct. Price reductions and innovations for telecommunications services like what we have seen in the last decade, which have only been possible because we now have competition, benefit the economy as a whole. Some markets, the online businesses for example, have become possible only because of the innovative power of the telecommunications markets. There are also indirect ramifications on businesses, which are on first look unrelated. eCommerce has helped bolster the logistic sectors turnover.

The main goal of regulation, enabling and strengthening competition, has proven its worth over and over again. It is expected, that a regulatory framework that is aligned with competition as a goal yields the best economical performance and at the same time furthers efficient investments in mobile and fixed broadband

**Biography:** Matthias Kurth is the President of the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (BNetzA), which is the federal regulatory authority for Telecommunications and Posts related regulations in Germany. He graduated in Law and Economics from the Frankfurt am Main University, and received the postgraduate legal training in the administration of justice of the state of Hesse. Mr. Kurth has had a long and distinguished career in Germany both on the state and federal levels. Before his appointment to the presidency of BNetzA in 2001, he served as Vice President in BNetzA (2000-2001) and earlier in a number of different positions on regulatory and economic development.



Wednesday, 4 May 2011 • 9:30 – 10:00 • Room: Berlin

## Douglas Sicker

Chief Technology Officer, Federal Communications Commission, USA  
Associate Professor of Computer Science, University of Colorado, Boulder

### Dynamic Spectrum Access Policy in the US

**Abstract:** This talk will concentrate on the recent spectrum policy directions that have emerged since the introduction of the National Broadband Plan. While the focus will be on dynamic spectrum access, we also consider spectrum policy more broadly, specifically the directions that the US government is considering to enable the availability of additional spectrum for broadband services.

**Biography:** Douglas Sicker is the FCC's Chief Technologist. Although based in OSP, he reports directly to the Chairman and works on issues that span the bureaus. He has held various positions in academia, industry and government. In addition to his role here at the FCC, he is an associate professor in the Department of Computer Science at the University of Colorado at Boulder with a joint appointment in the Interdisciplinary Telecommunications Program. Previously, he served as a senior advisor on the FCC National Broadband Plan and, before that, as Director of Global Architecture at Level 3 Communications, Inc.

Earlier still, Dr. Sicker served as Chief of the Network Technology Division at the FCC. After leaving this agency, he served as Chair of the Network Reliability and Interoperability Council steering committee, an FCC federal advisory committee that focuses on network reliability, wireline spectral integrity and Internet peering and interconnection. He also served on the Technical Advisory Council of the FCC. In addition, he has also held faculty and industry positions in the field of medical sciences.



Wednesday, 4 May 2011 • 10:00 – 10:30 • Room: Berlin

## David Cleevly

Chairman, CRFS, UK

### Radio Spectrum and Innovation: Realizing the Potential

**Abstract:** It might seem that more innovation is happening in apps than in spectrum. But if Cooper's Law is to be believed, the use of radio spectrum is doubling every 30 months. Keeping up this pace means that regulatory liberalization has to match advances in technology and new applications. How will this be possible? What kind of devices, services applications and demand will there be? Where might innovation happen, and how big will the impact be? What kind of innovation in regulation and business models will we need? What are the pitfalls along the way?

**Biography:** David Cleevly (FREng, FIET) is the Chairman of CRFS, which he co-founded in July 2007, and the founder and former Chairman of telecoms consultancy Analysys (acquired by Datatec International in 2004). In 1998, he co-founded the web based antibody company Abcam (ABC.L) with Jonathan Milner and was Chairman until November 2009.

In late 2004 he co-founded the 3G femto base station company, 3WayNetworks, which was sold to Airvana in April 2007. He has been a prime mover behind Cambridge Network, co-founder of Cambridge Wireless, co-founder and Chairman of Cambridge Angels and is a member of the IET Telecoms Sector Panel. For 8 years until March 2009 he was a member of the OFCOM Spectrum Advisory Board. From 2001 to 2008 he was a member of the Ministry of Defence Board overseeing information systems and services (DES-ISS, formerly the Defence Communications Services Agency).

After being sponsored to study Cybernetics at Reading by Post Office Telecommunications, he joined their Long Range Studies Division. A PhD at Cambridge was then followed by the Economist Intelligence Unit in London. He is a Fellow of the Royal Academy of Engineering and the IET and he has recently held an Industrial Fellowship at the University of Cambridge Computer Laboratory. He was recently appointed the Founding Director and Executive Committee Member of the Centre for Science and Policy, University of Cambridge.



Thursday, 5 May 2011 • 8:30 – 9:00 • Room: Berlin

## Pearse O'Donohue

Head of the Radio Spectrum Policy Unit, European Commission, Belgium

**Biography:** Pearse O'Donohue is responsible for the development and implementation of policies for efficient spectrum use and a coordinated approach to frequency management in the EU. This also involves the development of spectrum harmonization measures in the electronic communications field and in other internal market sectors such as transport and research. He is Chairman of the EU Radio Spectrum Committee. Prior to taking over his current post in June 2008, Pearse O'Donohue was the Assistant to the Director-General of DG INFSO (Information Society and Media). Before that, he was Deputy Head of the Unit responsible for monitoring and enforcing implementation of the EU regulatory framework in electronic communications, where he dealt amongst

other things with spectrum authorization and broadband access issues. Pearse O'Donohue began his career in the Irish Department of Foreign Affairs, from which he was posted to the Permanent Representation of Ireland to the EU in Brussels. In 1991 he was appointed Assistant Director of the Brussels office of the Irish Business & Employers' Confederation. In 1995 he joined the European Commission and subsequently became adviser to the Commissioner for Social Policy and Employment.



Thursday, 5 May 2011 • 9:00 – 9:30 • Room: Berlin

## Jon M. Peha

Assistant Director, White House Office of Science and Technology Policy

### Emerging U.S. Spectrum Policy and the Road to Innovation

**Abstract:** In the last two years, the President of the United States and the US National Broadband Plan have elevated the importance of spectrum policy to new heights, embraced ambitious goals for progress, and proposed consideration of new and sometimes controversial approaches intended to improve spectral efficiency. This will produce a period of opportunity for advances in dynamic spectrum sharing. Indeed, while there have been times when spectrum policymakers have been slow to adopt new ideas from the

research community, the research community may now find it challenging to keep up with the needs of spectrum policymakers for rapid progress. Meeting objectives for efficient use of spectrum will require advances in an already-complex innovation process, where putting concepts into practice often includes theoretical technical and policy research, extensive and transparent experimentation, standardization, changes in regulation, and changes in enforcement mechanisms, all before a single device can be deployed.

