

802.16™

**IEEE Standard for
Local and metropolitan area networks**

Part 16: Air Interface for Fixed Broadband Wireless Access Systems

**IEEE Computer Society
and the
IEEE Microwave Theory and Techniques Society**

Sponsored by the
LAN/MAN Standards Committee



3 Park Avenue, New York, NY 10016-5997, USA

1 October 2004

Print: SH95246

PDF: SH95246



Documents
Document Sharing Hub

IEEE Std 802.16™-2004

(Revision of
IEEE Std 802.16-2001)

**IEEE Standard for
Local and metropolitan area networks**

Part 16: Air Interface for Fixed Broadband Wireless Access Systems

Sponsor

LAN/MAN Standards Committee

of the

IEEE Computer Society

and the

IEEE Microwave Theory and Techniques Society

Approved 24 June 2004

IEEE-SA Standards Board



Grateful acknowledgment is made to Cable Television Laboratories for the permission to use the following source material:

Radio Frequency Interface Specification (version 1.1), part of Data-Over-Cable Service Interface Specifications, © Copyright 1999, Cable Television Laboratories.

Baseline Privacy Plus Interface Specification, © Copyright 1999, Cable Television Laboratories.

Abstract: This standard specifies the air interface of fixed broadband wireless access (BWA) systems supporting multimedia services. The medium access control layer (MAC) supports a primarily point-to-multipoint architecture, with an optional mesh topology. The MAC is structured to support multiple physical layer (PHY) specifications, each suited to a particular operational environment. For operational frequencies from 10–66 GHz, the PHY is based on single-carrier modulation. For frequencies below 11 GHz, where propagation without a direct line of sight must be accommodated, three alternatives are provided, using OFDM, OFDMA, and single-carrier modulation. This standard revises and consolidates IEEE Std 802.16-2001, IEEE Std 802.16a™-2003, and IEEE Std 802.16c™-2002.

Keywords: fixed broadband wireless access network, metropolitan area network, microwave, millimeter wave, WirelessMAN® standards

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2004 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 1 October 2004. Printed in the United States of America.

IEEE, 802, and WirelessMAN are registered trademarks in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

WirelessMAN-OFDM, WirelessMAN-OFDMA, WirelessMAN-SC, and WirelessMAN-SCa, are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

Print: ISBN 0-7381-4069-4 SH95246
PDF: ISBN 0-7381-4070-8 SS95246

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied “**AS IS.**”

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331 USA

NOTE—Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not part of IEEE Std 802.16-2004, IEEE Standard for Local and metropolitan area networks—Part 16: Air Interface for Fixed Broadband Wireless Access Systems.)

This standard specifies the air interface of fixed broadband wireless access (BWA) systems supporting multimedia services. The medium access control layer (MAC) supports a primarily point-to-multipoint architecture, with an optional mesh topology. The MAC is structured to support multiple physical layer (PHY) specifications, each suited to a particular operational environment. For operational frequencies from 10–66 GHz, the WirelessMAN-SC PHY, based on single-carrier modulation, is specified. For frequencies below 11 GHz, where propagation without a direct line of sight must be accommodated, three alternatives are provided: WirelessMAN-OFDM (using orthogonal frequency-division multiplexing), WirelessMAN-OFDMA (using orthogonal frequency-division multiple access), and WirelessMAN-SCa (using single-carrier modulation). This standard revises and consolidates IEEE Standards 802.16-2001, 802.16a-2003, and 802.16c-2002.

Conformance test methodology

The multipart conformance test documents for IEEE Standard 802.16 by “IEEE Standard 802.16/ConformanceXX”. For example, the first part of the conformance specification for IEEE 802.16 is designated “IEEE Standard 802.16/Conformance01.”

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents or patent applications for which a license may be required to implement an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention. A patent holder or patent applicant has filed a statement of assurance that it will grant licenses under these rights without compensation or under reasonable rates and nondiscriminatory, reasonable terms and conditions to applicants desiring to obtain such licenses. The IEEE makes no representation as to the reasonableness of rates, terms, and conditions of the license agreements offered by patent holders or patent applicants. Further information may be obtained from the IEEE Standards Department.

Notice to users

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

Participants

This document was developed by the IEEE 802.16 Working Group on Broadband Wireless Access, which develops the WirelessMAN[®] Standard for Wireless Metropolitan Area Networks.

IEEE 802.16 Working Group Officers

Roger B. Marks, *Chair*

Kenneth Stanwood, *Vice Chair*

Dean Chang, *Secretary*

Primary development was carried out by the Working Group's Task Group d:

TGd Officers

Gordon Antonello, *Chair*

Itzik Kitroser, *Chief Technical Editor*

Robert Nelson, *Assistant Editor*

Brian Eidson, *SCa PHY Editorial Contributor*

Nico van Waes, *Former Chief Technical Editor*

The following members of the IEEE 802.16 Working Group on Broadband Wireless Access participated in the Working Group Letter Ballot in which the draft of this standard was prepared and finalized for IEEE Ballot:

Aditya Agrawal
Gordon Antonello
Reza Arefi
Eli Avivi
Dean Chang
Naftali Chayat
Rémi Chayer
Brian Eidson
Carl Eklund
Marc Engels
Avraham Freedman
G. Jack Garrison
Marianna Goldhammer
Zion Hadad
David Johnston
Panyuh Joo
Tal Kaitz

Phil Kelly
Ofer Kelman
Brian Kiernan
Itzik Kitroser
Changhoi Koo
Jonathan Labs
Yigal Leiba
Barry Lewis
Lingjie Li
John Liebetreu
Lars Lindh
Hui-Ling Lou
Heinz Lycklama
Roger B. Marks
Russell McKown
Andrew Middleton

Ronald Murias
Robert Nelson
Kamlesh Rath
Gene Robinson
Yossi Segal
Radu Selea
James Simkins
Kenneth Stanwood
Carl Stevenson
Shawn Taylor
Rainer Ullmann
Nico van Waes
Eyal Verbin
Arthur Wang
Lei Wang
Stanley Wang
Vladimir Yanover

The following members of the IEEE Balloting Committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

John Adams	Tal Kaitz	Subbu Ponnuswamy
Gordon Antonello	Stuart Kerry	Vikram Punj
Eladio Arvelo	Brian Kiernan	Klaus Rapf
John Barnett	Itzik Kitroser	Durga Satapathy
Dean Chang	Jonathan Labs	Yossi Segal
Naftali Chayat	Yigal Leiba	Neil Shipp
Aik Chindapol	Jan-Ray Liao	Gil Shultz
Todor Cooklev	Randolph Little	Yoram Solomon
Guru Dutt Dhingra	Gregory Luri	Kenneth Stanwood
Thomas Dineen	Roger B. Marks	Carl Stevenson
Sourav Dutta	Kevin Marquess	Shawn Taylor
Brian Eidson	John McKown	Scott Valcourt
Avraham Freedman	Russell McKown	Nico van Waes
Theodore Georgantas	Ingolf Meier	Stanley Wang
Andrew Germano	Steve Methley	Cor van de Water
Mariana Goldhamer	George Miao	Hung-yu Wei
Zion Hadad	Yinghua Min	Vladimir Yanover
Andreas Hutter	Robert R Nelson	Huanchun Ye
Raj Jain	Michael Newman	Oren Yuen
Tony Jeffree	Charles Ngethe	Surong Zeng
David Johnston	Roger Pandanda	

When the IEEE-SA Standards Board approved this standard on 24 June 2004, it had the following membership:

Don Wright, Chair
Steve M. Mills, Vice Chair
Judith Gorman, Secretary

Chuck Adams	Raymond Hapeman	Daleep C. Mohla
H. Stephen Berger	Richard J. Holleman	Paul Nikolich
Mark D. Bowman	Richard H. Hulett	T. W. Olsen
Joseph A. Bruder	Lowell G. Johnson	Ronald C. Petersen
Bob Davis	Joseph L. Koepfinger*	Gary S. Robinson
Roberto de Boisson	Hermann Koch	Frank Stone
Julian Forster*	Thomas J. McGean	Malcolm V. Thaden
Arnold M. Greenspan		Doug Topping
Mark S. Halpin		Joe D. Watson

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Alan Cookson, *NIST Representative*

Michelle D. Turner
IEEE Standards Project Editor

Historical participants

Since the initial publication, many IEEE standards have added functionality or provided updates to material included in this standard. The following is a historical list of participants who have dedicated their valuable time, energy, and knowledge to the creation of this material:

IEEE 802.16 Standard	Date approved by IEEE	Officers at the time of Working Group Letter Ballot
IEEE Std 802.16-2001	6 December 2001	Roger B. Marks: <i>Working Group Chair, Task Group Chair, Technical Editor</i> Brian G. Kiernan: <i>Working Group Vice Chair</i> Carl J. Bushue: <i>Working Group Secretary</i> Carl Eklund: <i>MAC Chair</i> Jay Klein: <i>PHY Chair</i> Carl Eklund, Kenneth Stanwood, Stanley Wang: <i>MAC Editors</i> Jay Klein, Lars Lindh: <i>PHY Editors</i>
IEEE Std 802.16c-2002 (amendment)	12 December 2002	Roger B. Marks: <i>Working Group Chair</i> Paul F. Struhsaker: <i>Working Group Vice Chair</i> Dean Chang: <i>Working Group Secretary</i> Kenneth Stanwood: <i>Task Group Chair</i> Carl Eklund: <i>Technical Editor</i>
IEEE Std 802.16a-2003 (amendment)	29 January 2003	Roger B. Marks: <i>Working Group Chair</i> Carl Eklund: <i>Vice Chair</i> Dean Chang: <i>Working Group and Task Group Secretary</i> Brian G. Kiernan: <i>Task Group Chair</i> Nico van Waes: <i>Technical Editor</i> Brian Eidson: <i>Lead SCa PHY Editor</i>

Aditya Agrawal
 Song An
 Gordon Antonello
 Reza Arefi
 S. Lek Ariyavisitakul
 Jori Arrakoski
 Arun Arunachalam
 Malik Audeh
 Eli Avivi
 C. R. Baugh
 Yvon Belec
 Carlos Belfiore
 Anader Benyamin-Seeeyar
 Carl Bushue
 Baruch Buskila
 Yuankai Chang
 Dean Chang
 David Chauncey
 Naftali Chayat
 Rémi Chayer
 Mary Condie
 José Costa
 Bruce Currivan
 Amos Dotan
 Keith Doucet
 Roger Durand
 Brian Edmonston
 Brian Eidson
 Henry Eilts
 Carl Eklund
 David Falconer
 George Fishel
 Adrian Florea
 Rober Foster
 Avi Freedman
 Avraham Freedman
 Jeff Foerster
 Andrew Garrett
 G. Jack Garrison
 Brian Gieschen
 Marianna Goldhammer
 Conrad Grell
 Phil Guillemette
 Zion Hadad
 Baruch Halachmi
 Michael Mamilton
 Baya Hatim
 Yoav Hebron
 Srinath Hosur
 Coleman Hum

Wayne Hunter
 David Husson
 Eric Jacobsen
 Hamadi Jamali
 Jacob Jorgensen
 Tal Kaitz
 Mika Kasslin
 Phil Kelly
 Ofer Kelman
 Brian Kiernan
 John Kim
 Itzik Kitroser
 Allan Klein
 Jay Klein
 Thomas Kolze
 Demosthenes Kostas
 Jerome Krinock
 Rajeev Krishnamoorthy
 Jonathan Labs
 John Langley
 Yigal Leiba
 Moshe Levinson
 Barry Lewis
 Lingjie Li
 Xiaodong (Alex) Li
 Sergio Licardie
 John Liebetreu
 Lars Lindh
 Hui-Ling Lou
 Fred Lucas
 Willie Lu
 Heinz Lycklama
 J. Scott Marin
 Roger B. Marks
 Andy McGregor
 Russell McKown
 Ronald Meyer
 Andrew Middleton
 Apurva Mody
 Jim Mollenauer
 Ronald Murias
 William Myers
 Robert Nelson
 Lou Olsen
 Kim Olszewski
 Mike Paff
 Yunsang Park
 Manish Patel
 Kenneth Peirce
 Brian Petry

Wayne Plesant
 Subbu Ponnuswamy
 Moshe Ran
 Stanley Reible
 Valentine Rhodes
 David Ribner
 Gene Robinson
 Walt Roehr
 Shane Rogers
 Amir Sarajedini
 Octavian Sarca
 Durga Satapathy
 Glen Sater
 Vito Scaringi
 Carl Scarpa
 Randall Schwartz
 Yossi Segal
 Radu Selea
 Olivier Seller
 Menashe Shahar
 Chet Shirali
 James Simkins
 Manoneet Singh
 Sean Sonander
 George Stamatelos
 Kark Stambaugh
 Kenneth Stanwood
 Michael Stewart
 Paul F. Struhsaker
 John Sydor
 Shawn Taylor
 Jose Tellado
 Paul Thompson
 David Trinkwon
 Nico van Waes
 Subir Varma
 Arthur Wang
 Chao-Chun Wang
 Lei Wang
 Stanley Wang
 Bob Ward
 Philip Whitehead
 David G. Williams
 Curt Wise
 Vladimir Yanover
 Huanchun Ye
 Heejung Yu
 Chaoming Zeng
 Wenhan Zhang
 Juan Carlos Zúñiga

