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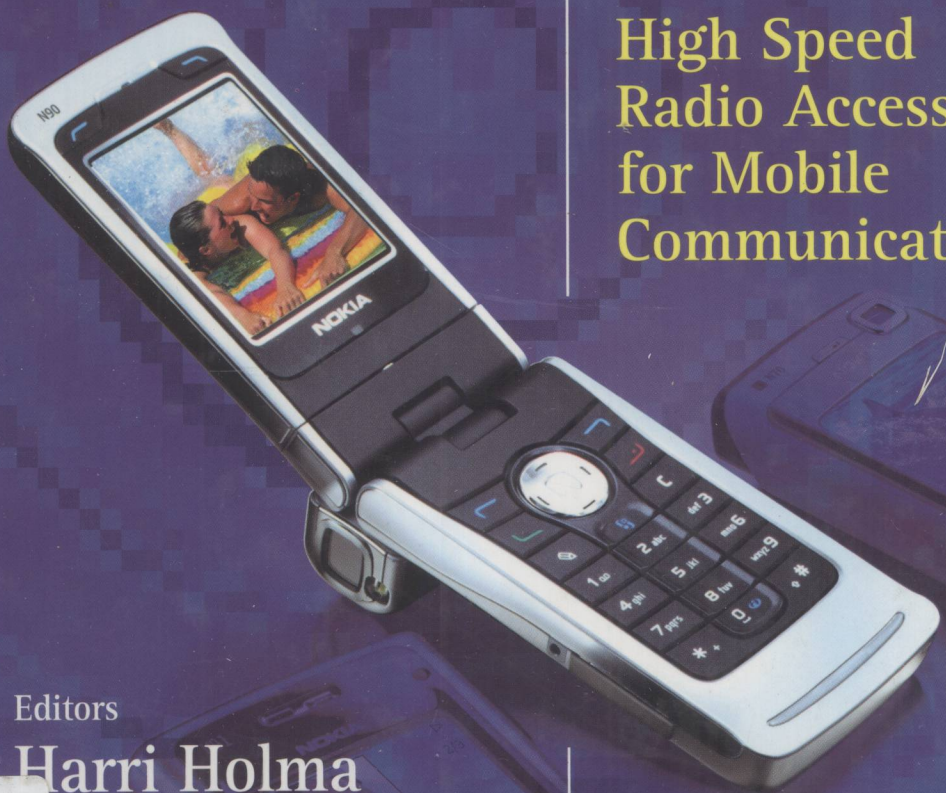
High Speed Radio Access for Mobile Communications



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HSDPA/HSUPA for UMTS

High Speed Radio Access for Mobile Communications

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Harri Holma and Antti Toskala
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HSDPA/HSUPA for UMTS

Preface

When the first edition of *WCDMA for UMTS* was published by John Wiley & Sons, Ltd 6 years ago (in April 2000), 3GPP had just completed the first set of wideband CDMA (WCDMA) specifications, called 'Release 99'. At the same time, the Universal Mobile Telecommunication Services (UMTS) spectrum auction was taking place in Europe. UMTS was ready to go. The following years were spent on optimizing UMTS system specifications, handset and network implementations, and mobile applications. As a result, WCDMA has been able to bring tangible benefits to operators in terms of network quality, voice capacity, and new data service capabilities. WCDMA has turned out to be the most global mobile access technology with deployments covering Europe, Asia including Korea and Japan, and the USA, and it is expected to be deployed soon in large markets like China, India, and Latin America.

WCDMA radio access has evolved strongly alongside high-speed downlink packet access (HSDPA) and high-speed uplink packet access (HSUPA), together called 'high-speed packet access' (HSPA). When the International Telegraphic Union (ITU) defined the targets for IMT-2000 systems in the 1990s, the required bit rate was 2 Mbps. 3rd Generation Partnership Project (3GPP) Release 99 does support up to 2 Mbps in the specifications, but the practical peak data rate chosen for implementations is limited to 384 kbps. HSPA is now able to push practical bit rates beyond 2 Mbps and is expected to exceed 10 Mbps in the near future. In addition to the higher peak data rate, HSPA also reduces latency and improves network capacity. The new radio capabilities enable a new set of packet-based applications to go wireless in an efficient way. For operators the network upgrade from WCDMA to HSPA is straightforward as the HSPA solution builds on top of the WCDMA radio network, reusing all network elements. The first commercial HSDPA networks were launched during the last quarter of 2005.