**Biography:** Jon M. Peha is serving as Assistant Director of the White House Office of Science and Technology Policy for Communications and Research issues, and before that he was the Chief Technologist of the U.S. Federal Communications Commission. He is also a Full Professor at Carnegie Mellon University in the Department of Electrical & Computer Engineering and the Department of Engineering & Public Policy, and former Associate Director of the university's Center for Wireless and Broadband Networking. He has been Chief Technical Officer of three high-tech start-ups, and a member of technical staff at SRI International, AT&T Bell Laboratories, and Microsoft. He has also addressed telecom and e-commerce issues on legislative staff in both the House and Senate of the U.S. Congress, and helped launch a US Government interagency program to assist developing countries with information infrastructure. His research spans technical and policy issues of communications networks, including spectrum management, broadband Internet, wireless networks, video and voice over IP, communications for emergency responders, universal service, secure Internet payment systems, dissemination of copyrighted material, e-commerce, and network security. He holds a Ph.D. in electrical engineering from Stanford, and a B.Sc. from Brown.





Friday, 6 May 2011 • 8:30 – 9:00 • Room: Berlin

## Krishan Sabnani

Vice President of Networking Research, Bell Labs, USA

### Spectrum and Infrastructure Virtualization for Next Next-Gen Cellular Networks

**Abstract:** With the 260%/year growth of mobile traffic in recent years, cellular operators world-wide have begun deploying new wideband access technologies (such as 4G LTE) along with small cells. Each operator must also increase the amount of spectrum used in its network to keep pace with the traffic. By some estimates, a total of 1.2 - 1.7 GHz is needed to deal with the expected traffic load. However, finding new spectrum, a scarce resource, will be difficult. The cost of infrastructure deployment and operations are additional serious issues.

When a resource is expensive and/or scarce, the most common solution is the concept of dynamic sharing among multiple interested entities. We believe that advances in key areas (such as RF processing in software, virtualization technologies, wideband digital radios and near real-time network monitoring) will enable sharing of spectrum and infrastructure virtualization, in a way similar to the virtualization and cloud revolutions in the computing industry. This talk will highlight current Bell Labs programs that will enable dynamic sharing. It will also briefly touch on the regulatory steps necessary to ensure a smooth evolution.

**Biography:** Krishan Sabnani is currently Vice President of Networking Research at Bell Labs. He manages all networking research in Bell Labs, comprising nine departments in six countries: USA, France, Germany, Ireland, India, and Belgium. Krishan has conceived and launched numerous systems projects in the areas of internetworking and wireless networking. His successful transfers of research ideas to products in Alcatel-Lucent and (previously) AT&T business units have had a major positive impact on the business. Krishan has also conducted extensive personal research in data and wireless networking. His contributions have played a major role in modern mobile networks, and his recent breakthrough re-engineering of routers has launched a revolution in network designs.

Krishan received the 2005 IEEE Eric E. Sumner Award and the 2005 IEEE W. Wallace McDowell Award. He is a Bell Labs Fellow and a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) and the Association of Computing Machinery (ACM). He received the Leonard G. Abraham Prize Paper Award from the IEEE Communications Society in 1991 and the 2005 Distinguished Alumni Award from the Indian Institute of Technology, New Delhi, India. He also won the Thomas Alva Patent Award from the R&D Council of New Jersey in 2005, 2009, and 2010. He holds 40 patents and has published more than 70 papers.

Krishan received his B. Tech. in electrical engineering from IIT Delhi in 1975, and a Ph.D. in electrical engineering from Columbia University, New York in 1981. He joined Bell Labs in 1981.



Friday, 6 May 2011 • 9:00 – 9:30 • Room: Berlin

## Victor Bahl

Principal Researcher and Director, Mobile Computing Research Center, Microsoft Research, USA

### The Promises and Challenges of the Wireless Frontier - from 600 MHz to 60 GHz

**Abstract:** This is a great time to be a wireless researcher. Even though hundreds of wireless networking papers in dozens of conferences and journals are published every year, there is still a lot to do. We continue to discover compelling new scenarios that require wireless connectivity that is difficult to deliver. Policy makers and engineers who came together to enable a world of wireless connectivity in public places, large enterprises, and communities, are now coming together to enable connectivity in

automobiles, hospitals, data centers and cell networks. In this talk, I will describe the rapidly changing landscape of the wireless frontier - discussing promising new directions in cognitive systems and opportunistic networks design. The problems we face need emerging technologies such as software defined radios, full-duplex radios, and multi-gigabit radios that operate in frequencies ranging from 600 MHz to 60 GHz. These problems will force us to continuously re-evaluate policies that come in the way of engineering. I will highlight some problems and discuss solutions that researchers have been developing. I will challenge the audience into taking on technical problems while thinking about associated policy changes and business models. My hope is that after listening to this talk, policy makers, scientists, engineers, students and entrepreneurs will agree that the wireless frontier is exciting and it is a great time to be a wireless researcher.

**Biography:** Victor Bahl is a Principal Researcher and the Founding Director of the Mobile Computing Research Center (MCRC). Formed in Jan. 2011, MCRC's mission is to make Microsoft's mobile devices indispensable to the world. The center engages in basic and applied multi-disciplinary research, builds proof-of-concept systems, engages with academia, publishes papers in prestigious conferences and journals, publishes software for the research community, and streamlines the transfer of cutting-edge technologies from MSR Labs world-wide to Microsoft's product divisions. Prior to MCRC, Victor founded the Networking Research Group and served as its manager for 8 years. He continues to help shape Microsoft's long-term vision related to networking technologies through research and associated policy engagement with governments and institutions around the world. His personal research interests span a variety of topics in mobile networking, wireless systems design, datacenter networking, and enterprise networking & management. He has authored over 110 peer-reviewed papers and 120 patent applications, 76 of which have issued; he has won best paper awards at SIGCOMM and CoNext and has delivered over two dozen keynote & plenary talks; he is the founder and past Chairperson of ACM SIGMOBILE, the founder and steering committee chair of the MobiSys; and the founder and past Editor-in-Chief of ACM Mobile Computing and Communications Review. He has served as the General Chair of several IEEE and ACM conferences including SIGCOMM and MobiCom, and is serving on the steering committees of seven IEEE & ACM conferences & workshop, several of which he co-founded. He has served on the board of over half-a-dozen journals; on several NSF, NRC and FCC panels, and on over six dozen program committees. He became an ACM Fellow in 2003, an IEEE Fellow in 2008 and a AAAS Fellow in 2010.

