

IEEE Standard for Ethernet

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
SA

IEEE Std 802.3™-2018
(Revision of
IEEE Std 802.3-2015)

IEEE Std 802.3™-2018
(Revision of
IEEE Std 802.3-2015)

IEEE Standard for Ethernet

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 14 June 2018
IEEE-SA Standards Board

Currently in preview, click buy full version

Abstract: Ethernet local area network operation is specified for selected speeds of operation from 1 Mb/s to 400 Gb/s using a common media access control (MAC) specification and management information base (MIB). The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) MAC protocol specifies shared medium (half duplex) operation, as well as full duplex operation. Speed specific Media Independent Interfaces (MIIs) allow use of selected Physical Layer devices (PHY) for operation over coaxial, twisted pair or fiber optic cables, or electrical backplanes. System considerations for multisegment shared access networks describe the use of Repeaters that are defined for operational speeds up to 1000 Mb/s. Local Area Network (LAN) operation is supported at all speeds. Other specified capabilities include: various PHY types for access networks, PHYs suitable for metropolitan area network applications, and the provision of power over selected twisted pair PHY types.

Keywords: 2.5 Gigabit Ethernet; 5 Gigabit Ethernet; 10 Gigabit Ethernet; 25 Gigabit Ethernet; 40 Gigabit Ethernet; 100 Gigabit Ethernet; 200 Gigabit Ethernet; 400 Gigabit Ethernet; attachment unit interface; AUI; Auto-Negotiation; Backplane Ethernet; data processing; DTE Power in the MDI; Energy Efficient Ethernet; EPoC; EPON; EPON Protocol over Coax; Ethernet; Ethernet in the First Mile; Ethernet passive optical network; express traffic; Fast Ethernet; Gigabit Ethernet; IEEE 802.3™; information exchange; LAN; local area network; management; MDI; media independent interface; media independent interface; MIB; MII; MPMC; multi-point MAC control; PCS; PHY; physical coding sublayer; Physical Layer; physical medium attachment; physical medium dependent; PMA; PMD; PoDL; Power over Data Lines; Power over Ethernet; reconciliation sublayer; repeater; RS; type field; VLAN tag

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

Copyright © 2018 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 31 August 2018. Printed in the United States of America.

IEEE and 02 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-1-5044-5090-4 STD23246
Print: ISBN 978-1-5044-5091-1 STDPD23246

IEEE prohibits discrimination, harassment and bullying.
For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>
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.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed through scientific, academic, and industry-based technical working groups. Volunteers in IEEE working groups are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, 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.

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers and users of IEEE Standards documents are responsible for determining and complying with an appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. 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.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own 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.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of 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 of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and its members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document 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

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted 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 these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, 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.

Updating of IEEE Standards documents

Users of IEEE Standards documents 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. A current 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.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, 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 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-SA Website at <http://ieeexplore.ieee.org/xpl/standards.jsp> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

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 by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the holder is willing or unwilling to grant licenses under patent 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.

Essential Patent Claims may exist for which a Letter 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

The following individuals were officers and members of the IEEE 802.3 working group at the beginning of the IEEE 802.3cj working group ballot.

David J. Law, IEEE 802.3 Working Group Chair
Adam Healey, IEEE 802.3 Working Group Vice-Chair
Pete Anslow, IEEE 802.3 Working Group Secretary
Steven B. Carlson, IEEE 802.3 Working Group Executive Secretary
Valerie Maguire, IEEE 802.3 Working Group Treasurer

Adam Healey, IEEE P802.3 (IEEE 802.3cj) Task Force Chair and Editor-in-Chief
Pete Anslow, IEEE P802.3 (IEEE 802.3cj) Task Force Section Editor
Marek Hajduczenia, IEEE P802.3 (IEEE 802.3cj) Task Force Section Editor

Historical participants

The following individuals participated in the IEEE 802.3 working group during various stages of the standard's development. Since the initial publication, many IEEE standards have added functionality or provided updates to material included in this standard. Included is a historical list of participants who have dedicated their valuable time, energy, and knowledge to the creation of this material:

