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# Contents

**List of Contributors** xv
**Foreword** xxi
**Preface** xxiii
**Acknowledgements** xxvii
**List of Acronyms** xxix

## I Introduction

1 **Introduction to WiMAX Technology** 3  
*Wonil Roh and Vladimir Yanover*

1.1 Overview of State-of-the-art WiMAX Technology 4
1.1.1 Structure of the System Profile 4
1.1.2 Key PHY Features 5
1.1.3 Key MAC Features 7
1.1.4 Advanced Networking Features 9
1.2 WiMAX Evolution Path 9
1.2.1 Release 1.5 10
1.2.2 Release 2.0 12
References 12

## II WiMAX Validation: Validating Current Fixed and Mobile WiMAX through Advanced Testbeds

2 **WiMAX Performance in Practice** 17  
*Kostas Pentikousis, Esa Piri, Jarno Pinola and Ilkka Harjula*

2.1 Empirical Evaluations of WiMAX 18
2.2 Fixed WiMAX Testbed Evaluation 20
2.2.1 Audio and Video Traffic over WiMAX 21
2.2.2 Traffic Generation 22
## CONTENTS

2.2.3 Host Clock Synchronization ........................................... 22
2.2.4 Baseline Capacity Measurements ................................... 25

2.3 VoIP Over Fixed WiMAX .................................................. 26
   2.3.1 VoIP Overhead .................................................... 26
   2.3.2 Synthetic G.723.1 VoIP Over WiMAX .............................. 27
   2.3.3 Synthetic G.729.1 VoIP Over WiMAX .............................. 27
   2.3.4 Synthetic Speex VoIP over WiMAX ................................ 28
   2.3.5 VoIP Aggregation .................................................. 29

2.4 IPTV Over fixed WiMAX ................................................. 34

2.5 Mobile WiMAX Testbed Evaluation .................................... 36
   2.5.1 The VTT CNL Mobile WiMAX Testbed ............................ 37
   2.5.2 Baseline Capacity Measurements .................................. 38

2.6 Summary ............................................................... 39

2.7 Further Reading ....................................................... 40

References ................................................................. 41

### III Novel Scenarios

3 Novel WiMAX Scenarios for Future Broadband Wireless Access Networks 47

*Pedro Neves, Kostas Pentikousis, Susana Sargento, Marília Curado, Paulo Simões and Francisco Fontes*

3.1 Introduction ............................................................. 47

3.2 WMAN Network Provider ............................................. 48
   3.2.1 Broadband Wireless Access .................................... 48
   3.2.2 Advanced Mobile WiMAX ......................................... 54

3.3 Telemedicine Applications ............................................ 57
   3.3.1 Remote Patient Monitoring ..................................... 58
   3.3.2 On-site Medical Assistance ..................................... 59

3.4 Environmental Monitoring ............................................ 60
   3.4.1 Seismic Activity ................................................ 60
   3.4.2 Fire Prevention .................................................. 61
   3.4.3 Other Applications .............................................. 65

3.5 Conclusions ........................................................... 66

References ................................................................. 66

### 4 Pricing in WiMAX Networks

*Ioannis Papapanagiotou, Jie Hui and Michael Devetsikiotis*

4.1 Introduction ............................................................. 69

4.2 Economics in Network Engineering .................................. 70
   4.2.1 Building a Business Model ..................................... 70
   4.2.2 Control and Pricing .............................................. 71

4.3 Building the Pricing Schemes ........................................ 73
   4.3.1 Utility, Demand Functions and Optimization Objectives ...... 73
   4.3.2 Flat-rate Pricing ................................................ 74
   4.3.3 User-based Pricing .............................................. 75
CONTENTS

4.4 Pricing in Different WiMAX Topologies .................................. 76
  4.4.1 Point-to-point Unlimited Capacity ................................ 76
  4.4.2 Mesh Mode Operation ............................................. 77
  4.4.3 Point-to-point Limited Capacity .................................. 78
  4.4.4 WiMAX/WiFi Architecture ........................................ 81
4.5 Conclusion ................................................................. 83
References ................................................................. 83

IV Advanced WiMAX Architectures .......................................... 85

5 WiMAX Femtocells .......................................................... 87
  Chris Smart, Clare Somerville and Doug Pulley

  5.1 Introduction ........................................................... 87
    5.1.1 A Brief History of Cell Sizes ................................ 87
    5.1.2 Definition of a Femtocell ..................................... 87
  5.2 Architecture of a WiMAX Femtocell ................................ 88
    5.2.1 WiMAX Network Architectures for a Femtocell ............. 88
    5.2.2 Femtocell Deployment Configurations ....................... 89
  5.3 Femtocell Fundamentals .............................................. 90
    5.3.1 Synchronization ................................................ 91
    5.3.2 Self-configuration ............................................. 92
    5.3.3 Remote Configuration ......................................... 94
    5.3.4 User Configuration ........................................... 95
    5.3.5 Backhaul Security ............................................. 95
    5.3.6 Handovers ...................................................... 95
  5.4 Femtocell–Macrocell Interference .................................. 97
    5.4.1 Interference Scenarios ....................................... 97
    5.4.2 Downlink Coverage Definitions .............................. 98
    5.4.3 Downlink Coverage Analysis .................................. 99
    5.4.4 Setting the Maximum Femtocell Transmit Power .......... 101
References ................................................................. 103

6 Cooperative Principles in WiMAX ......................................... 105
  Qi Zhang, Frank H.P. Fitzek and Marcos D. Katz

  6.1 Introduction ........................................................... 105
  6.2 Cooperative Diversity Schemes in Mobile Multihop Relay Based WiMAX (802.16j) ......................................................... 112
  6.3 Cooperative Schemes for Multicast Broadcast Services in WiMAX .......................................................... 115
    6.3.1 Cooperative Transmission for Multimedia Multicast Services .......................................................... 116
    6.3.2 Cooperative Retransmission Scheme for Reliable Multicast Services Using Network Coding .................................. 118
  6.4 Network Coding Implementation in the Commercial WiMAX Mobile Device .......................... 123
  6.5 Conclusion .............................................................. 125
References ................................................................. 126
# CONTENTS