Wednesday, 4 May 2011 • 11:30 – 12:30 • Room: Berlin

## Plenary Session I

Chair: Marina Petrova, RWTH Aachen, Germany

### UHF White Space in Europe - A Quantitative Study into the Potential of the 470-790 MHz Band

Jaap van de Beek (Huawei Technologies, Sweden)  
Janne Riihijärvi, Andreas Achtzehn, Petri Mähönen  
(RWTH Aachen University, Germany)

### SenseLess: A Database-Driven White Spaces Network

Rohan Murty (Harvard University, USA)  
Ranveer Chandra, Thomas Moscibroda, Victor Bahl  
(Microsoft Research, USA)

### Spectrum Requirements for TV Broadcast Services using Cellular Transmitters

Joerg Huschke (Ericsson, Germany)  
Kumar Balachandran (Ericsson, USA)  
Joachim Sachs (Ericsson Research, Germany)  
Jorgen Karlsson (Ericsson Research, Sweden)

Wednesday, 4 May 2011 • 13:30 – 15:00 • Room: Berlin 3

## Technology Session I: Measurements and Models

Chair: Dennis Roberson, Illinois Institute of Technology, USA

### Bounding the Error of Path Loss Models

Caleb Phillips, Douglas Sicker, Dirk Grunwald (University of Colorado, USA)

### Long-term Measurements of Spectrum Occupancy Characteristics

Timothy Harrold (University of Bristol, UK)  
Rafael Cepeda (Toshiba Research Europe Ltd, UK)  
Mark Beach (University of Bristol, UK)

### Discrete-Time Spectrum Occupancy Model based on Markov Chain and Duty Cycle Models

Miguel López-Benítez, Ferran Casadevall  
(Universitat Politècnica de Catalunya, Spain)

### Long-term Spectral Occupancy Findings in Chicago

Tanim Taher, Roger Bacchus, Kenneth Zdunek, Dennis Roberson  
(Illinois Institute of Technology, USA)

### Reliable Power Control for Secondary Users based on Distributed Measurements

Gitte Vanwinckelen, Martijn Van Otterlo, Kurt Driessens  
(Katholieke Universiteit Leuven, Belgium)  
Sofie Pollin (IMEC / University of California, Berkeley, USA)

Wednesday, 4 May 2011 • 13:30 – 15:00 • Room: Berlin 1

## Policy Session I: Usage Rights and Regulatory Models

Chair: Ruprecht Niepold, European Commission, Belgium

### Digital Switchover and Regulatory Design for Competing White Space Usage Rights

Benoit Freyens (University of Canberra, Australia)  
Mark Loney (Australian Communications and Media Authority, Australia)

### The Unfinished History of Usage Rights for Spectrum

Martin Cave (London School of Economics, UK)  
William Webb (Neul, UK)

### Exploiting Hybrid Models for Spectrum Access

Andrew Stirling (Larkhill Consultancy Limited, UK)

### The Three Ps: Increasing Concurrent Operation by Unambiguously Defining and Delegating Radio Rights

Pierre de Vries, Kaleb Sieh (University of Colorado, USA)

Wednesday, 4 May 2011 • 15:30 – 17:00 • Room: Berlin 3

## Technology Session II: Spectrum Sensing I

Chair: Timothy Newman, Virginia Tech, USA

### Compressive Sensing for Dynamic Spectrum Access Networks: Techniques and Tradeoffs

Jason Laska (Rice University, USA)  
Bill Bradley (Lyric Semiconductor, USA)  
Tom Rondeau (Center for Communications Research, USA)  
Keith Nolan (Trinity College, Ireland)  
Benjamin Vigoda (Lyric Semiconductor, USA)

### Multi-Channel Multi-Stage Spectrum Sensing: Link Layer Performance and Energy Consumption

Wesam Gabran, Przemyslaw Pawelczak, Danijela Cabric  
(University of California, Los Angeles, USA)

### Distributed Spectrum Sensing Utilizing Heterogeneous Wireless Devices and Measurement Equipment

Junichi Naganawa, Shunsuke Saruwatari (University of Tokyo, Japan)

### Robust Cooperative Sensing via State Estimation in Cognitive Radio Networks

Alexander Min (University of Michigan, USA)  
Kyu-Han Kim (Deutsche Telekom Inc. R&D Lab USA, USA)  
Kang G. Shin (University of Michigan, USA)

Wednesday, 4 May 2011 • 15:30 – 17:00 • Room: Berlin 1

## Joint Technology and Policy Session I

Chair: Berna Sayrac, Orange Labs, France

### Adaptive Channel Recommendation for Dynamic Spectrum Access

Xu Chen, Jianwei Huang (Chinese University of Hong Kong, Hong Kong)  
Husheng Li (University of Tennessee, USA)

### Pricing Mechanisms for Multi-Carrier Wireless Systems

Anil Kumar Chorppath, Tansu Alpcan (Technical University Berlin, Germany)  
Holger Boche (Technical University Munich, Germany)

### Profitability of Dynamic Spectrum Provision for Secondary Use

Murat Alanyali (Boston University, USA)  
Ashraf Al Daoud (University of Waterloo, Canada)  
David Starobinski (Boston University, USA)

### The Impact of Additional Unlicensed Spectrum on Wireless Services Competition

Thanh Nguyen, Hang Zhou, Randall Berry, Michael Honig, Rakesh Vohra  
(Northwestern University, USA)

Thursday, 5 May 2011 • 9:30 – 10:30 • Room: Berlin

## Plenary Session II

Chair: **Milind Buddhikot**, Alcatel-Lucent, USA

### Can Dynamic Spectrum Access Induce Heavy Tailed Delay?

Pu Wang, Ian Akyildiz (Georgia Institute of Technology, USA)

### Evaluating the Economic Impact of Cognitive Radio with a Three-player Oligopoly Model

Kimmo Berg (Aalto University School of Science and Technology, Finland)  
Mikko Uusitalo, Carl Wijting (Nokia Research Center, Finland)

### Spatio-Temporal Spectrum Holes and the Secondary User

Martin Weiss (University of Pittsburgh, USA)

Thursday, 5 May 2011 • 11:30 – 12:30 • Room: Berlin

## Panel: Regulatory Perspectives on Next Generation Radio Systems

### Panelists:

**Fadel Digham** (National Telecom Regulatory Authority, Egypt)

**Reza Karimi** (OFCOM, UK)

**Reiner Liebier** (Federal Network Agency, Germany)

**Ruprecht Niepold** (European Commission, Belgium)

**Douglas Sicker** (Federal Communications Commission, USA)

**Moderator: Martin Weiss**, University of Pittsburgh, USA

Thursday, 5 May 2011 • 13:30 – 15:00 • Room: Berlin 3

## Technology Session III: TV White Space

Chair: **Allen B. MacKenzie**, Virginia Tech, USA

### Database-Assisted Multi-AP Network on TV White Spaces: Architecture, Spectrum Allocation and AP Discovery

Xiaojun Feng, Jin Zhang, Qian Zhang  
(Hong Kong University of Science and Technology, Hong Kong)

### Monitoring-Based Spectrum Management for Expanding Opportunities of White Space Utilization

Kazushi Muraoka, Hiroto Sugahara, Masayuki Ariyoshi (NEC, Japan)

### Field Trials Of DVB-T Sensing For TV White Spaces

Rob Davies (Philips Research Laboratories, UK)  
Monisha Ghosh (Philips Research North America, USA)

### A TV White Space Spectrum Sensing Prototype

Raamkumar Balamurthi, Harshit Joshi, Cong Nguyen, Ahmed Sadek,  
Stephen Shellhammer, Cong Shen (Qualcomm, USA)

