



Heterogeneous Networks in LTE-Advanced

By Joydeep Acharya, Long Gao, Sudhanshu Gaur

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A comprehensive summary of theoretical and practical developments in LTE Heterogeneous Networks

The last decade has witnessed the proliferation of mobile broadband data and the trend is likely to increase in the coming years. Current cellular networks are ill equipped to deal with this surge in demand. To satisfy user demand and maximize profits, a new paradigm to operate networks is needed. Heterogeneous networks, that deploy an overlay of small cells with limited coverage and transmit power, over a macro coverage area is the solution by providing capacity and coverage where it is needed.

This book presents a comprehensive overview of small cell based heterogeneous networks within the framework of 3GPP LTE-Advanced which is the major enabler of current and future heterogeneous networks. The book first establishes the basics of LTE standards 8 -10. Wherever relevant, the underlying theory of wireless communications is explained and the signaling and protocol aspects of LTE Releases 8-10 are presented. Next the book presents a systematic study of the inter cell interference (eICIC and FeICIC) mechanisms that have been standardized in LTE releases 10 and 11 to mitigate the interference arising in heterogeneous networks. From simple blank subframe design and implementation, the book discusses more advanced transceiver signal processing and carrier aggregation (CA) based mechanisms to improve performance. Besides data, control channel enhancements such as enhanced PDCCH (ePDCCH) are also discussed.

Subsequently the book discusses the possibility of base stations being allowed to coordinate to manage interference. This technique, called CoMP, has the potential of vastly improving network performance. However several practical challenges first have to be overcome before this potential can be realized. The book presents the different CoMP categories introduced in LTE release 11, the required signal processing and the changes that were introduced in Release-11 for supporting CoMP. The book then presents the state of the art developments in heterogeneous networks that are currently taking place in 3GPP with the initiation of Release 12. A whole array of new technologies have been introduced such as dynamic switching of small cells, new carrier types with reduced control signaling, dynamic reconfiguration of TDD-LTE, joint configuration of TDD and

FDD via carrier aggregation and lastly advanced MIMO signal processing with three dimensional beamforming. All these technologies will work in unison leading to efficient operations of small cells.

The authors thus comprehensively summarize the advances in heterogeneous networks over the last couple of years as reflected in various LTE releases and then look ahead at what to expect in the future. Fully illustrated throughout and with an accompanying website including Matlab code for simulating heterogeneous networks, LTE channel models, and References to 3GPP specifications, contributions, and updates on recent standardization activities. The authors, being involved in LTE standardization, are well placed to give an excellent view on this topic, including valuable background and design rationale.

- A comprehensive summary of wireless communications theory and practical developments in LTE heterogeneous networks.
- Authors are experts in this field and are active members in standardization proceedings, enabling up-to-date coverage of current developments
- Multiple case studies explain network design optimization of various heterogeneous network deployments.
- Accompanying website includes Matlab code for simulating heterogeneous networks, LTE channel models, and References to 3GPP specifications, contributions, and updates on recent standardization activities

Essential reading for Engineers and practitioners in wireless industry.

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Editorial Review

From the Back Cover

A comprehensive summary of theoretical and practical developments in LTE Heterogeneous Networks

Essential reading for engineers and practitioners in the wireless industry, this book provides a comprehensive overview of small-cell-based heterogeneous networks within the framework of LTE-Advanced. It begins with a look at the heterogeneous networks presently in use, and considers developments included in Release 10–11 for improving the performance of heterogeneous networks, such as time domain inter-cell interference coordination (eICIC and FeICIC), carrier aggregation and enhancements in control signalling (ePDCCH). The book provides multiple case studies explaining network design optimization of present and future heterogeneous network deployments.

The book also covers base station coordination technology (CoMP), included in Release 11, by which multiple base stations can jointly serve users in a network. It discusses the related signal processing, scheduling, and signaling aspects. The book concludes by comprehensively summarizing the latest advances for heterogeneous networks under LTE Release 12, the state of the art in 3GPP standardization. Topics include dynamic switching of small cells, new carrier types with reduced control signaling, dynamic reconfiguration of TDD-LTE, joint configuration of TDD and FDD via carrier aggregation, and finally advanced MIMO signal processing with three-dimensional beamforming.

This book was written by industry experts working at the cutting edge of technological development, all of whom are active members in 3GPP standardization proceedings, well placed to give an excellent view on this topic including valuable background and design rationale, enabling up-to-date coverage of current developments.

- The accompanying website includes MatLab code for simulating heterogeneous networks, LTE channel models, and References to 3GPP specifications, contributions, and updates on recent standardization activities (www.ltehetnet.com).

About the Author

Joydeep Acharya received his PhD degree in Electrical Engineering from Rutgers University in 2009. Currently he is a staff research engineer at Hitachi America's Wireless Systems Research Lab (WSRL) where he is involved in physical layer research and standardization in LTE-Advanced. Previously, he had worked as a research consultant in GS Sanyal School of Telecommunications, Indian Institute of Technology Kharagpur on Physical Layer design of WCDMA. He has been participating in 3GPP RAN 1 and 2 meetings since 2009. He is the author of several IEEE conference and journal papers and inventor of several patents filed worldwide. His research topics include MIMO signal processing, base station coordination, massive MIMO and spectrum regulation and resource allocation for wireless systems.

Long Gao received his B.S. degree from Beijing Jiaotong University, Beijing, China, in 2003 and his M.S. degree from Beijing University of Posts and Telecommunications, Beijing, China, in 2006, both in Electrical Engineering. He received his Ph.D. degree in Electrical Engineering from Texas A&M University, College

Station, TX and joined Hitachi America, Ltd, Santa Clara, CA, in 2010. Since then, he has been involved in 3GPP LTE/LTE-Advanced standardization activities with focus on cooperative communication and heterogeneous networks. He has published several IEEE papers and submitted several technical contributions to 3GPP RAN1 conference. He has served as a TPC member in major IEEE conferences such as Globecom 2010-2013. He has presented tutorials on LTE-Advanced heterogeneous network in VTC 2012 and WCNC 2013.

Sudhanshu Gaur has over 10 years of research and industry experience in the field of wireless communications. He is currently the Principal Research Engineer at Hitachi America's Wireless System Research Lab (WSRL) where he leads LTE-Advanced standardization activities. Earlier he was also involved with IEEE 802.11aa standardization and contributed to Hitachi's wireless HD video system which was demonstrated in CES 2008. Prior to joining Hitachi, he attended Georgia Institute of Technology for PhD degree (2005) and received M.S and B.Tech degrees from Virginia Tech (2003) and Indian Institute of Technology, Kharagpur (2000), respectively. He is a Senior Member of IEEE, has authored several peer reviewed publications in wireless communications, and holds several patents.

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