## 7 The Role of WiMAX Technology in Distributed Wide Area Monitoring Applications
*Francesco Chiti, Romano Fantacci, Leonardo Maccari, Dania Marabissi and Daniele Tarchi*

- 7.1 Monitoring with the WSN Paradigm ........................................... 129
- 7.2 Overall System Architecture ...................................................... 131
- 7.3 Efficient Access Management Schemes ......................................... 133
  - 7.3.1 System Model and Problem Formulation ................................. 135
- 7.4 Secure Communications Approaches .......................................... 136

References ..................................................................................... 142

## 8 WiMAX Mesh Architectures and Network Coding
*Parag S. Mogre, Matthias Hollick, Christian Schwingenschloegl, Andreas Ziller and Ralf Steinmetz*

- 8.1 Introduction ................................................................................. 145
- 8.2 Background on the IEEE 802.16 MeSH Mode ............................ 147
- 8.3 Design Principles for Network Coding in the IEEE 802.16 MeSH Mode .......................................................... 149
- 8.4 Enabling WNC for the IEEE 802.16 MeSH Mode ..................... 153
  - 8.4.1 Modeling the Coding Gain ...................................................... 154
  - 8.4.2 Network Coding Framework ............................................... 155
  - 8.4.3 Reservation Strategies ......................................................... 156
  - 8.4.4 Implementation Issues ....................................................... 158
- 8.5 Related Work ............................................................................. 160
- 8.6 Conclusions and Outlook ......................................................... 161

References ..................................................................................... 162

## 9 ASN-GW High Availability through Cooperative Networking in Mobile WiMAX Deployments
*Alexander Bachmutsky*

- 9.1 Introduction ................................................................................. 163
- 9.2 Classic HA Implementation ....................................................... 165
- 9.3 Network-based Resiliency Solutions for Routing ..................... 167
- 9.4 WiMAX Network Elements R4/R6 Health Management .......... 168
- 9.5 R6 Load Balancing ................................................................. 172
- 9.6 ASN-GW Failure and Recovery ............................................... 172
- 9.7 N:N Redundancy ........................................................................ 177
- 9.8 Multi-instance ASN-GW .......................................................... 180
- 9.9 The Proposal Summary ........................................................... 181
- 9.10 Conclusions ............................................................................. 182

## V WiMAX Extensions

## 10 Robust Header Compression for WiMAX Femto Cells
*Frank H.P. Fitzek, Gerrit Schulte, Esa Piri, Jarno Pinola, Marcos D. Katz, Jyrki Huusko, Kostas Pentikousis and Patrick Seeling*
CONTENTS ix

10.1 Introduction ..................................185
10.2 ROHC in a Nutshell ...............................186
10.3 Scenario Under Investigation .....................188
10.4 WiMAX and ROHC Measurement Setup .................190
10.5 WiMAX and ROHC Measurements Results .......... 192
  10.5.1 ROHC on WiMAX Downlink ................. 192
  10.5.2 ROHC on WiMAX Uplink .................... 194
  10.5.3 ROHC Capacity Gain ...................... 195
10.6 Conclusion ..................................196
References .......................................197

11 A WiMAX Cross-layer Framework for Next Generation Networks 199
Pedro Neves, Susana Sargento, Ricardo Matos, Giada Landi, Kostas Pentikousis, Marília Curado and Francisco Fontes

11.1 Introduction ..................................199
11.2 IEEE 802.16 Reference Model ......................200
11.3 Cross-layer Design for WiMAX Networks ......... 203
  11.3.1 Cross-layer Mechanisms for QoS Support ....... 203
  11.3.2 Cross-layer Mechanisms for Seamless Mobility Optimization . 206
11.4 WEIRD: A Practical Case of WiMAX Cross-layer Design .......... 210
  11.4.1 WEIRD Architecture ....................... 212
11.5 WEIRD Framework Performance Evaluation .......... 215
  11.5.1 Cross-layer Signaling Measurements ........... 215
  11.5.2 QoS Evaluation ........................... 219
11.6 Summary ....................................222
References .......................................224

12 Speech Quality Aware Resource Control for Fixed and Mobile WiMAX 227
Thomas Michael Bohnert, Dirk Staehle and Edmundo Monteiro

12.1 Introduction ..................................227
12.2 Quality of Experience versus Quality of Service Assessment .... 228
12.3 Methods for Speech Quality Assessment ............. 230
  12.3.1 Auditory Quality Assessment ................ 230
  12.3.2 Instrumental Quality Assessment .......... 230
12.4 Continuous Speech Quality Assessment for VoIP .......... 231
  12.4.1 VoIP Components and their Impact on Speech Quality .......... 231
  12.4.2 Continuous Assessment of Time-varying QoE ........ 233
  12.4.3 Instationary Quality Distortion and Human Perception .... 235
12.5 Speech Quality Aware Admission Control for Fixed IEEE 802.16 Wireless MAN ...................................... 237
  12.5.1 IEEE 802.16d Background and the Deployment Scenario .... 237
  12.5.2 The Principle of Admission Control and its Application to VoIP . 238
  12.5.3 Experimental Setup and Parameterization .......... 239
  12.5.4 Performance Results ....................... 240
12.6 The Idea of an R-score-based Scheduler .............. 243
  12.6.1 Scenario ..................................243
12.6.2 The Most Simple R-Score Scheduler .......................... 244
12.6.3 Performance Evaluation ........................................... 245
12.7 Conclusion .............................................................. 248
References ................................................................. 249

