

Globecomm 2015 Industry Workshop – Taking LTE to Unlicensed Band

December 10, 2015

Workshop Agenda

8:00 – 8:30 a.m.: **Registration**

8:30 – 8:45 a.m.: **Chair Remarks** – Geng Wu: Chief Scientist, Wireless and Adv. Tech, Intel

8:45 – 9:15 a.m.: **License Assisted Access – Standardization and Experiments** – Yoshihisa Kishiyama, Manager of Radio Access Network Development Department, NTT DoCoMo

9:15 – 9:45 a.m.: **Realizing the Potential of Shared Spectrum** – Steve Martin, Sr. Vice President, Ruckus

9:45 – 10:15 a.m.: **Mobile Computing and Communications in Unlicensed Spectrum** – Geng Wu, Chief Scientist, Wireless and Adv Tech, Intel

10:15 – 10:30 a.m.: **Break**

10:30 – 11:00 a.m. **3GPP LAA technologies – development, benefits and evolution** – J.-F. Thomas Cheng, Sr. Specialist, Ericsson Inc.

11:00 – 11:30 a.m. **Licensed Assisted Access for LTE-Advanced and 5G** – Charlie Zhang, Vice President, Samsung Research U.S.

11:30 – 12:00 noon: **Bringing LTE-A to Unlicensed Spectrum: Use Cases, System Performance, Standards, and Coexistence Aspects** – Amitava Ghosh, Head, North America Radio Systems Research, Nokia Networks

12:00 – 12:30 noon **Technical Presentation 4** – Timothy Jefferies, Huawei Technologies, Inc.

12:30 – 2:00 p.m. Lunch Break

2:00 – 2:30 p.m. **Coexistence of Unlicensed LTE and Wi-Fi** – Jennifer Andreoli-Fang, Principle Architect, Network Technology Groups, CableLabs

2:30 – 3:00 p.m. **Spectral Efficiency Enhancement for the LTE Networks in the Unlicensed Spectrum for Multi-Operator Co-existence Deployment Scenario** – Mohammad R. Khawer, Distinguished Member of Technical Staff, Alcatel-Lucent

3:00 – 3:30 p.m. **LTE-U/LAA coexistence with Wi-Fi and Implications for Standards and Test Methodologies** – Kamesh Medapalli, Technical Director, Broadcom

3:30 – 4:00 p.m. **Taking LTE to Unlicensed Band** -- Yongbin Wei, Senior Director of Engineering, Qualcomm Technologies, Inc.

4:00 – 4:30 p.m. **Workshop Wrap-up** – Geng Wu: Chief Scientist, Wireless and Adv. Tech, Intel

Technical Presentation and Speaker Bio:

8:45 – 9:15 a.m.: **License Assisted Access – Standardization and Experiments**

Yoshihisa Kishiyama, Manager of Radio Access Network Development Department, NTT DoCoMo

Abstract: A frequency-separated macro/small-cell deployment with C/U splitting between lower and higher frequency bands is a promising scheme to address future traffic demand in the cellular mobile broadband. In the future, higher frequency bands including unlicensed spectrum bands should be efficiently utilized by the superior radio technology. This talk will present standardization and experimental activities focusing on “License Assisted Access” to efficiently utilize unlicensed frequency bands.

Speaker Bio: Dr. Yoshihisa Kishiyama received his B.E., M.E., and Dr. Eng. degrees from Hokkaido University, Japan in 1998, 2000, and 2010, respectively. Since he joined NTT DOCOMO, INC. in 2000, he has been involved in research and standardization activities for 4G LTE/LTE-Advanced and 5G. He is currently a Senior Research Engineer of 5G Laboratory in NTT DOCOMO for 5G radio access network research group. His current research interests include massive MIMO/beamforming technologies, non-orthogonal multiple access (NOMA), 5G experimental trials, and so on. In 2012, he received the International Telecommunication Union Association of Japan (ITU-AJ) Encouragement Award for his contributions to LTE international standardization.