CONTENTS

1.	Overview.....	1
1.1	Scope.....	1
1.2	Purpose.....	1
1.3	Frequency bands	1
1.3.1	10–66 GHz licensed bands	1
1.3.2	Frequencies below 11 GHz.....	2
1.3.3	License-exempt frequencies below 11 GHz (primarily 5–6 GHz)	2
1.3.4	Air interface nomenclature and PHY compliance	2
1.4	Reference model	3
2.	References.....	5
3.	Definitions	7
4.	Abbreviations and acronyms	13
5.	Service-specific CS	17
5.1	ATM CS.....	17
5.1.1	CS service definition.....	17
5.1.2	Data/Control plane	17
5.1.2.1	PDU formats	17
5.1.2.2	Classification	18
5.1.2.3	PHS	18
5.1.2.4	Signaling procedure	19
5.2	Packet CS	20
5.2.1	MAC SDU format.....	21
5.2.2	Classification	21
5.2.3	PHS	23
5.2.3.1	PHS operation	23
5.2.3.2	PHS signaling	26
5.2.4	IEEE Std 802.3/Ethernet-specific part.....	27
5.2.4.1	IEEE Std 802.3/Ethernet CS PDU format	27
5.2.4.2	IEEE Std 802.3/Ethernet CS classifiers	27
5.2.5	IEEE Std 802.1Q-1998 virtual local area network (VLAN) specific part.....	28
5.2.5.1	IEEE Std 802.1Q-1998 VLAN CS PDU format.....	28
5.2.5.2	IEEE Std 802.1Q-1998 CS classifiers	28
5.2.6	IP specific part	28
5.2.6.1	IP CS PDU format	28
5.2.6.2	IP classifiers.....	29
6.	MAC common part sublayer.....	31
6.1	PMP	31
6.2	Mesh.....	32
6.3	Data/Control plane	33
6.3.1	Addressing and connections	33
6.3.1.1	PMP	33
6.3.1.2	Mesh.....	34
6.3.2	MAC PDU formats	35

6.3.2.1	MAC header formats	35
6.3.2.2	MAC subheaders and special payloads	39
6.3.2.3	MAC Management messages	42
6.3.3	Construction and transmission of MAC PDUs	121
6.3.3.1	Conventions	121
6.3.3.2	Concatenation	123
6.3.3.3	Fragmentation	123
6.3.3.4	Packing.....	124
6.3.3.5	CRC calculation	127
6.3.3.6	Encryption of MAC PDUs.....	127
6.3.3.7	Padding	128
6.3.4	ARQ mechanism.....	128
6.3.4.1	ARQ Block Usage	128
6.3.4.2	ARQ Feedback IE format	130
6.3.4.3	ARQ parameters	132
6.3.4.4	ARQ procedures	132
6.3.4.5	ARQ-enabled connection setup and negotiation	133
6.3.4.6	ARQ operation.....	133
6.3.5	Scheduling services.....	138
6.3.5.1	Outbound transmission scheduling	139
6.3.5.2	Uplink request/grant scheduling	139
6.3.6	Bandwidth allocation and request mechanisms	141
6.3.6.1	Requests	141
6.3.6.2	Grants.....	142
6.3.6.3	Polling	142
6.3.6.4	Contention-based focused Bandwidth Requests for WirelessMAN-OFDM	147
6.3.6.5	Contention-based CDMA Bandwidth Requests for WirelessMAN-OFDMA	147
6.3.6.6	Optional Mesh topology support	148
6.3.7	MAC support of PHY	151
6.3.7.1	FDD	151
6.3.7.2	TDD	152
6.3.7.3	DL-MAP	152
6.3.7.4	UL-MAP	152
6.3.7.5	Map relevance and synchronization	154
6.3.7.6	Optional MAC AAS Support of WirelessMAN-SCa, OFDM, and OFDMA	162
6.3.8	Contention resolution.....	165
6.3.8.1	Transmission opportunities	167
6.3.9	Network entry and initialization	167
6.3.9.1	Scanning and synchronization to the downlink	169
6.3.9.2	Obtain downlink parameters	169
6.3.9.3	Obtain uplink parameters.....	171
6.3.9.4	Message flows during scanning and uplink parameter acquisition	173
6.3.9.5	Initial ranging and automatic adjustments	174
6.3.9.6	Ranging parameter adjustment	178
6.3.9.7	Negotiate basic capabilities	182
6.3.9.8	SS authorization and key exchange	184
6.3.9.9	Registration	184
6.3.9.10	Establish IP connectivity	187
6.3.9.11	Establish time of day.....	187
6.3.9.12	Transfer operational parameters	188
6.3.9.13	Establish provisioned connections.....	190

6.3.9.14	Network Entry and synchronization in Mesh mode	190
6.3.10	Ranging	199
6.3.10.1	Downlink burst profile management	199
6.3.10.2	Uplink periodic ranging	202
6.3.10.3	OFDMA-based ranging	204
6.3.11	Update of channel descriptors.....	213
6.3.12	Assigning SSs to multicast groups.....	215
6.3.13	Establishment of multicast connections.....	218
6.3.14	QoS	218
6.3.14.1	Theory of operation	218
6.3.14.2	Service flows.....	219
6.3.14.3	Object model.....	221
6.3.14.4	Service classes	222
6.3.14.5	Authorization	222
6.3.14.6	Types of service flows	223
6.3.14.7	Service Flow Creation	224
6.3.14.8	Dynamic service flow modification and deletion	226
6.3.14.9	Service flow management.....	226
6.3.15	DFS for license-exempt operation	263
6.3.15.1	Introduction.....	263
6.3.15.2	Testing channels for primary users	263
6.3.15.3	Discontinuing operations after detecting primary users	264
6.3.15.4	Detecting primary users	264
6.3.15.5	Scheduling for channel testing.....	264
6.3.15.6	Requesting and reporting of measurements.....	264
6.3.15.7	Selecting and advertising a new channel	265
6.3.16	MAC Management message tunneling in Mesh Mode	265
6.3.17	MAC support for H-ARQ	266
6.3.17.1	Subpacket generation.....	268
6.3.17.2	DL/UL ACK/NAK signaling.....	268
6.3.17.3	H-ARQ parameter signaling	268
6.3.17.4	CQICH Operations	268
7.	Security sublayer.....	271
7.1	Architecture	271
7.1.1	Packet data encryption.....	271
7.1.2	Key management protocol	271
7.1.3	Security Associations.....	272
7.1.4	Mapping of connections to SAs.....	273
7.1.5	Cryptographic Suite	273
7.2	PKM protocol	273
7.2.1	SS authorization and AK exchange overview	273
7.2.2	TEK exchange overview.....	274
7.2.2.1	TEK exchange overview for PMP topology.....	274
7.2.2.2	TEK exchange overview for Mesh Mode.....	275
7.2.3	Security capabilities selection.....	275
7.2.4	Authorization state machine	276
7.2.4.1	States	278
7.2.4.2	Messages.....	278
7.2.4.3	Events.....	279
7.2.4.4	Parameters.....	280
7.2.4.5	Actions	280
7.2.5	TEK state machine.....	282
7.2.5.1	States	284

7.2.5.2	Messages.....	285
7.2.5.3	Events.....	285
7.2.5.4	Parameters.....	286
7.2.5.5	Actions	286
7.3	Dynamic SA creation and mapping	288
7.3.1	Dynamic SA creation.....	288
7.3.2	Dynamic mapping of SA	288
7.4	Key usage.....	289
7.4.1	BS key usage.....	289
7.4.1.1	AK key lifetime	289
7.4.1.2	AK transition period on BS side	289
7.4.1.3	BS usage of AK	291
7.4.1.4	TEK lifetime	291
7.4.1.5	BS usage of TEK	292
7.4.1.6	Node re-authorization in Mesh Mode during normal operation	292
7.4.2	SS key usage	292
7.4.2.1	SS reauthorization.....	292
7.4.2.2	SS usage of AK.....	294
7.4.2.3	SS usage of TEK.....	294
7.4.2.4	TEK usage in Mesh Mode	294
7.4.2.5	Node usage of the Operator Shared Secret in Mesh Nodes	295
7.5	Cryptographic methods.....	295
7.5.1	Data Encryption methods.....	295
7.5.1.1	Data encryption with DES in CBC mode	295
7.5.1.2	Data encryption with AES in CCM mode	295
7.5.2	Encryption of TEK.....	298
7.5.2.1	Encryption of TEK with 3-DES.....	299
7.5.2.2	Encryption of TEK with RSA.....	299
7.5.2.3	Encryption of TEK-128 with AES.....	299
7.5.3	Calculation of HMAC-Digests	299
7.5.4	Derivation of TEKs, KEKs, and message authentication keys.....	300
7.5.4.1	DES Keys.....	300
7.5.4.2	3-DES KEKs.....	300
7.5.4.3	HMAC authentication keys	300
7.5.5	Public-key encryption of AK.....	301
7.5.6	Digital signatures	301
7.6	Certificate profile.....	301
7.6.1	Certificate format.....	301
7.6.1.1	tbsCertificate.validity.notBefore and tbsCertificate.validity.notAfter.....	302
7.6.1.2	tbsCertificate.serialNumber	302
7.6.1.3	tbsCertificate.signature and signatureAlgorithm	302
7.6.1.4	tbsCertificate.issuer and tbsCertificate.subject.....	302
7.6.1.5	tbsCertificate.subjectPublicKeyInfo	304
7.6.1.6	tbsCertificate.issuerUniqueID and tbsCertificate.subjectUniqueID	304
7.6.1.7	tbsCertificate.extensions	304
7.6.1.8	signatureValue	304
7.6.2	SS certificate storage and management in the SS.....	304
7.6.3	Certificate processing and management in the BS	305
8.	PHY	307
8.1	WirelessMAN-SC PHY specification	307
8.1.1	Overview	307
8.1.2	Framing	307

8.1.2.1	Supported frame durations.....	307
8.1.3	Duplexing techniques and PHY Type parameter encodings	307
8.1.3.1	FDD operation	308
8.1.3.2	TDD operation	309
8.1.4	Downlink PHY	309
8.1.4.1	Downlink subframe.....	310
8.1.4.2	Downlink burst allocation.....	316
8.1.4.3	Downlink Transmission Convergence sublayer	317
8.1.4.4	Downlink PMD sublayer	319
8.1.5	Uplink PHY	334
8.1.5.1	Uplink subframe	334
8.1.5.2	Uplink Transmission Convergence sublayer	339
8.1.5.3	Uplink PMD sublayer	339
8.1.6	Baud rates and channel bandwidths.....	343
8.1.7	Radio subsystem control	343
8.1.7.1	Synchronization technique.....	343
8.1.7.2	Frequency control	343
8.1.7.3	Power control.....	344
8.1.8	Minimum performance	344
8.1.8.1	Propagation conditions	346
8.1.8.2	Transmitter characteristics	348
8.1.9	Channel quality measurements	350
8.1.9.1	Introduction.....	350
8.1.9.2	RSSI mean and standard deviation	351
8.1.9.3	CINR mean and standard deviation.....	352
8.2	WirelessMAN-SCa PHY	355
8.2.1	Transmit processing	355
8.2.1.1	Source Bit Randomization	356
8.2.1.2	FEC	356
8.2.1.3	Modulations and constellation mapping.....	370
8.2.1.4	Burst set framing.....	378
8.2.1.5	Duplex framing	391
8.2.1.6	Support for AAS	396
8.2.1.7	Frame Control Header burst profile.....	401
8.2.1.8	Compressed FCH maps	402
8.2.1.9	MAP message fields and IEs	404
8.2.1.10	Burst profile formats	416
8.2.1.11	AAS-FBCK-REQ/RSP message bodies	418
8.2.1.12	Baseband Pulse Shaping	420
8.2.1.13	Quadrature modulation	420
8.2.1.14	Power control.....	420
8.2.2	Channel quality measurements	421
8.2.2.1	Introduction.....	421
8.2.2.2	RSSI mean and standard deviation	421
8.2.2.3	CINR mean and standard deviation.....	422
8.2.3	System requirements.....	423
8.2.3.1	Channel frequency accuracy	423
8.2.3.2	Symbol rate	424
8.2.3.3	Symbol timing jitter.....	424
8.2.3.4	Transmitter minimum SNR and EVM.....	424
8.2.3.5	Transmitter power level control.....	424
8.2.3.6	Ramp-up/down requirements.....	424
8.2.3.7	Spurious emissions during burst on/off transients	424
8.2.3.8	Out of band spurious emissions	424

8.2.3.9	Receiver sensitivity	424
8.2.3.10	Receiver maximum input signal	425
8.2.3.11	Receiver adjacent channel interference	425
8.3	WirelessMAN-OFDM PHY	427
8.3.1	Introduction.....	427
8.3.1.1	OFDM symbol description	427
8.3.2	OFDM symbol parameters and transmitted signal	428
8.3.2.1	Primitive parameter definitions	428
8.3.2.2	Derived parameter definitions	428
8.3.2.3	Transmitted signal.....	429
8.3.2.4	Parameters of transmitted signal.....	429
8.3.3	Channel coding	430
8.3.3.1	Randomization	430
8.3.3.2	FEC	432
8.3.3.3	Interleaving	440
8.3.3.4	Modulation.....	441
8.3.3.5	Example OFDM uplink RS-CC encoding	444
8.3.3.6	Preamble structure and modulation	446
8.3.4	Transmission convergence (TC) sublayer	449
8.3.5	Frame structure	449
8.3.5.1	PMP	449
8.3.5.2	PMP-AAS Zone	453
8.3.5.3	Mesh.....	459
8.3.5.4	Frame duration codes.....	460
8.3.5.5	Burst Profile format	460
8.3.6	Map message fields and IEs.....	461
8.3.6.1	DL-MAP PHY synchronization field	461
8.3.6.2	DL-MAP IE format.....	461
8.3.6.3	UL-MAP IE format.....	466
8.3.6.4	AAS-FBCK-REQ/RSP message bodies	472
8.3.6.5	AAS-BEAM-REQ/RSP message	474
8.3.7	Control mechanisms	476
8.3.7.1	Synchronization	476
8.3.7.2	Ranging	477
8.3.7.3	Bandwidth requesting	479
8.3.7.4	Power control.....	483
8.3.8	Transmit diversity: Space-Time Coding (optional)	484
8.3.8.1	Multiple input single output channel estimation and synchronization	484
8.3.8.2	STC encoding	485
8.3.8.3	STC decoding	485
8.3.9	Channel quality measurements	486
8.3.9.1	Introduction.....	486
8.3.9.2	RSSI mean and standard deviation	486
8.3.9.3	CINR mean and standard deviation.....	488
8.3.10	Transmitter requirements	489
8.3.10.1	Transmit power level control.....	489
8.3.10.2	Transmitter channel bandwidth and RF carrier frequencies	490
8.3.11	Receiver requirements	491
8.3.11.1	Receiver sensitivity	491
8.3.11.2	Receiver adjacent and alternate channel rejection.....	492
8.3.11.3	Receiver maximum input signal	493
8.3.11.4	Receiver maximum tolerable signal	493
8.3.11.5	Receiver image rejection	493
8.3.12	Frequency and timing requirements	493