13 VoIP over WiMAX .......................... 251
Rath Vannithamby and Roshni Srinivasan

13.1 Introduction .......................................................... 251
13.2 Features to Support VoIP over WiMAX .......................... 252
  13.2.1 Silence Suppression using ertPS ................................ 252
  13.2.2 HARQ ............................................................. 253
  13.2.3 Channel Aware Scheduling ...................................... 254
  13.2.4 Protocol Header Compression .................................. 255
13.3 Enhanced Features for Improved VoIP Capacity ................. 255
  13.3.1 VoIP Traffic Characteristics .................................... 255
  13.3.2 Dynamic Resource Allocation for VoIP ....................... 255
  13.3.3 Individual Persistent Scheduling .............................. 257
  13.3.4 Group Scheduling ............................................... 260
13.4 Simulation Results .................................................. 260
13.5 Conclusion .............................................................. 262
References ................................................................. 263

14 WiMAX User Data Load Balancing .................. 265
Alexander Bachmutsky

14.1 Introduction .......................................................... 265
14.2 Local Breakout Use for Load Balancing ......................... 265
  14.2.1 Local Breakout at the Base Station Level ................... 266
  14.2.2 Local Breakout at the ASN-GW Level ......................... 267
14.3 Network-level Load Balancing over Tunneled Interfaces ......... 267
  14.3.1 Is WiMAX Special for the Case of Traffic Load Balancing? 269
  14.3.2 Analysis of Possible Solutions ................................ 269
14.4 Conclusions .......................................................... 276

15 Enabling Per-flow and System-wide QoS and QoE in Mobile WiMAX 277
Thomas Casey, Xiongwen Zhao, Nenad Veselinovic, Jari Nurmi and Riku Jäntti

15.1 Introduction .......................................................... 277
15.2 Overview .............................................................. 279
  15.2.1 Incoming Traffic ............................................... 279
  15.2.2 System and Resources .......................................... 280
  15.2.3 QoS and QoE .................................................. 281
15.3 Per-flow-based QoS and QoE ........................................ 282
  15.3.1 MAC scheduler considerations .................................. 283
  15.3.2 Scheduler Optimization Based on the QoS and QoE Measures 284
15.4 System-wide Tools for Enabling QoS and QoE ................... 287
  15.4.1 Load Balancing ................................................. 287
CONTENTS

15.4.2 HO Prioritization .................................. 299
15.5 Conclusions ....................................... 303
References .............................................. 303

VI WiMAX Evolution and Future Developments 305

16 MIMO Technologies for WiMAX Systems: Present and Future 307
Chan-Byoung Chae, Kaibin Huang and Takao Inoue

16.1 Introduction ....................................... 307
16.2 IEEE802.16e: Single-user MIMO Technologies .......................... 308
  16.2.1 Open-loop Solutions ................................ 309
  16.2.2 Closed-loop Solutions ................................ 311
  16.2.3 Limitations ........................................ 311
16.3 IEEE802.16m: Evolution Towards Multiuser MIMO Technologies – Part I.
  Nonlinear Processing ................................... 312
  16.3.1 System Model ...................................... 312
  16.3.2 Vector Perturbation ................................ 314
  16.3.3 Performance of a Vector Perturbation System .............. 316
16.4 IEEE802.16m: Evolution Towards Multiuser MIMO Technologies – Part II.
  Linear Processing .................................... 316
  16.4.1 Linear Multiuser MIMO: Perfect Channel State Information .... 317
  16.4.2 Linear Multiuser MIMO: Limited Feedback .................. 322
  16.4.3 Linear Multiuser MIMO: Multiuser Diversity ............... 325
16.5 Conclusion .......................................... 331
References .............................................. 331

17 Hybrid Strategies for Link Adaptation Exploiting Several Degrees of
Freedom in WiMAX Systems 335
Suvra Sekhar Das, Muhammad Imadur Rahman and Yuanye Wang

17.1 Introduction ....................................... 335
17.2 Link Adaptation Preliminaries .................................. 336
  17.2.1 Trade-offs and Optimization Target ...................... 337
17.3 Link Adaptation Algorithms .................................. 339
  17.3.1 SAMPDA Algorithm ................................ 340
17.4 Link Adaptation Scenario .................................. 341
  17.4.1 Link Adaptation Process ................................ 341
  17.4.2 System Parameters ................................... 342
  17.4.3 Frame Structure ...................................... 343
17.5 Role of Power Adaptation in Collaboration with Bit Adaptation .... 344
  17.5.1 AMC and Power Adaptation at the Same Rate .............. 345
  17.5.2 AMC and Power Adaptation at Different Rates ............ 348
  17.5.3 Overhead Analysis .................................... 354
17.6 Link Adaptation Considering Several System Issues ............... 356
  17.6.1 Subchannelization .................................... 357
  17.6.2 Fixed Coding Rate ................................... 357
17.6.3 AMC Rate ........................................ 361
17.7 Summary ............................................ 363
17.7.1 Guidelines for Hybrid Link Adaptation .......... 363
17.7.2 Conclusion from Bit and Power Allocation Analysis 364
17.7.3 Future Work ....................................... 365
References .................................................. 365

18 Applying WiMAX in New Scenarios: Limitations of the Physical Layer and Possible Solutions 367
Ilkka Harjula, Paola Cardamone, Matti Weissenfelt, Mika Lasanen,
Sandrine Boumard, Aaron Byman and Marcos D. Katz

18.1 WiMAX in New Scenarios .......................... 367
18.2 Channel Model for Mountainous Environments ........ 369
18.2.1 COST 259/273 ..................................... 369
18.2.2 3GPP/3GPP2 Statistical Channel Model .......... 369
18.2.3 SUI Models and IEEE 802.16a Channel Models ... 370
18.2.4 WINNER Phase I and II Channel Models .......... 370
18.3 Mountainous Scenario and Channel Modeling ....... 371
18.3.1 Analytical Modeling of the Channel in the Presence of Mountains .......................... 371
18.3.2 Extension of the WINNER Phase I Channel Model for the Mountainous Scenario .......... 371
18.4 Beamforming Algorithms and Simulation .......... 372
18.4.1 Pre-FFT Receive EVD Beamforming ............ 373
18.4.2 Post-FFT Receive EVD Beamforming .......... 374
18.4.3 Simulation Results ................................ 374
18.5 A Timing Synchronization Study in a Mountain Environment .................................. 377
18.6 Analysis and Conclusions ........................... 382
References .................................................. 383