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3-1985, Original 10 Mb/s standard, MAC, PLS, AUI, 10BASE5	23 June 1983	Donald C. Loughry, Working Group Chair
IEEE Std 802.3b-1985 (Clause 11), 10 Mb/s Broadband MAU, 10BROAD36	19 September 1985	Donald C. Loughry, Working Group Chair Menachem Abraham, Task Force Chair
IEEE Std 802.3a-1988 (Clause 10), 10 Mb/s MAU 10BASE2	15 November 1985	Donald C. Loughry, Working Group Chair Alan Flatman, Task Force Chair
IEEE Std 802.3c-1985 (9.1–9.8), 10 Mb/s Baseband Repeater	12 December 1985	Donald C. Loughry, Working Group Chair Geoffrey O. Thompson, Task Force Chair
IEEE Std 802.3e-1987 (Clause 12), 1 Mb/s MAU and Hub 1BASE5	11 June 1987	Donald C. Loughry, Working Group Chair Robert Galin, Task Force Chair
IEEE Std 802.3d-1987 (9.9), 10 Mb/s Fiber MAU, 10FBROAD36	10 December 1987	Donald C. Loughry, Working Group Chair Steven Moustakas, Task Force Chair
IEEE Std 802.3f-1990 (Clause 5), 10 Mb/s Layer Management, 10BASE-T	28 September 1990	Donald C. Loughry, Working Group Chair Andy J. Luque, Task Force Chair
IEEE Std 802.3i-1990 (Clauses 13 and 14), 10 Mb/s UTP MAU, 10BASE-T	28 September 1990	Donald C. Loughry, Working Group Chair Patricia Thaler, Task Force Chair (initial) Richard Anderson, Task Force Chair (final)
IEEE Std 802.3k-1993 (Clause 19), 10 Mb/s Layer Management, Repeaters	17 September 1992	Patricia Thaler, Working Group Chair Joseph S. Skorupa, Task Force Chair Geoffrey O. Thompson, Vice Chair and Editor
IEEE Std 802.3l-1992 (14.10), 10 Mb/s PICS Proforma 10BASE-T MAU	17 September 1992	Patricia Thaler, Working Group Chair Mike Armstrong, Task Force Chair and Editor Paul Nikolich, Vice Chair William Randle, Editorial Coordinator

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3p-1993 (Clause 20), Management, 10 Mb/s Integrated MAUs	17 June 1993	Patricia Thaler , <i>Working Group Chair</i> Joseph S. Skorupa , <i>Task Force Chair</i> Geoffrey O. Thompson , <i>Vice Chair and Editor</i>
IEEE Std 802.3q-1993 (Clause 5), 10 Mb/s Layer Management, GDMO Format	17 June 1993)	Patricia Thaler , <i>Working Group Chair</i> Joseph S. Skorupa , <i>Task Force Chair</i> Geoffrey O. Thompson , <i>Vice Chair and Editor</i>
IEEE Std 802.3j-1993 (Clauses 15–18), 10 Mb/s Fiber MAUs 10BASE-FP, 10BASE-FB, and 10BASE-FL	15 September 1993	Patricia Thaler , <i>Working Group Chair</i> Keith Amundsen , <i>Task Force Chair (initial)</i> Frederick Scholl , <i>Task Force Chair (final)</i> Michael E. Lee , <i>Technical Editor</i>
IEEE Std 802.3t-1995, 120 Ω informative annex to 10BASE-T	14 June 1995	Geoffrey O. Thompson , <i>Working Group Chair</i> Jacques Christ , <i>Task Force Chair</i>
IEEE Std 802.3u-1995 (Clauses 21–30), Type 100BASE-T MAC parameters, Physical Layer, MAUs, and Repeater for 100 Mb/s Operation	14 June 1995	Geoffrey O. Thompson , <i>Working Group Chair</i> Peter Tarrant , <i>Task Force Chair (Phase 1)</i> Howard Frazier , <i>Task Force Chair (Phase 2)</i> Paul Sherer , <i>Task Force Editor-in-Chief (Phase 1)</i> Howard Johnson , <i>Task Force Editor-in-Chief (Phase 2)</i>
IEEE Std 802.3m-1995, Maintenance 2	21 September 1995	Patricia Thaler , <i>Working Group Chair</i> Gary Robinson , <i>Maintenance Chair</i>
IEEE Std 802.3n-1995, Maintenance 3	21 September 1995	Patricia Thaler , <i>Working Group Chair</i> Gary Robinson , <i>Maintenance Chair</i>
IEEE Std 802.3s-1995, Maintenance 4	21 September 1995	Geoffrey O. Thompson , <i>Working Group Chair</i> Gary Robinson , <i>Maintenance Chair</i>
IEEE Std 802.3v-1995, 150 Ω informative annex to 10BASE-T	12 December 1995	Geoffrey O. Thompson , <i>Working Group Chair</i> Larry Nicholson , <i>Task Force Chair</i>
IEEE Std 802.3r-1996 (8.8), Type 10BASE5 Medium Attachment Unit PICS proforma	29 July 1996	Patricia Thaler , <i>Working Group Chair</i> László Juhász , <i>Task Force Chair</i> William Randle , <i>Task Force Editor</i>
IEEE Std 802.3x-1997 and IEEE Std 802.3y-1997 (Revisions to IEEE Std 802.3, Clauses 31 and 32), Full-Duplex Operation and Type 100BASE-T2	20 March 1997	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Rich Seifert , <i>Task Force Chair and Editor (802.3x)</i> J. Scott Carter , <i>Task Force Chair (802.3y)</i> Colin Mick , <i>Task Force Editor (802.3y)</i>
IEEE Std 802.3z-1998 (Clauses 34–39, 41–42), Type 1000BASE-X MAC Parameters, Physical Layer, Repeater and Management Parameters for 1000 Mb/s Operation	25 June 1998	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Howard M. Frazier, Jr. , <i>Task Force Chair</i> Howard W. Johnson , <i>Task Force Editor</i>
IEEE Std 802.3aa-1998, Maintenance 5	25 June 1998	Geoffrey O. Thompson , <i>Working Group Chair</i> Colin Mick , <i>Task Force Editor</i>
IEEE Std 802.3ac-1998, Frame Extensions for Virtual Bridged Local Area Network (VLAN) Tagging on IEEE 802.3 Networks	16 September 1998	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Andy J. Luque , <i>Working Group Secretary</i> Ian Crayford , <i>Task Force Chair</i> Rich Seifert , <i>Task Force Editor</i>
IEEE Std 802.3ab-1999 (Clause 40), Physical Layer Parameters and Specifications for 1000 Mb/s Operation Over 4 Pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T	26 June 1999	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i> George Eisler , <i>Task Force Chair</i> Colin Mick , <i>Task Force Editor</i>

