INTERNATIONAL STANDARD

ISO/IEC/ IEEE 8802-22

First edition
2015-05-01

Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements —

Part 22: Cognitive Wireless RAN Medium Access Control (MCA) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Réseaux locaux et métropolitains — Exigences spécifiques —

Partie 22: Titre de partie

Reference number
ISO/IEC/IEEE 8802-22:2015(E)

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
Case postale 56
CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
E-mail inmail@iec.ch
Web www.iec.ch

Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York
NY 10016-5997, USA
E-mail stds.ipr@ieee.org
Web www.ieee.org

Published in Switzerland

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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.

The main task of ISO/IEC JTC 1 is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is called to the possibility that implementation of this standard may require the 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. ISO/IEEE is not responsible for identifying essential patents or patent claims for which a license may be required, for conducting inquiries into the legal validity or scope of patents or patent claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance or a Patent Statement and Licensing Declaration Form, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from ISO or the IEEE Standards Association.

ISO/IEC/IEEE 8802-22 was prepared by the LAN/MAN of the IEEE Computer Society (as IEEE 802.22-2011). It was adopted by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems,* in parallel with its approval by the ISO/IEC national bodies, under the “fast-track procedure” defined in the Partner Standards Development Organization cooperation agreement between ISO and IEEE. IEEE is responsible for the maintenance of this document with participation and input from ISO/IEC national bodies.

ISO/IEC/IEEE 8802 consists of the following parts, under the general title *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements*

— *Part 1: Overview of Local Area Network Standards*

— *Part 2: Logical link control*

— *Part 5: Token ring access method and physical layer specifications*

— *Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications*

— *Part 1X: Port-based network access control*

— *Part 1AB: Station and media access control connectivity discovery*

— *Part 1AE: Media access control (MAC) security*

— *Part 1AR: Secure device identity*

— *Part 1AS: Timing and synchronization for time-sensitive applications in bridged local area networks*

— *Part 15-4: Wireless medium access control (MAC) and physical layer (PHY) specifications for low-rate wireless personal area networks (WPANs)*

Abstract: This standard specifies the air interface, including the cognitive medium access control layer (MAC) and physical layer (PHY), of point-to-multipoint wireless regional area networks comprised of a professional fixed base station with fixed and portable user terminals operating in the VHF/UHF TV broadcast bands between 54 MHz to 862 MHz.
Keywords: broadband wireless access network, cognitive radio, fixed user terminals, IEEE 802.22, portable user terminals, radio spectrum sensing, regional area network, WRAN standards

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

PDF: **ISBN 978-0-7381-6723-7** **STD97146**
Print: **ISBN 978-0-7381-6724-4** **STDPD97146**

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 or the soundness of any judgments 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, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, 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 his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

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. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. 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. Recommendations to change the status of a stabilized standard should include a rationale as to why a revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board

445 Hoes Lane

Piscataway, NJ 08854

USA

Introduction

This introduction is not part of IEEE Std 802.22-2011, IEEE Standard for Information Technology—Telecommunications and information exchange between systems—Wireless Regional Area Networks (WRAN)—Specific requirements—Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands.

This standard specifies the air interface of broadband wireless access (BWA) systems for fixed and portable user terminals supporting multimedia services. The medium access control layer (MAC) supports a point-to-multipoint architecture. The MAC is structured to support a physical layer (PHY) specification especially suited for operation in TV broadcast bands while avoiding interference to the incumbent broadcast services.

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at http://ieeexplore.ieee.org/xpl/standards.jsp, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at http://standards.ieee.org.

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.

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. 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, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses. Other Essential Patent Claims may exist for which a statement of assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this standard was submitted to the IEEE-SA for approval, the following voting members had participated in the IEEE P802.22 Working Group:

Apurva N. Mody, *Chair*

Gerald Chouinard, *Vice-chair and lead editor*

Kyu Hwan An
Chee Wei Ang
Kwok Shum Au
Mark Austin
Anuj Batra
John Benko
Robert Berger
Dagnachew Birru
Scott Blue
Monique Bourgeois Brown
Gregory Buchwald
Winston Caldwell
Ed Callaway
Dave Cavalcanti
Kiran Challapali
Soo-Young Chang
Remi Chayer
Shiuh Yuan Chen
Tao Chen
Jinxia Cheng
Aik Chindapol
InHwan Choi
Liwen Chu
Joon-Hwa Chun
Chris Clanton
Charles Cook
Charles Cooper
Carlos Cordeiro
Subir Das
W. Carl Day
Upkar Dhaliwal
Johnny Dixon
Peter Ecclesine
Charles Einolf
Michael Fischer
Wen Gao
Ingo Gaspard
Monisha Ghosh
Joanna Guenin
Jin Guo
Thomas Gurley
JaeSong Han
Hiroshi Harada
Ahren Hartman
Robert F. Heile
Anh Twan Hoang
Michael Hoghooghi
Mark Hopkins
Victor Hou
Wendong Hu
Junhong Hui
Sung Hyun Hwang
Duckdong Hwang
Tae-In Hyon
Yutaka Ikeda
Soon Ik Jeon
Baowei Ji
Ravi Kalavakunta
Jerome J. Kalke
Bub-Joo Kang
Mark Kelley
Ramon Khalona
Thomas Kiernan
Chang-Joo Kim
Kihong Kim
Sangbum Kim
HakSun Kim
Byoung-Jo Kim
Gwangzeen Ko
Tom Kolze
Bruce Kraemer
Steve Kuffner
Denis Kuwahara
Jeong Suk Lee
Chang-Ho Lee
Geunho Lee
Haeyoung Lee
Zhongding Lei
Wing Seng Leon
Barry Lewis
Lingjie Li
Ying-Chang Liang
Kyutae Lim
Euntack Lim

Jiezhen Lin
Jinnan Liu
Hang Liu
Michael Lynch
Steve Mace
David Magee
Ben Manny
David Mazzarese
Tony Morella
Peter Murray
Max Muterspaugh
Mullaguru Naidu
Paul Nikolich
John Notor
Moh Nouroozian
Seungmok Oh
Barry O'Mahony
Ashish Pandharipande
Juha Pihlaja
Patrick Pirat
Ron Porat
Jeff Poston
Jim Raab
Mohammad Rahman
Ranga K. Reddy
Ivan Reede
Edgar Reihl
Jon Walter Rosdahl
William Rose
Luis Escobar Sanz
Shigenobu Sasaki
Jeffrey Schiffer
Chris Seagren
Alireza Seyedi
Cheng Shan
Steve Shellhammer
Dave Silk
Kirk Skeba
Douglas Smith
Eli Sofer
Myung Sun Song
Srikathyayani Srikanteswara
Jayne Stancavage
Carl Stevenson
William Stiles
Hideki Tanaka
Clifford Tavares
Victor Tawil
Shawn Taylor
Paul Thompson
James Tomcik
JungSun Um
George Vlantis
Lei Wang
Jianfeng Wang
Yunbiao Wang
Tom Wasilewski
Alfred Wieczorek
Kelly Williams
Yuchun Wu
Shiquan Wu
Bo Xia
Changlong Xu
ShanShan Xu
Steve Yao
Yonghong Zeng
Jianwei Zhang
Xin Zhang

Major contributions to this standard were made by the following individuals:

Kwok Shum Au
John Benko
Winston Caldwell
Dave Cavalcanti
Soo-Young Chang
Gerald Chouinard
Carlos Cordeiro
Charles Einolf
Wen Gao
Monisha Ghosh
Thomas Gurley
Anh Twan Hoang
Wendong Hu
Sung Hyun Hwang
Jerome J. Kalke
Ramon Khalona
Thomas Kiernan
Kihong Kim
Sangbum Kim
Kak-Sun Kim
Gwangzeen Ko
Steve Kuffner
Zhongding Lei
Lingjie Li
Kyutae Lim
Jinnan Liu
David Mazzarese
Apurva N. Mody
Peter Murray
Mogh Nouroozian
Ashish Pandharipande
Patrick Pirat
Mohammad Rahman
Ranga K. Reddy
Ivan Reede
Shigenobu Sasaki
Cheng Shan
Steve Shellhammer
Eli Sofer
Carl Stevenson
Victor Tawil
JungSun Um
George Vlantis
Jianfeng Wang
Yonghong Zeng