19 Application of Radio-over-Fiber in WiMAX: Results and Prospects 385
Juan Luis Corral, Roberto Llorente, Valentín Polo, Borja Vidal, Javier Martí,
Jonás Porcar, David Zorrilla and Antonio José Ramírez

19.1 Introduction .......................................... 385
19.1.1 Radio-over-Fiber systems .......................... 385
19.1.2 Analog Transmission on Fiber State-of-the-Art ........ 387
19.1.3 Market Overview and Technology Forecast ....... 387
19.2 Optical Transmission of WiMAX Signals ............ 388
19.2.1 Optical Link Key Elements ........................ 388
19.2.2 Transmission Performance ......................... 390
19.3 WiMAX-on-Fiber Applications ....................... 394
19.3.1 Target Applications ................................ 394
19.3.2 Transmission Impairments ......................... 395
19.3.3 Field Trials ....................................... 396
19.4 Conclusions .......................................... 398
References .................................................. 398
CONTENTS

20 Network Planning and its Part in Future WiMAX Systems 401
Avraham Freedman and Moshe Levin
20.1 Introduction .................................. 401
20.2 The Network Planning Process ......................... 403
  20.2.1 Data Collection .................................. 403
  20.2.2 Network Planning .................................. 404
  20.2.3 Planning Verification and Update ...................... 410
20.3 The Impact of WiMAX on Network Planning ................. 411
  20.3.1 Flexibility of WiMAX Deployment ...................... 411
  20.3.2 WiMAX Network Planning ...................... 412
20.4 Planning of Future WiMAX Networks ..................... 414
  20.4.1 Advanced Spatial Techniques ...................... 414
  20.4.2 Relays, Femtocells and Mesh Networks ................ 415
  20.4.3 Cognitive Radios, Self-configuring and Cooperative Networks ........... 416
20.5 Modeling: the Key to Integration of Planning Information .................... 417
  20.5.1 The Problem .................................. 418
  20.5.2 Suggested Solutions .................................. 419
20.6 Conclusions .................................. 420
References .................................. 422

21 WiMAX Network Automation: Neighbor Discovery, Capabilities Negotiation, Auto-configuration and Network Topology Learning 425
Alexander Bachmutsky
21.1 Introduction .................................. 425
21.2 WiMAX Network Elements Auto-discovery .................. 426
21.3 Automatic Learning of the WiMAX Network Topology .................. 430
21.4 Capabilities Exchange .................................. 433
21.5 Automatic WiMAX Version Management .................. 434
21.6 Automated Roaming .................................. 437
21.7 Conclusion: Network Automation as a WiMAX Differentiator .................. 438
References .................................. 439

22 An Overview of Next Generation Mobile WiMAX: Technology and Prospects 441
Sassan Ahmadi
22.1 Introduction .................................. 441
22.2 Summary of IEEE 802.16m System Requirements .................. 442
22.3 Areas of Improvement and Extension in Mobile WiMAX .................. 445
22.4 IEEE 802.16m Architecture and Protocol Structure .................. 447
22.5 IEEE 802.16m Mobile Station State Diagram .................. 452
22.6 IEEE 802.16m Physical Layer .................................. 456
22.7 IEEE 802.16m MAC Layer .................................. 460
22.8 Conclusions .................................. 462
References .................................. 462

Index 463
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Foreword

Mobile WiMAX: the Enabler for the Mobile Internet Revolution

The Internet has become one of the most important assets for the growth of economies across the globe. More than a billion people use the Internet at their workplace and in their daily lives for business interactions, social interactions and entertainment. The Internet has had a profound effect on the economy of developed and developing nations having made economic activity more efficient, accessible and affordable. Most of the productivity gains in today’s economies are thanks to the Internet and ecommerce. There have been profound social impacts from increased access to valuable information and social interaction between the masses. The impact is at many socioeconomic levels: business productivity, energy savings, healthcare delivery, improved government functions, education, improved citizen interactions (locally and globally), etc. Despite the benefits of the Internet, today only about 20% of the world’s population have access to the Internet. In particular, the emerging countries that could benefit greatly are seriously deprived of this valuable asset. There are a number of reasons for the small number of users in the emerging countries: lack of infrastructure, affordability of personal computers, unaffordable access fees, etc.

The next big step in the evolution of the Internet is ubiquitous availability enabled through mobile Internet. This revolutionary step is poised to increase the value of the Internet enormously as it will create a fundamental shift in the use of the Internet by bringing the Internet to the users as opposed to users having to go to the Internet. For this vision to become a reality, a number of requirements need to be met. First and foremost, affordable and ubiquitous mobile Internet access needs to be provided using the mobile cellular concept. This is poised to be fulfilled thanks to mobile WiMAX. Secondly, affordable and low-power mobile Internet devices and mobile PCs are needed. This is also happening with the computer industry making huge strides in making these devices more affordable. The low-cost netbook category with examples such as the ASUS Eee PC and variety of small mobile PCs or Mobile Internet Devices (MIDs) are now available and will undoubtedly become even more affordable in the near future.

Mobile WiMAX has been designed with the purpose of enabling mobile Internet from the physical layer to the network layer. The physical layer design relies on Orthogonal Frequency Division Multiple Access (OFDMA) and Multiple Input Multiple Output (MIMO) as the two key technologies to optimize coverage and spectral efficiency. In addition, sophisticated techniques for link adaptation and error control provide improved performance and robustness. Mobile WiMAX technology includes many other important aspects such as security.
and power-saving methods, provisions for location-based services, support for hierarchical deployments, quality-of-service, and open Internet user and network management schemes, which are essential in enabling deployment and consumer adoption of the technology.