Thursday, 5 May 2011 • 13:30 – 15:00 • Room: Berlin 1

## Policy Session II: Business Cases: Commercial Considerations for Deploying Shared Access Systems

Chair: **Martin Weiss**, University of Pittsburgh, USA

### Pricing of Spectrum Based On Physical Criteria

Andrew Kerans, Dat Vo, Phillip Conder  
(Australian Communications and Media Authority, Australia)  
Snezana Krusevac (Australian National University, Australia)

### The Value of Sensing for TV White Spaces

Vânia Gonçalves (IBBT-SMIT, Vrije Universiteit Brussel, Belgium)  
Sofie Pollin (IMEC / University of California, Berkeley, USA)

### Evaluation of Business Cases for a Cognitive Radio Network based on Wireless Sensor Network

Ole Grøndalen, Marku Lähteenoja, Pål R Grønsund (Telenor, Norway)

### Techno-economical Viability of Cognitive Solutions for a Factory Scenario

Lieven Tytgat (Ghent University, Belgium)  
Matthias Barrie, Vânia Gonçalves  
(IBBT-SMIT, Vrije Universiteit Brussel, Belgium)  
Opher Yaron, Ingrid Moerman, Piet Demeester (Ghent University, Belgium)  
Sofie Pollin (IMEC / University of California, Berkeley, USA)  
Pieter Ballon (Vrije Universiteit Brussel, Belgium)  
Simon Delaere (IBBT-SMIT, Vrije Universiteit Brussel, Belgium)

Thursday, 5 May 2011 • 16:30 – 18:00 • Room: Berlin 3

## Technology Session IV: Secondary Spectrum Access

Chair: **Ryan Thomas**, AFIT, USA

### License-exempt LTE Systems for Secondary Spectrum Usage: Scenarios and First Assessment

Muhammad Imadur Rahman, Ali Behravan (Ericsson, Sweden)  
Havish Koorapaty (Ericsson, USA)  
Joachim Sachs (Ericsson, Germany)  
Kumar Balachandran (Ericsson, USA)

### Influence of Primary Network Structure and Dynamics on Achievable Performance of Cognitive Wireless Networks

Janne Riihijärvi, Jad Nasreddine, Petri Mähönen  
(RWTH Aachen University, Germany)

### On the Requirements of Secondary Access to 960-1215 MHz Aeronautical Spectrum

Ki Won Sung, Evanny Obregon, Jens Zander  
(Royal Institute of Technology, Sweden)

### Adaptive Sensing and Transmission Durations for Cognitive Radios

Wessam Afifi, Ahmed Sultan, Mohammed Nafie (Nile University, Egypt)

Thursday, 5 May 2011 • 16:30 – 18:00 • Room: Berlin 1

## Policy Session III: Policy & Engineering: Impact of Technical Considerations on Policy Frameworks

Chair: **William Webb**, Neul, UK

### Improve Secure Communications in Cognitive Two-Way Relay Networks using Sequential Second Price Auction

Tianyu Wang, Lingyang Song (Peking University, China)  
Zhu Han (University of Houston, USA)  
Bingli Jiao (Peking University, China)

### Potential Collapse of Whitespaces and the Prospect for a Universal Power Rule

Kate Harrison, Anant Sahai (University of California, Berkeley, USA)

### Virtual Occupancy in Cognitive Radio

Mark Burke, Bridget Lally, Andrew Kerans  
(Australian Communications and Media Authority, Australia)

### Exclusive Sharing & Virtualization of the Cellular Network

Timothy K. Forde, Irene Macaluso, Linda Doyle  
(Trinity College Dublin, Ireland)

Friday, 6 May 2011 • 9:30 – 10:30 • Room: Berlin

## Panel: Perspectives on Cognitive Radios: The Past and Next 10 Years

### Panelists:

**John Chapin** (MIT, USA)  
**Joseph Mitola III** (Stevens Institute of Technology, USA)  
**Anant Sahai** (University of California, Berkeley, USA)

**Moderator: Petri Mähönen**, RWTH Aachen, Germany

Friday, 6 May 2011 • 11:00 – 12:30 • Room: Berlin

## Panel: Business Perspectives on Dynamic Spectrum Access

### Panelists:

**Paul Kolodzy** (Kolodzy Consulting, USA)  
**Berna Sayrac** (France Telecom, France)  
**Mahesh Sooriyabandara** (Toshiba Research, UK)  
**Lasse Wieweg** (Ericsson, Sweden)

**Moderator: Pierre de Vries**, Silicon Flatirons Center, USA

Friday, 6 May 2011 • 13:30 – 15:00 • Room: Berlin 3

## Technology Session V: Spectrum Sharing and Protocols

**Chair: Luiz DaSilva**, Virginia Tech, USA

### TRUMP: Supporting Efficient Realization of Protocols for Cognitive Radio Networks

Xi Zhang, Junaid Ansari, Guangwei Yang, Petri Mähönen (RWTH Aachen University, Germany)

### The Effects of a Dynamic Spectrum Access Overlay in LTE-Advanced Networks

Juan Deaton, Ryan Irwin (Virginia Polytechnic Institute / State University, USA)  
 Luiz A. DaSilva (Virginia Polytechnic Institute / State University, Ireland)

### A Cross-layer Framework for Symbiotic Relaying in Cognitive Radio Networks

Taskeen Nadkar, Vinaykumar Thumar, Konchady Shenoy, Amit Mehta (Indian Institute of Technology, Bombay, India)  
 Uday Desai (Indian Institute of Technology, Hyderabad, India)  
 Shabbir Merchant (Indian Institute of Technology, Bombay, India)

### Coexistence of Homogeneous and Heterogeneous Systems for IEEE 802.15.4g Smart Utility Networks

Chin-Sean Sum, Fumihide Kojima, Hiroshi Harada (National Institute of Information & Communications Technology, Japan)

Friday, 6 May 2011 • 13:30 – 15:00 • Room: Berlin 2

## Joint Technology and Policy Session II

**Chair: Jianwei Huang**, Chinese University of Hong Kong, Hong Kong

### Non-identical Objects Auction for Spectrum Sharing in TV White Spaces - The Perspective of Service Providers as Secondary Users

Marcin Parzy, Hanna Bogucka (Poznan University of Technology, Poland)

### Contract-based Cooperative Spectrum Sharing

Lingjie Duan, Lin Gao, Jianwei Huang (Chinese University of Hong Kong, Hong Kong)

### Signal Quality Pricing: Decomposition for Spectrum Scheduling and System Configuration

Eric Anderson (Carnegie Mellon University, USA)  
 Caleb Phillips, Douglas Sicker, Dirk Grunwald (University of Colorado, USA)

### Transmission Probability Control Game with Limited Energy

Johannes Dams, Thomas Kesselheim, Berthold Vöcking (RWTH Aachen, Germany)

Friday, 6 May 2011 • 13:30 – 15:00 • Room: Berlin 1

## Policy Session IV: Regulatory Engineering: Technical Solutions to Regulatory Problems

**Chair: Joachim Sachs**, Ericsson, Germany

### Why the Caged Cognitive Radio Sings

Kristen Woyach, Anant Sahai (University of California, Berkeley, USA)

