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## Toward a Smart, Fully Connected Society: An Overview of the 32nd Meeting of the Wireless World Research Forum

It's a very different world from when the Wireless World Research Forum (WWRF) started back in 2001, although some things seem similar. At the time, the focus was on preparing for European research programs that would drive research into fourth-generation (4G) systems, which are now being rolled out worldwide, and the WWRF played a major role in setting up the Wireless World Initiative, which itself played a crucial role in setting up and coordinating the main 4G research projects such as WINNER and Ambient Networks. Now, a generation later, we are considering the fifth generation (5G) of mobile communication networks. At the WWRF, we have been active in developing the discussion on what are the requirements and potential technologies for 5G, through our series of Wireless World 2020 workshops, which started at the IEEE Vehicular Technology Conference in September 2012. And now, we are about to launch our 5G Huddle that will bring together key players from across the industry to discuss the requirements and technologies for the next generation of wireless communication.

The 32nd meeting of the WWRF took place from 20 to 22 May 2014 in Marrakech, Morocco, and it was the

first time that the WWRF has held a meeting in Africa. The theme of the meeting was "toward a smart fully connected society."

During the meeting, the WWRF appointed two new Fellows, Prof. Ramjee Prasad of Aalborg University, Denmark, and Dr. Reinaldo Valenzuela of Alcatel-Lucent. This means that the WWRF now has 20 appointed Fellows. Prof. Ramjee Prasad was appointed in recognition of his many personal and insightful contributions to the development of wireless communications. In particular, we recognized his contributions to the development of code division multiple access (CDMA) and software-defined radio and to the field of education in wireless technologies in Europe and Asia. In his Fellow's address, Prof. Prasad spoke about "Human Bond Future Communications." In his presentation, he emphasized the future of personal networking and the importance of a multisensory approach. According to Prof. Prasad, future concepts of the personal network will have the capacity to gather, express, and transform input from all of the human senses and, as such, have an effect on future services, devices, and networks.

Dr. Reinaldo Valenzuela was appointed in recognition of his many personal and insightful contributions to the development of wireless communications. In particular, his work in leading industry research

on the development of high-capacity air interfaces, and in experimental activities for equipment design, will have significant impact on future wireless technologies. In this meeting, Valenzuela gave a presentation, "5G: Technology Options, Opportunities and Challenges." In his speech, Valenzuela presented design targets and possible solutions for future systems. He strongly emphasized the need for business cases for the development.

In this meeting, a memorandum of understanding (MOU) was signed between the WWRF and the Commonwealth Telecommunications Organization (CTO) by CTO Director-General Prof. Tim Unwin and the WWRF Chair Dr. Nigel Jefferies. The MoU provides for ongoing collaboration on the research into mobile communications relevant to the needs of developing regions. As a part of the meeting, Prof. Unwin gave a keynote speech, "Mobile Communication in the Commonwealth: Challenges and Potential for Development." This keynote speech strongly emphasized the inequality of wireless development. New systems are developed mostly by the needs of developed countries, while, in developing countries, wireless and mobile services and their utilization have completely different objectives. The solutions to questions like "How can technologies be used for social equality?" need to be prioritized.

In addition to the working group sessions, the meeting also included plenary sessions covering topics that the WWRF deems worthy of further attention, in this case, 5G development, ICT applicability in different fields, and regional development in Africa and the Middle East.

From the presentations and accepted papers, the following six best papers have been selected by at least three independent reviews from the guest editors for this special edition to represent the technical discussion at WWRF32. The subjects range from measurements of the radio channel for wireless sensor networks, investigations of new spectrum and the relation to the system architecture, through architectural and system issues, to applications such as the shareconomy and application scenarios for work-life balance using mobile devices. This selection is targeting many important issues for current as well as future 5G mobile systems.

The first article, by Fariborz Entezami, Martin Tuncliffe, and Christos Politis from Kingston University, London, United Kingdom, is titled “Find the Weakest Link.” In wireless sensors, the radio frequency (RF) modules consume most of the energy. Routing metrics are important in the determination of paths and maintaining quality of service in routing protocols. Most efficient metrics need to send packets to maintain link quality measurement using an RF module. In this article, two prominent link quality metrics: received signal strength indication (RSSI) and link quality indication (LQI) are introduced. The symmetry of RSSI and LQI in two directions is studied, and also relations between expected transmission count, RSSI, and LQI as link quality metrics are analyzed.

The next article, “5G Mobile,” is presented by Yi Wang, Jian Li, Lei Huang, and Yao Jing from Huawei Technology Corporation Limited, Shanghai, China, and Andreas

Georgakopoulos and Panagiotis Demestichas from the University of Piraeus, Piraeus, Greece.

Next-generation 5G mobile systems are broadening their spectrum to higher spectrum (above 6 GHz) to support a high data rate up to multi-gigabits per second. In this article, two contributions on higher-frequency communication are given. First, all candidate spectrums that are promising for 5G, including licensed and unlicensed spectrums are summarized. Second, a new network architecture for higher-frequency communication is proposed, which is featured with load-centric backhauling, multiple-frequency transmission, and intelligent control techniques.

The article “Extending the LTE/LTE-A Business Case” is presented by Ramon Ferrús and Oriol Sallent from Universitat Politècnica de Catalunya, Spain.

With the advent of faster 4G mobile broadband networks and the proliferation of a rich ecosystem of smartphone applications in the commercial domain, expectations and demand for much more sophisticated and high-bandwidth applications are also on the rise within professional users sectors such as public safety, utilities, and transportation. In this context, this article analyzes the extension of the LTE/LTE-A business case to the professional mobile radio users. To that end, an overview of the technical features that are expected to turn the LTE standard into a mission-critical-capable technology is first addressed. Afterward, a number of potential service delivery models for private mobile broadband communications are identified, discussing the pros and cons of each value proposition.