This book was motivated by the fact that HSDPA and HSUPA are the next big steps in upgrading WCDMA networks. While the WCDMA operation has experienced some enhancements on top of dedicated channel operation, there was a clear need – it was felt – to focus just on HSDPA and HSUPA issues without having to repeat what was already presented in the different editions of *WCDMA for UMTS* for Release 99 based systems. Also, valuable feedback obtained from different lecturing events on HSDPA and HSUPA training sessions had clearly indicated a shift in the learning focus from basic WCDMA to the HSPA area. Thus, this book's principal task is to focus on HSPA specifications, optimization, and performance. The presentation concentrates on the differences that HSPA has brought to WCDMA radio access. Detailed information about WCDMA radio can be obtained from *WCDMA for UMTS*.

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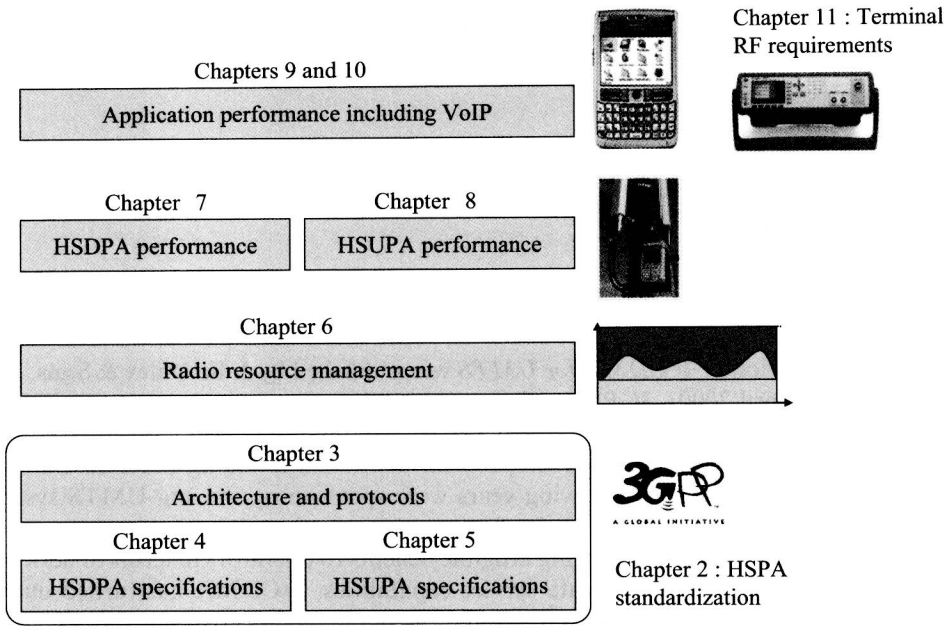

Summary of the book's contents.

The contents of this book are summarized in the above diagram. Chapter 1 gives an introduction to the status of WCDMA and HSPA capabilities. Chapter 2 provides an overview of HSPA standardization. Chapter 3 presents the HSPA network architecture and radio protocols. Chapters 4 and 5 explain the 3GPP physical layer HSDPA and HSUPA standards and the background of the selected solutions. Radio resource management algorithms are discussed in Chapter 6. Chapters 7 and 8 present HSDPA and HSUPA performance including data rates, capacity, and their coexistence with WCDMA. Application performance is presented in Chapter 9, and Voice over Internet Protocol (VoIP) performance aspects in Chapter 10. A terminal's radio frequency (RF) requirements are introduced in Chapter 11.

This book is aimed at R&D engineers, network planners, researchers, technical managers, regulators, and mobile application developers who wish to broaden their technical understanding to cover HSDPA and HSUPA as well. The views in the book are based on the authors' opinions and do not necessarily represent their employer's views.

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We would like to acknowledge Sierra Wireless for permission to use their product picture in the book.

Finally, it is good to remember that this book would not have been possible without the huge effort invested by our colleagues in the wireless industry within the 3rd Generation Partnership Project (3GPP) to produce the different specification releases of the global WCDMA/HSDPA/HSUPA standard and, thereby, making the writing of this book possible.

The editors and authors welcome any comments and suggestions for improvements or changes that could be implemented in forthcoming editions of this book.

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Abbreviations

16QAM	16 Quadrature Amplitude Modulation
2G	Second Generation
3G	Third Generation
3GPP	3rd Generation Partnership Project
64QAM	64 Quadrature Amplitude Modulation
8PSK	8 Phase Shift Keying
A-DPCH	Associated DPCH
AAL	ATM Adaptation Layer
AC	Admission Control
ACIR	Adjacent Channel Interference Ratio
ACK	ACKnowledgement
ACLR	Adjacent Channel Leakage Ratio
ACS	Adjacent Channel Selectivity
AG	Absolute Grant
AGC	Automatic Gain Control
ALCAP	Access Link Control Application Part
AM	Acknowledged Mode
AMC	Adaptive Modulation and Coding
AMR	Adaptive Multi-Rate
APN	Access Point Name
ARIB	Association of Radio Industries and Businesses (Japan)
ARP	Allocation and Retention Priority
ARQ	Automatic Repeat reQuest
ASN.1	Abstract Syntax Notation 1
ATIS	Alliance for Telecommunications Industry Solutions (US)
ATM	Asynchronous Transfer Mode
AWGN	Additive White Gaussian Noise
BCCH	BroadCast Control CHannel (logical channel)
BCFE	Broadcast Control Functional Entity
BCH	Broadcast CHannel (transport channel)
BER	Bit Error Rate
BLEP	BLock Error Probability
BLER	BLock Error Rate
BMC	Broadcast/Multicast Control protocol
BPSK	Binary Phase Shift Keying

