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OUTLOOK

Visions and research directions for the Wireless World

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Visions for the Wireless Future

Wireless World 2020 Workshops

WWRF Wireless World 2020 Workshops: Visions for the Wireless Future A white paper

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In view of the ever growing demand for higher spectral efficiency and support of wireless connectivity of a number of devices increasing by several orders of magnitude in the next decade, the Wireless World Research Forum (WWRF) recognized the need to set the investigation of requirements, technical challenges and deployment issues for wireless systems beyond IMT-Advanced as top priority. A series of workshops under the theme of "Wireless World 2020" are being organized in the timeframe of 2012-2013 around the globe, targeting the solicitation of views and visions of all relevant stakeholders.

This White Paper summarizes the views and discussions during the first two Wireless World 2020 workshops, held in Quebec City, Canada on September 4, 2012 and in Berlin, Germany on October 24, 2012.

1. Introduction

With the rapid proliferation of advanced wireless communication technologies and services, wireless communications are now facing many emerging challenges, including prominently spectrum demand and network capacity limitations. There has been dramatic growth of subscriber base, and increasing dependence of world economy and society on wireless communications.

The challenges of the Wireless World 2020 workshops organized by the Wireless World Research Forum (WWRF) were to identify the key technologies and enablers that will help to form the Wireless World in the era beyond 2020.

WWRF's goal is to encourage research that will achieve unbounded communications to address key societal challenges for the future. The term "Wireless World" was used in this broad sense to address the support of innovation and business, social inclusion and infrastructural challenges. This will be achieved by creating a range of new technological capabilities from wide-area networks to short-range communications, machine-to-machine communications, sensor networks, wireless broadband access technologies and optical networking, along with increasing intelligence and virtualization in networks. This will support a dependable future Internet of people, knowledge and things and the development of a service universe.

Areas of interest addressed in the workshops include, but were not limited to:

- Air Interfaces and enabling technologies;
- Interference management and flexible radio resources allocation;
- Novel system concept architectures based on centralized and/or distributed principles;
- Security, privacy and trust analysis;
- Spectrum management and cognitive network design;
- Internet of Things enablers and applications, and
- User Interface & Needs.

2. "Wireless World 2020 workshop", Quebec City, Canada, September 4, 2012

As part of the IEEE VTC 2012 Fall conference, a workshop was organized under the theme "Wireless World 2020". The challenge of the workshop was to kick off the discussions on wireless vision for 2020 by identifying the major challenges and most promising enablers. This half-day workshop was held on the 4th of September 2012, in Québec City, Canada. The following invited speakers presented during the first session of the workshop:

- "How Spectrum Regulation will lose to Technology", Jean Luc Bérubé, President, Communications Research Centre Canada.

  In this talk, the merits of the traditionally adopted public policy and business models based on slicing spectrum and safeguarding it for licensees were discussed along with the consequent development of technological innovations optimized for each spectrum slice. Triggered by the question, whether this is the most efficient use of spectrum, an observation was made that the rapid evolution of smart radios may initiate a new disruptive era, where dependence on dedicated spectrum will lose part of its influence to hardware-centric devices.

- "Access Networks: Is there a difference between Wireless and Wireline? Directions for Future Access Solutions", Theodore Sizer, Bell Labs, Alcatel-Lucent.

This presentation addressed the Beyond 2020 Access challenges and requirements. With the emphasis on local (short range) wireless connectivity, heterogeneity in access technologies available, increasing demand for backhaul capacity and cloud-based architectures, the access market beyond 2020 is expected to demonstrate exponential data growth, more focus on personalization and a plethora of new smart devices supporting various m2m applications. To this end, new solutions are required in wireline access in order to be able to support 100Mbps to every residence and small-cell Access Point, different deployment scenarios (consolidated or distributed), unbundling of providers and services, multi-media and cloud enablement and low cost deployments. Moreover, new research directions can be exploited in the wireless access part based on carrier aggregation and HetNets, intelligent networks strategies, interference management and self-organization approaches. The evolution to systems beyond 2020 would demand full integration of wireless and wireline access for cost-efficient solutions characterized by several paradigm shifts, such as: user-centric processing, virtualization, multi-service resource allocation, radio interface scalability, advanced waveform and pilot design, 3D channel modeling and advanced receiver processing.