### Geolocation Databases for White Space Devices in the UHF TV Bands: Specification of Regulatory Emission Limits

Hamid Reza Karimi (OFCOM, UK)

### Impact of Geographic Complementarity in Dynamic Spectrum Access

Junwhan Kim, Anil Kumar Vullikanti, Achla Marathe, Guan hong Pei, Sudip Saha, Balaaji Subbiah (Virginia Tech, USA)

### Lights and Sirens Broadband - How Spectrum Pooling, Cognitive Radio, and Dynamic Prioritization Management can Empower Emergency Communications, Restore Sanity and Save Billions

Nancy Jesuale (NetCity Engineering, USA)

Friday, 6 May 2011 • 15:30 – 17:00 • Room: Berlin 3

## Technology Session VI: PHY Issues and Experimental Studies

### Chair: Przemyslaw Pawelczak,

University of California, Los Angeles, USA

### Blind Synchronization for NC-OFDMs - When "Channels" Are Conventions, Not Mandates

Dola Saha, Aweek Dutta, Dirk Grunwald, Douglas Sicker (University of Colorado, USA)

### A Reconfigurable Wavelet Packet Filter Bank Transceiver for Spectral Analysis and Dynamic Spectrum Access

Madan Kumar Lakshmanan, Dyonisius Ariananda, Homayoun Nikookar (Delft University of Technology, Netherlands)

### A Cognitive Radio Architecture based on sub-Nyquist Sampling

Dennis Wieruch (Fraunhofer Institute for Telecommunications, Heinrich-Hertz Institut, Germany)  
 Volker Pohl (Technische Universität München, DE)

### Experimental Evaluation of Cyclostationarity-Based Multiple Signal Identification Method by using Spatial Channel Emulator

Hiroki Harada, Hiromasa Fujii, Shunji Miura, Hidetoshi Kayama, Yoshiki Okano, Tetsuro Imai (NTT DOCOMO, Inc., Japan)

Friday, 6 May 2011 • 15:30 – 17:00 • Room: Berlin 1

## Technology Session VII: Spectrum Sensing II

**Chair: Oliver Holland**, KCL, UK

### The Theoretical Performance of ATSC Spectrum Sensing

Stephen Shellhammer (Qualcomm, USA)

### Performance Evaluation of Sensing Solutions

Peter Van Wesemael (IMEC, Belgium)  
 Sofie Pollin (IMEC / University of California, Berkeley, USA)  
 Eduardo Lopez, Antoine Dejonghe (IMEC, Belgium)

### Edge based Wideband Sensing for Cognitive Radio: Algorithm and Performance Evaluation

Yonghong Zeng, Ying-Chang Liang, Meng Wah Chia (Institute of Infocomm Research, Singapore)

### A NLLS based Sub-Nyquist Rate Spectrum Sensing for Wideband Cognitive Radio

Moslem Rashidi, Kasra Haghighi, Ashkan Panahi, Mats Viberg (Chalmers University of Technology, Sweden)

Thursday, 5 May 2011 • 12:30 – 13:30 &amp; 15:00 – 16:30 • Room: Lissabon

**A Novel Multi-layer Framework for Modeling the Evolution of Spectrum Markets and Cognitive Radio Devices**Georgios Fortetsanakis, Markos Katsoulakis, Maria Papadopouli  
(University of Crete, Greece)**Aggregate Interference with FCC and ECC White Space Usage Rules: Case Study in Finland**Riku Jäntti (Helsinki University of Technology, Finland)  
Jussi Kerttula (Aalto University, Finland)  
Konstantinos Koufos (TKK, Finland)  
Kalle Ruttik (Helsinki University of Technology, Finland)**Experimental Spectrum Sensor Testbed for Constructing Indoor Radio Environmental Maps**Elena Meshkova, Junaid Ansari (RWTH Aachen University, Germany)  
Daniel Denkovski (Ss. Cyril and Methodius University, Skopje, Macedonia)  
Janne Riihijärvi, Jad Nasreddine (RWTH Aachen University, Germany)  
Mihajlo Pavloski, Liljana Gavrilovska  
(Ss Cyril and Methodius University, Skopje, Macedonia)  
Petri Mähönen (RWTH Aachen University, Germany)**Exploiting TV White Spaces in Europe: The COGEU Approach**

Joseph Mwangoka (Instituto de Telecomunicações - Aveiro, Portugal)

**Finding Green Spots and Turning the Spectrum Dial: Novel Techniques for Green Mobile Wireless Networks**Giordano Fusco (Stony Brook University, USA)  
Milind Buddhikot (Bell Labs, Alcatel-Lucent, USA)  
Himanshu Gupta (Stony Brook University, USA)  
Sivarama Venkatesan (Bell Labs, Alcatel-Lucent, USA)**IPTV Delivery using Cognitive Radio Principles**

Tim Farnham (Toshiba Research Europe Ltd., UK)

**Iterative Cooperative Sensing on Shared Primary Spectrum for Improving Sensing Ability**

Mai Ohta, Takeo Fujii (University of Electro-Communications, Japan)

**Model-based Spectrum Management: Loose Coupling Spectrum Management and Spectrum Access**

John Stine (The MITRE Corporation, USA)

**Multi-hop MAC Implementations for Affordable SDR Hardware**J. Colman O'Sullivan (Trinity College Dublin, Ireland)  
Paolo Di Francesco (University of Bologna, Italy)  
Uchenna Anyanwu (Virginia Tech, USA)  
Luiz DaSilva (Trinity College, Ireland)  
Allen MacKenzie (Virginia Tech, USA)**On Secondary Network Interference Alignment in Cognitive Radio**Haichuan Zhou, Tharmalingam Ratnarajah (Queen's University of Belfast, UK)  
Ying-Chang Liang (Institute for Infocomm Research, Singapore)**Reinforcement Learning based Distributed Multiagent sensing Policy for Cognitive Radio Networks**Jarmo Lunden (Teknillinen Korkeakoulu, Finland)  
Visa Koivunen (HUT, Finland)  
Sanjeev Kulkarni, H. Vincent Poor (Princeton University, USA)**Simplified DFT: A Novel Method for Wideband Spectrum Sensing**Yasin Miar, Claude D'Amours, Abbas Yongacoglu (University of Ottawa, Canada)  
Tyseer Aboulnasr (University of British Columbia, Canada)**Towards Characterizing Primary Usage in Cellular Networks: A Traffic-based Study**Maria Michalopoulou, Janne Riihijärvi, Petri Mähönen  
(RWTH Aachen University, Germany)