BS	Base Station
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver Station
C/I	Carrier-to-Interference ratio
CC	Congestion Control
CC	Chase Combining
CCSA	China Communications Standards Association
CCTrCH	Coded Composite Transport CHannel
CDMA	Code Division Multiple Access
CFN	Connection Frame Number
CLTD	Closed Loop Transmit Diversity
CLTD2	Closed Loop Transmit Diversity mode-2
CM	Cubic Metric
CN	Core Network
COST	COoperation Européenne dans le domaine de la recherche Scientifique et Technique
CP	Cyclic Prefix
CPICH	Common PIlot CHannel
CQI	Channel Quality Information
CRC	Cyclic Redundancy Check
CRNC	Controlling RNC
CS	Circuit Switched
CT	Core and Terminals
DAB	Digital Audio Broadcasting
DCCH	Dedicated Control CHannel (logical channel)
DCH	Dedicated CHannel (transport channel)
DDI	Data Description Indicator
DL	DownLink
DPCCH	Dedicated Physical Control CHannel
DPCH	Dedicated Physical CHannel
DPDCH	Dedicated Physical Data CHannel
DRNC	Drift RNC
DRX	Discontinuous Reception
DS-CDMA	Direct Spread Code Division Multiple Access
DSCH	Downlink Shared CHannel
DSL	Digital Subscriber Line
DT	Discard Timer
DTCH	Dedicated Traffic CHannel
DTX	Discontinuous Transmission
DVB	Digital Video Broadcasting
E-AGCH	E-DCH Absolute Grant CHannel
E-DCH	Enhanced uplink Dedicated CHannel
E-DPCCH	E-DCH Dedicated Physical Control CHannel
E-DPDCH	E-DCH Dedicated Physical Data CHannel
E-HICH	E-DCH Hybrid ARQ Indicator CHannel

E-RGCH	E-DCH Relative Grant CHannel
E-RNTI	E-DCH Radio Network Temporary Identifier
E-TFC	E-DCH Transport Format Combination
E-TFCI	E-DCH Transport Format Combination Indicator
ECR	Effective Code Rate
EDGE	Enhanced Data rates for GSM Evolution
EDGE	Enhanced Data Rate for Global Evolution
EGPRS	Enhanced GPRS
EGPRS	Extended GPRS
ETSI	European Telecommunications Standards Institute
EVM	Error Vector Magnitude
F-DCH	Fractional Dedicated CHannel
F-DPCH	Fractional Dedicated Physical CHannel
FACH	Forward Access CHannel
FBI	FeedBack Information
FCC	Federal Communications Commission
FCS	Fast Cell Selection
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FER	Frame Error Ratio
FER	Frame Erasure Rate
FFT	Fast Fourier Transform
FP	Frame Protocol
FRC	Fixed Reference Channel
FTP	File Transfer Protocol
G-factor	Geometry factor
GB	GigaByte
GBR	Guaranteed Bit Rate
GERAN	GSM/EDGE RAN
GGSN	Gateway GPRS Support Node
GI	Guard Interval
GP	Processing gain
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HARQ	Hybrid Automatic Repeat reQuest
HC	Handover Control
HLBS	Highest priority Logical channel Buffer Status
HLID	Highest priority Logical channel ID
HLR	Home Location Register
HS-DPCCH	Uplink High-Speed Dedicated Physical Control CHannel
HS-DSCH	High-Speed Downlink Shared CHannel
HS-PDSCH	High-Speed Physical Downlink Shared CHannel
HS-SCCH	High-Speed Shared Control CHannel
HSDPA	High-Speed Downlink Packet Access
HSPA	High-Speed Packet Access
HSUPA	High-Speed Uplink Packet Access