- "LTE-Beyond-Horizon in 2020", Peiying Zhu, Huawei.

In this presentation, systems beyond 2020 are signifying the era of hyper connectivity of everyone and everything. The major challenges of such a Mobile Broadband 'Tsunami' are the capability to support very high rate applications (such as HD video), very large number of connected devices and new applications, to provide adequate low-latency fixed access and capacity increase by orders of magnitude. In order to achieve this linear capacity scaling with the number of connected nodes, HetNets with Cloud RAN architectures and D2D and Cooperative MIMO without network infrastructure are promising approaches.

- "The Pros and Cons of Cooperative Communications", Lajos Hanzo, University of Southampton.

The Pros and Cons of Cooperative Communications were analyzed in this presentation, focusing on the paradigm of the Capacity of Successive Decode-and-Forward Relaying and the Use of Soft Multiple-Symbol Differential Sphere Detection. The evolution of cooperative communications was first discussed and Successive Relaying was shown to be able to achieve full diversity. A throughput efficiency of N/(N+1) can be achieved with Successive Relaying, where N is the number of symbols transmitted by the source. Hence the 50% throughput loss of conventional relaying can be recovered when N is large, at the cost of reducing the number of users supported. Moreover, to account for the fact that channel estimation errors may significantly impair the performance of some coherent detection schemes, non-coherent detection schemes can be used instead. Multiple-Symbol Differential Sphere Detection significantly reduces the system complexity imposed by Multiple-Symbol Differential Detection, without degrading its error correction capability. Finally, Turbo coding (or iterative detection) can substantially enhance the error correction capability of the decoder. It is envisioned in this presentation that the efficient combination of Successive Relaying, DS-CDMA, non-coherent differential sphere detection and iterative decoding will be key in the evolution of wireless in the era beyond 2020.

During the second session of the workshop 9 technical peer-reviewed papers were presented, addressing the research areas of channel equalization, spectrum allocation and sensing, retransmission strategies, cognitive radio techniques, cloud-based architectures and resources sharing, interference management and heterogeneous networks optimization.

3. "Wireless World 2020 Workshop", Berlin, Germany, October 24, 2012

Broadband wireless communications is now being deployed in many countries, providing true wireless Internet. The main challenge is to connect everyone irrespective of the economic conditions. Predictions show a further significant traffic growth, which cannot be covered by only allocating more frequency spectrum. The Future Internet is going beyond wireless Internet and will support solutions for societal challenges like traffic, energy, climate change and health. Therefore, research is expected to address ICT needs for other sectors. Such solutions will combine

collection and processing of data by means of sensor and machine-to-machine communications, in combination with wide-area heterogeneous networks, cloud computing and a wide range of applications. Wireless Communications in the 2020s will show paradigm shifts in networking and service provisioning, requiring a holistic view and cross-sector research cooperation. The 29th WWRF meeting, held in Berlin on October 23-25, 2012, addressed these new research challenges and the need for technical solutions.