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3ad-2000 (Clause 43), Aggregation of Multiple Link Segments	30 March 2000	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i> Steven Haddock , <i>Task Force Chair</i> Tony Jeffree , <i>Task Force Co-Editor</i> Rich Seifert , <i>Task Force Co-Editor</i>
IEEE Std 802.3-2002 (IEEE 802.3ag, Maintenance 6, Revision of the base), Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications	14 January 2002	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i>
IEEE Std 802.3ae-2002, (Clauses 44–53) Media Access Control (MAC) Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation	13 June 2002	Geoffrey O. Thompson , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary</i> R. Jonathan Thatcher , <i>Task Force Chair</i> Stephen Haddock , <i>Task Force Vice Chair</i> Bradley J. Booth , <i>Task Force Editor</i>
IEEE Std 802.3af-2003, (Clause 33) Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI)	12 June 2003	Geoffrey O. Thompson , <i>Working Group Chair (Phase 1)</i> Robert M. Grow , <i>Working Group Chair (Phase 2)</i> David J. Law , <i>Working Group Vice Chair</i> Robert M. Grow , <i>Working Group Secretary (Phase 1)</i> Steven B. Carlson , <i>Working Group Secretary (Phase 2)</i> Steven B. Carlson , <i>Task Force Chair</i> Michael S. M. ... , <i>Task Force Editor (Phase 1)</i> John J. ... , <i>Task Force Editor (Phase 2)</i>
IEEE Std 802.3aj-2003, Maintenance 7	11 September 2003	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Chair</i> Steven B. Carlson , <i>Working Group Secretary</i> Catherine K. N. Berger , <i>Task Force Editor</i>
IEEE Std 802.3ak-2004, Physical Layer and Management Parameters for 10Gb/s Operation, Type 10GBASE-CX4	9 February 2004	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Steven B. Carlson , <i>Working Group Secretary</i> Daniel J. Dove , <i>Task Force Chair</i> Howard A. Baumer , <i>Task Force Editor</i>
IEEE Std 802.3ah-2004, Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks	6 April 2005	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Steven B. Carlson , <i>Working Group Secretary</i> Howard Frazier , <i>Task Force Chair</i> Wael W. Diab , <i>Task Force Editor-in-Chief</i> Hugh Barrass , <i>Task Force Vice-Chair</i>
IEEE Std 802.3-2005 (IEEE 802.3REVam, Revision of the base), Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications	9 June 2005	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Chair, Task Force Chief Editor</i> Wael W. Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i>
IEEE Std 802.3-2006, Physical Layer and Management Parameter for 10 Gb/s Operation, Type 10GBASE-T	8 June 2006	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair</i> Wael William Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Task Force Chair</i> Sanjay Kasturia , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3-2005/Cor 1-2006 (IEEE 802.3au), DTE Power via MDI Isolation corrigendum	8 June 2006	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Chair, and Task Force Editor</i> Wael W. Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i>

