WiMAX Technology and Network Evolution

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The ComSoc Guides to Communications Technologies
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Contents

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Preface

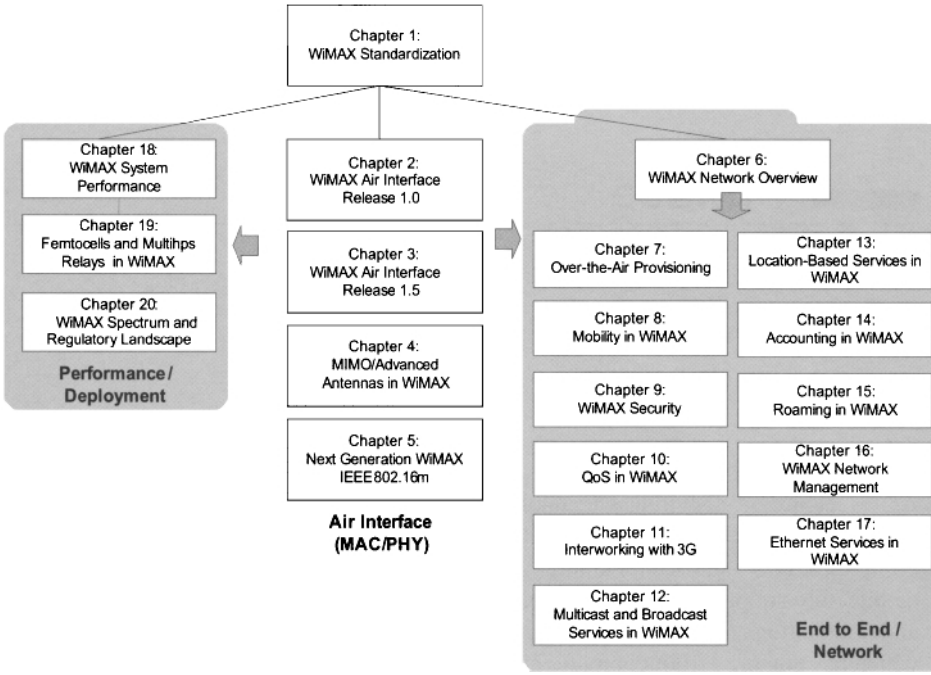
As the evolution of wireless technologies continues toward realization of mobile broadband access to content-rich multimedia services, the communication industry is going through a significant paradigm shift. There is an ever increasing emphasis on architecture simplicity and cost lowering, as well as leveraging the ongoing success and innovations in Internet-based protocols and applications. Mobile WiMAX, which has emerged from computer and Internet ecosystems, is one of the first technologies leading this change of paradigm.

Despite widespread interest in and debate on mobile WiMAX, there is no comprehensive end-to-end description of the technology available to the industry and academia. This book is planned and organized to provide an accurate, complete, and objective description of mobile WiMAX technology. The breadth and depth of the material is carefully balanced to cover a wide range of questions on WiMAX as a new wireless technology while emphasizing key technical concepts and design principles. Each chapter was developed by selected subject-matter experts who have been directly involved as leading contributors to this technology in the IEEE 802.16 Working Group and/or the WiMAX Forum.

The book is organized into 20 chapters as shown in the figure on page xviii.

Chapter 1 provides an overview of the WiMAX standardization and certification process and development in IEEE 802.16 and in the WiMAX Forum. It also presents the high-level evolution road map for the WiMAX technology. Chapters 2 through 5 focus on the mobile WiMAX air interface based on IEEE 802.16 standards, whereas Chapters 6 through 17 articulate the key concepts of WiMAX end-to-end architectures, protocols, and services, including both over-the-air and network aspects. Based on this functional organization, some of the important WiMAX features, such as security, mobility, quality of service (QoS), and multicast and broadcast service (MBS), which are briefly described in earlier overview chapters, are described more comprehensively in the dedicated chapters.