As part of the 29th WWRF meeting, a second workshop on the theme "Wireless World 2020" was organized. The challenge of the workshop was to identify the key next-generation wireless technologies and enablers that will form the Wireless World in the era beyond 2020. The following speakers presented in the workshop:

INDUSTRY TRENDS AND CHALLENGES

- "Challenges and Visions for the Future Wireless World", Dr Mikko Uusitalo, Nokia, Finland

The exponential growth of mobile data, the evolution towards advanced devices with various capabilities (smartphones, tablets, etc), as well as the increased importance of machine-generated data result in the dramatic increase in traffic generation. This challenging landscape for systems beyond 2020 sets the requirements for significant advances, both in the local area and macro area network evolution. In the local area evolution, small cells network optimization, offloading provisioning and interference management are key success factors but need to be rationalized taking into account handover and control signaling overhead and energy efficiency aspects. Critical objectives for the optimization of systems beyond 2020 are: (a) Efficiency, that is constant growth in capacity at acceptable overall cost and energy dissipation, (b) Scalability, i.e. ability to support a wide range of requirements regardless of whether a large or low amount of traffic is present, (c) Versatility, i.e. ability to support a significant diverse range of requirements and use cases. Furthermore, enablers for more efficient use of the spectrum are needed, such as Licensed Shared Access and cognitive radio functionalities.

- "Requirements for '5G' and Associated Technology and Research Challenges", Dr Erik Dahlmann, Ericsson, Sweden

The massive growth in the number of connected devices and the traffic volume, along with a wide range of characteristics and requirements for affordability and energy efficiency, set the most important challenges for the design of systems beyond 2020. Heterogeneous cellular deployments, machine-to-machine communications, new spectrum allocation and new ways of using the spectrum (including licensed, unlicensed, shared, secondary use, availability of millimeter-wave frequency bands etc), ultra-dense deployments, device-to-device, massive MIMO and multihop techniques are promising enablers.

- "Future Radio Access Challenges", Dr Yoshihisa Kishiyama, NTT DoCoMo, Japan

Future Radio Access systems are expected to provide a comprehensive solution to satisfy the requirement to support data traffic explosion, massive device connectivity, diverse Quality of User Experience metrics and cost- and energy-efficient intelligent networking. A conceptual view on the evolution towards systems beyond 2020 can be described by a cube, whose three axes reflect the following performance optimization dimensions: (i) Spectrum Efficiency, (ii) Spectrum Extension and (iii) Network Densification. Enhanced spectral efficiency can be achieved through the use of Non-Orthogonal Multiple Access (NOMA) leveraging superposition and interference cancellation techniques and transmitter/receiver cooperation. A promising way to treat heterogeneous cellular deployments can be based on the combined use of lower frequency bands (for coverage) and higher frequency bands (for high data rates). Moreover, in order to further facilitate heterogeneous deployments, different frequency bands can be used in the control and user planes. Simulation results indicate that spectrum extension with denser small cell deployment can substantially increase the network capacity.

- "Future Mobile and Wireless Communications – an Industry View", Dr Werner Mohr, Nokia Siemens Networks, Germany

Wireless systems beyond 2020 are expected to support 3 orders of magnitude more traffic, rock solid, ubiquitous connectivity, Gbps peak speed and millisecond latency for true 'local feel'. Important hardware

enablers towards these targets are wideband radios with multicarrier capabilities and Systems on Chip for small radio implementations with low power consumption. Heterogeneous access will be critical in achieving ubiquitous broadband coverage, leveraging on the key elements of the 'Liquid Radio' concept, i.e. baseband pooling, active antenna systems and Coordinated Multipoint Transmission. Main cornerstones for the evolution towards systems beyond 2020 are small-cell deployments, fiber availability and wireless backhaul solutions, interference coordination, cognitive radio, self-organization and multi-antenna, multisite processing. In this framework, energy efficiency is a major concern and a decisive parameter for both research and development.

- "Mobile networks at the 2020 horizon: challenges and potential technical directions", Dr Eric Hardouin, Orange, France

To address the predicted mobile data growth challenges mobile operators may need new frequencies before 2020 (low and high bands may be considered) and spectral efficiency enhancements through small cell deployments and cell-edge improvements. They also need to consider energy-efficient and cost-efficient approaches that also allow for network sharing. Potential solutions towards these goals include vertical sectorization and 3D beamforming, advanced receivers and joint Tx/Rx optimization, network-assisted Interference Cancellation receivers, cloud-RAN architectures, WiFi offloading, Self-Organization, massive MIMO, interference alignment and new efficient modulation schemes.