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3aq-2006, Physical Layer and Management Parameters for 10 Gb/s Operation, Type 10GBASE-LRM	15 September 2006	Robert M. Grow, Working Group Chair David J. Law, Working Group Vice Chair Wael William Diab, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary David G. Cunningham, Task Force Chair Nick Weiner, Task Force Editor
IEEE Std 802.3as-2006, Frame format extensions	15 September 2006	Robert M. Grow, Working Group Chair David J. Law, Working Group Vice Chair Wael William Diab, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary Kevin Q Daines, Task Force Chair Glenn W. Parsons, Task Force Editor
IEEE Std 802.3ap-2007, Ethernet Operation over Electrical Backplanes	22 March 2007	Robert M. Grow, Working Group Chair David J. Law, Working Group Vice-Chair Wael W. Diab, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary Bradley Booth, Working Group Treasurer Adam Healey, Task Force Chair Schelto vanDoorn, Task Force Editor-in-Chief (Phase 1) Ilango S. Ganga, Task Force Editor-in-Chief (Phase 2)
IEEE Std 802.3-2005/Cor 2-2007 (IEEE 802.3aw), 10GBASE-T corrigendum	7 June 2007	Robert M. Grow, Working Group Chair David J. Law, Working Group Vice Chair, Task Force Chair, and Task Force Editor Wael W. Diab, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary Bradley Booth, Working Group Treasurer
IEEE Std 802.3-2008 (IEEE 802.3ay), Maintenance #9 (Revision of the base), Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications	26 September 2008	Robert M. Grow, Working Group Chair David J. Law, Working Group Vice Chair, Task Force Chair, and Task Force Editor Wael William Diab, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary Bradley Booth, Working Group Treasurer
IEEE Std 802.3at-2009 Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements	11 September 2009	David J. Law, Working Group Chair Wael William Diab, Working Group Vice Chair Adam Healey, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary Bradley Booth, Working Group Treasurer Mike McCormack, Task Force Chair D. Matthew Landry, Task Force Chief Editor
IEEE Std 802.3av-2009 Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks	11 September 2009	David J. Law, Working Group Chair Wael William Diab, Working Group Vice Chair Adam Healey, Working Group Secretary Steven B. Carlson, Working Group Executive Secretary Bradley Booth, Working Group Treasurer Glen Kramer, Task Force Chair Duane Remein, Task Force Chief Editor
IEEE Std 802.3bc-2009 Ethernet Organizationally Specific Type, Length Variable (TLVs)	11 September 2009	David J. Law, Working Group Chair and Task Force Editor Wael W. Diab, Working Group Vice Chair and Task Force Chair Steven B. Carlson, Working Group Executive Secretary Adam Healey, Working Group Secretary Bradley Booth, Working Group Treasurer
IEEE Std 802.3-2008/Cor 1-2009 (IEEE 802.3bb) Pause Reaction Delay Corrigendum.	9 December 2009	David J. Law, Working Group Chair Wael William Diab, Working Group Vice-Chair Steven B. Carlson, Working Group Executive Secretary Adam Healey, Working Group Secretary Bradley Booth, Working Group Treasurer

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3ba Media Access Control Parameters, Physical Layers, and Management Parameters for 40 Gb/s and 100 Gb/s Operation	17 June 2010	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Adam Healey , <i>Working Group Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> John D'Ambrosia , <i>Task Force Chair</i> Ilango S. Ganga , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3az-2010 Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet	30 September 2010	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice Chair</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Adam Healey , <i>Working Group Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> Michael Bennett , <i>Task Force Chair</i> Sanjay Kasturia , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bg-2011 Physical Layer and Management Parameters for Serial 40 Gb/s Ethernet Operation Over Single-Mode Fiber	31 March 2011	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Mark Nowell , <i>Task Force Chair</i> Pete Anslow , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bf-2011 Media Access Control (MAC) Service Interface and Management Parameters to Support Time Synchronization Protocols	16 May 2011	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Steven B. Carlson , <i>Task Force Chair</i> Marek Hajduczenia , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bd-2011 MAC Control Frame for Priority-based Flow Control	16 June 2011	Tony Jeffree , <i>IEEE 802.1 Working Group Chair</i> Paul Congdon , <i>IEEE 802.1 Working Group Vice Chair</i> David J. Law , <i>IEEE 802.3 Working Group Chair</i> Wael W. Diab , <i>IEEE 802.3 Working Group Vice Chair</i> Pat Thaler , <i>Data Center Bridging Task Group Chair</i>
IEEE Std 802.3-2012 (IEEE 802.3ah), Maintenance #10 (Revision of the base), Standard for Ethernet	28 December 2012	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair, Task Force Chair, and Task Force Editor-in-Chief</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i>
IEEE Std 802.3bk-2013 Physical Layer Specifications and Management Parameters for Extended Ethernet Passive Optical Networks	23 August 2013	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair</i> Adam Healey , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Marek Hajduczenia , <i>Task Force Chair</i> Susumu Nishihara , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bj-2014 Physical Layer Specifications and Management Parameters for 100 Gb/s Operation Over Backplanes and Copper Cables	12 June 2014	David J. Law , <i>Working Group Chair</i> Wael William Diab , <i>Working Group Vice-Chair (initial)</i> Adam Healey , <i>Working Group Secretary, (initial), Task Force Editor-in-Chief (initial), Working Group Vice-Chair (final), and Task Force Chair (final)</i> Peter Anslow , <i>Working Group Secretary (final)</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> John D'Ambrosia , <i>Task Force Chair (initial)</i> Matthew Brown , <i>Task Force Editor-in-Chief (final)</i>
IEEE Std 802.3bm-2015 Physical Layer Specifications and Management Parameters for 40 Gb/s and 100 Gb/s Operation Over Fiber Optic Cables	16 February 2015	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary and Task Force Editor-in-Chief</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Dan Dove , <i>Task Force Chair</i> Kapil Shrikhande , <i>Task Force Vice-Chair</i>