More specifically, Chapter 2 describes the physical (PHY) and media access control (MAC) layers of WiMAX Release 1.0 in detail, whereas Chapter 3 summarizes key improvements and enhancements introduced in Release 1.5. Chapter 4



Organization of the book.

provides an overview of advanced antenna systems, which play a key role in improving radio-link-layer efficiency and provide high data throughput and system capacity. Chapter 5 presents a technical overview of IEEE 802.16m standard, which is the basis for the next-generation mobile WiMAX radio technology in Release 2.0 and also is a candidate for ITU International Mobile Telecommunications—Advanced (IMT-ADV) technologies. Chapter 7 describes over-the-air provisioning and activation in mobile WiMAX, which is a key feature to enable the open retail device distribution model. Mobility, security, and QoS, which constitute the essential end-to-end working of mobile WiMAX technology and require coherent air interface and network specifications, are covered in Chapters 8, 9, and 10, respectively. Chapter 11 addresses WiMAX interworking with 3G cellular networks and technologies, such as UMTS/HSPA and CDMA2000/1X-EVDO. The interworking enables seamless overlay and integration of WiMAX systems with existing mobile operators' networks.

Multicast and broadcast services and location-based services, which are advanced network features introduced in network Release 1.5 and are expected to be key enablers for new services and usage models, are covered in Chapters 12 and 13, respectively. Chapters 14 through 16 cover the important WiMAX network aspects in accounting, roaming, and network management. Although mobile WiMAX is primarily IP-based, the architecture can also support Ethernet-based services, which are described in Chapter 17.

The last three chapters describe different perspectives on performance and deployment issues. Chapter 18 presents an overall structure of an end-to-end application performance simulator followed by radio performance evaluation focusing on link-level and system-level performance. Chapter 19 describes two advanced radio network solutions—femtocells and multihop relays—to improve coverage and system capacity. Finally, Chapter 20 highlights the spectrum allocation and regulatory issues that have direct influence on WiMAX deployments and global adoption.

The editors and contributing authors dedicate the result of this teamwork to our colleagues, families, and friends, and hope that this book provides a helpful educational reference for those who seek to learn about WiMAX technology and prepare for future related innovations.

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Potomac, Maryland
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January 2010

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Acronyms

1XRTT	Single-Carrier Radio Transmission Technology
3DES	Triple DES
3GPP	3rd Generation Partnership Project
3GPP2	3rd Generation Partnership Project 2
3WHS	Three-Way Handshake
A-A-AMAP	Assignment A-MAP
A-MAP	Advanced MAP
A-GPS	Assisted Global Positioning System
A-PCEF	Access Policy Control Enforcing Fucntion
A-PREAMBLE	Advanced Preamble
AAA	Authentication, Authorization, Accounting
AAS	Advanced Antenna Systems
AAV	Alternative Access Vendor
AES	Advanced Encryption Standard
AF	Application Function, Assured Forwarding
AFC	Automatic Frequency Control
AK	Authentication Key
AKA	Anonymity Key
AKA	Authentication and Key Agreement
AMC	Adaptive Modulation and Coding
AMF	Authenticated Message Field
AN	Access Network
ANDSF	Access Network Discovery and Selection Function
AO	Authentication Option
AP	Access Point
APT	Asia-Pacific Telecommunity
AQM	Active Queue Management
ARQ	Automatic Repeat reQuest
ASMG	Arab Spectrum Management Group