- "Virtualizing Future Radio Access", Dr Jianglei Ma, Huawei Technologies, Canada

Current radio access network performance is limited by interference created at the cell edge. In order to solve the interference issue in a fundamental way and significantly boost radio access capacity, cell virtualization and dynamic configuration of virtual data pipes to meet different QoS requirements can be applied. Main enablers of Radio Access Network virtualization are: (i) Centralized baseband processing with Cloud RAN, able to support the "hyper-cell" concept and low-cost hierarchical structures , and (ii) Low-cost Hype Transceiver, realizing a UE-centric transmit and receive node optimization.

- "Evolution Towards Softer RAN", Dr Alice Li, Fujitsu, UK

The concept of softer Radio Access Network is based on the use of a Cloud of Antennas (CoA) for ultra-dense RAN deployments, centralized network processing and ubiquitous high-speed backhaul. A Centralized Radio Controller, Remote Antenna elements and a macrocell overlay are the main components of a CoA architecture. CoA enables new capabilities, such as dynamic network structures, smarter control signaling, improved dynamic load handling and terminal/customer-centric operation. Moreover, in-home CoA allows for intelligent inter-Radio Access Technology scheduling, interference coordination, transmission power optimization and low cost roll-outs. CoA helps realize a softer network system concept, where cell identity and handover become much more flexible and fluid concepts. The network can respond in new ways to the terminals within it and is able to move capacity and capability around as needed.

- "A Peek at 5G", Dr Fang Xie, China Mobile Research Institute

The explosive growth of mobile data traffic, the fragmentation of spectrum, the unbalanced traffic between downlink and uplink, the dense utilization of low-band spectrum and the huge power consumption required for the implementation of new technologies are some of the most critical challenges in the wireless evolution towards 2020. Time Division Duplex (TDD) has several promising features, which make it an efficient alternative for Beyond 4G system, such as: i)channel reciprocity to be exploited in advanced MIMO/Beamforming, ii) dynamic adaptation to asymmetrical traffic, resulting in higher capacity and energy efficiency, iii) capability to support unpaired frequency usage and utilize the limited spectrum in the most efficient way. Furthermore, cloud-RAN based architectures, by leveraging on centralized processing, collaborative radio principles and real-time cloud processing, can help towards lower CAPEX and OPEX, faster system roll-out and lower energy consumption. The evolution of cellular is expected to move away from the traditional coverage-based deployment towards more flexible system concepts, exploiting the benefits of on-off small cells, signaling and data decoupling and uplink

and downlink decoupling. Finally, LTE-Hi (Hotspot & Indoor) offers small cell enhancements for hotspots/indoor, where the vast majority of traffic is predicted in future systems.

REGULATORY AND REGIONAL ASPECTS

- "Regulation Issues and Challenges towards the increasing Market's Needs for Radio Resources", Mr Paul Bender, German Regulator, BNETZA, Germany

Key drivers to influence the spectrum related policies and decisions are associated with the dramatic increase in the smartphone use, video traffic, social networks, M2M communications and data traffic. Activities in different fronts are therefore required in order to cover new technologies and new network structures adoption and standardization aspects, spectrum policy programmes and preparatory work for WRC-15, which will decide on the need for allocation of new frequency bands for systems beyond 2020. In this respect, the use of Reconfigurable Radio Systems (RRS) radio technologies is seen as an enabler providing more efficient spectrum sharing and providing more dynamic access to the spectrum. Moreover, regulation is open to infrastructure and spectrum sharing between mobile network operators, as long as the competitive environment and other regulatory objectives are not affected. Combining mobile and broadcasting networks is another alternative towards exploiting spectrum availability.