The Internet is dynamic by nature and is evolving rapidly on the application level and creating ever-increasing demands on connectivity. Studies indicate that Internet traffic has been doubling roughly every two years. Mobile Internet will undoubtedly change the Internet as we know it today and may create even more traffic than ever anticipated. Mobile WiMAX needs to evolve constantly to keep up with the growth of mobile Internet. The WiMAX industry has already been working on the next technology in IEEE 802.16m to build the basis for the next generation of mobile Internet.

This book provides the material that is essential to understand the underlying concepts for mobile WiMAX and it also provides an overview of technologies that will enable the evolution of the technology in the future. I sincerely hope that the book will further motivate researchers and developers to create innovative ideas and techniques that will help fulfill the promise of the new era of mobile Internet.

Siavash M. Alamouti, Intel Fellow
Chief Technology Officer, Mobile Wireless Group
The remarkable development of wireless and mobile communications in the last two decades is a unique phenomenon in the history of technology. Even the most optimistic predictions on penetration of mobile subscribers and capabilities of wireless devices have been surpassed by reality. In a quarter of century the number of mobile subscribers soared from a few to half the world population (in 2008), and according to some forecasts by 2010 the number of mobile users will exceed the number of toothbrush users (four billion). The Wireless World Research Forum (WWRF) envisions that by year 2017 there will be seven trillion wireless devices serving seven billion people. Two main development directions in untethered communications can be identified, wide-area communications, with the omnipresent cellular systems as the most representative example, and short-range communications, involving an array of networking technologies for providing wireless connectivity over short distances, for instance Wireless Local Area Networks (WLANs), Wireless Personal Area Networks (WPANs), Wireless Body Area Networks (WBANs), Wireless Sensor Networks (WSNs), Bluetooth, etc. Recent years have witnessed an enormous growth in interest in the metropolitan wireless networks. This should not be a surprise, as in 2008, for the first time in history more than half of the world population lives in urban areas, according to the United Nations Population Fund. WiMAX (Worldwide Interoperability for Microwave Access) is the most representative worldwide initiative focusing on metropolitan communications. WiMAX, based on the IEEE 802.16 standard, defines wireless networks combining key characteristics of wide-area cellular networks as well as short-range networks, namely mobility and high data throughput. IEEE 802.16 is a very active and rapidly evolving standard that serves as the fundamental basis for WiMAX systems. Several amendments are currently being developed addressing particular technical aspects or capabilities, including 802.16g, 802.16h, 802.16i, 802.16j, 802.16k and 802.16m. There are already several books dealing with WiMAX technology, describing mostly the basic operating principles, current standards and associated technical solutions. The current vertiginous developments in the WiMAX arena have lead the Editors to conceive of this book, taking over where most of the published WiMAX volumes left off, that is, looking in future directions. Leading research scientists and engineers from key WiMAX industry, academia and research centers worldwide have contributed to this book with their ideas, concepts, concrete technical suggestions and visions.

As WiMAX as a whole encompasses a very broad area, it is impossible to find a single author able to write in detail about a large array of advanced concepts and solutions applicable at different system levels of WiMAX: the Editors have thus invited specialists in the field to contribute with their ideas in different chapters. The goal of this book is
to create concrete supportive links between the presented concepts and future metropolitan communication systems, discussing technical solutions as well as novel identified scenarios, business applications and visions that are likely to become integral parts of the future WiMAX. Thus, this book tries to answer questions including the following. Which are the emerging WiMAX technologies that are being developed? What are the new scenarios for deploying WiMAX? What are the most promising WiMAX applications and business? How are standards evolving? What are the visions of industry? What are the capabilities and measured performance of real (commercial) WiMAX systems?

As shown in Figure 1, this book has been organized into six independent parts, covering different aspects of WiMAX technology and its evolution. Part One overview of the current state of WiMAX technology, serving as an introduction to WiMAX. Part Two presents measurements and validation results carried out on real state-of-the-art WiMAX testbeds (fixed and mobile), providing unique results on the achievable capabilities of commercial equipment operating in real scenarios. Novel scenarios and business cases for WiMAX are considered in Part Three. In Part Four new promising architectures for WiMAX are discussed, including wireless sensor networks, mesh and cooperative networking as well as femtocells. Part Five discusses several extensions to the current WiMAX, that is, new solutions that can be used in conjunction with the current WiMAX standard. Finally, Part Six looks into technical developments beyond the immediate WiMAX future, including PHY and MAC evolution, prospects and visions, emerging technologies, evolution of standards, etc.

WiMAX Evolution: Emerging Technologies and Applications is a book intended for research, development and standardization engineers working in industry, as well as for scientists in academic and research institutes. Graduate students conducting research in
WiMAX and next generation mobile communications will also find in this book relevant material for further research. The Editors think that this book provides novel views and detailed technical solutions, foreseeing future WiMAX while being a stimulating source of inspiration for further advanced research in the field.

The Editors welcome any suggestions, comments or constructive criticism on this book. Such feedback will be used to improve forthcoming editions. The Editors can be contacted at wimixeditor@es.aau.dk.

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Frank H.P. Fitzek
Aalborg University, Denmark

September 2008
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At times, our own light goes out, and is rekindled by a spark from another person. Each of us has cause to think with deep gratitude of those who have lighted the flame within us.