9:15 – 9:45 a.m.: **Realizing the Potential of Shared Spectrum**

Steve Martin, Sr. Vice President, Ruckus

Abstract: Policymakers and regulators are moving to introduce new models for spectrum management that would provide coordinated use of shared spectrum. Conceptual frameworks and actual proposals in this area include Licensed Shared Access (LSA) in Europe as well as the US FCC’s Ruling & Order for the Citizen’s Band Radio Service (CBRS) in 3550-3700 MHz band. A key objective of these programs is to “blur” the distinctions between Fully Licensed and Unlicensed spectrum, and to provide conditional access to portions of spectrum with varying levels of priority based upon status in order to drive innovation, new business models, and economic growth.

Speaker Bio: Mr. Steve Martin is SVP/GM of Emerging Technologies for Ruckus Wireless. With more than 25 years of engineering experience in the networking industry with companies such as Ruckus Wireless, Airespace (acquired by Cisco), 3Com, and US Robotics Corporation, Steve is an expert in networking hardware and software design and development. He’s a veteran at developing state-of-the-art wireless technologies, and then successfully bringing them to market.

Since joining Ruckus Wireless in 2006, Steve has helped lead the company from an early stage startup to its present day form as a publicly traded company that is a leader in the wireless industry. Prior to joining Ruckus, Steve was an engineering executive with Airespace which was an early leader in the enterprise WLAN market where he served as VP of Engineering prior to Airespace’s acquisition by Cisco’s wireless networking group. Prior to Airespace, Steve also held several senior management positions in the Carrier Networks Business Unit of 3Com (formerly US Robotics) which was acquired by UTStarcom in 2003.

Steve was born in Cincinnati, Ohio, and received a Master of Science in Telecommunications Systems from DePaul University and a Bachelor of Science in Computer Engineering from San Jose State University. And yes, people always ask him if he's somehow related to THAT Steve Martin.

9:45 – 10:15 a.m.: **Mobile Computing and Communications in Unlicensed Spectrum**

Geng Wu, Chief Scientist, Wireless and Adv Tech, Intel

Abstract: Today wireless industry is at a turning point. On wireless technologies, further improving spectral efficiency at radio link level is becoming increasingly challenging. We need new ways to build our future networks and devices to meet our ever increasing capacity demands. On services and applications, as smartphone penetration accelerating globally and starting to saturate in many developed markets, we need to develop new technologies that make things smarter, our daily work more efficient and our living environment intelligent. On user experience, we need to create a technology foundation that enables future generations of applications and services for the coming decades that are likely beyond what we could imagine today. To achieve these goals, 5G and future generations of networks and devices need to explore new technologies to best use spectrum, and to make mobile computing and communications in licensed, licensed shared, and unlicensed spectrum. This presentation will discuss this paradigm shift and what it means to the industry, key challenges and opportunities, and future research directions for mobile computing and communications in unlicensed spectrum.

Speaker Bio: Dr. Geng Wu is an Intel Fellow and chief technologist for wireless standards in the Platform Engineering Group at Intel Corporation. Wu leads Intel's 5th-generation (5G) wireless standards development and ecosystem collaboration. He also heads Intel's delegation to 3GPP. Dr. Wu has more than 20 years of research and development experience in the wireless industry. He has contributed extensively to global 2G CDMA, 3G 1xRTT, UMTS, HSPA and 4G WiMAX, LTE radio interface and network architecture design and development. His current research interests include mobile computing and communication platforms, heterogeneous networks, channel modeling, next-generation air interface technologies, and cross-layer optimization for mobile services and applications. Before joining Intel, Dr. Wu served as director of wireless architecture and standards at Nortel Networks, where he was responsible for system performance, standards research, and technology development in 3GPP2, 3GPP, IEEE and WiMAX.

