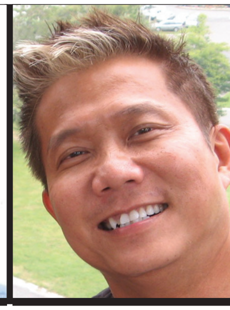
# LTE-ADVANCED AND 4G WIRELESS COMMUNICATIONS



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The Release-10 LTE-Advanced (LTE-A) is a major enhancement of the Long Term Evolution (LTE) standard developed by the 3rd Generation Partnership Project (3GPP). LTE-A was ratified by the International Telecommunication Union (ITU) as an IMT-Advanced (fourth generation, 4G) technology in November 2010. The 4G objective is to meet challenges presented by the ever increasing use of "smart" wireless devices that require significantly higher spectral resources than conventional cell phones. LTE-A addresses those challenges by targeting peak data rates up to 1 Gb/s with up to 100 MHz supported spectrum bandwidth and by making use of high-order multiple-input multiple-output (MIMO) transmission with up to eight spatial layers on the downlink and four spatial layers on the uplink.

LTE-A also features a mix of new system concepts, such as coordinated multipoint (CoMP) transmission, advanced heterogeneous networks (HetNets), relay, and cross-layer optimization, with the ultimate goal of designing a system that is drastically enhanced in both cell capacity and coverage. For example, advanced HetNet jointly optimizes network resources in time, frequency, spatial beam, and power across multiple tiers of network nodes with different transmit power capabilities. Relay improves coverage and provides higher deployment flexibility for operators by introducing low-power nodes without requiring additional wired backhaul. These new designs are already bringing significant performance benefits to Release 10 LTE-A, and we expect the trend of multipoint cross-layer design to continue in future releases.

The goal of this feature topic is to give a comprehensive system-level overview of the LTE-A standard, which includes not only the description of how various new techniques work, but also the rationales and motivation behind how technical decisions were made during the Release-10 standardization process. Our hope is that this will motivate interested researchers to explore and propose newer ideas for enhancements in future LTE-A releases as well as the next-generation wireless systems.

The feature topic begins with an article coauthored by delegates from major operators in six countries: Vodafone (United Kingdom), NTT DoCoMo (Japan), Telefonica (Spain), Orange (France), China Mobile (China), and Verizon (United States). The article gives an overview of all key LTE-A new features in a uniform easy-to-read format, while also providing an operator's view on each feature's use cases, deployment scenarios, and challenges. The second article describes LTE-A and its future evolution as envisioned by one of our invited authors, Matthew Baker, who is the current chair of 3GPP RAN1 (physical layer specifications).

The remaining seven articles of this issue go into greater detail on individual new LTE-A features. Most of these articles (all except the last) are, again, coauthored by delegates from various organizations and reflect their impressive teamwork. The third article, by Shen *et al.*, offers an overview of LTE-A carrier aggregation, which includes the deployment scenarios, main design features, and PHY/MAC procedures of Release 10, and also discusses potential key enhancements for future standard releases. The fourth article, by Nam *et al.*, provides an overview on the evolution of reference signal (RS) provisioning from LTE to LTE-A, where the fixed, one-size-fits-all common RS (CRS) is being replaced by a more scalable design, which makes a distinction between channel state information RS (CSI-RS) and demodulation RS (DM-RS). The fifth article highlights the key downlink MIMO enhancements in LTE-A, and shows that dynamic switching between single-user MIMO (SU-MIMO) and multi-user MIMO (MU-MIMO) provides a significant gain over the traditional SU-MIMO-only operation.

The sixth article, by Lee *et al.*, describes CoMP techniques and provides some detailed evaluation by 3GPP RAN1, which shows that CoMP can greatly improve cell edge coverage in many deployment scenarios. The seventh article, by Hoymann *et al.*, discusses the benefits, challenges, and solutions for wireless relay operation in LTE-A. The eighth article, by Damnjanovic *et al.*, explains why simple deployment of low-power nodes in HetNets is problematic, and how the time domain enhanced intercell interference coordination (ICIC) methods introduced in LTE-A are essential in achieving the full potential of such overlay networks. The last article, by Bai *et al.*, discusses the design challenges related to new LTE-A features modem engineers face and offers solutions to those challenges.

As we conclude our editorial, we would like to thank all the authors who submitted their manuscripts, and the reviewers for high-quality reviews that helped improve both the content and presentation of the articles in this special issue. We received nearly 40 submissions, and many good papers could not be accepted due to the limited space and tight publication schedule — we are addressing this by working on a second issue to be published later this year. We would also like to thank the Editor-in-Chief of *IEEE Communications Magazine*

for his continuous guidance and support, and the IEEE publication staff for their diligent work and timely assistance. Last but not least, we would like to thank the hundreds of engineers and researchers who contributed to the development of LTE/LTE-A standards; they are the unsung heroes to whom the world should pay tribute as we usher in a new era of high-speed wireless communications made possible by LTE/LTE-A.

## BIOGRAPHIES

CHARLIE (JIANZHONG) ZHANG [SM] (jzhang@sta.samsung.com) is a standards director with the Samsung Dallas Technology R&D center, where he leads the 3GPP LTE/LTE-A standard project as well as a task force focusing on new biomedical devices and applications. He is currently serving as the Vice Chairman (first elected August 2009, re-elected August 2011) of 3GPP RAN1, the physical layer working group for the radio access network. Before he joined Samsung, he was with Motorola from 2006 to 2007 where he worked on the 3GPP HSPA standardization; and he was with Nokia Research Center from 2001 to 2006, where he worked on IEEE 802.16e (WiMAX) standard and EDGE/CDMA/HSPA receiver algorithms. He received his Ph. D. degree in electrical engineering from the University of Wisconsin at Madison. He is also serving as the Standards Subcommittee Chair of the Industry DSP Applications Committee of the IEEE Signal Processing Society.

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