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3-2015 (IEEE 802.3bx), Maintenance #11 (Revision of the base), Standard for Ethernet	3 September 2015	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair, Task Force Chair, and Task Force Editor-in-Chief</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i>
IEEE Std 802.3bw-2015 Physical Layer Specifications and Management Parameters for 100 Mb/s Operation over a Single Balanced Twisted Pair Cable (100BASE-T1)	26 October 2015	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary and Task Force Chair, Phase 2</i> Valerie Maguire , <i>Working Group Treasurer</i> Thomas Hogenmüller , <i>Task Force Chair, Phase 1</i> Mehmet Tazebay , <i>Task Force Vice-Chair</i> Curtis Donahue , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3by-2016 Media Access Control Parameters, Physical Layers, and Management Parameters for 25 Gb/s Operation	30 June 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Mark Nowell , <i>Task Force Chair</i> Matthew Brown , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bq-2016 Physical Layers and Management Parameters for 25 Gb/s and 40 Gb/s Operation, Types 25GBASE-T and 40GBASE-T	30 June 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> David Chalupsky , <i>Task Force Chair</i> George Zimmerman , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bp-2016 Physical Layer Specifications and Management Parameters for 1 Gb/s Operation over a Single Twisted-Pair Copper Cable	30 June 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary and Task Force Chair</i> Valerie Maguire , <i>Working Group Treasurer</i> Marek Hajduczenia , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3br-2016 Specification and Management Parameters for Interspersing Express Traffic	30 June 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Ludwig Winkel , <i>Task Force Chair</i> Patricia Thaler , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bn-2016 Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax	22 September 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Mark Laubach , <i>Task Force Chair</i> Duane Remein , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bz-2016 Media Access Control Parameters, Physical Layers, and Management Parameters for 2.5 Gb/s and 5 Gb/s Operation, Types 2.5GBASE-T and 5GBASE-T	22 September 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> David Chalupsky , <i>Task Force Chair</i> George Zimmerman , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3bu-2016 Physical Layer and Management Parameters for Power over Data Lines (PoDL) of Single Balanced Twisted-Pair Ethernet	7 December 2016	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Dave Dwelley , <i>Task Force Chair, Phase 1</i> Dan Dove , <i>Task Force Chair, Phase 2</i> Andy Gardner , <i>Task Force Editor-in-Chief</i>

IEEE Std 802.3 document	Date approved by IEEE	Working Group officers, Task Force Chair, and Task Force Editors as listed in the document
IEEE Std 802.3bv-2017 Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber	14 February 2017	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> Robert M. Grow , <i>Task Force Chair</i> Rubén Pérez-Aranda , <i>Task Force Editor-in-Chief</i>
IEEE Std 802.3-2015/Cor 1-2017 (IEEE 802.3ce) Multilane Timestamping	23 March 2017	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair, Task Force Chair, and Task Force Editor-in-Chief</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i>
IEEE Std 802.3bs-2017 Media Access Control Parameters, Physical Layers, and Management Parameters for 200 Gb/s and 400 Gb/s Operation	6 December 2017	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary and Task Force Editor-in-Chief</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> John D'Ambrosia , <i>Task Force Chair</i>
IEEE Std 802.3cc-2017 Physical Layer and Management Parameters for Serial 25 Gb/s Ethernet Operation Over Single-Mode Fiber	6 December 2017	David J. Law , <i>Working Group Chair</i> Adam Healey , <i>Working Group Vice-Chair</i> Pete Anslow , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Valerie Maguire , <i>Working Group Treasurer</i> David Lewis , <i>Task Force Chair</i> Kohichi R. Tamura , <i>Task Force Editor-in-Chief</i>