The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Iwan Adhicandra
Thomas Alexander
Nobumitsu Amachi
Yafan An
Butch Anton
Franklin A. Antony
Danilo Antonelli
Kwok Shum Au
Tuncer Baykas
Maciej Borowka
Nancy Bravin
Vern Brethour
William Byrd
Meredith Caldwell
Radhakrishna Canchi
Juan Carreon
Kenneth Carrigan
Dave Cavalcanti
Gerald Chouinard
Keith Chow
Charles Cook
Todor Cooklev
Subir Das
Patrick Diamond
Thomas Dineen
Carlo Donati
Sourav Dutta
Peter Ecclesine
Richard Eckard
Charles Einolf
Shulan Feng
Stanislav Filin
Avraham Freedman
Monisha Ghosh
Pieter-Paul Giesberts
James Gilb
Gregory Gillooly
Reinhard Gloger
Patrick Gonia
Randall Groves
Thomas Gurley
C. Guy
Seishi Hanaoka
Robert F. Heile
Oliver Hoffmann
Wendong Hu
Yerang Hur
Sung Hyun Hwang
Akio Iso
Atsushi Ito
Raj Jain
Junghoon Jee
Bobby Jose
Tal Kaitz
Shinkyo Kaku
Masahiko Kaneko
Piotr Karocki
Richard Kennedy
Stuart J. Kerry
Kihong Kim
Yongbum Kim
Gwangzeen Ko
Bruce Kraemer
Joseph Kwak
Jeremy Landt
Zhongding Lei
Lingjie Li
Jan-Ray Liao
Arthur Light
Lu Liru
Daniel Lubar
Greg Luri
Michael Lynch
Elvis Maculuba
Syam Madanapalli
Wayne W Manges
Roger Marks
Jeffery Masters
Stephen Mccann
Michael Mcinnis
Steven Methley
Gary Michel
Apurva Mody
Jose Morales
Ronald Murias
Rick Murphy
Peter Murray
Juichi Nakada
Michael S. Newman
Nick S. A Nikjoo
Paul Nikolich
John Notor
Chris Osterloh
Satoshi Oyama
Riku Pirhonen
Clinton Powell
Venkatesha Prasad
Mohammad Rahman
Ranga K. Reddy
Ivan Reede
Alex Reznik
Maximilian Riegel
Robert Robinson
Benjamin Rolfe
William Rose
Herbert Ruck
Randall Safier
Shigenobu Sasaki
Naotaka Sato
Ryo Sawai
Bartien Sayogo
Matthew Sherman
Gil Shultz
Kapil Sood
Amjad Soomro
Chad Spooner
Thomas Starai
Rene Struik
Walter Struppler
Mark Sturza
Alourdes Sully
Chin-Sean Sum
Jun Ichi Takada
Victor Tawil
Ha Nguyen Tran
Mark-Rene Uchida
JungSun Um
Anna Urra
Dmitri Varsanofiev
Prabodh Varshney
Jane Verner
George Vlantis
Jianfeng Wang
Hung-Yu Wei
Alfred Wieczorek
Akira Yamaguchi
Oren Yuen
Janusz Zalewski
Xin Zhang

When the IEEE-SA Standards Board approved this on 16 June 2011, it had the following membership:

Richard H. Hulett, *Chair*
John Kulick, *Vice Chair*
Robert M. Grow, *Past Chair*
Judith Gorman, *Secretary*

Masayuki Ariyoshi
William Bartley
Ted Burse
Clint Chaplin
Wael Diab
Jean-Philippe Faure
Alexander Gelman
Paul Houzé
Jim Hughes
Joseph L. Koepfinger*
David J. Law
Thomas Lee
Hung Ling
Oleg Logvinov
Ted Olsen
Gary Robinson
Jon Walter Rosdahl
Sam Sciacca
Mike Seavey
Curtis Siller
Phil Winston
Howard L. Wolfman
Don Wright

*Member Emeritus

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

Satish Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Patricia Gerdon
IEEE Standards Program Manager, Document Development

Catherine Berger
IEEE Standards Project Editor

Contents

IEEE Standard for Information Technology—Telecommunications and information exchange between systems Wireless Regional Area Networks (WRAN)—Specific requirements

Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands

1. Overview

1.1 Scope

This standard specifies the air interface, including the cognitive medium access control layer (MAC) and physical layer (PHY), of point-to-multipoint wireless regional area networks comprised of a professional fixed base station with fixed and portable user terminals operating in the VHF/UHF TV broadcast bands between 54 MHz to 862 MHz.