Wednesday, 4 May 2011 • 12:30 – 13:30 &amp; 15:00 – 15:30 • Room: Lissabon

Thursday, 5 May 2011 • 12:30 – 13:30 &amp; 15:00 – 16:30 • Room: Lissabon

**An Integrated Reconfigurable Engine for Multi-purpose sensing up to 6 GHz**Sofie Pollin (IMEC / University of California, Berkeley, USA)  
Lieven Hollevoet, Peter Van Wesemael, Mattias Desmet, Andre Bourdoux,  
Eduardo Lopez, Frederik Naessens (IMEC, Belgium)  
Praveen Raghavan (IMEC / Katholieke Universiteit, Leuven, Belgium)  
Veerle Derudder, Steven Dupont, Antoine Dejonghe (IMEC, Belgium)**Blind Identification of Commercial Wireless Standards**

Jacques Palicot (SUPELEC, France)

**Cognitive Radio Developments for Emergency Communication Systems**Phillip Conder (Australian Communications and Media Authority, Australia)  
Lance Linton, Mike Faulkner (Victoria University, Australia)**Constructing Radio Environment Maps with Heterogeneous Spectrum Sensors**Vladimir Atanasovski (Ss. Cyril and Methodius University, Skopje, Macedonia)  
Jaap van de Beek (Huawei Technologies, Sweden)  
Antoine Dejonghe (IMEC, Belgium)  
Daniel Denkovski, Liljana Gavrilovska  
(Ss Cyril and Methodius University, Skopje, Macedonia)  
Sébastien Grimoud (France Telecom R&D, France)  
Petri Mähönen (RWTH Aachen University, Germany)  
Mihajlo Pavloski, Valentin Rakovic  
(Ss. Cyril and Methodius University, Skopje, Macedonia)  
Janne Riihijärvi (RWTH Aachen University, Germany)  
Berna Sayrac (Orange Labs, France)**OpenAirInterface.org and Agile Spectrum Access**Christian Bonnet, Riadh Ghaddab, Aawatif Hayar, Florian Kaltenberger,  
Raymond Knopp, Dominique Nussbaum, Navid Nikaein, Erhan Yilmaz,  
Daniel Camara, Bassem Zayen (Eurecom, France)  
Bertrand Mercier, Lorenzo Iacobelli (Thales, France)**Peak Power Reduction of Flexible OFDM Waveforms for Cognitive Radio**

Baris Ozgul, Paul Sutton, Linda Doyle (Trinity College Dublin, Ireland)

**Self-organizing Home Networking based on Cognitive Radio Technologies**Zhou Wang (European Microsoft Innovation Center, Germany)  
Junaid Ansari (RWTH Aachen University, Germany)  
Vladimir Atanasovski, Daniel Denkovski  
(Ss. Cyril and Methodius University in Skopje, Macedonia)  
Tim Farnham (Toshiba Research Europe Ltd., UK)  
Alain Gefflaut (European Microsoft Innovation Center, Germany)  
Riccardo Manfrin (University of Padova, Italy)  
Elena Meshkova, Jad Nasreddine, Krisakorn Rerkrai  
(RWTH Aachen University, Germany)  
Mahesh Sooriyabandara (Toshiba Research Europe Limited, UK)  
Andrea Zanella (University of Padova, Italy)**Spectrum Mobility Demonstration over SMSE based Overlay Cognitive Radio via Software Defined Radio**Ruolin Zhou, Xue Li (Wright State University, USA)  
Vasu Chakravarthy (Air Force Research Laboratory, USA)  
Zhiqiang Wu (Wright State University, USA)**TRUMP: Efficient Realization of PHY/MAC Protocols for Cognitive Radio Networks**Xi Zhang, Junaid Ansari, Petri Mähönen, Guangwei Yang  
(RWTH Aachen University, Germany)

Tuesday, 3 May 2011 • 9:00 – 17:00 • Room: Institute for Networked Systems, RWTH Aachen University  
(Transportation: Shuttle bus will be provided for the participants from the conference hotel, departing at 8:30)

## **T1: Cognitive Wireless Networking with WARP**

**Presenters:** Petri Mahonen (RWTH Aachen, Germany)

**Ashutosh Sabharwal** (Rice University, USA)

This hands-on tutorial will introduce the participants to developing cognitive radio prototypes, especially for higher layer concepts.

The first part of the tutorial will explain the WARP platform basics, including introduction to the hardware and design flows. This will include the current Rice MIMO-OFDM reference design implementation on WARP. Building on the WARP PHY, we will introduce RWTH flexible cognitive radio MAC layer design. We will discuss also the key lessons learnt from clean-slate implementations on the WARP hardware, and methods to leverage existing open-source code base.

In the second part of the tutorial, participants will have a full access to dozen WARP boards and necessary infrastructure. We would use the rest of the day for hands-on tutorial, where the participants will engage to interactive tutorial to learn in intensive course manner the basic parts of the platform and tool-chain. Furthermore, they will be able to work with several research demonstrations built by Rice and RWTH researchers. This part will also serve to encourage collaborative discussions between the workshop participants.

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Tuesday, 3 May 2011 • 9:00 – 12:30 • Room: Berlin 1

## **T2: Non-Contiguous Multicarrier Transmission for Spectrally Opportunistic Wireless Access: Design Decisions and Trade-Offs**

**Presenters:** Alexander M. Wyglinski (Worcester Polytechnic Institute, USA)

**Hanna Bogucka** and **Adrian Kliks** (University of Technology, Poland)

**Srikanth Pagadarai** (Worcester Polytechnic Institute, USA)

Multicarrier modulation has been employed in numerous modern wireless communications standards due to its ability in providing high data rates while simultaneously counteracting the effects of intersymbol interference due to multipath fading channels. In the recent years, multicarrier modulation is being investigated as a possible candidate data transmission scheme for achieving spectrally agile wireless access in scenarios where unlicensed users temporarily “borrow” unoccupied licensed frequency bands while minimizing interference with spectrally adjacent signals, i.e., opportunistic wireless access. Specifically, the divide-and-conquer data transmission approach employed by multicarrier modulation makes it an attractive option for realizing wireless communication systems that do not require a single continuous transmission frequency band.

In this tutorial, we present several multicarrier transmission solutions designed for efficiently achieving opportunistic wireless access. In particular, we shall investigate two types of spectrally-agile multicarrier modulation schemes, namely, non-contiguous orthogonal frequency division multiplexing (NC-OFDM) and non-contiguous non-orthogonal frequency division multiplexing (NC-NOFDM). The viability of these two techniques employed within an opportunistic wireless access scenario is assessed using actual spectrum measurement data, and a comparative study in terms of out-of-band (OOB) interference mitigation as well as implementation complexity is provided.

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Tuesday, 3 May 2011 • 9:00 – 12:30 • Room: Berlin 2

## **T3: Advanced Antennas for Cognitive Radio: New Foundations for Transformational System Design**

**Presenter:** Jennifer T. Bernhard (University of Illinois, Urbana-Champaign, USA)

Emerging models for cognitive radio often rely solely on abilities to sense and/or adjust operating frequencies. These approaches envision antennas in a very traditional way, assuming either broadband or, perhaps, tunable frequency operation, but nothing more. However, if included early in the system concept and design cycle, new kinds of advanced antennas, including reconfigurable antennas and novel antenna arrays, promise to deliver a much deeper knowledge of the electromagnetic environment than traditional antenna solutions, as well as a much broader range of capabilities with which to use and leverage this environment to greater effect.