- "Future 3GPP RAN standardization activities for LTE/LTE Advanced", Dr Joern Krause, ETSI 3GPP, France

3GPP work is structured in releases of 1-3 years duration. Each release consists of several work items and study items. 3GPP releases aim to meet ITU-R IMT requirements and operator and end user requirements. Long Term Evolution (LTE) Release 8 is based on a different radio access technology than UMTS and uses OFDMA technology and multi-antenna processing at the air interface. Main features of LTE-Advanced (Release 10) is the support of higher bandwidth (through carrier aggregation), advanced MIMO techniques, heterogeneous network structures and enhanced Inter-Cell Interference Coordination, relaying, and minimization of drive tests. The evolution of LTE-Advanced in Release 11 introduces Coordinated Multi-Point operations (CoMP), enhanced physical downlink control channel (E-PDCCH) and a number of further enhancements including Machine Type Communications, Self-Optimizing Networks and Home eNode B. 3GPP organized a workshop in June 2012 to discuss Release 12 and beyond. Common requirements identified in this workshop focus on: capacity increase to cope with traffic explosion, energy and cost efficiency, support of diverse applications and traffic types, better user experience and higher data rate and backhaul enhancements. Potential promising technologies identified in this workshop include small cell enhancements, multi-antenna processing, interworking with WiFi, Machine Type and Device-to-Device Communications.

- "2020 Vision: Shaping the Wireless World through Standards", Matthew Baker, 3GPP RAN, France

The success of current wireless technologies/systems is closely tied to standardization, especially in what relates to creating economies of scale, promoting technological innovation and satisfying requirements of end users and network operators. In the evolution towards systems beyond 2020 several changes of paradigm can be observed: i) data traffic is dominated by smart phones and a wider range of applications, resulting in new revenue streams for operators; ii) consumer behavior is characterized by personalization, ubiquitous connectivity expectation and multi-device, multi-application usage; iii) the Internet of Things vision predicts billions of connected devices and things. 3GPP addressed the requirements for future releases (12 and 13) in its June 2012 workshop. Potential promising technological directions recognized to play a decisive role in longer term evolution towards systems in 2020 include: new spectrum allocation, multi-RAT interworking, 3D MIMO and massive MIMO and small-cell deployments. A new ecosystem is to be enabled with new applications and revenue opportunities, such as the reliable support of machine-to-machine communications and emergency services.

- "Strategic Perspectives of the EU Spectrum Agenda", Dr Branimir Stantchev, European Commission, Belgium

Wireless broadband access and the Internet of Things trigger an exponential growth of wireless traffic. A smart approach to management of spectrum resources is essential to respond to traffic surge in a sustainable way. The EU spectrum policy aims to ensure efficient spectrum use while meeting sector demand by running an inventory and making informed decisions on follow-up harmonization measures, underpinned by shared spectrum use. The wireless research and development, especially with respect to new technologies, pre-commercial validation and standardization, is key for achieving EU policy goals.

- "ITU-R spectrum requirement estimation for IMT systems", Ms Marja Matinmikko, VTT, Finland

Spectral efficiency of future IMT (International Mobile Telecommunication) networks will improve, but technology developments and new deployment configurations alone are not sufficient to meet the growing demand. Therefore, countries are already considering the need for additional spectrum for IMT. ITU-R arranges World Radiocommunication Conferences (WRC) every three to four years to review and revise Radio Regulations, the international treaty governing the use of radio-frequency spectrum and geostationary-satellite and non-geostationary-satellite orbits. WRC-15 will consider the need for identification of additional spectrum for IMT. The ITU-R spectrum requirement estimation methodology, at a first step, involves the study of several input parameters, such as market-related parameters (e.g. user density, session arrival rate per user, average session duration, mean service bit rate, and mobility ratios), service category parameters and radio-related parameters (e.g. spectral efficiency and cell area). The calculation steps include traffic calculation and distribution, capacity calculation and spectrum requirement calculation. The final outcome consists in spectrum requirements for Radio Access Technology Groups (RATG). The role of research is important in this process in order to provide input to help the regulatory process.