HTTP	Hypertext markup language
IFFT	Inverse Fast Fourier Transform
IP	Internet Protocol
IR	Incremental Redundancy
IRC	Interference Rejection Combining
IS-95	Interim Standard 95
ITU	International Telecommunication Union
ITU	International Telegraphic Union
LAU	Location Area Update
LMMSE	Linear Minimum Mean Square Error
LTE	Long-Term Evolution
MAC	Medium Access Control
MAC-d	dedicated MAC
MAC-es/s	E-DCH MAC
MAC-hs	high-speed MAC
MAI	Multiple Access Interference
MAP	Maximum *A Posteriori*
max-C/I	maximum Carrier-to-Interference ratio
MB	MegaByte
MBMS	Multimedia Broadcast and Multicast Service
MIMO	Multiple Input Multiple Output
min-GBR	minimum Guaranteed Bit Rate
MRC	Maximal Ratio Combining
MS	Mobile Station
MSC	Mobile Switching Centre
MSC/VLR	Mobile services Switching Centre/Visitor Location Register
MUD	MultiUser Detection
MUX	Multiplexing
NACC	Network Assisted Cell Change
NBAP	Node B Application Part
NF	Noise Figure
Node B	Base station
O&M	Operation & Maintenance
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OLPC	Outer Loop Power Control
OMA	Open Mobile Alliance
OSS	Operations Support System
OTDOA	Observed Time Difference Of Arrival
OVSF	Orthogonal Variable Spreading Factor
P-CPICH	Primary CPICH
PA	Power Amplifier
PAD	PADding
PAR	Peak-to-Average Ratio
PAS	Power Azimuth Spectrum
PC	Power Control

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PCCC	Parallel Concatenated Convolutional Code
PCH	Paging CHannel
PCMCIA	Personal Computer Memory Card Industry Association
PCS	Personal Communication Services
PCS	Personal Communication System
PDCP	Packet Data Convergence Protocol
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PDU	Payload Data Unit
PF	Proportional Fair
POC	Push-to-talk Over Cellular
PRACH	Physical RACH
PS	Packet Switched
PU	Payload Unit
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RAB	Radio Access Bearer
RACH	Random Access CHannel
RAN	Radio Access Network
RANAP	Radio Access Network Application Part
RAU	Routing Area Update
RB	Radio Bearer
RF	Radio Frequency
RG	Relative Grant
RLC	Radio Link Control
RLL	Radio Link Layer
RLS	Radio Link Set
RM	Resource Manager
RNC	Radio Network Controller
RNTI	Radio Network Temporary Identifier
ROHC	RObust Header Compression
RR	Round Robin
RRC	Radio Resource Control
RRM	Radio Resource Management
RSCP	Received Signal Code Power
RSN	Retransmission Sequence Number
RSSI	Received Signal Strength Indicator
RTCP	Real Time Control Protocol
RTO	Retransmission TimeOut
RTP	Real Time Protocol
RTT	Round Trip Time
RTWP	Received Total Wideband Power
S-CCPCH	Secondary CCPCH
SA	Services and system Architecture
SC-FDMA	Single Carrier FDMA

SCCP	Signalling Connection Control Part
SCCPCH	Secondary Common Control Physical CHannel
SDU	Service Data Unit
SF	Spreading Factor
SGSN	Serving GPRS Support Node
SI	Scheduling Information
SIB	System Information Block
SID	Size index IDentifier
SINR	Signal-to-Interference-plus-Noise Ratio
SIR	Signal to Interference Ratio
SNR	Signal to Noise Ratio
SPI	Scheduling Priority Indicator
SRB	Signalling Radio Bearer
SRNC	Serving RNC
SRNS	Serving Radio Network System
STTD	Space Time Transmit Diversity
TC	Traffic Class
TCP	Transmission Control Protocol
TD-SCDMA	Time division synchronous CDMA
TDD	Time Division Duplex
TEBS	Total E-DCH Buffer Status
TF	Transport Format
TFCI	Transport Format Combination Indicator
TFRC	Transport Format and Resource Combination
THP	Traffic Handling Priority
TMSI	Temporary Mobile Subscriber Identity
TPC	Transmission Power Control
TR	Technical Report
TS	Technical Specification
TSG	Technical Specification Group
TSN	Transmission Sequence Number
TTA	Telecommunications Technology Association (Korea)
TTC	Telecommunication Technology Committee (Japan)
TTI	Transmission Time Interval
TX GAP	Transmit GAP
TxAA	Transmit Adaptive Antennas
UDP	User Datagram Protocol
UE	User Equipment
UL	UpLink
UM	Unacknowledged Mode
UM-RLC	Unacknowledged Mode RLC
UMTS	Universal Mobile Telecommunications System
UPH	UE Power Headroom
UPH	UE transmission Power Headroom
URA	UTRAN Registration Area
UTRA	UMTS Terrestrial Radio Access (ETSI)

UTRA	Universal Terrestrial Radio Access (3GPP)
UTRAN	UMTS Terrestrial Radio Access Network
VCC	Virtual Channel Connection
VF	Version Flag
VoIP	Voice over IP
VPN	Virtual Private Network
WAP	Wireless Application Protocol
WCDMA	Wideband CDMA
WG	Working Group
Wimax	Worldwide Interoperability for microwave access
WLAN	Wireless Local Area Network
WWW	World Wide Web 9

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