Albert Schweitzer

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# List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>µC</td>
<td>MicroController</td>
</tr>
<tr>
<td>16-QAM</td>
<td>16 Quadrature Amplitude Modulation</td>
</tr>
<tr>
<td>2G</td>
<td>2nd Generation</td>
</tr>
<tr>
<td>3G</td>
<td>3rd Generation</td>
</tr>
<tr>
<td>3GPP</td>
<td>3rd Generation Partnership Project</td>
</tr>
<tr>
<td>3GPP2</td>
<td>3rd Generation Partnership Project 2</td>
</tr>
<tr>
<td>4G</td>
<td>Fourth Generation</td>
</tr>
<tr>
<td>A/V</td>
<td>Audio/Visual</td>
</tr>
<tr>
<td>AAA</td>
<td>Authentication, Authorization and Accounting</td>
</tr>
<tr>
<td>AAS</td>
<td>Adaptive Antenna System</td>
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<tr>
<td>AC</td>
<td>Admission Control; Antenna Circulation</td>
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<tr>
<td>ACIR</td>
<td>Adjacent Channel Interference Ratio</td>
</tr>
<tr>
<td>ACK</td>
<td>Acknowledgement</td>
</tr>
<tr>
<td>ACR</td>
<td>Absolute Category Rating</td>
</tr>
<tr>
<td>ADSL</td>
<td>Asymmetric Digital Subscriber Line</td>
</tr>
<tr>
<td>AG</td>
<td>Antenna Grouping</td>
</tr>
<tr>
<td>AMC</td>
<td>adaptive modulation and coding</td>
</tr>
<tr>
<td>AMR</td>
<td>Adaptive Multi-Rate</td>
</tr>
<tr>
<td>AMS</td>
<td>Adaptive MIMO Switching</td>
</tr>
<tr>
<td>AP</td>
<td>Access Point</td>
</tr>
<tr>
<td>APD</td>
<td>Adaptive Power Distribution</td>
</tr>
<tr>
<td>APFR</td>
<td>Adaptive Power Fixed Rate</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>APMC</td>
<td>Adaptive Power, Modulation and Coding</td>
</tr>
<tr>
<td>AQ</td>
<td>Assessed QoS</td>
</tr>
<tr>
<td>ARP</td>
<td>Address Resolution Protocol</td>
</tr>
<tr>
<td>ARQ</td>
<td>Automatic Repeat Request</td>
</tr>
<tr>
<td>AS</td>
<td>Antenna Selection</td>
</tr>
<tr>
<td>ASN</td>
<td>Access Service Network</td>
</tr>
<tr>
<td>ASN-GW</td>
<td>Access Service Network Gateway</td>
</tr>
<tr>
<td>ATM</td>
<td>Asynchronous Transfer Mode</td>
</tr>
<tr>
<td>AVC</td>
<td>Advanced Video Coding</td>
</tr>
<tr>
<td>AWGN</td>
<td>Additive White Gaussian Noise</td>
</tr>
<tr>
<td>BD</td>
<td>Block Diagonalization</td>
</tr>
<tr>
<td>BE</td>
<td>Best Effort</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Rate</td>
</tr>
<tr>
<td>BF</td>
<td>Beamforming</td>
</tr>
<tr>
<td>BGP</td>
<td>Border Gateway Protocol (routing)</td>
</tr>
<tr>
<td>BLER</td>
<td>Block Error Rate</td>
</tr>
<tr>
<td>BOM</td>
<td>Bill Off Materials</td>
</tr>
<tr>
<td>bps</td>
<td>Bits Per Second</td>
</tr>
<tr>
<td>BPSK</td>
<td>Binary Phase Shift Keying</td>
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<tr>
<td>BS</td>
<td>Base Station</td>
</tr>
<tr>
<td>BSID</td>
<td>Base Station Identifier</td>
</tr>
<tr>
<td>BWA</td>
<td>Broadband Wireless Access</td>
</tr>
<tr>
<td>C/I</td>
<td>Carrier to Interference Ratio</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Capital Expenditures</td>
</tr>
<tr>
<td>CATV</td>
<td>Cable Television</td>
</tr>
<tr>
<td>CBC</td>
<td>Cipher Block Chaining</td>
</tr>
<tr>
<td>CBF</td>
<td>Coordinated Beamforming</td>
</tr>
<tr>
<td>CBR</td>
<td>Constant Bit Rate</td>
</tr>
<tr>
<td>CC</td>
<td>Chase Combining; Convolutional Code; Coordination Center</td>
</tr>
<tr>
<td>CCF</td>
<td>Call Control Function</td>
</tr>
<tr>
<td>CCP2P</td>
<td>Cellular Controlled Peer to Peer</td>
</tr>
<tr>
<td>CDF</td>
<td>Cumulative Distribution Function</td>
</tr>
<tr>
<td>CDL</td>
<td>Clustered Delay Line</td>
</tr>
</tbody>
</table>
CDMA  Code Division Multiplex Access
CELP  Code Excited Linear Prediction
CH   Compressed Header
C/I   Carrier-to-Interference Ratio
CID   Connection Identifier
CI-STBC Coordinate Interleaved Space–Time Block Code
CMIP  Client Mobile IP
CN   Correspondent Node
CN   Core Network
CNL  VTT Converging Networks Laboratory
CNR  Channel-to-Noise Ratio
CoA  Care-of-Address
CODEC Compression/Decompression
COST European Cooperation in the Field of Scientific and Technical Research
COTS Commercial Off The Shelf
CP   Cyclic Prefix
CPE  Customer Premises Equipment
CPS  Common Part Sublayer
CPU  Central Processing Unit
CQI  Channel Quality Indicator
CQICH Channel Quality Indicator Channel
CRC  Cyclic Redundancy Check
CS   Convergence Sublayer
C-SAP Control Service Access Point
CSG  Closed Subscriber Group
CSI  Channel State Information
CSN  Connectivity Services Network
CTS  Clear to Send
DAS  Distributed Antenna System
DCA  Dynamic Channel Allocation
DCD  Downlink Channel Descriptor
DCF  Discounted Cash Flow
DES  Data Encryption Standard
DFB  Distributed Feedback
DHCP Dynamic Host Configuration Protocol
DL   Downlink
DMTBR Dynamic Multiple-Threshold Bandwidth Reservation
DNS  Domain Name System
DNS-SD Dynamic Name System Service Discovery
DPT  Dirty Paper Theory
DRR  Deficit Round Robin
DRX  Discontinuous Reception
DS-CDMA Direct Sequence Code Division Multiple Access
DSL  Digital Subscriber Line
DSLAM Digital Subscriber Line Access Multiplexer
DWRR  Deficit Weighed Round Robin
EAP  Extensible Authentication Protocol
ECMP  Equal Cost Multi-Path
EDF  Earliest Deadline First
EpBR  Energy per Bit Ratio
ertPS Extended Real-Time Polling Service
ERT-VR Extended Real-Time Variable Rate
ESP  Encapsulating Security Payload
ETX  Expected Transmission Count
EVD  Eigenvalue Decomposition
EVRC Enhanced Variable Rate Codec
FA   Foreign Agent
FBSS  Fast Base Station Switching
FCH  Frame Control Header
FDD  Frequency-Division Duplex
FDM  Frequency Division Multiplexing
FEC  Forward Error Correction
FER  Frame Error Rate
FFMS  Forest Fire Monitoring Station
FFT  Fast Fourier Transform
FIFO  First In First Out
FP   Framework Programme
FPAR  Fixed Power Adaptive Rate
FPGA  Field-programmable Gate Array
FTP  File Transfer Protocol
FUSC Fully Used Subcarriers
GA   Generic Adapter
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GIST</td>
<td>General Internet Signaling Transport</td>
</tr>
<tr>
<td>GMH</td>
<td>Generic MAC Header</td>
</tr>
<tr>
<td>GoS</td>
<td>Grade of Service</td>
</tr>
<tr>
<td>GPRS</td>
<td>General Packet Radio Service</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GRE</td>
<td>Generic Routing Encapsulation</td>
</tr>
<tr>
<td>GSM</td>
<td>Global System for Mobile Communications</td>
</tr>
<tr>
<td>GTP</td>
<td>GPRS Tunneling Protocol</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>GW</td>
<td>Gateway</td>
</tr>
<tr>
<td>HA</td>
<td>High Availability; Home Agent</td>
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<tr>
<td>HARQ</td>
<td>Hybrid Automatic Repeat Request</td>
</tr>
<tr>
<td>HD</td>
<td>High Definition</td>
</tr>
<tr>
<td>HFC</td>
<td>Hybrid Fiber Coaxial</td>
</tr>
<tr>
<td>HFDD</td>
<td>Half-duplex Frequency Division Duplex</td>
</tr>
<tr>
<td>HFR</td>
<td>Hybrid Fiber Radio</td>
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<tr>
<td>HHO</td>
<td>Hard Handover</td>
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<tr>
<td>HO</td>
<td>Handover</td>
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<tr>
<td>HSDPA</td>
<td>High Speed Data Packet Access</td>
</tr>
<tr>
<td>HSPA</td>
<td>High Speed Packet Access</td>
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<tr>
<td>HSRP</td>
<td>Hot Standby Router Protocol</td>
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<td>HTTP</td>
<td>Hyper Text Transfer Protocol</td>
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<tr>
<td>HW</td>
<td>Hardware</td>
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<tr>