This tutorial will first provide a foundational overview of antenna behavior and parameters, with an emphasis on the relationships between antenna parameters and system performance as well as the differences between theoretical and realistic antenna characteristics. Second, the tutorial will help the audience carefully consider the assumptions made about antennas for cognitive radio and the inherent limitations these assumptions impose on the final system configuration. Participants will then discuss what antenna functionality would ultimately be desired to fully sense and leverage the existing electromagnetic environment. Next, the tutorial will highlight some ongoing work in the area of innovative antennas for cognitive radio, including electrically small direction-finding arrays and reconfigurable adaptive arrays for small platforms. System-level implications of inclusion of antenna control and feedback will be addressed.

Finally, promising areas for future research and development will be presented, with emphasis placed on illumination of areas for collaboration between researchers and developers in antennas, radios, communications, signal processing, and protocols. As part of this presentation, the results of the recent NSF Enhancing Access to the Radio Spectrum Workshop will also be summarized.

Tuesday, 3 May 2011 • 9:00 – 12:30 • Room: Berlin 3

#### **T4: Dynamic Spectrum Access Related Standards**

**Presenters:** Markus Mueck (Intel Mobile Communications, Germany)

Oliver Holland (Kings College London, UK)

Mahesh Sooriyabandara (Toshiba Research Europe Limited, UK)

Przemysław Pawełczak (University of California, Los Angeles, USA)

Significant progress is being made on the technical capabilities of mobile and wireless devices and systems in terms of, e.g., spectrum usage flexibility and radio access adaptability. Furthermore, regulations in various countries are opening up to the idea of cognitive radio and other dynamic spectrum access related paradigms. In tandem with such developments, various standards are being developed by the IEEE, ETSI and others, with a view to taking advantage of the opportunities in cognitive radio and dynamic spectrum access that are being created. This is important, because although regulations may allow such technologies to exist while ensuring that no negative impacts result, standards are necessary to ensure that the dynamic spectrum access related products developed by a range of manufacturers are compatible, will coexist efficiently, or indeed will be able to communicate and form dynamic spectrum access links and networks.

This tutorial provides a general overview of the objectives and purposes of standardization, particularly discussing the importance of standards to the viability and performance of various facets of dynamic spectrum access. It then focuses on some specific dynamic spectrum access related standards, starting with the IEEE 802.22 wireless regional area networks standard--the first standard being worked on to utilize TV Whitespace. Next it discusses the IEEE DySPAN Standards Committee (1900 series) standards as well as ongoing efforts within ETSI's Reconfigurable Radio Systems work area on standardizing a range of technologies which facilitate dynamic spectrum access concepts. Finally, the tutorial briefly touches on some lesser-known, newer, or related standards work of interest, including the relatively recent drive to extend Wi-Fi for operation in TV Whitespace (the IEEE 802.11af standards task group), the IEEE 802.19 "Wireless Coexistence" standards working group, the ECMA-392 standard, and the IEEE 802.11y and 802.16h standards.

Tuesday, 3 May 2011 • 13:30 – 17:00 • Room: Berlin 1

#### **T5: Dynamic Spectrum Markets**

**Presenters:** Randall Berry and Michael Honig (Northwestern University, USA)

Dynamic spectrum markets are emerging as a key paradigm for rethinking current spectrum allocations. Such markets could improve the efficiency of radio spectrum allocations by allowing under-utilized spectrum to be re-allocated (traded) over short time-scales in response to changing demand. While technical advances, such as frequency-agile and cognitive radios, are needed to facilitate flexible spectrum use and distributed interference management, introducing markets raises additional issues that intersect technology, micro-economics, and policy.

This tutorial will first motivate dynamic spectrum markets and relate these to current and proposed spectrum sharing mechanisms. We will then discuss how the choice of spectrum assets to be traded may influence the technology and the resulting market mechanism. Potential market structures that could emerge will be discussed along with associated interference management issues. We will conclude with a comparison of markets with other mechanisms for spectrum sharing (in particular, cognitive radio) and discuss some possible implications for wireless system design.

Tuesday, 3 May 2011 • 13:30 – 17:00 • Room: Berlin 3

#### **T6: Policy Questions Relevant to Dynamic Spectrum and Cognitive Radios: An Introduction from a Technologist's Point of View**

**Presenter:** Anant Sahai (University of California, Berkeley, USA)

Although dynamic spectrum access is inherently an interdisciplinary area, many have difficulty interacting across the technology/policy divide. Policy folks tend to have simplified models for what the technological constraints and possibilities are. One role of technology/policy interaction is to help them upgrade their outdated technical models, while still keeping things simple and understandable.

In an ideal world, the technology folks would also have simplified models for what the policy concerns and constraints are. These too can become outdated and require upgrades. Successful interaction requires both sides to not only have simplified models of each other's concerns and constraints, but also to know what the other's simplified models are for their own concerns and constraints. Being able to arbitrage across this interface is a powerful way to gain new insights.

This tutorial is designed to quickly introduce the key policy concerns to a technical audience and will do so with reference to a selection of seminal papers. This will be done in a beginner-friendly way. I will try to make explicit the simplified technology models that policy folks rely upon as well as to help synthesize simplified models for the policy concerns that technology folks can use to guide their own work. This tutorial should attract a mixed audience so that productive interaction can start happening during the event itself.

One desired side-effect is for this tutorial to better prepare people to appreciate the sessions in the conference. And so, as a special treat, this tutorial will have a bonus recap session that will meet at the end of the conference to further discuss the new policy ideas and papers that emerge at this conference, as well as to put the exciting new emerging technology ideas within a policy context.

**NOTE: An additional follow-up 90-minute session to this tutorial will be from 15:30 – 17:00 in Berlin 2 on Friday, 6 May.**

# SOCIAL PROGRAM

## Welcome Reception

Tuesday, 3 May 2011 • 19:00 – 21:00

The welcome reception is your chance to connect with peers and presenters in a relaxed, informal setting – and the organizing committee's chance to celebrate your arrival at IEEE DySPAN 2011. It will be held in the Kaminhalle Room at the conference hotel from 19:00 – 21:00, and is included in full, student and life registrations.



## Cathedral Tours

Wednesday, 4 May 2011 • 17:15 & 18:00

As part of the social program, we will organize guided tours on the evening of Wednesday, 4 May, to the historical Cathedral of Aachen. Over a period of 600 years this Cathedral commenced by Charlemagne, and also acting as his burial site, has served as the church of coronation for 30 German kings and 12 queens. Being one of the original UNESCO world heritage sites, the Aachen Cathedral is considered as one of the most important historical landmarks in northern Europe. During the tour attendees will be led through the interior of the Cathedral, including the collections of historical artifacts stored there. The tours will be leaving from the conference hotel, from which the Cathedral is within a walking distance.