Toktam Mahmoodi from King's College London and Srinu Seetharaman from Deutsche Telekom USA discuss in their article the important subject “Traffic Jam.”

Today's mobile operators face significant challenges with handling

the ever-increasing volume of mobile data traffic. With new mobile communication standards, the mobile backhaul architecture has a clear split of a packet-only data plane and a management plane. Although this new backhaul architecture yields to easier management, this architecture can be improved further by applying the principles of SDN. SDN allows for better evolvability of the data plane without depending on a slew of management or control protocols, centralized control of the overall infrastructure, and a richer feature set based on its programmable nature. This article investigates the redesign and illustrates its potential with mobility management as an example.

In the fifth article, Marcos Katz from the University of Oulu, Finland; Frank H.P. Fitzek and Daniel E. Lucani from Aalborg University, Denmark; and Patrick Seeling from Central Michigan University present “Mobile Clouds as the Building Blocks of Shareconomy.”

Mobile clouds embody a concept where mobile and wireless networks naturally interplay with social networks in a practically efficient fashion. This means not only using social networks over mobile networks but also creating mobile networks by social networks. In addition to enhancing communications performance and improving the efficiency in radio resource utilization, mobile clouds are a flexible platform for sharing distributed resources. The converged mobile, wireless, and social networks have the potential to become a key enabling technology of a novel trading paradigm called the *shareconomy*, a concept that can be readily exploited by 5G networks.

In the sixth and final article by Klaus David et al. from Kassel University and the Technical University of Darmstadt, Germany, the challenge of “Balancing the Online Life” and “Broken Rail Detection” is discussed.

## 5G MOBILE SYSTEMS ARE BROADENING THEIR SPECTRUM TO HIGHER SPECTRUM.

Basically, connectivity through mobile devices and working at any place and time can be a double-edged sword: on the one hand, it can open up very important advantages, such as increased flexibility, efficiency, and effectiveness. On the other hand, working individuals may increasingly struggle to balance their work and life domains.

This article has the following three contributions: 1) scenarios on mobile usage, which illustrate the challenges of being “always online” and keeping a functioning work–life balance are developed and 2) a new technical solution to address these problems—implicit communication based on contexts—is introduced. Based on this, the third contribution is the new communication paradigm, its definition, and related research questions.

A further elaboration of the themes of the WWRF will happen during our combined week of 5G events, comprising the 5G Huddle and WWRF33 meeting in September in the United Kingdom.

### Author Information

**Vasilis Friderikos** is a senior lecturer at the Centre for Telecommunications Research at King's College, London. He has been visiting researcher at WinLab in Rutgers University, United States. His research interests lie broadly within the closely overlapped areas of wireless networking, mobile computing, and architectural aspects of the Future Internet. His current areas of interest are network virtualization for emerging (long-term evolution-advanced) and future cellular networks (fifth generation), advanced mobility management techniques as well as device-to-device communications, and delay tolerant networking techniques in cellular networks. He is the recipient of the British Telecom

Fellowship Award in 2005. He has published more than 120 research papers and book chapters and received two best article awards in IEEE ICC 2010 and the WWRF conferences, respectively.

**Maryline H  lard** received the Ph.D. degree from the National Institute of Applied Science (INSA) Rennes and the Habilitation degree from Rennes 1 University, France, in 1984, and 2004, respectively. In 1985, she joined France Telecom as a research engineer and, since 1991, has been studying the physical layer in the field of digital television and wireless communications. In 2007, she joined the INSA as a professor, and she is now the codirector of the communication department of the Electronics and Telecommunications Institute of Rennes. Her current research interests are in the areas of digital communications, such as multiple-input, multiple-output techniques; orthogonal frequency-division multiplexing; multi-carrier code division multiple access (MC-CDMA); channel estimation; equalization; and iterative processing applied to wireless communications and more recently to wire communications (asymmetric digital subscriber line and optical). She was involved in several French and European collaborative research projects including digital television, MC-CDMA techniques and time reversal. She is a coauthor of more than 125 technical papers and 25 patents.

**Jari Porras** received the Dr. Sc. (Tech.) degree from the Lappeenranta University of Technology, Finland, in 1998 on modeling and simulation of communication networks in a distributed computing environment. He is a professor of distributed systems and wireless communications and is currently head of the software engineering and information management

department at the Lappeenranta University of Technology, Finland. His work and interests include wireless networks, ad hoc networking, peer-to-peer computing, and aspects of cloud computing as well as distributed computing and distributed environments and simulation and modeling. He has published over 100 scientific articles in his expertise areas. He is actively participating in European Union research and education programs. He also acts as the chair of the Working Group B—Services, Devices and Service Architectures in the Wireless World Research Forum (WWRF).

**T. Rama Rao** received the Ph.D. degree on radio wave propagation studies for fixed and mobile communications over southern India from S.V. University, Tirupati, India, in the year 2000. Earlier, he associated with Aalborg University, Denmark, as a research professor and with Universidad Carlos III de Madrid, Spain, and at the University of Sydney, Australia, as a visiting professor. His research interests are antennas and their applications, broadband wireless communications, and mobile cellular communications. He is working as a professor and head of the telecommunication engineering department at Sri Ramaswamy Memorial University, Chennai, India. He has authored several papers in reputed journals and in international/national conferences. Recently, he served as the cochair for the seventh edition of the 2013 IEEE International Conference on Advanced Networks and Telecommunication Systems. He is a Member of the IEEE, an IETE fellow (India), a member of the ACM, and a member of the WWRF. He was the recipient of the “Young Scientist” award from the XXVIth International Union of Radio Science, General Assembly, University of Toronto, Canada, held in August 1999.

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