8.4	WirelessMAN-OFDMA PHY	493
8.4.1	Introduction.....	493
8.4.2	OFDMA symbol description, symbol parameters and transmitted signal	494
8.4.2.1	Time domain description	494
8.4.2.2	Frequency domain description.....	494
8.4.2.3	Primitive parameters	495
8.4.2.4	Derived parameters	495
8.4.2.5	Transmitted signal.....	495
8.4.3	OFDMA basic terms definition	496
8.4.3.1	Slot and Data Region	496
8.4.3.2	Segment	496
8.4.3.3	Permutation Zone.....	496
8.4.3.4	OFDMA data mapping	497
8.4.4	Frame structure	499
8.4.4.1	Duplexing modes	499
8.4.4.2	PMP frame structure	499
8.4.4.3	DL Frame Prefix	501
8.4.4.4	Allocation of subchannels for FCH, and logical subchannel numbering	502
8.4.4.5	Uplink transmission allocations.....	505
8.4.4.6	Optional Diversity-Map Scan	505
8.4.4.7	Optional Direct Signaling Method.....	509
8.4.5	Map message fields and IEs.....	520
8.4.5.1	DL-MAP PHY Synchronization Field.....	520
8.4.5.2	Frame duration codes.....	520
8.4.5.3	DL-MAP IE format.....	521
8.4.5.4	UL-MAP IE format.....	531
8.4.5.5	Burst profile format	547
8.4.5.6	Compressed maps	547
8.4.5.7	AAS-FBCK-REQ/RSP message bodies	550
8.4.6	OFDMA subcarrier allocations.....	551
8.4.6.1	Downlink	552
8.4.6.2	Uplink	568
8.4.6.3	Optional permutations for AAS and AMC subchannels	574
8.4.7	OFDMA ranging.....	576
8.4.7.1	Initial-ranging transmissions.....	576
8.4.7.2	Periodic-ranging and bandwidth-request transmissions	577
8.4.7.3	Ranging codes.....	578
8.4.8	Transmit diversity (optional)	579
8.4.8.1	Transmit diversity using two antennas	579
8.4.8.2	Transmit diversity for four antennas.....	585
8.4.9	Channel coding	587
8.4.9.1	Randomization	588
8.4.9.2	Encoding.....	589
8.4.9.3	Interleaving	615
8.4.9.4	Modulation.....	616
8.4.10	Control mechanisms	620
8.4.10.1	Synchronization	620
8.4.10.2	Ranging.....	620
8.4.10.3	Power control.....	620
8.4.11	Channel quality measurements	622
8.4.11.1	Introduction.....	622
8.4.11.2	RSSI mean and standard deviation	622
8.4.11.3	CINR mean and standard deviation.....	624
8.4.12	Transmitter requirements	625

8.4.12.1	Transmit power level control	625
8.4.12.2	Transmitter spectral flatness	625
8.4.12.3	Transmitter constellation error and test method	625
8.4.13	Receiver requirements	627
8.4.13.1	Receiver sensitivity	627
8.4.13.2	Receiver adjacent and alternate channel rejection	628
8.4.13.3	Receiver maximum input signal	629
8.4.13.4	Receiver maximum tolerable signal	629
8.4.14	Frequency control requirements	629
8.4.14.1	Center frequency and symbol clock frequency tolerance	629
8.5	WirelessHUMAN specific components.....	629
8.5.1	Channelization	629
8.5.2	Transmit spectral mask	631
9.	Configuration	633
9.1	SS IP addressing	633
9.1.1	DHCP fields used by the SS	633
9.2	SS Configuration file	634
9.2.1	SS binary configuration file format	634
9.2.2	Configuration file settings	634
9.2.3	Configuration file creation	635
9.2.3.1	SS MIC calculation	636
10.	Parameters and constants	637
10.1	Global values	637
10.2	PKM parameter values.....	640
10.3	PHY-specific values	641
10.3.1	WirelessMAN-SC parameter and constant definitions.....	641
10.3.1.1	PS	641
10.3.1.2	Symbol rate	641
10.3.1.3	Uplink center frequency.....	642
10.3.1.4	Downlink center frequency.....	642
10.3.1.5	Tolerated poll jitter	642
10.3.1.6	Allocation Start Time.....	642
10.3.1.7	Timing Adjust Units	642
10.3.2	WirelessMAN-SCa parameters and constant definitions	642
10.3.2.1	Uplink Allocation Start Time	642
10.3.2.2	PS	642
10.3.2.3	Timing adjust units	642
10.3.3	WirelessMAN-OFDM parameters and constant definitions	642
10.3.3.1	Uplink Allocation Start Time	642
10.3.3.2	PS	642
10.3.3.3	Timing adjust units	643
10.3.4	WirelessMAN-OFDMA parameters and constant definitions.....	643
10.3.4.1	Uplink Allocation Start Time	643
10.3.4.2	PS	643
10.3.4.3	Timing adjust units	643
10.4	Well-known addresses and identifiers	643
11.	TLV encodings	645
11.1	Common encodings	646

11.1.1	Current transmit power	646
11.1.2	HMAC tuple	646
11.1.3	MAC version encoding	647
11.1.4	Service flow descriptors.....	647
11.1.5	Vendor ID encoding.....	647
11.1.6	Vendor-specific information.....	648
11.2	Configuration file encodings	649
11.2.1	SS MIC configuration setting	649
11.2.2	Software upgrade descriptors.....	649
11.2.2.1	Vendor ID	649
11.2.2.2	Hardware ID	649
11.2.2.3	Software version	650
11.2.2.4	Upgrade filename.....	650
11.2.3	Software upgrade TFTP server	650
11.2.4	TFTP Server Timestamp.....	650
11.2.5	Authorization Node.....	651
11.2.6	Registration Node	651
11.2.7	Provisioning Node	651
11.3	UCD management message encodings	651
11.3.1	UCD channel encodings	651
11.3.1.1	Uplink burst profile encodings	655
11.4	DCD management message encodings.....	659
11.4.1	DCD channel encodings	659
11.4.2	Downlink burst profile encodings.....	660
11.5	RNG-REQ management message encodings	664
11.6	RNG-RSP management message encodings	665
11.7	REG-REQ/RSP management message encodings.....	667
11.7.1	ARQ Parameters	667
11.7.2	SS management support.....	667
11.7.3	IP management mode.....	667
11.7.4	IP version	668
11.7.5	Secondary Management CID.....	668
11.7.6	Number of uplink CID supported	668
11.7.7	Convergence Sublayer Capabilities	668
11.7.7.1	Classification/PHS options and SDU encapsulation support	668
11.7.7.2	Maximum number of classifiers	669
11.7.7.3	PHS support	669
11.7.8	SS capabilities encodings.....	669
11.7.8.1	ARQ Support	669
11.7.8.2	DSx flow control.....	669
11.7.8.3	MAC CRC support	670
11.7.8.4	MCA flow control.....	670
11.7.8.5	Multicast polling group CID support.....	670
11.7.8.6	PKM flow control	670
11.7.8.7	Authorization Policy Support	670
11.7.8.8	Maximum number of supported security associations	671
11.8	SBC-REQ/RSP management message encodings	671
11.8.1	Bandwidth Allocation Support	671
11.8.2	Capabilities for Construction and Transmission of MAC PDUs	671
11.8.3	Physical Parameters Supported.....	671
11.8.3.1	Subscriber transition gaps	671
11.8.3.2	Maximum transmit power.....	672
11.8.3.3	Current transmit power	672
11.8.3.4	WirelessMAN-SC specific parameters	672

11.8.3.5	WirelessMAN-SCa specific parameters	674
11.8.3.6	WirelessMAN-OFDM specific parameters	678
11.8.3.7	WirelessMAN-OFDMA specific parameters	680
11.9	PKM-REQ/RSP management message encodings	681
11.9.1	Display string.....	683
11.9.2	AUTH-Key	683
11.9.3	TEK.....	683
11.9.4	Key lifetime	684
11.9.5	Key-Sequence-Number.....	684
11.9.6	HMAC-Digest.....	684
11.9.7	SAID	684
11.9.8	TEK parameters	685
11.9.9	CBC-IV.....	685
11.9.10	Error code.....	685
11.9.11	CA certificate	686
11.9.12	SS certificate	687
11.9.13	Security capabilities	687
11.9.14	Cryptographic suite	688
11.9.15	Cryptographic-Suite-List	689
11.9.16	Version.....	689
11.9.17	SA-Descriptor	690
11.9.18	SA type.....	690
11.9.19	PKM configuration settings	691
11.9.19.1	Authorize wait timeout	691
11.9.19.2	Reauthorize wait timeout	691
11.9.19.3	Authorization grace time.....	691
11.9.19.4	Operational wait timeout.....	691
11.9.19.5	Rekey wait timeout	692
11.9.19.6	TEK grace time	692
11.9.19.7	Authorize reject wait timeout.....	692
11.10	MCA-REQ management message encodings	692
11.11	REP-REQ management message encodings	693
11.12	REP-RSP management message encodings	694
11.13	Service Flow management encodings.....	694
11.13.1	SFID	697
11.13.2	CID	697
11.13.3	Service Class Name.....	697
11.13.4	QoS parameter set type	698
11.13.5	Traffic priority	699
11.13.6	Maximum sustained traffic rate.....	699
11.13.7	Maximum traffic burst	699
11.13.8	Minimum reserved traffic rate.....	700
11.13.9	Minimum tolerable traffic rate	700
11.13.10	Vendor-specific QoS parameters	701
11.13.11	Service flow scheduling type	701
11.13.12	Request/transmission policy.....	701
11.13.13	Tolerated jitter	702
11.13.14	Maximum latency.....	702
11.13.15	Fixed-length versus variable-length SDU indicator.....	703
11.13.16	SDU size.....	703
11.13.17	Target SAID	703
11.13.18	ARQ TLVs for ARQ-enabled connections	703
11.13.18.1	ARQ Enable	703
11.13.18.2	ARQ_WINDOW_SIZE	704

11.13.18.3	ARQ_RETRY_TIMEOUT	704
11.13.18.4	ARQ_BLOCK_LIFETIME.....	705
11.13.18.5	ARQ_SYNC_LOSS_TIMEOUT	705
11.13.18.6	ARQ_DELIVER_IN_ORDER	705
11.13.18.7	ARQ_RX_PURGE_TIMEOUT.....	705
11.13.18.8	ARQ_BLOCK_SIZE	706
11.13.19	CS specific service flow encodings.....	706
11.13.19.1	CS specification	706
11.13.19.2	CS parameter encoding rules	707
11.13.19.3	Packet CS encodings for configuration and MAC messaging.....	707
11.13.19.4	ATM CS Encodings for Configuration and MAC Messaging	718
12.	System profiles	721
12.1	WirelessMAN-SC (10–66 GHz) system profiles	721
12.1.1	WirelessMAN-SC MAC system profiles	721
12.1.1.1	Basic ATM MAC system profile.....	721
12.1.1.2	Basic Packet MAC system profile	722
12.1.1.3	Conventions for MAC Management messages for profiles profM1 and profM2	722
12.1.1.4	MAC Management message Parameter Transmission Order	722
12.1.1.5	Message parameters specific to profM1	728
12.1.1.6	Message parameters specific to profM2	729
12.1.2	WirelessMAN-SC PHY Profiles	730
12.1.2.1	WirelessMAN-SC 25 MHz Channel PHY Profile	730
12.1.2.2	WirelessMAN-SC 28 MHz Channel PHY Profile	735
12.1.2.3	Conventions for MAC Management messages for profiles profP1 and profP2.....	741
12.1.2.4	UCD and DCD parameter transmission order for profP1 and profP2	741
12.1.2.5	Initial Ranging IE usage for profP1 and profP2	742
12.2	WirelessMAN-SCa and WirelessHUMAN(-SCa) system profiles	742
12.2.1	WirelessMAN-SCa MAC System Profiles.....	742
12.2.1.1	Basic ATM MAC System Profile	742
12.2.1.2	Basic Packet MAC System Profile	742
12.2.1.3	Conventions for MAC Management Messages for profiles profM4 and profM5	743
12.2.2	WirelessMAN-SCa Power class profiles	743
12.2.3	WirelessMAN-SCa Physical Layer (PHY) Profiles	744
12.2.3.1	Common features of PHY profiles	747
12.2.3.2	Specific PHY profiles	749
12.2.4	WirelessMAN-SCa RF profiles	750
12.2.4.1	RF profiles for 3.5 MHz channelization	750
12.2.4.2	RF profiles for 7 MHz channelization	750
12.2.4.3	RF profiles for 10 MHz channelization	751
12.2.4.4	RF profiles for 20 MHz channelization	752
12.3	WirelessMAN-OFDM and WirelessHUMAN(-OFDM) System Profiles.....	752
12.3.1	WirelessMAN-OFDM and WirelessHUMAN(-OFDM) MAC Profiles	753
12.3.1.1	ProfM3_PMP: Basic Packet PMP MAC System Profile.....	754
12.3.1.2	ProfM3_Mesh: Basic Packet Mesh MAC System Profile	756
12.3.2	WirelessMAN-OFDM and WirelessHUMAN(-OFDM) Physical Layer Profiles	758
12.3.2.1	ProfP3_1.75: WirelessMAN-OFDM PHY profile for 1.75MHz channelization	760
12.3.2.2	ProfP3_3.5: WirelessMAN-OFDM PHY profile for 3.5 MHz channelization	760
12.3.2.3	ProfP3_7: WirelessMAN-OFDM PHY profile for 7 MHz channelization	761