<td>ICMP</td>
<td>Internet Control Message Protocol</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technologies</td>
</tr>
<tr>
<td>ID</td>
<td>Identification</td>
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<tr>
<td>IETF</td>
<td>Internet Engineering Task Force</td>
</tr>
<tr>
<td>IFFT</td>
<td>Inverse Fast Fourier Transform</td>
</tr>
<tr>
<td>IMDD</td>
<td>Intensity Modulation, Direct Detection</td>
</tr>
<tr>
<td>IMS</td>
<td>IP Multimedia Subsystem</td>
</tr>
<tr>
<td>IMT</td>
<td>International Mobile Telecommunications</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
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<tr>
<td>Ipsec</td>
<td>Internet Protocol Security</td>
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<td>IPTV</td>
<td>Internet Protocol Television</td>
</tr>
<tr>
<td>IPv4</td>
<td>Internet Protocol version 4</td>
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<tr>
<td>IPv6</td>
<td>Internet Protocol version 6</td>
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<tr>
<td>IQ</td>
<td>Intrinsic QoS</td>
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<tr>
<td>IQA</td>
<td>Instrumental Quality Assessment</td>
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<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
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<tr>
<td>ISD</td>
<td>Inter-site Distance</td>
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<tr>
<td>IST</td>
<td>Information Society Technologies</td>
</tr>
<tr>
<td>ITU</td>
<td>International Telecommunications Technologies</td>
</tr>
<tr>
<td>kbps</td>
<td>Kilobits per second (1000 bits s(^{-1}))</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
</tr>
<tr>
<td>L1</td>
<td>Layer 1 (Physical Layer)</td>
</tr>
<tr>
<td>L2</td>
<td>Layer 2 (Data Link Layer)</td>
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<td>MAN</td>
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<td>MAP</td>
<td>Medium Access Protocol; Mobile Application Part</td>
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<td>MBAC</td>
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<td>MBB</td>
<td>Make Before Break</td>
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<td>MBMS</td>
<td>Multimedia Broadcast Multicast Service</td>
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<tr>
<td>Mbps</td>
<td>Megabits per second (1 000 000 bits s(^{-1}))</td>
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<td>Multicast and Broadcast Service</td>
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<td>MCS</td>
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<td>MCW</td>
<td>Multi Codeword</td>
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<td>Macro Diversity Handover</td>
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<td>MeSH</td>
<td>IEEE 802.16-2004 Mesh Mode</td>
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<td>Mobile Initiated Handover</td>
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<td>MIHU</td>
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<td>Media Independent Information Service</td>
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<td>Multiple Input Multiple Output</td>
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<td>Mobile Multihop Relay</td>
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<td>MMSE</td>
<td>Minimum Mean Square Error</td>
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<td>MN</td>
<td>Mobile Node</td>
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<td>MOS</td>
<td>Mean Opinion Score</td>
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<td>MPEG</td>
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<td>MRC</td>
<td>Maximum Ratio Combining</td>
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<td>MRT</td>
<td>Maximum Ratio Transmission</td>
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<td>MRTR</td>
<td>Minimum Reserved Traffic Rate</td>
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<td>Most Significant Bit</td>
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<td>MAC Service Data Unit</td>
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<td>Mean Square Error</td>
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<td>MSID</td>
<td>Mobile Subscriber ID</td>
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<tr>
<td>MSTR</td>
<td>Maximum Sustained Traffic Rate</td>
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<td>MTBF</td>
<td>Mean Time Between Failures</td>
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<tr>
<td>MTU</td>
<td>Maximum Transmission Unit</td>
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<td>NACK</td>
<td>Negative Acknowledgement</td>
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<td>Network Access Identifier</td>
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<td>NC</td>
<td>Network Coding</td>
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<td>NDCQ</td>
<td>Nondegenerate Constraint Qualification</td>
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<td>NE</td>
<td>Network Element</td>
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<td>NET</td>
<td>Network Layer</td>
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<td>Next-Generation Mobile Network</td>
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<td>Next Generation Network</td>
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<td>Network Initiated Handover</td>
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<td>NPV</td>
<td>Net Present Value</td>
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<td>NR</td>
<td>Non-real-time</td>
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<td>nrtPS</td>
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<td>Network Working Group</td>
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<td>O&amp;M</td>
<td>Operations and Management</td>
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<td>OFDM</td>
<td>Orthogonal Frequency Division Multiplexing</td>
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<td>OFDMA</td>
<td>Orthogonal Frequency Division Multiple Access</td>
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<td>OGBF</td>
<td>Orthogonal Beamforming</td>
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<td>Operation and Maintenance Function</td>
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<td>Operational Expenditures</td>
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<td>OSPF</td>
<td>Open Shortest Path First</td>
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<td>P2P</td>
<td>Peer to Peer</td>
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<td>PA</td>
<td>ITU Pedestrian A</td>
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<tr>
<td>PB</td>
<td>ITU Pedestrian B</td>
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<td>Personal Area Network</td>
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<tr>
<td>PAPR</td>
<td>Peak to Average Power Ratio</td>
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<td>PBE</td>
<td>Perfect Bayesian Equilibrium</td>
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<tr>
<td>PC</td>
<td>Paging Controller; Power Control</td>
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<tr>
<td>PCM</td>
<td>Pulse Code Modulation</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
</tr>
<tr>
<td>PDU</td>
<td>Protocol Data Unit</td>
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</table>
LIST OF ACRONYMS