10:30 – 11:00 a.m.: **3GPP LAA technologies – development, benefits and evolution**

Thomas Cheng, Senior Specialist, Ericsson Silicon Valley

Abstract: To meet ever growing mobile data traffic demand from users and in concentrated high traffic buildings or hot spots in particular, cellular operators has increasingly considered augmenting and complementing their service offering with the large amount of spectrum available in the unlicensed bands around the globe. 3GPP introduced licensed assist access (LAA) technology in LTE Rel-13 to enable LTE DL operations in unlicensed band secondary carriers with control and coordination from the always available licensed band primary carrier. In this presentation, we survey the development and technical characteristics of the 3GPP LAA technologies. We review the benefits of the LAA designs and

deployment. We showcase industry implementation and cooperation to bring the technology to reality. Finally, we highlight features of further evolution of the LAA technologies.

Speaker Bio: Dr. Thomas Cheng is with Ericsson Silicon Valley where he leads research and development of advanced wireless communication technologies. Since joining Ericsson in 1999, he has been driving a wide range of projects evolving cellular wireless PHY and MAC layer technologies from 2.5G EDGE, 3G HSPA to 4G LTE. His research interests include iterative processing, coding and signal processing algorithms for wireless communications. He was the principal contributor to the LTE specification of turbo and convolutional coding and rate matching procedures. He is responsible for driving Ericsson's global strategy, research and standardization of small and heterogeneous cell operations using LTE technologies. Dr. Cheng holds over a hundred granted US patents and he was named Ericsson Inventor of the Year in 2012. He was a co-recipient of the 1999 IEEE Communications Society Leonard G. Abraham Prize Paper Award in the Field of Communications Systems. He received the B.S. and M.S. degrees in Electrical Engineering from National Taiwan University, Taipei, Taiwan. He received the Ph.D. degree in Electrical Engineering from California Institute of Technology, Pasadena, CA.

11:00 –11:30 a.m.: **Licensed Assisted Access for LTE-Advanced and 5G**

Charlie Zhang, Vice President, Samsung Research U.S.

Abstract: Licensed Assisted Access (LAA), a new LTE based technology for the unlicensed band, is a promising way for cellular operators to complement the services on the licensed spectrum. How LAA can co-exist with Wi-Fi in a fair manner has attracted great interests and generated intense discussions in the industry and standards organizations and regulatory bodies. In this talk, we provide an overview of co-existence methodology and evaluation, design challenges and solutions for LAA, and the role of LAA in future evolution of LTE and 5G.

Speaker Bio: Dr. Charlie Jianzhong Zhang is a VP and head of Standards and Research Lab with Samsung Research America at Dallas, where he leads research and standard efforts for 5G cellular systems and next generation multimedia networks. From Aug 2009 to Aug 2013, he served as the Vice Chairman of the 3GPP RAN1 working group and led development of LTE and LTE-Advanced technologies such as 3D channel modeling, UL-MIMO and CoMP, Carrier Aggregation for TD-LTE, etc. Before joining Samsung, he was with Motorola from 2006 to 2007 working on 3GPP HSPA standards, and with Nokia Research Center from 2001 to 2006 working on IEEE 802.16e (WiMAX) standard and EDGE/CDMA receiver algorithms. He received his Ph.D. degree from University of Wisconsin, Madison.

11:30 – 12:00 noon: **Bringing LTE-A to Unlicensed Spectrum: Use Cases, System Performance, Standards, and Coexistence Aspects**

Amitava Ghosh, Head, North America Radio Systems Research, Nokia Networks

Abstract: The deployment of LTE in unlicensed spectrum has recently been proposed to improve cellular data capacity. There are different flavors of unlicensed band technologies namely LTE-U, License Assisted Access (LAA), LTE/Wi-Fi Aggregation (LWA) and LTE/Wi-Fi Interworking (LWI). This talk presents a brief comparison of different unlicensed band technologies, spectrum assets for deploying this

technology, LAA/Wi-Fi co-existence results, performance of the system with and without listen before talk (LBT) mechanism and performance of LAA vs. LWA and LWI. The talk also touches on evolution of LAA standard.