1.2 Purpose

This standard is intended to enable deployment of interoperable IEEE 802® multivendor wireless regional area network products, to facilitate competition in broadband access by providing alternatives to wireline broadband access and extending the deployability of such systems into diverse geographic areas, including sparsely populated rural areas, while preventing harmful interference to incumbent licensed services in the TV broadcast bands.

1.3 Reference application

The Wireless Regional Area Networks (WRANs) for which this standard has been developed are expected to operate primarily in low population density areas in order to provide broadband access to data networks. The WRAN systems will use vacant channels in the VHF and UHF bands allocated to the Television Broadcasting Service in the frequency range between 54 MHz and 862 MHz while avoiding interference to the broadcast incumbents in these bands. A typical application can be the coverage of the rural area around a village, as illustrated in Figure 1, within a radius of 10 km to 30 km from the base station depending on its EIRP and antenna height. The MAC can also accommodate user terminals located as far as 100 km with proper scheduling of the traffic in the frame when exceptional RF signal propagation conditions are present. With the PHY implemented in this standard, WRAN systems can cover up to a radius of 30 km without special scheduling.

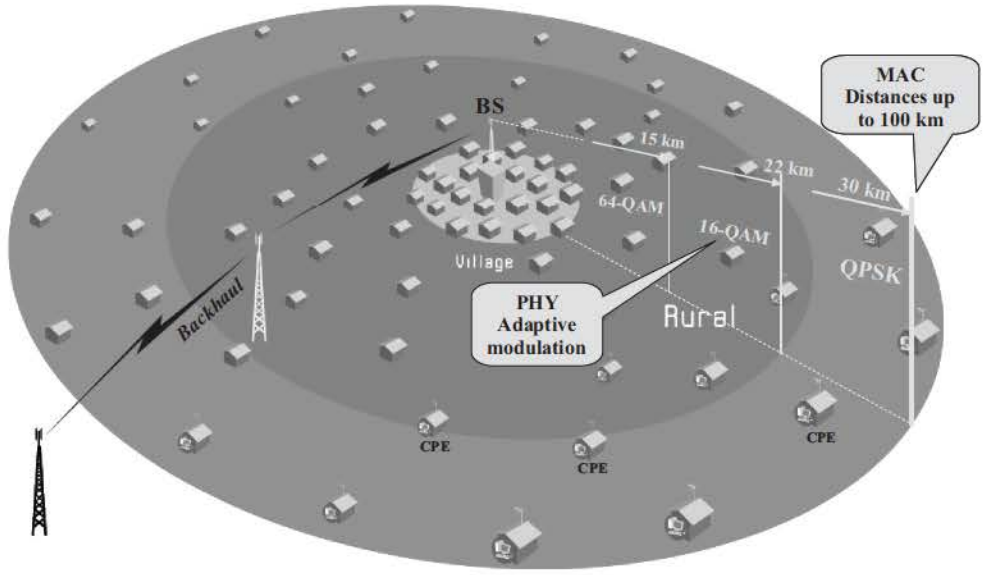

Figure 1 — An IEEE 802.22 WRAN cell with a base station and user terminals

A base station (BS) complying with this standard shall be able to provide high-speed Internet service for up to 512 fixed or portable customer premise equipment (CPE) devices or groups of devices within its coverage area assuming different quality of service (QoS) requirements for various CPEs, while meeting the regulatory requirements for protection of the incumbents.

The standard includes cognitive radio techniques to mitigate interference to incumbents, including geolocation capability, provision to access a database of incumbent services, and spectrum-sensing technology to detect the presence of incumbent services, other WRAN systems, and IEEE 802.22.1 wireless beacons.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. At the time of publication, the editions indicated were valid. All standards and specifications are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the references listed below.

ANSI X9.62-2005, Public Key Cryptography for the Financial Services Industry: The Elliptic Curve Digital Signature Algorithm (ECDSA), November 2005.[1]

ANSI X9.63-2001, Public Key Cryptography for the Financial Services Industry: Key Agreement and Key Transport Using Elliptic Curve Cryptography, November 2001.

IEEE Std 802®-2001, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.[2, 3]

IEEE Std 802.16™-2009, IEEE Standard for Local and Metropolitan Area Networks—Part 16: Air Interface for Broadband Wireless Access Systems.