12.3.2.4	ProfP3_3: WirelessMAN-OFDM PHY profile for 3 MHz channelization .	762
12.3.2.5	ProfP3_5.5: WirelessMAN-OFDM PHY profile for 5.5 MHz channelization	763
12.3.2.6	profP3_10: WirelessHUMAN(-OFDM) PHY profile for 10 MHz channelization	764
12.3.3	WirelessMAN-OFDM RF profiles	765
12.3.3.1	RF profiles for 10 MHz channelization	765
12.4	WirelessMAN-OFDMA and WirelessHUMAN(-OFDMA) system profiles.....	766
12.4.1	WirelessMAN-OFDMA Power class profiles	766
12.4.2	WirelessMAN-OFDMA and WirelessHUMAN(-OFDMA) MAC Profiles	767
12.4.2.1	Basic Packet PMP MAC Profile.....	767
12.4.3	WirelessMAN-OFDMA and WirelessHUMAN(-OFDMA) System PHY Profiles....	768
12.4.3.1	Common Features of PHY Profiles	768
12.4.3.2	WirelessMAN-OFDMA 1.25 MHz channel basic PHY Profile.....	770
12.4.3.3	WirelessMAN-OFDMA 3.5 MHz channel basic PHY Profile.....	771
12.4.3.4	WirelessMAN-OFDMA 7 MHz channel basic PHY Profile.....	772
12.4.3.5	WirelessMAN-OFDMA 8.75 MHz channel basic PHY Profile.....	773
12.4.3.6	WirelessMAN-OFDMA 14 MHz channel basic PHY Profile.....	774
12.4.3.7	WirelessMAN-OFDMA 17.5 MHz channel basic PHY Profile.....	775
12.4.3.8	WirelessMAN-OFDMA 28 MHz channel basic PHY Profile.....	776
12.4.3.9	WirelessHUMAN(-OFDMA) 10 MHz channel basic PHY Profile	777
12.4.3.10	WirelessHUMAN(-OFDMA) 20 MHz channel basic PHY Profile	778
12.4.4	WirelessMAN-OFDMA RF profiles	778
Annex A (informative) Bibliography		781
Annex B (informative) Supporting material for frequencies below 11 GHz.....		785
Annex C (informative) Example MAC common part sublayer service definition.....		841

List of Figures

Figure 1—IEEE Std 802.16 protocol layering, showing SAPs	3
Figure 2—PDU and SDU in a protocol stack	10
Figure 3—ATM CS PDU format	18
Figure 4—CS PDU format for VP-switched ATM connections	19
Figure 5—CS PDU format for VC-switched ATM connections	19
Figure 6—MAC SDU format	21
Figure 7—Classification and CID mapping (BS to SS)	22
Figure 8—Classification and CID mapping (SS to BS)	22
Figure 9—PHS operation	25
Figure 10—PHS with masking	26
Figure 11—PHS signaling example	27
Figure 12—IEEE 802.3/Ethernet CS PDU format without header suppression	27
Figure 13—IEEE 802.3/Ethernet CS PDU format with header suppression	27
Figure 14—IEEE 802.1Q VLAN CS PDU format without header suppression	28
Figure 15—IEEE 802.1Q VLAN CS PDU format with header suppression	28
Figure 16—IP CS PDU format without header suppression	29
Figure 17—IP CS PDU format with header suppression	29
Figure 18—MAC PDU formats	35
Figure 19—Generic MAC header format	36
Figure 20—Bandwidth request header format	38
Figure 20—Bandwidth Request Header Format	38
Figure 21—MAC Management message format	43
Figure 22—Reduced CID Decoding	106
Figure 23—Subchannel allocation modes of Compact DL-MAP_IE for Band AMC	112
Figure 24—Construction of a MAC PDU	122
Figure 25—MAC PDU concatenation showing example CIDs	123
Figure 26—Packing fixed-length MAC SDUs into a single MAC PDU	124
Figure 27—Packing variable-length MAC SDUs into a single MAC PDU	125
Figure 28—Packing with fragmentation	125
Figure 29—Example MAC PDU with extended Fragmentation subheaders	126
Figure 30—Example MAC PDU with ARQ Packing subheader	126
Figure 31—MAC PDU encryption	127
Figure 32—Block usage examples for ARQ with and without rearrangement	129
Figure 33—ARQ transmit block states	134
Figure 34—ARQ Reset message dialog—transmitter initiated	135
Figure 35—ARQ Reset message dialog—receiver initiated	136
Figure 36—ARQ block reception	137
Figure 37—SS Request/Grant flow chart	143
Figure 38—Unicast polling	144
Figure 39—Multicast and broadcast polling	146
Figure 40—PM bit usage	147
Figure 41—MSH-CSCF schedule example	149
Figure 42—MSH-CSCH flow usage example	150
Figure 43—MSH-CSCH schedule validity	151
Figure 44—Example of Burst FDD bandwidth allocation	152
Figure 45—TDD frame structure.	153
Figure 46—Maximum time relevance of DL-MAP and UL-MAP(TDD)	155
Figure 47—Minimum time relevance of DL-MAP and UL-MAP (TDD)	155
Figure 48—Maximum time relevance of DL-MAP and UL-MAP (FDD)	155
Figure 49—Minimum time relevance of DL-MAP and UL-MAP (FDD)	156
Figure 50—Time relevance example of MSH-DSCH in distributed scheduling	158

Figure 51—Time relevance example of MSH-CSCH in centralized scheduling.....	158
Figure 52—AAS Zone, FDD.....	163
Figure 53—AAS Zone, TDD.....	164
Figure 54—Example of Request IE containing multiple transmission opportunities	167
Figure 55—SS Initialization overview	168
Figure 56—Obtaining downlink synchronization	170
Figure 57—Maintaining downlink synchronization.....	171
Figure 58—Obtaining uplink parameters	172
Figure 59—Maintain uplink parameters.....	173
Figure 60—Initial Ranging—SS (part 1).....	178
Figure 61—Initial Ranging—SS (part 2).....	179
Figure 62—Initial Ranging—BS	180
Figure 63—Initial Ranging, Polled Phase—BS	181
Figure 64—Initial ranging—BS response to undecodable message	182
Figure 65—Negotiate Basic Capabilities—SS	182
Figure 66—Wait for SBC-RSP—SS	183
Figure 67—Negotiate Basic Capabilities—BS.....	183
Figure 68—Registration—SS	184
Figure 69—Wait for REG-RSP—SS.....	185
Figure 70—Registration—BS.....	186
Figure 71—Wait for TFTP-CPLT—BS	189
Figure 72—Wait for TFTP-RSP—SS	189
Figure 73—Mesh network synchronization and entry—New node—I.....	192
Figure 74—Mesh network synchronization and entry—New node—II.....	193
Figure 75—Mesh network synchronization and entry—Sponsor node.....	194
Figure 76—Registration—Candidate node	196
Figure 77—Wait for registration response—Candidate node	196
Figure 78—Registration—Registration node	197
Figure 79—Transition to a more robust burst profile	200
Figure 80—Transition to a less robust burst profile	201
Figure 81—Burst profile threshold usage.....	201
Figure 82—Periodic Ranging receiver processing—BS	203
Figure 83—Periodic Ranging opportunity allocation—BS.....	203
Figure 84—Periodic Ranging—SS.....	204
Figure 85—CDMA Initial Ranging—SS (part 1).....	207
Figure 86—CDMA Initial Ranging—SS (part 2).....	208
Figure 87—CDMA Initial Ranging—BS	209
Figure 88—Periodic CDMA ranging—BS.....	210
Figure 89—Periodic ranging—Received ranging code—BS	211
Figure 90—Periodic CDMA ranging—SS	212
Figure 91—Multicast polling assignment—SS	216
Figure 92—Multicast polling assignment—BS.....	217
Figure 93—Provisioned authorization model “envelopes”	220
Figure 94—Dynamic authorization model “envelopes”.....	220
Figure 95—Theory of Operation Object Model.....	221
Figure 96—DSA message flow—SS-initiated	225
Figure 97—DSA message flow—BS-initiated.....	226
Figure 98—Dynamic service flow overview.....	227
Figure 99—Dynamic Service Flow state transition diagram.....	230
Figure 100—DSA—Locally Initiated Transaction state transition diagram	231
Figure 101—DSA—Remotely Initiated Transaction state transition diagram.....	232
Figure 102—DSC—Locally Initiated Transaction state transition diagram	233
Figure 103—DSC—Remotely Initiated Transaction state transition diagram.....	234
Figure 104—DSD—Locally Initiated Transaction state transition diagram	235

Figure 105—DSD—Remotely Initiated Transaction state transition diagram.....	236
Figure 106—DSA—Locally Initiated Transaction Begin state flow diagram	239
Figure 107—DSA—Locally Initiated Transaction DSA-RSP Pending state flow diagram	240
Figure 108—DSA—Locally Initiated Transaction Holding state flow diagram.....	241
Figure 109—DSA—Locally Initiated Transaction Retries Exhausted state flow diagram.....	242
Figure 110—DSA—Locally Initiated Transaction Deleting Service Flow state flow diagram.....	243
Figure 111—DSA—Remotely Initiated Transaction Begin state flow diagram	244
Figure 112—DSA—Remotely Initiated Transaction DSA-ACK Pending state flow diagram.....	245
Figure 113—DSA—Remotely Initiated Transaction Holding Down state flow diagram.....	246
Figure 114—DSA—Remotely Initiated Transaction Deleting Service state flow diagram.....	246
Figure 115—DSC—Locally Initiated Transaction Begin state flow diagram	250
Figure 116—DSC—Locally Initiated Transaction DSC-RSP Pending state flow diagram.....	251
Figure 117—DSC—Locally iNitiated Transaction Holding Down state flow diagram	252
Figure 118—DSC—Locally Initiated Transaction Retries Exhausted state flow diagram	253
Figure 119—DSC—Locally Initiated Transaction Deleting Service Flow state flow diagram	254
Figure 120—DSC—Remotely Initiated Transaction Begin state flow diagram	255
Figure 121—DSC—Remotely Initiated Transaction DSC-ACK Pending state flow diagram	256
Figure 122—DSC—Remotely Initiated Transaction Holding Down state flow diagram.....	257
Figure 123—DSC—Remotely Initiated Transaction Deleting Service Flow state flow diagram.....	257
Figure 124—DSD—Locally Initiated Transaction Begin state flow diagram	259
Figure 125—DSD—Locally Initiated Transaction DSD-RSP Pending state flow diagram	260
Figure 126—DSD—Locally Initiated Transaction Holding Down state flow diagram.....	261
Figure 127—DSD—Remotely Initiated Transaction Begin state flow diagram	262
Figure 128—DSD—Remotely Initiated Transaction Holding Down state flow diagram.....	263
Figure 129—MAC over UDP/IP tunneling.....	266
Figure 130—Construction of H-ARQ encoder packet	267
Figure 131—Authorization state machine flow diagram	277
Figure 132—TEK state machine flow diagram	283
Figure 133—AK management in BS and SS.....	290
Figure 134—TEK management in BS and SS.....	293
Figure 135—TEK management in BS and SS.....	296
Figure 136—Initial CCM Block B_0	297
Figure 137—Construction of A_i	298
Figure 138—Example of FDD bandwidth allocation.....	308
Figure 139—TDD frame structure	309
Figure 140—TDD downlink subframe structure	310
Figure 141—FDD downlink subframe structure	311
Figure 142—DL-MAP usage with shortened FEC blocks—TDM case	317
Figure 144—Format of the downlink Transmission Convergence sublayer PDU	317
Figure 143—DL-MAP usage with shortened FEC blocks—TDMA case	318
Figure 145—Conceptual block diagram of the downlink PMD sublayer	319
Figure 146—Randomizer logic diagram	320
Figure 147—Inner code for Code Type 2 in the downlink.....	323
Figure 148—Two-dimensional product code matrix.....	324
Figure 149—Example encoder for a (16,11) extended Hamming Code	325
Figure 150—Structure of shortened 2 D block.....	327
Figure 151—QPSK constellation	329
Figure 152—16-QAM constellation (gray-coded)	330
Figure 153—64-QAM constellation (gray-coded)	331
Figure 154—Uplink subframe structure.....	335
Figure 155—Conceptual block diagram of the uplink PHY	340
Figure 156—Structure of shortened 2 D block.....	341
Figure 157—Illustration of EVM	350
Figure 158—Transmit processing	356

Figure 159—Randomizer for energy dispersal.....	356
Figure 160—Concatenated FEC encoder blocks.....	357
Figure 161—Binary rate 1/2 convolutional encoder.....	359
Figure 162—Pragmatic TCM encoder for rate 1/2 16-QAM.....	362
Figure 163—Pragmatic TCM encoder for rate 3/4 16-QAM.....	362
Figure 164—Pragmatic TCM encoder for rate 2/3 64-QAM.....	363
Figure 165—Pragmatic TCM encoder for rate 5/6 64-QAM.....	363
Figure 166—Optional pragmatic TCM encoder for rate 3/4 256-QAM.....	364
Figure 167—Optional pragmatic TCM encoder for rate 7/8 256-QAM.....	364
Figure 168—BTC and shortened BTC structures.....	365
Figure 169—CTC encoder.....	368
Figure 170—BPSK Constellation maps.....	371
Figure 171—Gray maps for QPSK and 16-QAM constellations.....	371
Figure 172—Gray map for 64-QAM constellation.....	372
Figure 173—Gray map for 256-QAM constellation.....	373
Figure 174—Pragmatic maps for 16-QAM and 64-QAM constellations.....	374
Figure 175—Pragmatic map for 256-QAM constellation.....	375
Figure 176—Spread BPSK processing.....	376
Figure 177—Spreading PN sequence generator.....	377
Figure 178—Fundamental framing elements in a standard format burst set.....	380
Figure 179—Burst set preamble composition.....	380
Figure 180—Pilot Word patterning within a burst set.....	382
Figure 181—Paired blocks used in STC transmit diversity combining.....	383
Figure 182—STC dual blocks without UWs.....	384
Figure 183—STC dual blocks with UWs.....	385
Figure 184—STC burst set preamble.....	386
Figure 185—Base frame.....	387
Figure 186—Base frame partitioning and padding.....	387
Figure 187—Forming an appended block.....	387
Figure 188—Forming a repeat segment.....	388
Figure 189—Forming a burst set segment from repeat segments.....	388
Figure 190—Forming of subchannel burst set from segments.....	389
Figure 191—Segment alignment for overlapping burst sets on different subchannels.....	390
Figure 192—Example of FDD frame format.....	392
Figure 193—Example of TDD frame format.....	395
Figure 194—MAC frame contents with AAS elements.....	397
Figure 195—OFDM symbol time structure.....	427
Figure 196—OFDM frequency description.....	428
Figure 197—PRBS for data randomization.....	431
Figure 198—OFDM randomizer downlink initialization vector for burst #2...N.....	431
Figure 199—OFDM randomizer uplink initialization vector.....	431
Figure 200—Convolutional encoder of rate 1/2.....	433
Figure 201—BTC and shortened BTC structure.....	436
Figure 202—CTC encoder.....	438
Figure 203—BPSK, QPSK, 16-QAM, and 64-QAM constellations.....	442
Figure 204—PRBS for pilot modulation.....	443
Figure 205—Downlink and network entry preamble structure.....	447
Figure 206— P_{EVEN} time domain structure.....	448
Figure 207—Example of OFDM frame structure with TDD.....	450
Figure 208—Example of OFDM frame structure with FDD.....	451
Figure 209—Structure of AAS Zone.....	454
Figure 210—Mesh frame structure.....	459
Figure 211—Illustration of STC.....	485
Figure 212—STC usage with OFDM.....	486

