

# LTE Small Cell Optimization

3GPP Evolution to Release 13

Edited by

Harri Holma

Antti Toskala

Jussi Reunanen



WILEY

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# **LTE SMALL CELL OPTIMIZATION**

# Preface

We have witnessed a fast growth in mobile broadband capabilities during the last 10 years in terms of data rates, service availability, number of customers and data volumes. The launch of the first LTE network in December 2009 further boosted the growth of data rates and capacities. LTE turned out to be a success because of efficient performance and global economics of scale. The first LTE-Advanced network started in 2013, increasing the data rate to 300 Mbps by 2014, 450 Mbps in 2015 and soon to 1 Gbps. The number of LTE networks had grown globally to more than 460 by end 2015.

This book focuses on those solutions improving the practical LTE performance: small cells and network optimization. The small cells are driven by the need to increase network capacity and practical user data rates. The small cell deployment creates a number of new challenges for practical deployment ranging from interference management to low-cost products, site solutions and optimization. The network optimization targets to squeeze everything out of the LTE radio in terms of coverage, capacity and end-user performance.

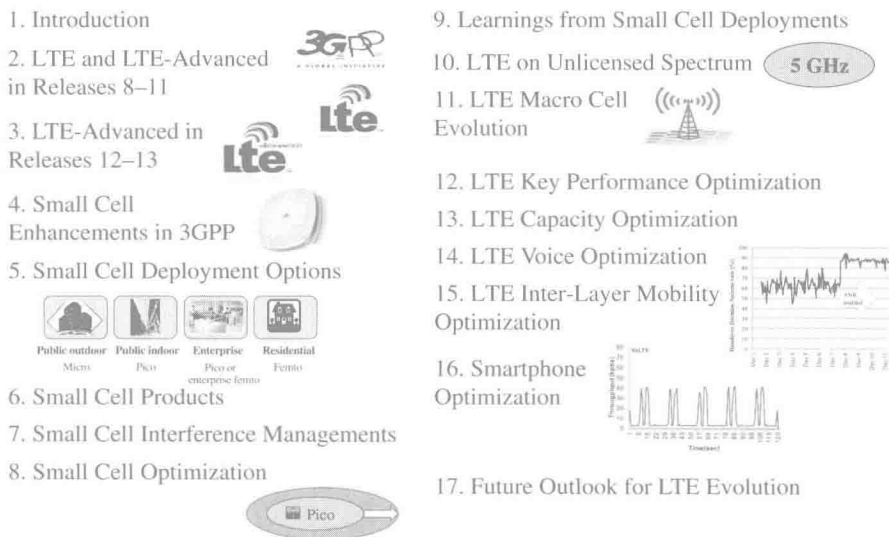


Figure P.1 Contents of the book

Smartphones, tablets and laptops are the main use cases for LTE networks currently, but LTE radio will be the foundation for many new applications in the future. Internet of things, public safety, device-to-device communication, broadcast services and vehicle communication are a few examples that can take benefit of future LTE radio.

The contents of the book are summarized in Figure P.1. Chapters 1–3 provide an introduction to LTE in 3GPP Releases 8–13. The small cell-specific topics are discussed in Chapters 4–10 including 3GPP features, network architecture, products, interference management, optimization, practical learnings and unlicensed spectrum. The LTE optimization is presented in Chapters 11–16 including 3GPP evolution, performance, voice, inter-layer and smartphone optimization. Chapter 17 illustrates the outlook for further LTE evolution.

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The editors and authors welcome any comments and suggestions for improvements or changes that could be implemented in forthcoming editions of this book. The feedback may be addressed to: harri.holma@nokia.com, antti.toskala@nokia.com and jussi.reunanen@nokia.com

# List of Abbreviations

3D	Three Dimensional
3GPP	Third Generation Partnership Project
AAS	Active Antenna System
ABS	Almost Blank Subframe
AC	Alternating Current
ACK	Acknowledgement
AIR	Antenna Integrated Radio
AM	Acknowledge Mode
AMR	Adaptive Multirate
ANDSF	Access Network Discovery and Selection Function
ANR	Automatic Neighbour Relations
APP	Applications
APT	Average Power Tracking
ARFCN	Absolute Radio Frequency Channel Number
ARQ	Automatic Repeat Request
AS	Application Server
ASA	Authorized Shared Access
AWS	Advanced Wireless Spectrum
BBU	Baseband Unit
BCCH	Broadcast Channel
BLER	Block Error Rate
BSIC	Base Station Identity Code
BSR	Buffer Status Report
BTS	Base Station
C-RNTI	Cell Radio Network Temporary Identifier
CA	Carrier Aggregation
CAPEX	Capital Expenditure
CAT	Category
CC	Component Carrier
CCA	Clear Channel Assessment
CCE	Control Channel Element
CDF	Cumulative Density Function
CDMA	Code Division Multiple Access
cDRX	Connected Discontinuous Reception