Speaker Bio: Amitabha (Amitava) Ghosh is Head, North America Radio Systems Research within the Technology and Innovation office of Nokia Networks. He joined Motorola in 1990 after receiving his, Ph.D in Electrical Engineering from Southern Methodist University, Dallas. Since joining Motorola he worked on multiple wireless technologies starting from IS-95, cdma-2000, 1xEV-DV/1XTREME, 1xEV-DO, UMTS, HSPA, 802.16e/WiMAX and 3GPP LTE. Dr. Ghosh has 60 issued patents and more than 100 external technical papers. He is currently working on 3GPP LTE-Advanced and 5G technologies. His research interests are in the area of digital communications, signal processing and wireless communications. He is a Fellow of IEEE, has co-authored multiple book chapters and co-author of the book titled “Essentials of LTE and LTE-A”.

12:00 – 12:30: **Technical Presentation 4**

Timothy Jefferies, Huawei Technologies, Inc.

2:00 – 2:30 p.m.: **Coexistence of Unlicensed LTE and Wi-Fi**

Jennifer Andreoli-Fang, Principal Architect, Network Technology Group, CableLabs

Abstract: In this talk, we will give an overview and status of the different flavors of unlicensed LTE, and briefly cover our recent research on LTE-U. Then we will outline our thoughts for a comprehensive research roadmap. This is our view of the scope of research that needs to be undertaken in order to ensure a path toward good coexistence between various unlicensed technologies.

Speaker Bio: Dr, Jennifer Andreoli-Fang is a Principal Architect in the Network Technology Group at CableLabs. Jennifer joined CableLabs in 2007, and has been a technical leader in developing several key technologies for the cable industry. She is currently leading the LTE Unlicensed project, as well as the multi-vendor team for the development of DOCSIS 3.1 MAC and upper layers, and was the technical leader for the evolution of the DOCSIS 3.0 MAC. Jennifer is actively involved in research and development of both wireless and wired broadband communication systems. Jennifer has 9 patents and 17 pending patents. Prior to joining CableLabs, Jennifer held position in the wireless industry. She received the Ph.D. degree in Electrical and Computer Engineering from the University of California, San Diego in 2005 and the B.S. degree in Electrical Engineering from the California Institute of Technology in 1998.

2:30 – 3:00 p.m.: **Spectral Efficiency Enhancement for the LTE Networks in the Unlicensed Spectrum for Multi-Operator Co-existence Deployment Scenario**

Mohammad R. Khawer, Distinguished Member of Technical Staff, Alcatel-Lucent

Abstract: The U.S. 5 GHz Unlicensed spectrum that is currently under consideration for LTE deployment contains only a limited number of 20 MHz channels. In a dense multi-operator deployment scenario, one or more LTE-U small cells may thus have to co-exist and share the same unlicensed channel with each other and with the incumbent Wi-Fi. LTE may harmoniously co-exist with Wi-Fi by employing carefully designed co-existence mechanism, such as the Carrier Sense Adaptive Transmission (CSAT) mechanism that is adopted by the LTE-U Forum. The co-channel Wi-Fi backs off during the LTE-U ON transmission period of the CSAT gating cycle due to the Carrier Sense Multiple Access (CSMA) nature of its Medium Access Control (MAC) layer. However, none of the LTE-U small cells sharing the same channel backs off to each other's LTE-U transmissions during their respective LTE-U ON period of the gating cycle. This presentation illustrates the scenario and presents the simulation results, to demonstrate that by employing an appropriate inter cell CSAT gating cycle coordination mechanism, there will be a 40% or more improvement in the overall LTE-U system performance for multi-operator LTE-U co-channel co-existence scenario in countries such as U.S. that do not mandate Listen-Before-Talk (LBT) requirements.