Figure 213—OFDMA symbol time structure.....	494
Figure 214—OFDMA frequency description (3 channel schematic example)	495
Figure 215—Example of the data region which defines the OFDMA allocation	496
Figure 216—Example of mapping OFDMA slots to subchannels and symbols in the downlink (in PUSC mode).....	498
Figure 217—Example of mapping OFDMA slots to subchannels and symbols in the uplink.....	499
Figure 218—Time plan - one TDD time frame (with only mandatory zone)	500
Figure 219—Illustration of OFDMA frame with multiple zones.....	501
Figure 220—FCH subchannel allocation for all 3 segments.....	503
Figure 221—Example of DL renumbering the allocated subchannels for segment 1 in PUSC.....	504
Figure 222—Example of UL renumbering the allocated subchannels for segment 1 in PUSC.....	505
Figure 223—Example of allocation for AAS_DL_Scan IE	506
Figure 224—AAS Diversity Map Frame Structure.....	507
Figure 225—Frame Layout in the AAS Region.....	511
Figure 226—Downlink BW Allocation/Access channel.....	512
Figure 227—Reverse link AAS subframe structure showing RLT signaling	514
Figure 228—Forward link subframe structure showing FLI and FLT signaling	515
Figure 229—PHY control signal sequence diagrams.....	516
Figure 230—Mapping order of FAST-FEEDBACK messages to the FAST-FEEDBACK region	539
Figure 231—Mapping of MIMO coefficients to fast MIMO feedback payload bits	542
Figure 232—Downlink transmission basic structure.....	552
Figure 233—Downlink basic structure.....	553
Figure 234—Cluster structure	564
Figure 235—Downlink symbol structure for segment 0 on symbol number 1 using FUSC.....	566
Figure 236—Description of an uplink tile	569
Figure 237—Description of an uplink tile	572
Figure 238—Bin structure	575
Figure 239—Initial-ranging transmission for OFDMA.....	576
Figure 240—Initial-ranging transmission for OFDMA, using two consecutive initial ranging codes	577
Figure 241—Periodic-ranging or bandwidth-request transmission for OFDMA using one code.....	577
Figure 242—Periodic-ranging or bandwidth-request transmission for OFDMA using three consecutive codes	578
Figure 243—PRBS for ranging code generation.....	578
Figure 244—Illustration of STC.....	579
Figure 245—Cluster structure	581
Figure 246—STC usage with PUSC	581
Figure 247—STC usage with FUSC	582
Figure 248—Example of using FHDC in PUSC	583
Figure 249—UL STC tile	584
Figure 250—Illustration of Transmit diversity using four antennas	585
Figure 251—Cluster structure	586
Figure 252—Channel coding process for regular and repetition coding transmission.....	588
Figure 253—PRBS for data randomization.....	588
Figure 254—Creation of OFDMA randomizer initialization vector	589
Figure 255—Convolutional encoder of rate 1/2.....	590
Figure 256—BTC and shortened BTC structure	593
Figure 257—CTC encoder.....	595
Figure 258—Block diagram of subpacket generation	600
Figure 259—Block diagram of the interleaving scheme	600
Figure 260—PRBS of the randomization	604
Figure 261—Initialization construction for the PRBS of the randomizer	604
Figure 262—PRBS for pilot modulation	616
Figure 263—QPSK, 16-QAM, and 64-QAM constellations.....	617
Figure 264—Channelization, 20 MHz.....	630

Figure 265—Transmit spectral mask (see Table 341)	631
Figure 266—Configuration file structure	634
Figure 267—Create TLV entries for parameters required by the SS	635
Figure 268—Add SS MIC	635
Figure 269—Add end of data marker and pad	635
Figure B.1—WirelessHUMAN Mesh deployment model	788
Figure B.2—Mesh interference code sample	798
Figure B.3—Immediate neighborhood scenario.....	800
Figure B.4—Example network scenario.....	803
Figure B.5—Reuse of 1 configuration, 3 sectors per cell.....	814
Figure B.6—Reuse of 1 configuration, 3 sectors per cell.....	815
Figure C.1—Use of primitives to request service of MAC and generate response.....	842
Figure C.2—MAC SAP event and MAC event sequence for connection creation stimulated by CS	850
Figure C.3—MAC SAP event and MAC event sequence for connection change stimulated by CS	851
Figure C.4—MAC SAP event and MAC event sequence for connection deletion stimulated by CS	851

List of Tables

Table 1—Air interface nomenclature	2
Table 2—ATM CS PDU header.....	17
Table 3—Mesh CID construction.....	34
Table 4—MAC header format.....	35
Table 5—Generic MAC header fields	37
Table 6—Type encodings.....	37
Table 7—Bandwidth request header fields.....	38
Table 8—Fragmentation subheader format.....	39
Table 9—Grant Management subheader format.....	40
Table 10—Grant Management subheader fields	40
Table 11—Packing subheader format.....	41
Table 12—Mesh subheader format.....	42
Table 13—FAST-FEEDBACK allocation subheader format	42
Table 14—MAC Management messages	43
Table 15—DCD message format.....	45
Table 16—DL-MAP message format.....	46
Table 17—UCD message format.....	47
Table 18—UL-MAP message format.....	48
Table 19—RNG-REQ message format	49
Table 20—RNG-RSP message format	50
Table 21—REG-REQ message format.....	51
Table 22—REG-RSP message format.....	53
Table 23—PKM MAC messages	54
Table 24—PKM request (PKM-REQ) message format	54
Table 25—PKM response (PKM-RSP) message format.....	54
Table 26—PKM message codes	55
Table 27—SA Add attributes	56
Table 28—Auth Request attributes.....	57
Table 29—Auth Reply attributes	57
Table 30—Auth Reject attributes	58
Table 31—Key Request attributes	58
Table 32—Key Request attributes for Mesh Mode.....	58
Table 33—Key Reply attributes	59
Table 34—Key Reject attributes.....	60
Table 35—Authorization Invalid attributes.....	60
Table 36—TEK Invalid attributes	61
Table 37—Auth Info attributes.....	61
Table 38—DSA-REQ message format.....	62
Table 39—DSA-RSP message format.....	63
Table 40—DSA-ACK message format	64
Table 41—DSC-REQ message format	65
Table 42—DSC-RSP message format.....	66
Table 43—DSC-ACK message format.....	67
Table 44—DSD-REQ message format.....	68
Table 45—DSD-RSP message format.....	69
Table 46—MCA-REQ message format.....	70
Table 47—MCA-RSP message format.....	70
Table 48—DBPC-REQ message format	71
Table 49—DBPC-RSP message format	72
Table 50—RES-CMD message format	72
Table 51—SS SBC-REQ message format.....	73

Table 52—SS SBC-RSP message format.....	73
Table 53—CLK-CMP message format	74
Table 54—DREG-CMD message format.....	75
Table 55—Action Codes and actions	75
Table 56—DSX-RVD message format	76
Table 57—TFTP-CPLT message format.....	76
Table 58—Config File TFTP-RSP message format	77
Table 59—ARQ Feedback message format	77
Table 60—ARQ Discard message format	78
Table 61—ARQ Reset message format.....	79
Table 62—Channel measurements Report Request (REP-REQ) message format.....	79
Table 63—Channel measurement Report Response (REP-RSP) message format.....	80
Table 64—Fast power control message format	80
Table 65—MSH-NCFG message format	81
Table 66—Nbr Physical IE	84
Table 67—Nbr Logical IE	84
Table 68—MSH-NCFG embedded data.....	85
Table 69—Network Descriptor IE.....	86
Table 70—MSH-NCFG Channel IE (license-exempt).....	87
Table 71—MSH-NCFG Channel IE (licensed).....	87
Table 72—Network Entry Open IE.....	88
Table 73—Network Entry Reject IE	88
Table 74—Neighbor Link Establishment IE	89
Table 75—MSH-NENT message format	89
Table 76—MSH-NENT Request IE	90
Table 77—MSH-DSCH message format	91
Table 78—MSH-DSCH Scheduling IE	93
Table 79—MSH-DSCH Request IE	93
Table 80—MSH-DSCH Availability IE.....	94
Table 81—MSH-DSCH Grants IE	95
Table 82—MSH-CSCH message format.....	97
Table 83—MSH-CSCF message format	98
Table 84—AAS Feedback Request (AAS-FBCK-REQ) message format	100
Table 85—AAS Feedback Response (AAS-FBCK-RSP) message format.....	100
Table 86—AAS_Beam_Select message format.....	100
Table 87—DREG-REQ message format	101
Table 88—H-ARQ MAP message format.....	102
Table 89—Compact_DL-MAP IE types	103
Table 90—Compact_UL-MAP IE types	103
Table 91—Format configuration IE	104
Table 92—Field length for Band AMC MAP_IE	105
Table 93—RCID_IE format	106
Table 94—H-ARQ_Control IE format	107
Table 95—H-ARQ_Control IE format.....	108
Table 96—H-ARQ Compact_DL-MAP IE format for normal subchannel.....	109
Table 97—H-ARQ Compact_DL-MAP IE format for band AMC	110
Table 98—H-ARQ Compact_DL-MAP IE format for safety	112
Table 99—H-ARQ Compact_DL-MAP IE format for DIUC subchannel	113
Table 100—H-ARQ Compact_DL-MAP IE format for H-ARQ BITMAP	114
Table 101—H-ARQ Compact_DL-MAP IE format for extension	115
Table 102—H-ARQ Compact_UL-MAP IE format for normal subchannel.....	115
Table 103—H-ARQ Compact_UL-MAP IE format for band AMC	116
Table 104—H-ARQ Compact_UL-MAP IE format for safety	118
Table 105—H-ARQ Compact_UL-MAP IE format for UIUC subchannel	118

Table 106—H-ARQ Compact_UL-MAP IE format for H-ARQ Region allocation.....	119
Table 107—H-ARQ Compact_UL-MAP IE format for CQI Region allocation.....	120
Table 108—H-ARQ Compact_UL-MAP IE format for extension	121
Table 109—Fragmentation rules	123
Table 110—ARQ Feedback Payload format	127
Table 111—ARQ Feedback IE.....	130
Table 112—Scheduling services and usage rules	139
Table 113—Sample UL-MAP with multicast and broadcast IE for SC and SCa	145
Table 114—Message flows during scanning and uplink parameter acquisition	173
Table 115—Ranging and automatic adjustments procedure	176
Table 116—Establishing IP connectivity	187
Table 117—Establishing time of day	188
Table 118—Transfer of Operational Parameters.....	188
Table 119—Successful network entry message exchange	195
Table 120—Establishing link connectivity.....	198
Table 121—CDMA initial Ranging and automatic adjustments procedure	206
Table 122—CDMA periodic Ranging and automatic adjustments procedure	212
Table 123—UCD update	214
Table 124—DCD update	215
Table 125—DSA initiated from SS.....	236
Table 126—DSA initiated from BS.....	237
Table 127—SS-initiated DSC.....	248
Table 128—BS-initiated DSC	249
Table 129—DSD-initiated from SS.....	258
Table 130—DSD-initiated from BS	258
Table 132—Tunnel subheader Format	266
Table 131—MAC Management messages tunneled over UDP during network entry.....	266
Table 133—Authorization FSM state transition matrix	277
Table 134—TEK FSM state transition matrix.....	284
Table 135—Basic fields of an X.509 Version 3 certificate	301
Table 136—Frame durations and frame duration codes.....	308
Table 137—PHY Type parameter encoding	308
Table 138—Downlink burst preambles	311
Table 139—Frame start preamble	312
Table 140—Downlink TDMA burst preamble.....	312
Table 141—SC DL-MAP_IE	313
Table 142—SC PHY synchronization field.....	314
Table 143—Mapping of burst profile to DIUC	315
Table 144—SC Downlink_Burst_Profile format	316
Table 145—SC DIUC allocation	319
Table 146—FEC Code Types	320
Table 147—Parameters of the inner codes for the BCC	323
Table 148—SC Hamming code generator polynomials.....	324
Table 150—Encoded block	326
Table 149—Original data for encoding	326
Table 151—Required block codes for the BTC option for the downlink channel	327
Table 152—Parameters for burst profile (DIUC=0).....	328
Table 153—QPSK bits to symbol mapping	330
Table 154—16-QAM bits to symbol mapping	331
Table 155—64-QAM bits to symbol mapping	332
Table 156—16-symbol uplink preamble sequence	335
Table 158—SC UL-MAP_IE format.....	336
Table 157—32-symbol uplink preamble sequence	336
Table 159—SC UIUC values	337