CoMP	Coordinated Multipoint
CPRI	Common Public Radio Interface
CN	Core Network
CPICH	Common Pilot Channel
CPU	Central Processing Unit
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CRAN	Centralized Radio Access Network
CRS	Common Reference Signals
CRS-IC	Common Reference Signal interference cancellation
CS	Circuit Switched
CS	Cell Selection
CSCF	Call Session Control Function
CSFB	Circuit Switched Fallback
CSG	Closed Subscriber Group
CSI	Channel State Information
CSI-RS	Channel State Information Reference Signals
CSMO	Circuit Switched Mobile Originated
CSMT	Circuit Switched Mobile Terminated
CSSR	Call Setup Success Rate
CWIC	Code Word Interference Cancellation
CWDM	Coarse Wavelength Division Multiplexing
D2D	Device-to-Device
DAS	Distributed Antenna System
DC	Direct Current
DC	Dual Connectivity
DCCH	Dedicated Control Channel
DCH	Dedicated Channel
DCI	Downlink Control Information
DCR	Drop Call Rate
DFS	Dynamic Frequency Selection
DMCR	Deferred Measurement Control Reading
DMRS	Demodulation Reference Signals
DMTC	Discovery Measurement Timing Configuration
DPS	Dynamic Point Selection
DRB	Data Radio Bearer
DRS	Discovery Reference Signals
DRX	Discontinuous Reception
DSL	Digital Subscriber Line
DTX	Discontinuous Transmission
DU	Digital Unit
ECGI	E-UTRAN Cell Global Identifier
eCoMP	Enhanced Coordinated Multipoint
EDPCCH	Enhanced Downlink Physical Control Channel
EFR	Enhanced Full Rate
eICIC	Enhanced Inter-Cell Interference Coordination

eMBMS	Enhanced Multimedia Broadcast Multicast Solution
EPA	Enhanced Pedestrian A
EPC	Evolved Packet Core
EPRE	Energy Per Resource Element
eRAB	Enhanced Radio Access Bearer
ESR	Extended Service Request
ET	Envelope Tracking
EVM	Error Vector Magnitude
EVS	Enhanced Voice Services
FACH	Forward Access Channel
FD-LTE	Frequency Division Long Term Evolution
FDD	Frequency Division Duplex
feICIC	Further Enhanced Inter-Cell Interference Coordination
FFT	Fast Fourier Transformation
FSS	Frequency Selective Scheduling
FTP	File Transfer Protocol
GBR	Guaranteed Bit Rate
GCID	Global Cell Identity
GERAN	GSM EDGE Radio Access Network
GPON	Gigabit Passive Optical Network
GPS	Global Positioning System
GS	Gain Switching
GSM	Global System for Mobile Communications
HARQ	Hybrid Automatic Repeat Request
HD	High Definition
HetNet	Heterogeneous Network
HFC	Hybrid Fibre Coaxial
HO	Handover
HOF	Handover Failure
HPM	High-Performance Mobile
HSPA	High-Speed Packet Access
HSDPA	High-Speed Downlink Packet Access
HSUPA	High-Speed Uplink Packet Access
HTTP	Hypertext Transfer Protocol
IAS	Integrated Antenna System
IC	Interference Cancellation
ICIC	Inter-Cell Interference Coordination
IRC	Interference Rejection Combining
IEEE	Institute of Electrical and Electronics Engineers
IM	Instant Messaging
IMEI	International Mobile Station Equipment Identity
IMPEX	Implementation Expenditure
IMS	Internet Protocol Multimedia Subsystem
IMT	International Mobile Telecommunication
IoT	Internet-of-Things
IQ	In-phase and Quadrature

IRC	Interference Rejection Combining
IRU	Indoor Radio Unit
ISD	Inter Site Distance
IT	Information Technology
ITU-R	International Telecommunications Union – Radiocommunications Sector
JP	Joint Processing
JT	Joint Transmission
KPI	Key Performance Indicator
LAA	Licensed Assisted Access
LAN	Local Area Network
LAU	Location Area Update
LBT	Listen-Before-Talk
LMMSE-IRC	Linear Minimum Mean Squared Error Interference Rejection Combining
LOS	Line of Sight
LP	Low Power
LTE	Long-Term Evolution
LTE-A	LTE-Advanced
LU	Location Update
MAC	Medium Access Control
MBSFN	Multicast Broadcast Single Frequency Network
MDT	Minimization of Drive Testing
MeNB	Macro eNodeB
MeNodeB	Master eNodeB
M2M	Machine-to-Machine
MCL	Minimum Coupling Loss
MCS	Modulation and Coding Scheme
ML	Maximum Likelihood
MLB	Mobility Load Balancing
MIMO	Multiple Input Multiple Output
MME	Mobility Management Entity
MMSE	Minimum Mean Square Error
MOS	Mean Opinion Score
MRC	Maximal Ratio Combining
MRO	Mobility Robustness Optimization
MSS	Mobile Switching centre Server
MTC	Machine Type Communications
MTC	Mobile Terminating Call
MTRF	Mobile Terminating Roaming Forwarding
MTRR	Mobile Terminating Roaming Retry
M2M	Machine-to-Machine
NAICS	Network Assisted Interference Cancellation and Suppression
NAS	Non-access Stratum
NB	Narrowband
NLOS	Non-line of Sight
NOMA	Non-orthogonal Multiple Access
OBSAI	Open Base Station Architecture Initiative