The number of places on the tours will be limited, and will be available on a first come, first served basis. More information and registration to the tours will be available at the registration desk of the conference.



## Conference Banquet

Thursday, 5 May 2011 • 19:00 – 22:00

The conference banquet will take place in the Coronation Hall of the historical Aachen City Hall, where kings of Germany traditionally held their coronation banquets over centuries. The banquet will begin with a reception, during which the attendees can visit different parts of the City Hall. Guides will be also available during this part of the event. Following the reception, banquet itself will commence in the Coronation Hall. The banquet is included in full registration. Additional banquet tickets are available for purchase at the registration desk.





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## Distributed real-time spectrum and signal monitoring systems

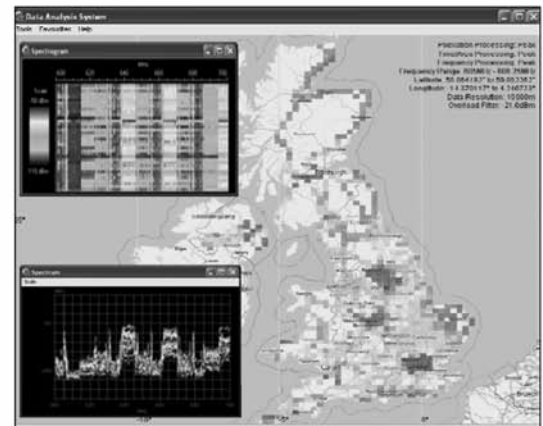
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## Wireless Research at Microsoft

Microsoft has opened a new center, called **Mobile Computing Research Center**. The mission of this center is “to invent technologies that make Microsoft’s Devices and Services indispensable to the world”. On-going projects include white spaces, 60 GHz, and software defined radios. Microsoft Research is credited with the deployment of the first urban white space network. Spectrum regulators from all over the world have visited the Microsoft campus to see the white spaces trial and discuss regulatory and technical issues. In the US, the landmark white space policy was influenced by the work done in Microsoft. Details are at: <http://research.microsoft.com/knows>



mobile computing  
research center

Microsoft  
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**LTE PHY Software**

**LTE Stack Software**

For

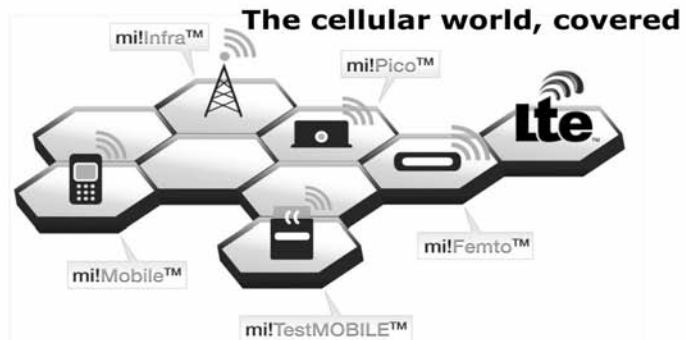
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UMIC is a research center at RWTH Aachen University established under the German Federal and State Government Excellence Initiative. In its focus are Ultra high-speed Mobile Information and Communication systems (UMIC) supporting the demands of future mobile applications and systems. As an academic research centre with strong links to industry and mobile network operators, UMIC pursues research on basic concepts and new paradigms, on key solutions and tools, the development of prototypes and demonstrators, and the technology transfer to industry. A major strength of the UMIC research center is the interdisciplinary research combining the expertise of more than 15 institutes from computer science and electrical engineering and covering all aspects from mobile applications, networks and terminals down to design and implementation of radio frequency subsystems and multi-processor systems on chip.

The logo for inETS features the lowercase letter 'i' in a bold, sans-serif font, followed by the uppercase letters 'NETS' in a larger, bold, sans-serif font. The 'i' has a solid black dot above it.

[www.inets.rwth-aachen.de](http://www.inets.rwth-aachen.de)

## PRELIMINARY CALL FOR PAPERS

IEEE DySPAN is the premier conference to discuss, publish and present recent results in Dynamic Spectrum Access (DSA) and Cognitive Radio Domain, including discussion on any radical and novel approaches towards more efficient spectrum use and technologies related to that. There has been tremendous progress in the research and development of DSA in recent years and the organizers of IEEE DySPAN 2012 encourage submissions that exhibit the recent success stories and research that go also beyond narrow meaning of DSA. The special themes for 2012 are advanced spectrum engineering, novel spectrum sharing methods and policies, and systems oriented research.

IEEE DySPAN 2012, like its predecessors, is a unique symposium that gathers technology, policy and regulatory communities together. In addition to program tracks for technology and policy papers, the conference will hold system demonstrations, panels, and tutorials that are tailored for special audiences such as regulators and industry. The conference will also host several keynote sessions given by leaders of the technology and policy communities.

IEEE DySPAN 2012 welcomes contributions dealing with regulatory aspects of dynamic spectrum access, theoretical studies, algorithm and protocol design for cognitive radios and networks, as well as application-oriented contributions dealing with architectures, platforms, signaling and multiple access schemes. We are particularly looking for papers reporting on systems aspects and prototypes, summaries on the regulatory advancements, spectrum measurements and analysis of white space opportunities, and business cases for advanced spectrum engineering. We invite contributions outlining advances in self-optimization, learning, and context sensitivity of cognitive radios, and DSA concepts that consider a complete network and describe novel optimization schemes.

We seek original and unpublished work not currently under review by any other journal/magazine/conference. We seek technology and policy topics including, but not limited to, the following:

### TECHNOLOGY PROGRAM

- Spectrum measurement and models
- Architecture and platform for dynamic spectrum access networks
- Efficient and broadband spectrum sensing
- Spectrum sensing mechanisms and protocol support
- Interference metrics and measurements
- Radio resource management and dynamic spectrum access networks
- Applications of DSA
- New spectrum sharing models
- Multiple access schemes for cognitive radio networks
- Cross-layer optimization for cognitive radio networks
- Information-theoretic aspects of cognitive radio networks
- QoS provisioning and MAC protocol
- Trust and security issues
- Experimental prototypes and results

### POLICY PROGRAM

- Business model / Pricing for dynamic spectrum access
- Market trends for secondary spectrum usage
- Regulations for dynamic spectrum access
- Software regulation / standardization and equipment certification
- Industrial and government role in dynamic spectrum access
- Dynamic spectrum auction and economics
- Spectrum etiquettes for unlicensed bands
- Defining / Enforcing rights and responsibilities of spectrum licensees and easements

**PAPER SUBMISSIONS:** The conference language is English. Papers should be concisely written. Maximum paper length for review is 12-pages in IEEE conference proceedings format (two-column and 10-point font). Register and submit your paper via EDAS (<http://edas.info>).

### IMPORTANT DATES

**Paper Submissions Due:**  
2 November 2011 (tentative)

**Acceptance Notification:**  
6 January 2012

**Camera-Ready Paper Due:**  
31 January 2012



# IEEE DySPAN 2011 PATRONS