Table 160—SC UL-MAP extended IE format	337
Table 161—SC Power Control IE format.....	338
Table 162—SC Uplink_Burst_Profile format	339
Table 163—Required block codes for the BTC option for the uplink channel	342
Table 164—Baud rates and channel sizes for a roll-off factor of 0.25.....	343
Table 165—Minimum BS transmitter performance	344
Table 166—Minimum SS transmitter performance	345
Table 167—Minimum SS receiver performance	346
Table 168—Propagation models	347
Table 169—Downlink spectrum mask at 28MHz channel.....	348
Table 170—Uplink spectrum mask at 28MHz channel.....	349
Table 171—Downlink and uplink NFD mask	349
Table 172—EVM values vs. modulation scheme	350
Table 173—Operating parameters for block interleaver	358
Table 174—Puncture patterns and serialization for convolution code.....	359
Table 175—Supported modulations and inner (TCM) code rates.....	360
Table 176—Flushing bit requirements for inner code termination	360
Table 177—BTC component codes.....	365
Table 178—(n-1,k) Hamming code generator polynomials	366
Table 179—BTC code banks.....	367
Table 180—Circulation state lookup table (Sc)	369
Table 181—Circulation state lookup table (Sc)	370
Table 182—Modulations supported	370
Table 183—Unity average power normalization factors.....	376
Table 184—Spreading PN sequence generator seeds.....	378
Table 185—Unique Word lengths, types, and support.....	379
Table 186—Multiplexing arrangement for block STC processing	383
Table 187—Channel settings for FCH burst	401
Table 188—Burst profile settings for FCH burst	402
Table 189—SCa compressed DL-MAP format.....	403
Table 190—SCa compressed UL-MAP format.....	404
Table 191—SCa PHY synchronization field.....	404
Table 192—SCa DL-MAP IE format	405
Table 193—SCa DIUCs	406
Table 194—SCa DL-MAP extended IE format	407
Table 195—SCa Channel measurement extended IE format	407
Table 196—SCa FCH burst profile change extended IE format	408
Table 197—SCa AAS DL extended IE format	408
Table 198—SCa burst set delimiter extended IE format	409
Table 199—SCa AAS DL preamble index extended IE format.....	410
Table 200—SCa concurrent transmission extended IE format	411
Table 201—SCa UL-MAP IE format	412
Table 202—SCa UL-MAP IEs.....	413
Table 203—SCa UL-MAP extended IE format	414
Table 204—SCa power control extended IE format	414
Table 205—SCa AAS UL extended IE format	415
Table 206—SCa AAS UL preamble index extended IE format.....	415
Table 207—SCa concurrent transmission extended IE format	416
Table 208—SCa Downlink_Burst_Profile format	417
Table 209—SCa Uplink_Burst_Profile format	417
Table 210—SCa AAS Feedback Request message body	418
Table 211—SCa AAS Feedback Request message body	419
Table 212—Minimum adjacent and alternate adjacent channel interference performance	425
Table 213—OFDM symbol parameters	429

Table 214—The inner convolutional code with puncturing configuration	433
Table 216—BTC component codes.....	434
Table 215—Mandatory channel coding per modulation	434
Table 217—OFDM Hamming code generator polynomials	435
Table 218—Optional BTC channel coding per modulation	436
Table 219—Optional BTC channel coding with subchannelization	437
Table 220—Optional CTC channel coding per modulation	438
Table 222—CTC puncturing (Sc).....	440
Table 221—Circulation state lookup table (Sc)	440
Table 223—Block sizes of the Bit Interleaver.....	441
Table 224—OFDM Rate ID encodings	443
Table 225—OFDM downlink frame prefix format	452
Table 226—AAS_DLFP Structure	454
Table 227—AAS_DLFP_DL IE format.....	455
Table 228—AAS_DLFP_UL IE format.....	456
Table 229—AAS_COMP_UL IE format	456
Table 230—UIUC Usage in AAS Zone	457
Table 231—AAS NW Entry Response IE format	458
Table 232—OFDM frame duration (TF ms) codes.....	460
Table 233—OFDM Downlink_Burst_Profile format.....	460
Table 234—OFDM Uplink_Burst_Profile format	461
Table 235—OFDM PHY synchronization field.....	461
Table 236—OFDM DL-MAP IE.....	461
Table 237—OFDM DIUC values.....	463
Table 238—DL-MAP extended IE format	463
Table 239—OFDM Channel measurement IE format.....	464
Table 240—OFDM AAS DL IE format.....	464
Table 242—OFDM DL-MAP Concurrent transmission IE format.....	465
Table 241—OFDM STC IE format.....	465
Table 244—OFDM DL-MAP dummy IE format.....	466
Table 243—OFDM DL-MAP Physical Modifier IE format	466
Table 245—OFDM UL-MAP IE format	467
Table 246—OFDM UIUC values.....	468
Table 247—OFDM focused contention IE format	468
Table 248—Subchannelized network entry IE format	469
Table 249—OFDM UL-MAP extended IE format.....	470
Table 250—OFDM power control IE format	470
Table 251—OFDM AAS UL IE format.....	471
Table 252—OFDM UL-MAP Physical Modifier IE format	471
Table 253—OFDM UL-MAP dummy IE format.....	472
Table 254—OFDM AAS Feedback Request message body	472
Table 255—OFDM AAS Feedback Response message body.....	473
Table 256—AAS Beam request message format	474
Table 257—AAS Beam response message format	475
Table 258—AAS Beam report IE format	476
Table 259—OFDM AAS_NW_ENTRY_REQ format	478
Table 260—OFDM SBCH_AAS_NW_ENTRY_REQ format.....	479
Table 261—OFDM Contention codes	481
Table 262—OFDM Contention channels	481
Table 263—OFDM Spectral flatness	489
Table 264—Allowed relative constellation error versus data rate.....	489
Table 265—Example of channelization for licensed bands	491
Table 266—Receiver SNR assumptions.....	491
Table 267—Adjacent and nonadjacent channel rejection	493

Table 268—OFDMA downlink Frame Prefix format	501
Table 269—AAS-DLFP Structure, Diversity-Map Scan	508
Table 270—Structure of AAS_COMP_DL_IE ()	509
Table 271—AAS-DLFP2 Structure, Directed Signaling	512
Table 272—Bandwidth Granularity with AAS and AMC subchannels.....	517
Table 273—OFDMA PHY Synchronization Field	520
Table 274—OFDMA frame duration (TF ms) codes	520
Table 275—OFDMA DL-MAP_IE format	521
Table 276—OFDMA DIUC values.....	522
Table 277—DL-MAP extended IE format	523
Table 278—OFDMA downlink AAS IE	523
Table 279—OFDMA downlink TD_ZONE IE format	524
Table 280—OFDMA channel measurement IE	525
Table 281—OFDMA Data location in another BS IE.....	525
Table 282—OFDMA downlink CID Switch IE format	526
Table 283—MIMO DL basic IE format.....	527
Table 284—MIMO DL enhanced IE format	528
Table 285—H-ARQ MAP pointer IE format	529
Table 286—OFDMA DL-MAP Physical Modifier IE format	530
Table 287—OFDMA UL-MAP IE format	532
Table 288—OFDMA UIUC values.....	533
Table 289—PAPR reduction and safety zone allocation IE format	534
Table 290—CDMA Allocation IE format	534
Table 291—OFDMA UL-MAP extended IE format.....	535
Table 292—OFDMA Power Control IE.....	536
Table 293—OFDMA uplink AAS IE	536
Table 294—OFDMA uplink ZONE IE format.....	537
Table 295—Mini-subchannel allocation IE format.....	537
Table 296—FAST_FEEDBACK channel subcarrier modulation.....	539
Table 297—FAST_FEEDBACK subcarrier modulation in each vector.....	540
Table 298—Encoding of payload bits for FAST-FEEDBACK slot.....	542
Table 299—MIMO UL basic IE format.....	543
Table 300—CQICH alloc IE format.....	544
Table 301—Orthogonal Modulation for ACK channel	545
Table 302—OFDMA UL-MAP Physical Modifier IE format	546
Table 303—OFDMA Downlink_Burst_Profile TLV format	547
Table 304—OFDMA Uplink_burst_profile TLV format.....	547
Table 305—Compressed DL-MAP message format	548
Table 306—Compressed UL-MAP message format	549
Table 307—OFDMA AAS Feedback Request message body	550
Table 308—OFDMA AAS Feedback Response message body.....	551
Table 309—Preamble modulation series per segment	553
Table 310—OFDMA downlink carrier allocations—PUSC	563
Table 311—OFDMA downlink carrier allocations.....	565
Table 312—OFDMA optional FUSC downlink subcarrier allocation.....	567
Table 313—OFDMA uplink subcarrier allocations	568
Table 314—Subchannel partitioning into mini-subchannels.....	571
Table 315—OFDMA uplink subcarrier allocations	572
Table 316—OFDMA AAS subcarrier allocations.....	575
Table 317—Subchannel concatenation rule	589
Table 318—Encoding Subchannel concatenation for different allocations and modulations.....	590
Table 319—The inner convolutional code with puncturing configuration	591
Table 320—Useful data payload for a subchannel	591
Table 321—OFDMA Hamming code generator polynomials	592

Table 322—Useful data payload for a subchannel	593
Table 323—Optional channel coding per modulation	593
Table 324—Subchannel concatenation rule for CTC	596
Table 325—Encoding subchannel concatenation for different rates in CTC	596
Table 326—Optimal CTC channel coding per modulation	597
Table 327—Optimal CTC channel coding per modulation when supporting H-ARQ	598
Table 328—Circulation state lookup table (Sc)	599
Table 329—Parameters for the subblock interleavers	601
Table 330—Parameters for the subblock interleavers when supporting H-ARQ	602
Table 331—Transmission format and modulation level for DL	606
Table 332— N_{EP} encoding	610
Table 333—Transmission format and modulation level for UL	611
Table 334—Normalized C/N per modulation	621
Table 335—Spectral flatness	625
Table 336—Allowed relative constellation error versus data rate	625
Table 337—Receiver minimum input level sensitivity (dBm)	627
Table 338—Receiver SNR and E_b/N_0 assumptions	627
Table 339—Adjacent and nonadjacent channel rejection	629
Table 340—Channelizations	630
Table 341—Transmit spectral mask parameters	631
Table 342—Parameters and constants	637
Table 343—Operational ranges for privacy configuration settings	641
Table 344—Values for privacy configuration setting for protocol testing	641
Table 345—CIDs	643
Table 346—Type values for common TLV encodings	646
Table 347—HMAC Tuple definition	646
Table 348—HMAC Tuple value field	647
Table 349—UCD common channel encodings	651
Table 350—UCD PHY-specific channel encodings — WirelessMAN-SC	652
Table 351—UCD PHY-specific channel encodings — WirelessMAN-SCa	653
Table 352—UCD PHY-specific channel encodings — WirelessMAN-OFDM	653
Table 353—UCD PHY-specific channel encodings — WirelessMAN-OFDMA	654
Table 354—UCD burst profile encodings—WirelessMAN-SC	655
Table 355—UCD burst profile encodings—WirelessMAN-SCa	656
Table 356—UCD burst profile encodings—WirelessMAN-OFDM	657
Table 357—UCD burst profile encodings—WirelessMAN-OFDMA	658
Table 358—DCD channel encoding	659
Table 359—DCD PHY-common burst profile encodings	660
Table 360—DCD burst profile encodings—WirelessMAN-SC	660
Table 361—DCD burst profile encodings—WirelessMAN-SCa	661
Table 362—DCD burst profile encodings—WirelessMAN-OFDM	663
Table 363—DCD burst profile encodings—WirelessMAN-OFDMA	663
Table 364—RNG-REQ message encodings	664
Table 365—SCa-specific RNG-REQ message encodings	664
Table 366—SCa-specific RNG-RSP message encodings	665
Table 367—RNG-RSP message encodings	665
Table 368—OFDM-specific RNG-RSP message encodings	666
Table 369—OFDMA-specific RNG-RSP message encodings	666
Table 370—PKM attribute types	682
Table 371—Attribute value data types	683
Table 372—TEK-parameters subattributes	685
Table 373—Error-code attribute code values	686
Table 374—Security-capabilities subattributes	687
Table 375—Data encryption algorithm identifiers	688

Table 376—Data authentication algorithm identifiers	688
Table 377—TEK encryption algorithm identifiers	688
Table 378—Allowed cryptographic suites	689
Table 379—Version attribute values	689
Table 380—SA-Descriptor subattributes	690
Table 381—SA-type attribute values	690
Table 382—Multicast assignment request message encodings	692
Table 383—Service flow encodings	695
Table 384—CC values	696
Table 385—Values used in Dynamic Service messages	698
Table 386—Profile definitions	721
Table 387—SS Minimum Performance requirements for profP1	731
Table 388—BS Tx minimum performance requirements for profP1	733
Table 389—BS Rx minimum performance for profP1	734
Table 390—SS Minimum performance for profP2	736
Table 391—BS Tx minimum performance for profP2	738
Table 392—BS Rx minimum performance for profP2	739
Table 393—Power classes	743
Table 394—SS minimum Tx performance requirements	744
Table 395—SS minimum Rx performance requirements	744
Table 396—BS minimum Tx performance requirements	745
Table 397—BS minimum Rx performance requirements	746
Table 398—Profile definitions	752
Table 399—Power classes profiles	753
Table 400—Sample system profile	753
Table 401—Optional feature requirements profM3_PMP	754
Table 402—Optional feature requirements profM3_mesh	756
Table 403—Optional PHY feature requirements	758
Table 404—Minimum Performance basic requirements	759
Table 405—Minimum Performance requirements for profP3_1.75	760
Table 406—Minimum Performance requirements for profP3_3.5	761
Table 407—Minimum Performance requirements for profP3_7	762
Table 408—Minimum Performance requirements for profP3_3	763
Table 409—Minimum Performance requirements for profP3_5.5	764
Table 410—Minimum Performance requirements for profP3_10	765
Table 411—Profile definitions	766
Table 412—Power classes	767
Table 413—Minimum performance requirements for all profiles	769
Table 414—Minimum performance requirements for OFDMA_ProfP1	770
Table 415—Minimum Performance requirements for OFDMA_ProfP2	771
Table 416—Minimum Performance requirements for OFDMA_ProfP3	772
Table 417—Minimum Performance requirements for OFDMA_ProfP4	773
Table 418—Minimum Performance requirements for OFDMA_ProfP5	774
Table 419—Minimum Performance requirements for OFDMA_ProfP6	775
Table 420—Minimum Performance requirements for OFDMA_ProfP7	776
Table 421—Minimum Performance requirements for OFDMA_ProfP8	777
Table 422—Minimum Performance requirements for OFDMA_ProfP9	778
Table 423—License bands RF Profiles List	779
Table B.1—Frequency bands and channel allocation	785
Table B.2—Single U-NII BWA to synthetic aperture radar 4 (SAR-4) Interference	787
Table B.3—Tx activity parameters	788
Table B.4—Antenna parameters	789
Table B.5—Relevant radio parameters	789
Table B.6—Altimeter satellite characteristics	790

Table B.7—Typical space borne imaging radar characteristics	790
Table B.8—Typical space borne imaging radar characteristics	792
Table B.9—RLAN Parameters I.....	793
Table B.10—RLAN parameters II.....	793
Table B.11—RTTT RSU parameters	794
Table B.12—RTTT OBU Parameters (–35× to +35×).....	794
Table B.13—Relevant radar parameters.....	795
Table B.14—Single U-NII BWA to SAR-4 interference	795
Table B.15—WirelessHUMAN Mesh devices in the SAR footprint.....	799
Table B.16—Tolerable Mesh nodes for FSS operation.....	800
Table B.17—Link attenuations and ranges.....	803
Table B.18— Tx Power, conducted and EIRP (regulatory limited).....	804
Table B.19—Received Signal Levels (dBm)	804
Table B.20—Sustainable modulation during interference	805
Table B.21—Needed separation distance Mesh to RSU and OBU	805
Table B.22—Minimum separation distance of radar to Mesh.....	806
Table B.23—Minimum separation distance of Mesh to radar.....	807
Table B.24—WirelessMAN-SCa raw bit rates (Mb/s) for 0.25 roll-off.....	808
Table B.25—WirelessMAN-SCa raw bit rates (Mb/s) for 0.15 roll-off.....	808
Table B.26—OFDM channelization parameters for licensed bands	810
Table B.27—OFDMA channelization parameters for licensed bands	811
Table B.28—OFDM/OFDMA channelization parameters for license-exempt bands.....	812
Table B.29—OFDM/OFDMA raw bitrates (Mb/s).....	812

IEEE Standard for
Local and metropolitan area networks

Part 16: Air Interface for Fixed Broadband Wireless Access Systems

1. Overview

1.1 Scope

This revised standard specifies the air interface, including the medium access control layer and multiple physical layer specifications, of fixed BWA systems supporting multiple services. It consolidates IEEE Std 802.16™, IEEE Std 802.16a™, and IEEE Std 802.16c™, retaining all modes and major features without adding modes. Content is added or revised to improve performance, ease deployment, or replace incorrect, ambiguous, or incomplete material, including system profiles.