PEP  Performance Enhancing Proxy
PER  Packet Error Rate
PHB  Per Hop Behavior
PHY  Physical Layer
PLC  Packet Loss Concealment
PLR  Packet Loss Rate
PMIP Proxy Mobile IP
PMP  Point to Multipoint
PN   Pseudo Random Noise
POF  Plastic Optical Fiber
PQ   Perceived QoS
PSTN Public Switched Telephone Network
PTMP Point-to-Multipoint
PTP  Precision Time Protocol
PTP  Point-to-point
PU2RC Per-User Unitary and Rate Control
PUSC Partially Used Subcarrier; Partially Used Subchannelization
QAM  Quadrature Amplitude Modulation
QoE  Quality of Experience
QoS  Quality of Service
QPSK Quadrature Phase-Shift Keying
RADIUS Remote Authentication Dial-In User Service
RAN  Radio Access Network
RAU  Remote Antenna Unit
RB   Resource Block
RF   Radiofrequency
RFC  Request for Comments (IETF standard document)
RMF  Resource Management Function
RMS  Root Mean Square
RoF  Radio-over-Fiber
ROHC Robust Header Compression
RRM  Radio Resource Management
RS   Relay Station
RSS  Received Signal Strength
RSSI Received Signal Strength Indicator
rt   real-time
RTP  Real-time Transport Protocol
rtPS Real-Time Polling Service
RTS  Request to Send
RTT  Round Trip Time
RT-VR Real-Time Variable Rate
Rx   Receive
SA   Specific Adapter
SAF  Service Availability Forum
SAMPDA Simple Adaptive Modulation and Power Adaptation Algorithm
SAP  Service Access Point
SBS  Serving Base Station
SC   Serra do Carvalho
SCM  Spatial Channel Model
SCR  Spare Capacity Report
SCTP Stream Control Transmission Protocol
SCW  Single Codeword
SDMA Spatial Division Multiple Access
SDU  Service Data Unit
SE   Spectral Efficiency
SF   Service Flow
SFDR Spurious Free Dynamic Range
SFM  Service Flow Management
SID  Silent Insertion Descriptor
SINR Signal-to-Interference + Noise Ratio
SIP  Session Initiation Protocol
SISO Single Input Single Output
SL   Serra da Lousã
SLA  Service Level Agreement
SM   Spatial Multiplexing
SMF  Singlemode Fiber
SMS  Short Message Service
SNMP Simple Network Management Protocol
SNR  Signal-to-Noise Ratio
S-OFDMA Scalable Orthogonal Frequency Division Multiple Access
SOHO Small Office/Home Office
SON  Self-Organized Network
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>SP</td>
<td>Synchronization Pattern</td>
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<td>SRA</td>
<td>Simple Rate Adaptation</td>
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<td>SRD</td>
<td>System Requirement Document</td>
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<td>Subscriber Station</td>
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<td>Secure Socket Layer</td>
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<td>Space Time Block Coding</td>
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<td>Space-Time Coding</td>
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<td>Standford University Interim</td>
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<td>SW</td>
<td>Software</td>
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<td>Target Base Station</td>
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<td>Transmission Control Protocol</td>
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<td>Variable Bit Rate</td>
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<td>Vertical Cavity Surface Emitting Laser</td>
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<td>Very-Large-Scale Integration</td>
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<td>Wireless Fidelity</td>
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