ASN	Access Service Network
ASN-GW	Access Service Network Gateway
ASP	Application Service Provider
ATU	Access Terminal, African Telecommunications Union
AV	Authentication Vector
AWG	Application Working Group
AWGN	Additive White Gaussian Noise
BA	Binding Acknowledgement
BBERF	Bearer Binding and Event Reporting Function
BCG	Band Class Group
BE	Best Effort
BEK	Bootstrap Encryption Key
BEM	Block Edge Mask
BER	Bit Error Rate
BGCF	Breakout Gateway Control Function
BLER	Block Error
BML	Business Management Layer
BNG	Broadband Network Gateway
bps	bit per second
BPSK	Binary Phase Shift Keying
BS	Base Station
BSC	Base Station Controller
BSHO	Base Station Initiated Handover
BS ID	Base Station Identifier
BSS	Business Support System
BTC	Block Turbo Code
BU	Binding Update
BWA	Broadband Wireless Access
C/No	Carrier-to-Noise Density
C-PCEF	Core Policy Control Enforcing Function
C-SAP	Control Service Access Point
C-SM	Collaborative Spatial Multiplexing
CA	Certificate Authority
CAC	Call Admission Control
CALEA	Communications Assistance for Law Enforcement Act
Cap-Ex	Capital Expenditure
CAPL	Contractual Agreement Preference List
CBC	Cipher Block Chaining
CBR	Constant Bit Rate
CC	Convolutional Coding, Chase Combining
CCM	Counter-Mode Encryption (CTR) with Cipher Block Chaining Message Authentication Code (CBC-MAC)
CDD	Cyclic Delay Diversity
CDF	Charging Distribution Function, Cumulative Distribution Function

CDMA	Code Division Multiple Access
CEPT	European Conference of Postal and Telecommunications Administrations
CID	Connection Identifier
CINR	Carrier-to-Interference and Noise Ratio
CITEL	Inter-American Telecommunication Commission
CMAC	Cipher-based Message Authentication Code
CMIP	Client Mobile IP
CoA	Care of Address
CoRe	Constellation Rearrangement
CP	Cyclic Prefix
CPE	Customer Premise Equipment
CPS	Common Part Sublayer
CQI	Channel Quality Information
CQICH	Channel Quality Information Channel
CRC	Cyclic Redundancy Check
CRU	Contiguous Resource Unit
CS	Convergence Sublayer
CSCF	Call Session Control Function
CSG	Closed Subscriber Group
CSI	Channel State Information
CSM	Collaborated Spatial Multiplexing
CSN	Connectivity Service Network
CTC	Convolutional Turbo Coding
CUI	Chargeable User Identity
CWG	Certification Working Group
D-TDOA	Downlink Time Difference of Arrival
DB	Database
dB	decibel
dBm	decibels of power, w.r.t. 1 milliwatt
DCD	Downlink Channel Descriptor
DES	Data Encryption Standard
DF	Don't Fragment
DHCP	Dynamic Host Configuration Protocol
DiffServ	Diffrentiated Services
DL	Downlink
DLFP	Downlink Frame Prefix
DM	Device Management
DNS	Domain Name System
DOCSIS	Data-Over-Cable-Service Interface Specification
DPF	Data Path Function
DPI	Deep Packet Inspection
DPID	Data Path IDentification
DRMD	Device-Reported Metrics and Diagnostics
DRU	Distributed Resource Unit

DSA	Dynamic Service Addition
DSA-ACK	Dynamic Service Addition Acknowledgement
DSA-REQ	Dynamic Service Addition Request
DSA-RSP	Dynamic Service Addition Response
DSC	Dynamic Service Change
DSCP	DiffServ Code Point
DSD	Dynamic Service Deletion
DSL	Digital Subscriber Line
DSx	Dynamic Service Addition, Change, or Deletion
DIUC	Downlink Interval Usage Code
E-CSCF	Emergency Call Session Control Function
E-MBS	Enhanced Multicast Broadcast Service
E-UTRAN	Evolved UTRAN (3GPP)
E2E	End-to-End
EAP	Extensible Authentication Protocol
EAP-AKA	EAP Authentication and Key Agreement
EAP-TLS	EAP Transport-Layer Security
EAP-TTLS	EAP Tunneled Transport-Layer Security
ECINR	Effective Carrier-to-Interference and Noise Ratio
EESM	Exponential-Effective SINR Mapping
EDE	Encrypt-Decrypt-Encrypt
EDGE	Enhanced Data rates for GSM Evolution
EF	Expedited Forwarding
EH	Extended Header
EIK	EAP Integrity Key
EML	Element Management Layer
EMS	Element Management System
EMSK	Extended Master Session Key
EPC	Evolved Packet Core
EPDG	Evolved Packet Data Gateway
EPS	Evolved Packet System
ERTPS	Enhanced Real-Time Polling Service
ES	Emergency Service
ESM	Effective SINR Mapping
eTOM	Enhanced Operations Map
EVC	Ethernet Virtual Circuits
EVDO	EVolution Data Optimized
EVM	Vector Magnitude
FA	Foreign Agent
FBBS	Fast BS Switching
FCH	Frame Control Header
FCC	Federal Communications Commission
FDD	Frequency Division Duplexing
FD-FDD	Full-Duplex Frequency Division Duplex
FDMA	Frequency Division Multiple Access