1.2 Purpose

This standard enables rapid worldwide deployment of innovative, cost-effective, and interoperable multi-vendor BWA products, facilitates competition in broadband access by providing alternatives to wireline broadband access, encourages worldwide spectrum allocation, and accelerates the commercialization of BWA systems.

1.3 Frequency bands

The applications depend on the spectrum to be used. The primary bands of interest are as follows:

1.3.1 10–66 GHz licensed bands

The 10–66 GHz bands provide a physical environment where, due to the short wavelength, line-of-sight (LOS) is required and multipath is negligible. In the 10–66 GHz band, channel bandwidths of 25 MHz or 28 MHz are typical. With raw data rates in excess of 120 Mb/s, this environment is well suited for PMP access serving applications from small office/home office (SOHO) through medium to large office applications.

The single-carrier modulation air interface specified herein for 10–66 GHz shall be known as the “WirelessMAN-SC®” air interface.

1.3.2 Frequencies below 11 GHz

Frequencies below 11 GHz provide a physical environment where, due to the longer wavelength, LOS is not necessary and multipath may be significant. The ability to support near-LOS and non-LOS (NLOS) scenarios requires additional PHY functionality, such as the support of advanced power management techniques, interference mitigation/coexistence, and multiple antennas.

Additional MAC features such as mesh topology and automatic repeat request (ARQ) are introduced.

1.3.3 License-exempt frequencies below 11 GHz (primarily 5–6 GHz)

The physical environment for the license-exempt bands below 11 GHz is similar to that of the licensed bands in the same frequency range, as described in 1.3.2. However, the license-exempt nature introduces additional interference and co-existence issues, whereas regulatory constraints limit the allowed radiated power. In addition to the features described in 1.3.2, the PHY and MAC introduce mechanisms such as dynamic frequency selection (DFS) to detect and avoid interference.

1.3.4 Air interface nomenclature and PHY compliance

Table 1 summarizes the nomenclature for the various air interface specifications in this standard.

Table 1—Air interface nomenclature

Designation	Applicability	PHY	Additional MAC requirements	Options	Duplexing alternative
WirelessMAN-SC™	10–66 GHz	8.1			TDD FDD
WirelessMAN-SCa™	Below 11 GHz licensed bands	8.2		AAS (6.3.7.6) ARQ (6.3.4) STC (8.2.1.4.3)	TDD FDD
WirelessMAN-OFDM™	Below 11 GHz licensed bands	8.3		AAS (6.3.7.6) ARQ (6.3.4) Mesh (6.3.6.6) STC (8.3.8)	TDD FDD
WirelessMAN-OFDMA	Below 11 GHz licensed bands	8.4		AAS (6.3.7.6) ARQ (6.3.4) STC (8.4.8)	TDD FDD
WirelessHUMAN™	Below 11 GHz license-exempt bands	[8.2, 8.3, or 8.4] and 8.5	DFS (6.3.15)	AAS (6.3.7.6) ARQ (6.3.4) Mesh (6.3.6.6) (with 8.3 only) STC (8.2.1.4.3/8.3.8/ 8.4.8)	TDD

All implementations of this standard shall comply with the requirements of Clause 6 and Clause 7.

Implementations of this standard for any applicable frequencies between 10 GHz and 66 GHz shall comply with the WirelessMAN-SC PHY as described in 8.1.

Implementations of this standard for licensed frequencies below 11 GHz (such as those listed in B.1) shall either comply with the WirelessMAN-SCa PHY as described in 8.2, the WirelessMAN-OFDM PHY as described in 8.3, the WirelessMAN-OFDMA PHY as described in 8.4, or the WirelessMAN-SC PHY as described in 8.1 for licensed frequencies above 10 GHz.

Implementations of this standard for license-exempt frequencies below 11 GHz (such as those listed in B.1) shall comply with the WirelessMAN-SCa PHY as described in 8.2, the WirelessMAN-OFDM PHY as described in 8.3, or the WirelessMAN-OFDMA PHY as described in 8.4. They shall further comply with the DFS protocols (6.3.15) and with 8.5.

1.4 Reference model

Figure 1 illustrates the reference model and scope of this standard.

The MAC comprises three sublayers. The Service-Specific Convergence Sublayer (CS) provides any transformation or mapping of external network data, received through the CS service access point (SAP), into MAC SDUs received by the MAC Common Part Sublayer (CPS) through the MAC SAP. This includes classifying external network service data units (SDUs) and associating them to the proper MAC service flow identifier (SFID) and connection identifier (CID). It may also include such functions as payload header suppression (PHS). Multiple CS specifications are provided for interfacing with various protocols. The internal format of the CS payload is unique to the CS, and the MAC CPS is not required to understand the format of or parse any information from the CS payload.

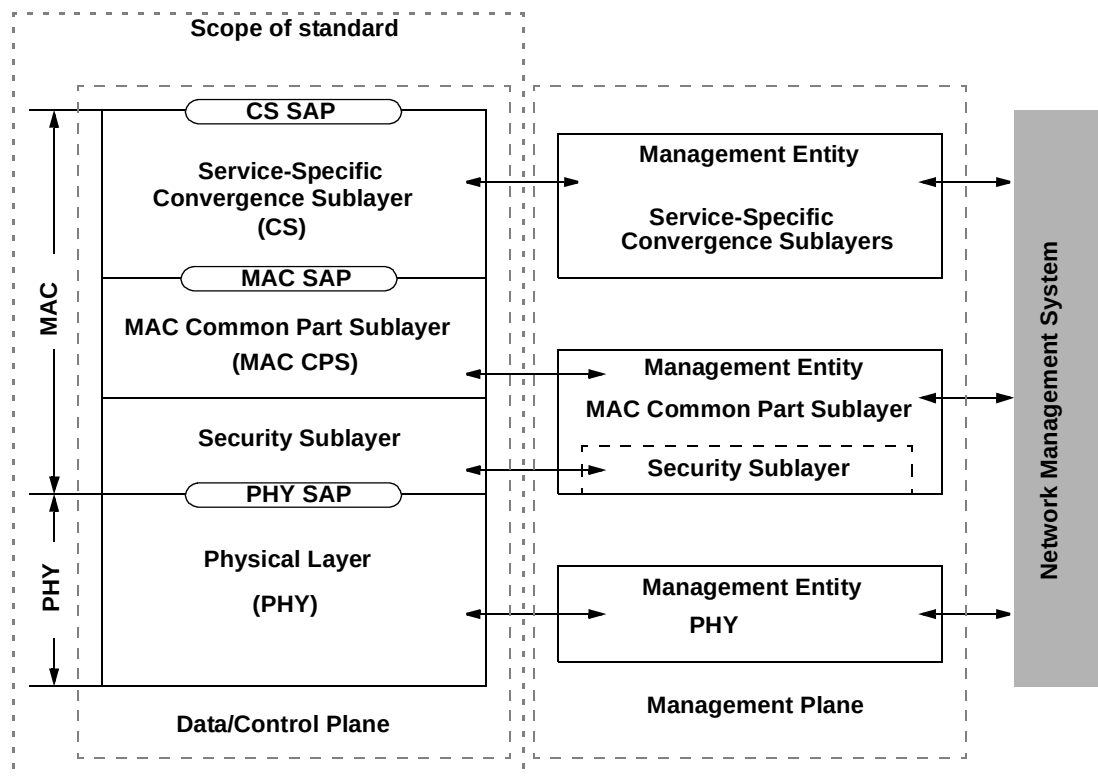


Figure 1—IEEE Std 802.16 protocol layering, showing SAPs

The MAC CPS provides the core MAC functionality of system access, bandwidth allocation, connection establishment, and connection maintenance. It receives data from the various CSs, through the MAC SAP, classified to particular MAC connections. An example of MAC CPS service definition is given in Annex C. Quality of Service (QoS) is applied to the transmission and scheduling of data over the PHY.

The MAC also contains a separate security sublayer providing authentication, secure key exchange, and encryption.

Data, PHY control, and statistics are transferred between the MAC CPS and the PHY via the PHY SAP (which is implementation specific).

The PHY definition includes multiple specifications, each appropriate to a particular frequency range and application. The various PHY specifications supported are discussed in Clause 8.

2. References

This standard shall be used in conjunction with the following publications. When the following specifications are superseded by an approved revision, the revision shall apply.

ATM Forum Specification af-uni-0010.002, ATM User-Network Interface Specification, Version 3.1, September 1994.¹

ATM Forum Specification af-sig-0061.000, ATM User-Network Interface (UNI) Signalling Specification, Version 4.0, July 1996.

ETSI EN 301 213-3, Fixed Radio Systems; Point-to-multipoint equipment; Point-to-multipoint digital radio systems in frequency bands in the range 24,25 GHz to 29,5 GHz using different access methods; Part 3: Time Division Multiple Access (TDMA) methods, Version 1.3.1, September 2001.²

FIPS 46-3, Data Encryption Standard (DES), October, 1999.³

FIPS 74, Guidelines for Implementing and Using the NBS Data Encryption Standard, April 1981.

FIPS 81, DES Modes of Operation, December 1980.

FIPS 180-1, Secure Hash Standard (SHS), April 1995.

FIPS 186-2, Digital Signature Standard (DSS), January 2000.

IEEE Std 802[®]-2001, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture.^{4, 5}

IEEE Std 802.1D[™]-2004, IEEE Standard for Local and metropolitan Area Networks: Media Access Control (MAC) Bridges.⁶

IEEE Std 802.1Q, 2003 Edition, IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks.

IEEE Std 802.2[™]-1998 (ISO/IEC 8802-2: 1998), Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical Link Control.

IEEE Std 802.3[™]-2002, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

IEEE Std 802.16.2[™]-2004, IEEE Recommended Practice for Local and metropolitan area networks—Coexistence of Fixed Broadband Wireless Access Systems.

¹ATM Forum publications are available from the ATM Forum at <http://www.atmforum.com/>.

²ETSI publications are available from the European Telecommunications Standards Institute at <http://www.etsi.org/>.

³FIPS publications are available from the National Technical Information Service (NTIS), U. S. Dept. of Commerce, 5285 Port Royal Road, Springfield, VA 22161 (<http://www.ntis.gov/>).

⁴IEEE and 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

⁵IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁶IEEE standards referred to in Clause 2 are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

IETF RFC 791, “Internet Protocol,” J. Postel, September 1981.⁷

IETF RFC 868, “Time Protocol,” J. Postel, K. Harrenstien, May 1983.

IETF RFC 1042, “A Standard for the Transmission of IP Datagrams over IEEE 802 Networks,” J. Postel, J. Reynolds, February 1988.

IETF RFC 1123, “Requirements for Internet Hosts—Application and Support,” R. Braden, October 1989.

IETF RFC 1157, “A Simple Network Management Protocol (SNMP),” M. Schoffstall, M. Fedor, J. Davin, and J. Case, May 1990.

IETF RFC 2104, “HMAC: Keyed-Hashing for Message Authentication,” H. Krawczyk, M. Bellare, R. Canetti, February 1997.

IETF RFC 2131, “Dynamic Host Configuration Protocol,” R. Droms, March 1997.

IETF RFC 2132, “DHCP Options and BOOTP Vendor Extensions,” S. Alexander, and R. Droms, March 1997.

IETF RFC 2349, “TFTP Timeout Interval and Transfer Size Options,” G. Malkin and A. Harkin, May 1998.

IETF RFC 2459, “Internet X.509 Public Key Infrastructure Certificate and CRL Profile,” R. Housley, W. Ford, W. Polk, D. Solo, January 1999.

IETF RFC 2460, “Internet Protocol, Version 6 (IPv6) Specification,” S. Deering, R. Hinden, December 1998.

IETF RFC 2474, “Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers,” K. Nichols, S. Blake, F. Baker, D. Black, December 1998.

Internet Assigned Numbers Authority (IANA), “Protocol Numbers,” <<http://www.iana.org/assignments/protocol-numbers>>, June 2001.