Speaker Bio: Dr. Mohammad R. Khawer is a Distinguished Member of Technical Staff in the Wireless CTO organization of Alcatel-Lucent, Murray Hill, New Jersey. He is a wireless R&D innovator who has made significant contributions towards the architecture, design and implementation of numerous 4G, 3G, and 2G commercial wireless base station products over the past two decades. He received his M.S. degree (1995) in Computer Science and Ph.D degree (expected December 2015) in Computer and Information Science Engineering from Syracuse University, NY, USA. He got accepted as a member of the elite Alcatel-Lucent Technical Academy (ALTA) in 2009, and currently holds 26 granted patents.

3:00 – 3:30 p.m.: LTE-U/LAA coexistence with Wi-Fi and Implications for Standards and Test Methodologies

Kamesh Medapalli, Technical Director, Broadcom

Abstract: Multiple coexistence challenges must be addressed before LTE begins operating in the unlicensed spectrum. In this talk, we present measurement results comparing LTE-U vs Wi-Fi interference on Wi-Fi performance. We show that LTE-U interference has detrimental impact on Wi-Fi links with median/weak RSSI and provide suggestions for better coexistence as the way forward. In addition, we discuss test methodologies the industry should consider for realistic coexistence performance studies especially as it pertains to standardization of LAA in 3GPP.

Speaker Bio: Kamesh Medapalli is a Technical Director at Broadcom. He is currently responsible for providing Engineering Leadership to Wi-Fi Access and LTE-U/LAA Coexistence areas. He has extensive Systems Architecture and Product Development experience in LTE/Cellular and Wi-Fi technologies; both from a device as well as infrastructure perspective. Kamesh joined Broadcom through acquisition of Beceem in 2010 which pioneered MIMO OFDMA technology called WiMAX and led Systems Engineering functions relating to innovative WiMAX/CDMA dual-mode and WiMAX/WiFi coexistence technologies. Prior to Beceem, he worked at Bell Labs and BellCore on Wireless Data User Scheduling with Throughput/Fairness constraints, TCP performance in Wireless, 3G Standards and VoIP over WiFi. He is a named inventor on several patents especially in the area of LTE/Wi-Fi Coexistence and Interworking.

Kamesh received his PhD in Electrical Engineering from Stanford University where he also served as a Consulting Faculty member.

3:30 – 4:00 p.m.: **Taking LTE to Unlicensed Band**

Yongbin Wei, Senior Director of Engineering, Qualcomm Technology, Inc.

Abstract: Innovations enabling efficient spectrum utilization is a key element to optimize user experience with growing data demand. This presentation discusses the approach of extending the benefit of LTE to unlicensed band for higher spectral efficiency and better user experience and realization via licensed-assisted access as well as standalone deployment. A key challenge for such extension is the coexistence with legacy technology such as Wi-Fi. The present highlights techniques for effective coexistence. The results include evaluation and lab data that demonstrate how the technology provide benefit to surrounding Wi-Fi deployment and contribute towards enhancing spectral efficiency of the unlicensed band.

Bio: Dr. Yongbin Wei is currently a Senior Director of Engineering with Qualcomm Research of Qualcomm Incorporated. Qualcomm is an S&P 500 company, leading in developing and delivering innovative digital wireless communications products and services. Its business areas include integrated chipsets and system software for cellular communications, technology licensing, satellite-based systems, etc. At Qualcomm research, Yongbin has been leading new technology development for Qualcomm's current and future generation products, in particular the cutting-edge 4G cellular technology such as LTE and LTE-advanced. Prior to that, he worked on the system design and international standardization of cdma2000 Rev. C and Rev. D. (1xEV-DV), HRPD (1xEV-DO), and the product development, and was one of the leading contributors for the physical layer design and evaluation of these systems. He also represented Qualcomm in 3GPP2 from 2000 to 2006. His research areas includes wireless communications systems, adaptive signal processing, modem algorithms, coding and modulation, machine-to-machine communication, and spectrum and RF engineering. He has authored more than 20 journal and conference papers, and holds more than 120 US issued patents with other hundreds in process.