- "Spectrum for Mobile Broadband Wireless Access", Mr Colin Langtry, ITU-R, Switzerland

The role of ITU Radiocommunication Sector Rights of access to the spectrum is to provide regulations and assistance for the efficient use of spectrum, the interference-free operation, economies of scale, interoperability and roaming, global harmonization and guidelines for national and regional regulations. Radio regulations is an intergovernmental treaty covering both legal, operational and technical provisions, serving as a supranational instrument for the optimal international management of the radio spectrum, defining rights and obligations of ITU Member States to access spectrum. They are updated every 3 to 4 years. The ITU-R studies for WRC-15 on IMT will focus on spectrum requirements for the mobile service, including suitable frequency ranges, and other specific requirements, spectrum sharing and compatibility with other services. Initial views of Working Party 5D on suitable frequency ranges (between 400 MHz and 6 GHz) are currently under consideration. Sharing studies and compatibility will be addressed by JTG 4-5-6-7. The IMT 2020 vision consists in defining the framework and overall objectives of IMT for 2020 and beyond to drive the future developments of IMT. Like its predecessor, Rec. ITU-R M.1645, this study can be helpful to drive the industries and administrations to encourage further development of IMT for 2020 and beyond, based on the global market and technology trends, including user demand for mobile broadband communication service, new service applications and the needs of developing countries. This study will be supported by other relevant ITU-R studies. Cooperation with external organizations is also needed. It is planned for completion in 2015.

ACADEMIC RESEARCH DIRECTIONS

- "Important Problems and Some Thoughts on Their Solutions in Beyond-2020 Wireless Networks: Radio Access Network Architectures, Layer-1, and Layer-2", Prof Halim Yanikomerolglu, Carleton University, Canada

Research in wireless has progressed a great deal in understanding the particularities and performance of point-to-point communications, multiuser and broadcast channel and multiple access communications. There are still, however, some open research problems, e.g. related with the analytical understanding of the general interference channel (e.g. in ad hoc networks). On the other hand, the wireless networks evolution keeps imposing new challenges (thus opening up new research questions) such as the demand for extremely high data rates and variable rate and traffic behavior, cost efficiency and diverse Quality of Service and Quality of Experience criteria. To address these new constraints a number of promising research directions could be taken into account:

an interference-robust Physical layer, channel estimation and prediction, non-coherent communications, novel Quality of Experience performance metrics, context-aware resource allocation, inter-cell load coordination, cloud-RAN architectures, terminal relaying, random access in cellular, small(er) cell deployment, beamforming at the terminal, cell switching off and Layer 8 – 'user in the loop' approaches.

- "High Impact Emerging Technologies for Beyond 2020 Wireless Communications", Prof Ramjee Prasad, University of Aalborg, Denmark

GISFI (Global ICT Standardisation Forum for India) is an organization active in standardization and research in future communication technologies, addressing the themes of Internet of Things, Cloud and Service-Oriented Networks, Green ICT, Future Radio Network, Spectrum and Security issues. In view of the fast evolving definition of a telecommunication system, innovation in ICT needs to pursue human-centric, ubiquitous terabit wireless connectivity that will enable the mega-communication applications over the network of the future. The aim is to let people seamlessly bridge the virtual and physical worlds, offering the same level of all-senses, context-based, rich communication experience over fixed and wireless networks. GIFSI's WISDOM (Wireless Innovative System for Dynamic Operating MegaCommunications) initiative addresses these challenges, leveraging on information theoretic, end-to-end performance and cognitive principles. The WISDOM approach integrates several technologies, such as advanced machine-to-machine communication technologies, autonomic networking, data mining and decision-making, security and privacy protection, cloud computing with advanced sensing and actuating technologies.