ISO/IEC 8825, Information technology—Open Systems Interconnection—Specification of the Basic Encoding Rules for Abstract Syntax Notation One (ASN.1), May 1999.⁸

ITU-T Recommendation X.690, Information Technology—ASN.1 Encoding Rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER), and Distinguished Encoding Rules (DER), December 1997.⁹

PKCS #1 v2.0, RSA Cryptography Standard, RSA Laboratories, October 1998 <<http://www.rsasecurity.com/rsalabs/pkcs/pkcs-1>>.

⁷IETF publications are available from the Internet Engineering Task Force at <http://www.ietf.org/>.

⁸ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Geneva 20, Switzerland/Suisse or the IEC Sales Department, Case Postale 131, 3, rue de Varembe, CH-1211, Geneva 20, Switzerland/Suisse. They are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th floor, New York, NY 10036, USA.

⁹ITU-T publications are available from the International Telecommunications Union, Place des Nations, CH-1211, Geneva 20, Switzerland/Suisse (<http://www.itu.int/>).

3. Definitions

For the purposes of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms*, Seventh Edition [B23],¹⁰ should be referenced for terms not defined in this clause.

3.1 adaptive antenna system (AAS): A system adaptively exploiting more than one antenna to improve the coverage and the system capacity.

3.2 adaptive modulation: A system's ability to communicate with another system using multiple burst profiles and a system's ability to subsequently communicate with multiple systems using different burst profiles.

3.3 automatic repeat request (ARQ) block: A distinct unit of data that is carried on an ARQ-enabled connection. Such a unit is assigned a sequence number, and is managed as a distinct entity by the ARQ state machines. Block size is a parameter negotiated during connection establishment.

3.4 bandwidth stealing: The use, by a subscriber station (SS), of a portion of the bandwidth allocated in response to a Bandwidth Request for a connection to send another Bandwidth Request rather than sending data.

3.5 base station (BS): A generalized equipment set providing connectivity, management, and control of the subscriber station (SS).

3.6 basic connection: Connection that is established during subscriber station (SS) initial ranging and used to transport delay-intolerant medium access control (MAC) management messages.

3.7 broadband: Having instantaneous bandwidths greater than around 1 MHz and supporting data rates greater than about 1.5 Mb/s.

3.8 broadband wireless access (BWA): Wireless access in which the connection(s) capabilities are broadband.

3.9 burst profile: Set of parameters that describe the uplink or downlink transmission properties associated with an interval usage code. Each profile contains parameters such as modulation type, forward error correction (FEC) type, preamble length, guard times, etc. *See also:* **interval usage code**.

3.10 channel identifier (ChID): An identifier used to distinguish between multiple uplink channels, all of which are associated with the same downlink channel.

3.11 concatenation: The act of combining multiple medium access control (MAC) protocol data units (PDUs) into a single PHY SDU.

3.12 connection: A unidirectional mapping between base station (BS) and subscriber station (SS) medium access control (MAC) peers for the purpose of transporting a service flow's traffic. Connections are identified by a connection identifier (CID). All traffic is carried on a connection, even for service flows that implement connectionless protocols, such as Internet Protocol (IP). *See also:* **connection identifier**.

3.13 connection identifier (CID): A 16-bit value that identifies a connection to equivalent peers in the MAC of the base station (BS) and subscriber station (SS). It maps to a service flow identifier (SFID), which defines the Quality of Service (QoS) parameters of the service flow associated with that connection. Security associations (SAs) also exist between keying material and CIDs. *See also:* **service flow identifier**.

¹⁰The numbers in brackets correspond to those of the bibliography in Annex A.

3.14 DC subcarrier: In an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal, the subcarrier whose frequency would be equal to the RF center frequency of the station.

3.15 directed mesh (DM): The realization of a physical mesh using substantially directional antennas. *See also: mesh.*

3.16 downlink: The direction from the base station (BS) to the subscriber station (SS).

3.17 downlink burst transition gap (DLBTG): Gap included on the trailing edge of each allocated downlink burst so that ramp down can occur and delay spread can clear receivers.

3.18 downlink channel descriptor (DCD): A MAC message that describes the PHY characteristics of a downlink channel.

3.19 downlink interval usage code (DIUC): An interval usage code specific to a downlink. *See also: interval usage code.*

3.20 downlink map (DL-MAP): A MAC message that defines burst start times for both time division multiplex and time division multiple access (TDMA) by a subscriber station (SS) on the downlink.

3.21 dynamic frequency selection (DFS): The ability of a system to switch to different physical RF channels between transmit and receive activity based on channel measurement criteria.

3.22 dynamic service: The set of messages and protocols that allow the base station (BS) and subscriber station (SS) to add, modify, or delete the characteristics of a service flow.

3.23 fixed wireless access: Wireless access application in which the location of the base station (BS) and subscriber station (SS) are fixed in location during operation.

3.24 frame: A structured data sequence of fixed duration used by some PHY specifications. A frame may contain both an uplink subframe and a downlink subframe.

3.25 frequency division duplex (FDD): A duplex scheme in which uplink and downlink transmissions use different frequencies but are typically simultaneous.

3.26 frequency offset index: An index number identifying a particular subcarrier in an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal, which is related to its subcarrier index. Frequency offset indices may be positive or negative.

3.27 initial ranging connection identifier: A well-known CID that is used by a subscriber station (SS) during the initial ranging process. This CID is defined as constant value within the protocol since an SS has no addressing information available until the initial ranging process is complete.

3.28 interval usage code: A code identifying a particular burst profile that can be used by a downlink or uplink transmission interval.

3.29 mesh (MSH): Network architecture, wherein systems are capable of forwarding traffic from and to multiple other systems.

3.30 minislot: A unit of uplink bandwidth allocation equivalent to n physical slots (PSs), where $n = 2^m$ and m is an integer ranging from 0 through 7.

3.31 multicast polling group: A group of zero or more subscriber stations (SSs) that are assigned a multicast address for the purposes of polling.

3.32 node: A term associated with a mesh network station. A node, due to the nature of mesh, may behave as a BS, SS, or both, and will generate and forward data to other nodes.

3.33 packing: The act of combining multiple service data units (SDUs) from a higher layer into a single medium access control protocol data unit (PDU).

3.34 payload header suppression (PHS): The process of suppressing the repetitive portion of payload headers at the sender and restoring the headers at the receiver.

3.35 payload header suppression field (PHSF): A string of bytes representing the header portion of a protocol data unit (PDU) in which one or more bytes are to be suppressed (i.e., a snapshot of the uncompressed PDU header inclusive of suppressed and unsuppressed bytes).

3.36 payload header suppression index (PHSI): An 8-bit mask that indicates which bytes in the Payload Header Suppression Field (PHSF) to suppress and which bytes to not suppress.

3.37 payload header suppression size (PHSS): The length of the suppressed field in bytes. This value is equivalent to the number of bytes in the Payload Header Suppression Field (PHSF) and also the number of valid bits in the Payload Header Suppression Mask (PHSM).

3.38 payload header suppression valid (PHSV): A flag that tells the sending entity to verify all bytes that are to be suppressed.

3.39 physical slot (PS): A unit of time, dependent on the PHY specification, for allocating bandwidth

3.40 point to point (PtP): A mode of operation whereby a link exists between two network entities.

3.41 primary management connection: A connection that is established during initial subscriber station (SS) ranging and used to transport delay-tolerant medium access control (MAC) management messages.

3.42 privacy key management (PKM) protocol: A client/server model between the base station (BS) and subscriber station (SS) that is used to secure distribution of keying material.

3.43 protocol data unit (PDU): The data unit exchanged between peer entities of the same protocol layer. On the downward direction, it is the data unit generated for the next lower layer. On the upward direction, it is the data unit received from the previous lower layer (see Figure 2).

3.44 RF center frequency: The center of the frequency band in which a base station (BS) or SS is intended to transmit.

3.45 receive/transmit transition gap (RTG): A gap between the uplink burst and the subsequent downlink burst in a time division duplex (TDD) transceiver. This gap allows time for the base station (BS) to switch from receive to transmit mode and SSs to switch from transmit to receive mode. During this gap, the BS and SS are not transmitting modulated data but simply allowing the BS transmitter carrier to ramp up, the transmit/receive (Tx/Rx) antenna switch to actuate, and the SS receiver sections to activate. Not applicable for FDD systems.

3.46 secondary management connection: A connection that may be established during subscriber station (SS) registration that is used to transport standards-based (SNMP, DHCP, etc.) messages.

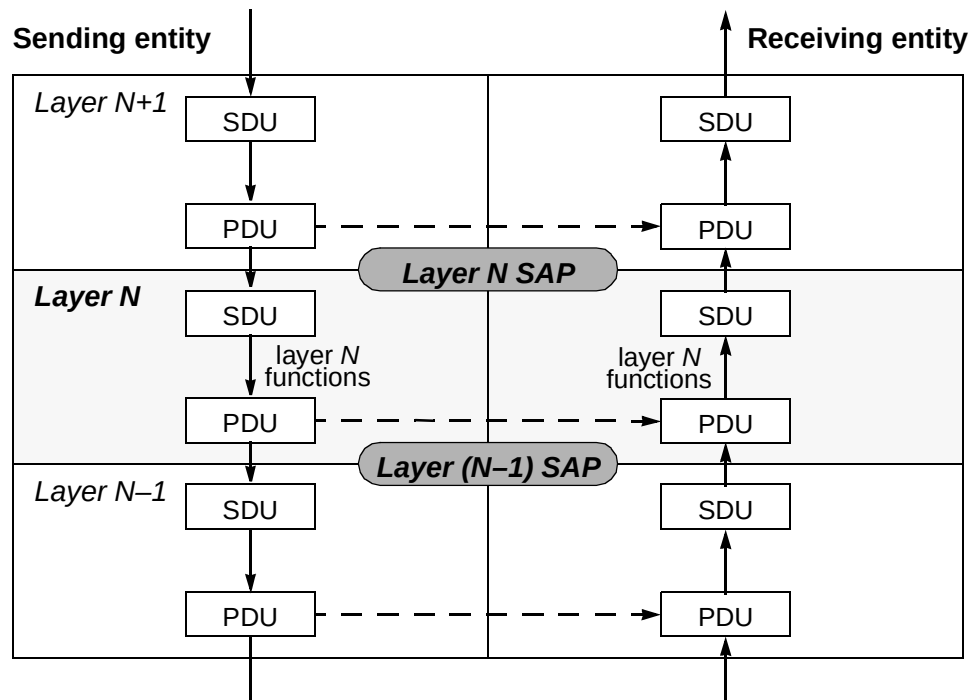


Figure 2—PDU and SDU in a protocol stack

3.47 security association (SA): The set of security information a base station (BS) and one or more of its client subscriber stations (SSs) share in order to support secure communications. This shared information includes traffic encryption keys (TEKs) and cipher block chaining (CBC) initialization vectors.

3.48 security association identifier (SAID): An identifier shared between the base station (BS) and subscriber station that uniquely identifies a security association (SA).

3.49 service access point (SAP): The point in a protocol stack where the services of a lower layer are available to its next higher layer.

3.50 service data unit (SDU): The data unit exchanged between two adjacent protocol layers. On the downward direction, it is the data unit received from the previous higher layer. On the upward direction, it is the data unit sent to the next higher layer (see Figure 2).

3.51 service flow (SF): A unidirectional flow of medium access control (MAC) service data units (SDUs) on a connection that is provided a particular Quality of Service (QoS).

3.52 service flow identifier (SFID): A 32-bit quantity that uniquely identifies a service flow to both the subscriber station and base station (BS).

3.53 SS Rx/Tx gap (SSRTG): The SSRTG is the minimum receive to transmit turnaround gap. SSRTG is measured from the time of the last sample of the received burst to the first sample of the transmitted burst, at the antenna port of the SS.

3.54 SS Tx/Rx gap (SSTTG): The SSTTG is the minimum transmit to receive turnaround gap. SSTTG is measured from the time of the last sample of the transmitted burst to the first sample of the received burst, at the antenna port of the SS.

3.55 subcarrier index: An index number identifying a particular used subcarrier in an orthogonal frequency division multiplexing (OFDM) or orthogonal frequency division multiple access (OFDMA) signal. Subcarrier indices are greater than or equal to zero.

3.56 subscriber station (SS): A generalized equipment set providing connectivity between subscriber equipment and a base station (BS).

3.57 time division duplex (TDD): A duplex scheme where uplink and downlink transmissions occur at different times but may share the same frequency.

3.58 time division multiple access (TDMA) burst: A contiguous portion of the uplink or downlink using PHY parameters, determined by the Downlink Interval Usage Code (DIUC) or Uplink Interval Usage Code (UIUC), that remain constant for the duration of the burst. TDMA bursts are separated by preambles and are separated by gaps in transmission if subsequent bursts are from different transmitters.

3.59 time division multiplexing (TDM) burst: A contiguous portion of a TDM data stream using PHY parameters, determined by the Downlink Interval Usage Code (DIUC), that remain constant for the duration of the burst. TDM bursts are not separated by gaps or preambles.

3.60 transport connection: A connection used to transport user data.

3.61 transport connection identifier: A unique identifier taken from the CID address space that uniquely identifies the transport connection.

3.62 turbo decoding: Iterative decoding, using soft inputs and soft outputs.

3.63 transmit/receive transition gap (TTG): A gap between the downlink burst and the subsequent uplink burst in a time division duplex (TDD) transceiver. This gap allows time for the base station (BS) to switch from transmit to receive mode and SSs to switch from receive to transmit mode. During this gap, the BS and SS are not transmitting modulated data but simply allowing the BS transmitter carrier to ramp down, the transmit/receive (Tx/Rx) antenna switch to actuate, and the BS receiver section to activate. Not applicable for FDD systems.

3.64 type/length/value (TLV): A formatting scheme that adds a tag to each transmitted parameter containing the parameter type (and implicitly its encoding rules) and the length of the encoded parameter.

3.65 uplink: The direction from a subscriber station to the base station (BS).

3.66 uplink channel descriptor (UCD): A medium access control message that describes the PHY characteristics of an uplink.

3.67 uplink interval usage code (UIUC): An interval usage code specific to an uplink.

3.68 uplink map (UL-MAP): A set of information that defines the entire access for a scheduling interval.

3.69 user data: PDUs of any protocol above a Service Specific Convergence Sublayer received over the CS SAP.

3.70 wireless access: End-user radio connection(s) to core networks.