FEC	Forward Error Correction
Femto-AP	Femto Access Point (or FAP)
FFR	Fractional Frequency Reuse
FFT	Fast Fourier Transform
FID	Flow Identifier
FIFO	First In, First Out
FTP	File Transfer Protocol
FUSC	Full Usage of Subchannels
GARP	Generic Attribute Registration Protocol
GDOP	Geometric Dilution of Precision
GERAN	GSM EDGE Radio Access Network
GGSN	Gateway GPRS Support Node
GMH	Generic MAC Header
GPRS	General Packet Radio Service
GPS	Global Positioning System
GRE	Generic Route Encapsulation
GRWG	Global Roaming Working Group
GSM	Global System for Mobile communications
GT	Guard Time
GTP	GPRS Tunneling Protocol
GW	Gateway
H-NSP	Home Network Service Provider
H-NSP-ID	Home Network Service Provider Identifier
HA	Home Agent
HAAA	Home AAA
HARQ	Hybrid Automatic Repeat reQuest
HARQ-CC	Hybrid Automatic Repeat reQuest for Convolutional Code
HCSN	Home Connectivity Service Network
HD-FDD	Half-Duplex Frequency Division Duplex
HHO	Hard Handover
HLR	Home Location Register
HMAC	keyed-Hash Message Authentication Code
HO	Handover
HoA	Home Address
HODI	Handover Data Integrity
HSPA	High Speed Packet Access (3GPP)
HSS	Home Subscriber Server
HTTP	Hypertext Transfer Protocol
I-CSCF	Interrogating Call Session Control Function
IAS	Internet Access and Services
IASP	Internet Application Service Provider
ICMP	Internet Control Message Protocol
ICT	Information and Communication Technologies
ID	Identifier
IE	Information Element

IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IIOT	Infrastructure Interoperability Testing
IM	Instant Messaging
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IMT	International Mobile Telecommunications
IntServ	Integrated Services
IOT	Interoperability Testing
IP	Internet Protocol
IP-CAN	IP Connectivity Access Network
Ipsec	Internet Protocol Security
IPTV	Internet Protocol TV
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
IR	Incremental Redundancy
IRP	Integration Reference Point
IS	Information Services
ISF	Initial Service Flow
ISM	Industrial, Scientific, and Medical
ISP	Internet Service Provider
ITU	International Telecommunications Union
ITU-D	International Telecommunications Union-Development Sector
ITU-R	International Telecommunications Union-Radiocommunications Sector
ITU-T	International Telecommuncations Union-Telecom Standardization Sector
IWK	Interworking
JTG 5-6	Joint Task Group 5-6
KEK	Key-Encryption-Key
KPI	Key Performance Indicators
L2	Layer 2
L3	Layer 3
LAES	Lawfully Authorized Electronic Surveillance
LBO	Local Breakout
LBS	Location-Based Service
LCID	Logical Channel IDentifier
LDAP	Lightweight Directory Access Protocol
LDPC	Low Density Parity Check
LEC	Local Exchange Carrier
LI	Lawful Interception
LRU	Logical Resource Unit
LTE	Long-Term Evolution (3GPP)