Ali Abaye	John Allen	Phil L. Arst	Hugh Barrass
Fazal Abbas	Zehavit Alon	Doug Artman	Bob Barrett
Ghani Abbas	Arne Alping	Venkat Arunarthi	Scott Barrick
John S. Abbott	Michael Altman	Jean-Pierre Astorg	Meir Bartur
Justin Abbott	Yehuda Alush	Mehran Ataee	Yoram Barzilai
Hamlet Abedmamoore	Dale Amason	Ilan Atias	Stephen Bates
Joe Abler	Karen Amavisca	Steve Augusta	Howard Baumer
Menachem Abraham	Andrew Ambrose	Phil Auld	Denis Beaudoin
David Abramson	Khaled Amer	Siamack Ayandeh	Michaël Beck
Shadi AbuGhazaleh	Nitish Amin	Kameron Azadet	Jonathan Beckwith
Martin Adams	Peerouz Amlashi	Joseph N. Babanezhad	Christian Beia
Luc Adriaenssens	Keith Amundsen	Oleksandr Babenko	Edward Beili
Don Aelmore	Ole Christian Andersen	Chet Babla	Alexei Beliaev
Puneet Agarwal	Arlan J. Anderson	Gerard E. Bachand	William Belknap
Akira Agata	Eric Anderson	Eric Baden	Eran Bello
Oscar Agazzi	Jon Anderson	Kwang-Hyun Baek	Yakov Belopolsky
John R. Agee	Paul Anderson	Amrik Bains	Randy J. Below
Nand Aggarwal	Richard Anderson	Guna Bala	Vincent Bemmell
Andrea Agnes	Stephen D. Anderson	R. V. Balakrishnam	Liav Ben-Artsi
Faisal Ahmad	Stephen J. Anderson	Koussalya Balasubramanian	Michael Bennett
Mohammad Ahmed	Tony Anderson	Vittal Balasubramanian	Richard Bennett
Paul Ahrens	Ralph Andersson	Andy Baldman	Miles Benson
Youichi Akasaka	Jack S. Andresen	Thananya Baldwin	Chris Bergey
Vish Akella	J. Michael Andrewartha	Keith Balmer	Sidney Berglund
Reza Alavi	Ali Angha	Mogens Cash Balsby	Ernest E. Bergmann
Alan Albrecht	Peter Anslow	Bruce Bandali	April Bergstrom
Keith Albright	Ekkehard Antz	Jaya Bandyopadhyay	David J. Berman
Don Alderrou	Ken-ichi Arai	Majid Barazande-Pour	Gary Bernstein
Jan Alexander	Bert Armijo	Ozdal Barkan	Roberto Bertoldi
Thomas Alexander	Mike Armstrong	Ian Barker	John L. Bestel
Abe Ali	Susie Armstrong	Eyal Barnea	Dave Bethune
Michel Allard	Brian Arnold	Barry Barnett	John Bevilacqua
Brad Allen	Lewis B. Aronson	Jim Barnette	Vipul Bhatt
David Allen	Simcha Aronson	David Barr	Sudeep Bhoja

Harmeet Bhugra	Jairo Bustos Heredia	Jin-Seek Choi	John Dallesasse
Jan Bialkowski	Thomas T. Butler	Rahul Chopra	John D'Ambrosia
James Binder	Adrian Butter	Joseph Chou	Nabil Damouny
Larry Birenbaum	Roy Bynum	Golam Choudhury	Rupert S. Dance
Jeff E. Bisberg	Ed Cady	Jacky Chow	Mark Darby
William Bliss	Luca Cafiero	Kuen Chow	Mike Darling
Michel Bohbot	Francesco Caggioni	Henry Choy	Yair Darshan
Mark Bohm	John Cagle	Chris Christ	Peter Dartnell
Mark Bohrer	Jeffrey C. Cain	Jacques Christ	Subrata Datta
Jean-Michel Bonnamy	Anthony Calbone	George Chu	John Davidson
Bradley J. Booth	Juan-Carlos Calderon	Keng Hua Chuang	David Davies
Paul Booth	Donald Caldwell	Hwan-Seok Chung	Edward Davis
Paul Bottorff	Maurice Caldwell	Yue-Der Chzh	Peter Dawe
Thomas J. Boucino	Richard Cam	Peter Cibula	Piers J. G. Dawe
Martin Bouda	Bob Campbell	Roy Cideciyan	Fred Dawson
Samuel Bourche	Peter Campbell	Albert Claessen	John De Andrea
David Bourque	Robert R. Campbell	Guss Claessen	Kathryn de Graaf
Gary Bourque	Luigi Canavese	G. J. Clancy	Gerald de Grace
Sidney Bouzaglo	James T. Carlo	Brice Clark	Michael de la Garrigue
Kirk Bovill	Craig Carlson	Susan Roden Clarke	Moshe De Leon
John Bowerman	Steven B. Carlson	George Claseman	Bernard O. Debbasch
Richard Bowers	Dan Carmine	Terry Cobb	Michael deBie
Edward Boyd	J. Martin Carroll	Michael Coden	Tom Debiec
Peter Bradshaw	J. Scott Carter	Kelly B. Coffey	John DeCramer
Al Braga	Clark Carty	Larry Cohen	Ian Dedic
Richard Brand	Patrick Casher	Christopher R. Cole	Joel Dedrick
Rudolf Brandner	Andrew Castellano	Doug Coleman	Steve Deffley
David Brandt	Ron Cates	Régis Colla	Dave Delaney
Ralf-Peter Braun	Jeffrey D. Catlin	Kevin Cone	Moshe De-Leon
Richard S. Brehove	Craig Chabot	Herbert V. Congdon	William Delveaux
Dirk Breuer	Geoffrey Chacon Simon	Paul Congdon	Ralph DeMent
Steve Brewer	Mandeep Chadha	Patrick Conlon	Joe DeNicholas
Robert F. Bridge	David Chalupsky	Don Connor	Tazio M. DeNicolo
Vince Bridgers	Edward Chang	Keith Conroy	Sanjay Desai
Dave Brier	Edward G. Chang	Robert Conte	Claudio Desanti
Andrew Brierley-Green	Edward S. Chang	Charles I. Cook	Peter Desaulniers
Rhett Brikovskis	Frank Chang	Ronald J. Cooper	Mark Devon
Charles Brill	Fuhlim Chang	Stephen Cooper	Sanjay Dhawan
Theodore Brillhart	Jacky Chang	Neil Coote	Chris Di Minico
Robert D. Brink	Justin Chang	Edward Cornejo	Wael William Diab
Paul Brooks	Kiwon Chang	Ronald Crane	Patrick Diamond
Rick Brooks	Luke Chang	George Cravens	Eric DiBiaso
Timothy Brophy	Samuel Chang	Ian Crayford	Erik Dickens
Alan M. Brown	Sun-Hyok Chang	John Creigh	John Dickinson
Benjamin Brown	Xin Chang	J. Francois Crepin	Bryan Dietz
Daniel J. Brown	Thomas Chantrell	Bill Cronin	John Dillard
Dave Brown	Howard Charney	Peter Cross	Daniel Dillow
David Brown	Chan Chen	Richard Cross	Christopher Diminico
Jack Brown	Chung-Jue Chen	Brian Cruikshank	Thomas J. Dineen
Kevin Brown	David Chen	Diego Crupnicoff	Zheming Ding
Matthew Brown	Jian Chen	Kai Cui	Sean Dingman
Suzy Brown	Xiaopeng Chen	David Cullerot	Thuyen Dinh
Thomas Brown	Zinan (Nan) Chen	Chris Cullin	Hans Peter Dittler
Phillip Brownlee	Linda Cheng	David G. Cunningham	Hamish Dobson
Brian Brunn	Weiyang Cheng	Joe Curcio	David W. Dolfi
Robert Brunner	Wheling Cheng	Robert A. Curtis	Curtis Donahue
Steve F. Buck	Kok-Wui Cheong	Simon Cushin	Mark Donhowe
Lisa Buckman	Giovanni Cherubini	Dariusz Dabiri	Elizabeth Donnay
Mark Bugg	Rao Cherukuri	Robert Dahlgren	Hank (H. N.) Dorris
Chris Bullock	Albert Chiang	Saleem Dahmouh	Daniel Dove
Juan Bulnes	David Chin	Eugene Dai	James Doyle
Bill Bunch	Hon Wah Chin	Shaoan Dai	Daniel S. Draper
James Burgess	Ahmad Chini	Fumio Daido	Scott Dredge
Scott Burton	Jae hun Cho	Bernard Daines	Brian Drever
Robert A. Busse	Francis Choi	Kevin Q Daines	Steve Dreyer

