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EVOLUTION OF 3GPP LTE IN RELEASE 11 AND BEYOND

As momentum behind the evolution of broadband mobile radio networks continues, the Third Generation Partnership Project (3GPP) is leading the way in crystalizing the new requirements and defining standard-based solutions to meet the challenges. While specification work for Release 11 of Long Term Evolution (LTE) is coming to completion, the next stage of enhancements for Release 12 is now beginning.

It is widely recognized that the greatest challenge facing mobile operators and their technology suppliers is satisfying the exponential growth of data traffic, especially video. The challenge is not just meeting the demand for more, but also providing suitable user experience for the new applications and services delivered through ever more sophisticated and diverse devices. Given the multidimensional nature of the challenge, a multidimensional approach to face them is to be expected.

Making more spectrum available is one key to meeting the demand, but it needs long-term regulatory coordination and planning. While new licensed bands, including higher frequencies such as 3.5 GHz for small cell and hot-spot zones, are expected to be introduced, new spectrum alone cannot come close to matching the rate of increase in data traffic.

Cell densification with extensive deployment of small cells will therefore be essential for the provision of substantial capacity increases.

In addition to greater and improved provision of existing data services, LTE is also poised to be a platform for new service models with high added value, such as machine-type communications and public safety communications, the latter necessitating new functionality such as device-to-device discovery and direct communication, which may also be useful for proximity-based commercial services.

In this issue, as a complement to the special issue in November 2012, we draw together some of the key technologies marking the transition from Release 11 to Release 12, and focus on areas of enhancement that will characterize the development of LTE in the next two years. The articles are largely prepared by industry experts who are directly involved in 3GPP standardization.

The first article, by Christian Hoymann *et al.*, presents motivations and use cases for introducing new carrier types for LTE. Such carriers represent an enhancement with wide applicability, but with particular relevance to small cells. Going beyond the motivations, this article provides an overview of some of the technical challenges and design options, as well as some performance evaluations quantifying the benefits of so-called Lean Carriers for Release 12.

The second article, by Sigen Ye *et al.*, explains the design principles and considerations for introducing enhanced control signaling in Release 11 via the enhanced physical downlink control channel (EPDCCH). The need for this development is evident from the observation that with the increase in data traffic, the downlink control channels may become the bottleneck if they cannot benefit from the same advanced techniques as the data channels. The new EPDCCH design therefore includes support for increased downlink control channel capacity using beamforming and improved spatial reuse, as well as frequency-domain intercell interference coordination.

Some of the new multimedia and social networking applications generate frequent streams of autonomous and/or user generated traffic, causing mobile devices to move back and forth between connected and idle states. Such frequent transitions, often made only to send short bursts of data, reduce handset battery life and cause excessive signaling overhead in the network. The third article, by Maruti Gupta *et al.*, therefore investigates such traffic characteristics, and presents the technical and signaling solutions to mitigate their impact. This article presents design principles and techniques specified in LTE Release 11 to provide power and signaling optimizations for diverse data applications, and outlines the authors' view on future possible extensions in 3GPP Release 12.

As mentioned earlier, network densification and the expected proliferation of small cell deployments is the largest potential contributor to fulfilling the growing demand for data capacity. The fourth article, by Takehiro Nakamura *et al.*, presents an overview of the requirements for such small cells as identified in 3GPP, and also provides important insights and technical perspectives from two key operators actively considering such deployments.

The fifth and final article in this issue, by Tewfik Doumi *et al.*, provides an overview of the new public safety use cases for LTE. It addresses the critical requirements of public safety systems, shows the extent to which LTE can already satisfy these needs, and highlights the reasons LTE is likely to be the technology of choice for such systems in the future. Finally, the article identifies the enhancements to LTE that are likely to be necessary to further improve its ability to provide the necessary services.

We thank all the authors for their contributions to this publication, and hope that this collection of articles provides readers with useful insights into the latest developments and future direction of evolution of LTE Advanced systems.

BIOGRAPHIES

KAMRAN ETEMAD (kamran.etemad@intel.com) received his B.S. degree in electronic engineering from Sharif University of Technology, and his M.S. and Ph.D. degrees in electrical engineering from the University of Maryland. He is currently a director of technology standards at Intel Corporation, where he has been leading various technical and strategic standardization initiatives related to 3GPP/LTE, and previously in WiMAX and IEEE802.16. Prior to Intel, he held senior technical and management positions with Sprint-Nextel, WFI International, and Hughes Network Systems. His current areas of research include radio network architecture/protocols design for multilayer and multicarrier networks, multicast/broadcast protocols, peer-to-peer and cooperative communications, as well as positioning. Prior to his involvement in 3GPP and WiMAX, he also made many contributions to development of cdma2000 technology in 3GPP2. He has numerous publications and patents in wireless communications, including two books, *CDMA2000 Evolution* and *WiMAX Technology and Network Evolution*.

MATTHEW BAKER (matthew.baker@alcatel-lucent.com) holds degrees in engineering and electrical and information sciences from the University of Cambridge. He has been actively participating in the standardization of both UMTS WCDMA and LTE in 3GPP since 1999. He has been with Alcatel-Lucent since 2009, and he has been Chairman of 3GPP TSG RAN Working Group 1 since being elected to the post in August of that year. Prior to joining Alcatel-Lucent, he worked at Philips for 12 years, where he conducted research into a variety of wireless communication systems and techniques, including propagation modeling, DECT, Hiperlan, and UMTS, as well as leading the Philips 3GPP RAN standardization team. He is a Chartered Engineer, a member of the Institution of Engineering and Technology, and a visiting professor at the University of Reading, United Kingdom. He is also co-editor of *LTE — The UMTS Long Term Evolution: From Theory to Practice* (Wiley, 2nd ed., 2012).