- "From Smart Wireless Technologies to Smart Cities", Dr Zaher Dawy, American University of Beirut, Lebanon

Ericsson Networked Society Innovation Center (ENSIC) has launched a research initiative under the theme: 'Mobile Solutions for Thinking Cities', where "people" and "things" are connected any time any where and emerging wireless technologies are smart, i.e. dynamic, adaptive, flexible, and scalable. The objective is to exploit wireless connectivity to develop mobile solutions for smarter cities with focus on the Middle East region. The initiative is in collaboration with the American University of Beirut, the American University of Cairo and Bogazici University.

Qatar Mobility Innovations Center (QMIC) has also launched an initiative with the objective to develop and deploy intelligent platforms and innovative applications and services that utilize mobility technologies to address needs of different sectors in Qatar and the region. The major regional priorities addressed are: Transport and Logistics, Environment Digital Content Delivery, Intelligent Sensing and Mobile Applications.

- "Smart Cities: Applications and Challenges", Prof Luis Correia, IST - Technical University of Lisbon, Portugal

The paperless society will have a huge impact on networks: media will be consumed in portable devices and daily commuters will need a lot of information on an instantaneous basis. The terminal of tomorrow will carry everyone's personal RF SIM, which will enable the use of other devices and will be appropriate for various uses (in car, at home, in the airplane, at the office, etc). Location awareness will be one of the main features and the Internet of Things may result in machine-to-machine communications dominating future networks. Smart Cities aim at increasing citizens' quality of life, and improving the efficiency and quality of services provided by governing entities and businesses. A number of challenges can be identified that extend beyond ICT, emphasizing the need to incorporate the social and political dimensions. The complexity of the value network increases quite a lot, with services and platforms playing an augmented role. New business models are required, namely based on open data. Additionally, the aspects of privacy, security and trust are very important. The most critical application domains include: Health, Inclusion and Assisted Living, Intelligent Transportation Systems and Environment and Energy Efficiency.

4. Concluding remarks

This White Paper serves the purpose of summarizing the views and discussions during the first two Wireless World 2020 workshops, held in Quebec City, Canada on September 4, 2012 and in Berlin, Germany on October 24, 2012. Additional workshops will be held in 2013 to explore the theme further.

Industrial, regulatory and academic views from several organizations around the globe were presented and a large number of expectations, requirements, trends, challenges, potential technologies, deployment approaches and application frameworks were analyzed. Moreover, information was shared on research initiatives, standardization plans and regulatory agendas. One of the most promising messages clearly articulated during the presentations and discussions is that the delivery of the Wireless World 2020 vision can only be based on the engagement of all stakeholders towards technological innovation and research collaborations.

5. Upcoming workshops and next steps

A follow-up workshop under the theme of "Wireless World 2020" is organized on March 11, 2013 in Pune, India, as part of the GISFI meeting.

WWRF Meeting Timetable for 2013:

Date	Meeting	Location	Theme	Status
March 11th	Workshop with GISFI	Pune, India	Wireless Broadband in emerging markets – the way forward for inclusive growth	Confirmed
April 23rd - 25th	30th Meeting	Oulu, Finland	Smart Cities	Confirmed
May 21st	Workshop ITU	Geneva, Switzerland		Confirmed
May	Workshop	Accra, Ghana		Planning
September	Workshop	South Africa		Planning
October 22nd – 24th	31st Meeting	Vancouver, Canada	Wireless Enabled Smart Society in the 2020s	Confirmed
October 21st	Workshop	Vancouver, Canada	DRAFT: Wireless World 2020 and Smart Grids: Status, Challenges and Further Win-Win Situations	Planning

6. WWRF WGD White Papers on Radio Communication Technologies for Wireless Systems beyond 2020

The following White Papers are currently in progress in WWRF WGD and are planned for completion by September 2013:

- "Wireless World 2020: System Concept Trends, Technology Enablers and Radio Interface Challenges"
- "Small Cell Evolution for Wireless World 2020: Hotspots&Indoor improvement".

7. References

Further information on WWRF activities and documents can be found on www.wireless-world-research.org/.

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