John Dring	Julien Fiere	Franz Goetz	Mogens Hansen
Michael Dudek	James Fife	Volker Goetzfried	Del Hanson
Marcus Duell	Dave Fifield	Adi Golbert	Onn Haran
Nick Duer	Norival Figueira	Glenn Golden	Hacene Hariti
Richard Dugan	Juan Figueroa	Moty Goldis	Guy Harkins
Raymond S. Duley	Robert G. Finch	Matthew Goldman	Milton C. Harper
Linda Dunbar	Norman Finn	Zhigang Gong	Doug Harshbarger
Joseph E. Dupuis	Farzin Firoozmand	Timothy D. Goodman	G. R. Hartley
Marc R. Dupuis	David Fischer	Steve Goody	Tomohiro Hashimoto
David Dwelley	Thomas Fischer	Steven Gorshe	Lloyd Hasley
J. Craig Easley	John Fitzgerald	Sanjay Goswami	Marwan Hassoun
Paul Eastman	Alan Flatman	Jens Gottron	Mehdi Hatamian
Jeff Ebeling	Steve Flickinger	James Graba	W. B. Hatfield
Peter Ecclesine	Norbert Folkens	Steffen Graber	Tom Hatley
Edward J. Eckert	Christian G. Foltling	Rich Graham	Stephen Haughey
Clay Eddings	Harry Forbes	Russ Granger	Haw Ming Haung
Phil Edholm	Brian Ford	Eric B. Grann	Akinori Hayakawa
Tom Edsall	Brian Franchuk	Tom Grasmehr	Takehiro Hayashi
Dean Edwards	Richard Fransen	Olaf Grau	Kirk Hayden
Gareth Edwards	Roger Fraser	C. Thomas Gray	Claude Hayek
Frank J. Effenberger	Howard M. Frazier	Eric Gray	Robert Hays
John Egan	Robert Frazier	Larry Green	Carl G. Hayssen
Herman Eiliya	Ladd Freitag	Martin Green	Asif Hazarika
George Eisler	Ken Friedenbach	Jonathan E. Greenlaw	Adam Healey
Cornelia Eitel	Matthias Fritsche	Bryan Gregory	Jeffrey Heath
Hesham Elbakoury	Scott Fritz	Richard Grenier	Gaby Hecht
Martin Elhøj	Krister Frojdh	Karanvir Grewal	Jim Heckroth
David Elie-Dit-Cosaque	Richard Froke	Michael R. Grimwood	Chris Heegard
Kevin M. Elliff	Ingrid Fromm	Edward Grivna	Gopal Hegde
Michael Elswick	Richard Frosch	Robert M. Grow	Rajmohan Hegde
Paul "Skip" Ely	Hongyan Fu	Robert Gudz	Wolfgang Heidasch
Richard Ely	Judy Fuess	Andreas Gulle	Ronen Heldman
Kent English	Yukihiro Fujimoto	Karunakar Gulukota	David Helster
Gregory Ennis	Atsuhisa Fukuoka	Ajay Gummalla	Ariel Hendel
Gianfranco Enrico	John Fuller	Richard Gumpertz	Itzik Hendel
Brian S. Ensign	Darrell Furlong	Sudhakar Gundubogula	Susan Hennenfent
Simone Erba	Michael Furlong	Craig Gunther	Carl Herman
Norman Erbacher	Mel Gable	Bin Guo	Ken Herrity
Tooraj Esmailian	Robert D. Gaglianella	Yong Guo	Pierre Herve
Nick Esser	Justin Gaither	Sandeep Gupta	David Hess
Daniel Essig	Robert Galin	Sudhir Gupta	James H. Hesson
David Estes	Sharad Gandhi	Tanmay Gupta	John Hickey
Judith Estrin	Tom Gandy	Mitch Gusat	Chip Hicks
Jim Everitt	Ilango S. Ganga	Jonas Gustafsson	Yasuo Hidaka
Steve Evitts	Robin Gangopadhya	Mark Gustlin	Tetsuya Higuchi
John F. Ewen	Xiao Ming Gao	Paul J. Gyugyi	Olli-Pekka Hiironen
Richard Fabbri	Andrea Garavaglia	Russ Gyurek	John Hill
Siavash Fallahi	Clete Gardenhour	Steven Haas	Tricia Hill
Josef Faller	Andrew Gardner	Michael Hackert	Sammy Hindi
Sabina Fanfoni	Mike Gardner	Tariq Haddad	William Hingston
Arash Farhoodfar	Geoffrey M. Garner	Stephen Haddock	Henry Hinrichs
Ramin Farjad	Claude Gauthier	Atikem Haile-Mariam	David Hinzl
Janos Farkas	Denton Gentry	Marek Hajduczenia	Riu Hirai
Rebecca Farley	John George	Sharam Hakimi	Kengo Hirano
Donald Fedyk	Floyd H. Gerhardt	Clive Hallatt	Ryan Hirth
Eldon Feist	Keith Gerhardt	Hiroshi Hamano	Charlie Hochstedler
Daniel Feldman	Mark Gerhold	Farid Hamidy	Charles Hoffner
Shahar Feldman	Anoop Ghanwani	Kevin Hamilton	Jay Hoge
Dongning Feng	Ali Ghiasi	Bernie Hammond	Thomas Hogenmueller
Feifei (Felix) Feng	Sajol Ghoshal	Benny Hanigal	David Hoglund
Severn Ferdun	Dimitrios Giannakopoulos	Greg Hankins	Brian Holden
Jean-Loup Ferrant	Giorgio Giaretta	Charaf Hanna	Bryan Hoover
Mark Feuertraeter	Pat Gilliland	G. Y. Hanna	Gregory Hopkins
German Feyh	George Ginis	Chris Hansen	Keith Hopwood
Jens Fiedler	Joel Goergen	Johannes Hansen	Rita Horner