IEEE Std 802.22.1™-2010, IEEE Standard for Local and metropolitan area networks—Part 22.1: Methods to Enhance Protection of Low-Power, Licensed Device Operation in the TV Broadcast Bands from Harmful Interference from License-Exempt Devices Operating in those Bands.

FIPS 180-3, Secure Hash Standard (SHS), October 2008.[4]

FIPS 186-3, Digital Signature Standard (DSS), June 2009.

FIPS 197, Advanced Encryption Standard, November 2001.

IETF RFC 2437, PKCS #1: RSA Cryptography Specification Version 2.0, October 1998.[5]

IETF RFC 2578, "Structure of Management Information Version 2 (SMIv2)," K. McCloghrie, D. Perkins, J. Schoenwaelder, J. Case, M. Rose, S. Waldbusser, April 1999.

IETF RFC 2758, "Definitions of Managed Objects for Service Level Agreements Performance Monitoring," K. White, February 2000.

IETF RFC 3279, Algorithms and Identifiers for the Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile, April 2002.

IETF RFC 4492, Elliptic Curve Crytopgraphy (ECC) for Transport Layer Security (TLS), May 2006.

IETF RFC 5216, The EAP-TLS Authentical Protocol, March 2008.

IETF RFC 5246, The Transport Layer Security (TLS) Protocol Version 1.2, August 2008.

---

[1] ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).
[2] IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).
[3] The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.
[4] FIPS publications are available from the National Technical Information Service (NTIS), U. S. Dept. of Commerce, 5285 Port Royal Rd., Springfield, VA 22161 (http://www.ntis.org/).
[5] Internet Requests for Comments (RFCs) are available on the World Wide Web at the following ftp site: venera.isi.edu; logon: anony¬mous; password: user's e-mail address; directory: in-inotes.

IETF RFC 5280, Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile, May 2008.

IETF RFC 5281, Extensible Authentication Protocol Tunneled Transport Layer Security Authenticated Protocol Version 0 (EAP-TTLSv0), August 2008.

IETF RFC 5649, Advanced Encryption Standard (AES) Key Wrap Algorithm with Padding, August 2009.

NIST Special Publication 800-38D, Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC, November 2007.[6]

NMEA 0183, Interface Standard of the National Marine Electronics Association, Version 4.00 http://www.nmea.org/content/nmea_standards/nmea_083_v_400.asp.

Radio Regulations, International Telecommunications Union, Geneva, Switzerland, Edition of 2008.

SEC 4, Standards for Efficient Cryptography Group (SECG)—SEC 4: Elliptic Curve Qu-Vanstone Implicit Certificate Scheme (ECQV) Working Draft, March 9, 2011, http://www.secg.org/download/aid-785/sec4-0.97.pdf.[7]

Trusted Computing Group, "TPM Main Specification Level 2 Version 1.2 (Revision 103)—Part 1—Design Principles," July 2007, http://www.trustedcomputinggroup.org/files/resource_files/ACD19914-1D09-3519-ADA64741A1A15795/mainP1DPrev103.zip.

Trusted Computing Group, "TPM Main Specification Level 2 Version 1.2 (Revision 103) —Part 2— Structures of the TPM," October 2006, http://www.trustedcomputinggroup.org/files/resource_files/8D3D6571-1D09-3519-AD22EA2911D4E9D0/mainP2Structrev103.pdf.

Trusted Computing Group, "TPM Main Specification Level 2 Version 1.2 (Revision 103)—Part 3— Commands," October 2006, http://www.trustedcomputinggroup.org/files/static_page_files/ACD28F6C-1D09-3519-AD210DC2597F1E4C/mainP3Commandsrev103.pdf.

U.S. FCC, ET Docket 08-260, "Second Report and Order and Memorandum Opinion and Order in the Matter of Unlicensed Operation in the TV Broadcast Bands," November 14, 2008.

U.S. FCC, ET Docket 10-174, "Second Memorandum Opinion and Order in the Matter of Unlicensed Operation in the TV Broadcast Bands," September 23, 2010.

[6] NIST SP 800-38D can be found at http://csrc.nist.gov/publications/nistpubs/800-38D/SP-800-38D.pdf.

[7] At the time this standard published, SEC 4 was still in draft form. The draft can be found at http://www.secg.org/. Alternately, users may contact the IEEE to obtain this draft.