O&M	Operations and Maintenance
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OPEX	Operating Expenditure
OS	Operating System
OSG	Open Subscriber Group
OTT	Over the Top
PA	Power Amplifier
PBCH	Physical Broadcast Channel
PCell	Primary Cell
PCFICH	Physical Control Format Indicator Channel
PCH	Paging Channel
PCI	Physical Cell Identity
PDCCH	Physical Downlink Control Channel
PDCP	Packet Data Convergence Protocol
PDF	Power Density Function
PDSCH	Physical Downlink Shared Channel
PDU	Protocol Data Unit
PESQ	Perceptual Evaluation of Speech
PHR	Power Headroom Report
PWG	Packet Data Network Gateway
PLMN	Public Land Mobile Network
PMI	Precoding Matrix Indicator
PoE	Power over Ethernet
POLQA	Perceptual Objective Listening Quality
PON	Passive Optical Network
PRB	Physical Resource Block
PSCCH	Physical Sidelink Control Channel
PSBCH	Physical Sidelink Broadcast Channel
PSCCH	Physical Sidelink Control Channel
PSD	Power Spectral Density
PSDCH	Physical Sidelink Discovery Channel
PSM	Power-Saving Mode
PSSCH	Physical Sidelink-Shared Channel
PUCCH	Physical Uplink-Control Channel
PUSCH	Physical Uplink-Shared Channel
pRRU	Pico Remote Radio Unit
QAM	Quadrature Amplitude Modulation
QCI	Quality of Service Class Identifier
QoS	Quality of Service
RA-RNTI	Random Access Radio Network Temporary Identifier
RACH	Random Access Channel
RAN	Radio Access Network
RAO	Random Access Opportunity
RAT	Radio Access Technology
RB	Radio Bearer

---

RCS	Rich Call Services
RE	Range Extension
RET	Remote Electrical Tilting
RF	Radio Frequency
RHUB	Remote Radio Unit Hub
RI	Rank Indicator
RIM	Radio Information Management
RLC	Radio Link Control
RNC	Radio Network Controller
RRH	Remote Radio Head
RAT	Radio Access Technology
RLF	Radio Link Failure
RLM	Radio Link Monitoring
RNC	Radio Network Controller
RNTP	Relative Narrow-Band Transmit Power
ROHC	Robust Header Compression
RoT	Rise over Thermal
RRC	Radio Resource Control
RRM	Radio Resource Management
RS	Reference Signal
RSCP	Received Signal Code Power
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RSSI	Received Signal Strength Indication
RX	Reception
SC-FDMA	Single Carrier Frequency Division Multiple Access
SDU	Service Data Unit
S-GW	Serving Gateway
S-TMSI	SAE Temporary Mobile Subscriber Identity
SIAP	S1 Application Protocol
SeNB	Small eNodeB
SeNodeB	Secondary eNodeB
SCell	Secondary Cell
SCS	Short Control Signalling
SFN	Single Frequency Network
SGW	Serving Gateway
SI-RNTI	System Information Radio Network Temporary Identifier
SIB	System Information Block
SINR	Signal to Interference and Noise Ratio
SIP	Session Initiation Protocol
SISO	Single Input Single Output
SLIC	Symbol Level Interference Cancellation
SMS	Short Message Service
SNR	Signal-to-Noise Ratio
SON	Self-Organizing Network
SPS	Semi Persistent Scheduling

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SR	Scheduling Request
SRB	Signalling Radio Bearer
SRS	Sounding Reference Signals
SRVCC	Single Radio Voice Call Continuity
SU	Single User
SWB	Super Wideband
TA	Timing Advance
TAU	Tracking Area Update
TBS	Transport Block Size
TC	Test Case
TCO	Total Cost of Ownership
TCP	Transmission Control Protocol
TDD	Time Division Duplex
TD-LTE	Time Division Long-Term Evolution
TETRA	Terrestrial Trunked Radio
TM	Transmission Mode
TPC	Transmission Power Control
TTI	Transmission Time Interval
TTT	Time to Trigger
TX	Transmission
UCI	Uplink Control Information
UDN	Ultra Dense Network
UDP	User Datagram Protocol
UE	User Equipment
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module
UTRA	Universal Terrestrial Radio Access
UTRAN	Universal Terrestrial Radio Access Network
VAD	Voice Activity Detection
VDSL	Very High Bit Rate Digital Subscriber Line
VoLTE	Voice over LTE
V2X	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WB	Wideband
WCDMA	Wideband Code Division Multiple Access
WDM	Wavelength Division Multiplexing
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
X2AP	X2 Application Protocol

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