Steven E. Horowitz	Michael D. Johas Teener	Tuan Khuu	C Kumar
Bernd Hormmeyer	Richard John	Gary Kidwell	Pankaj Kumar
Michael Horvat	Donald C. Johnson	Keti Kilcrease	Vinod Kumar
Yoshifumi Hotta	Howard Johnson	Bob Kilgore	Ted Kummert
Victor Hou	John Johnson	Chan Kim	Aniruddha Kundu
Stanley Hronik	Mize Johnson	Dae Young Kim	David Kung
Henry Hsiaw	Scott Johnson	Jin H. Kim	Albert Kuo
Jacob Hsu	Cristopher Jolly	Seung-Hwan Kim	Jeffrey Kuo
Rui Hua	Chad Jones	Su-Hyung Kim	David Kurcharczyk
Fred Huang	Nick Jones	Yongbum Kim	Christopher Kurker
Liang-wei Huang	Peter Jones	Eric Kimber	Yasuyuki Kuroda
Xi Huang	William W. Jones	Mark Kimber	Hidetsune Kurokawa
Xingang Huang	Ulf Jonsson	Myles Kimmitt	Toshihiko Kusano
Charles Hudson	Bheom-Soon Joo	Marc Kimpe	Gerard Kuyt
Chuck Hudson	Seong-Soon Joo	Mitsunobu Kimura	Bengt Kvist
Todd Hudson	Anthony Jordan	John Kincaid	Bruce Kwan
Michael Hughes	Thomas K. Jørgensen	Bill Kind	Alan Kwentus
Walter K. Hurwitz	Antony Joseph	Jonathan P. King	Lee LaBarre
Dean Huumala	Juan Jover	Neal King	Adel Henry Labib
Thong Huynh	Imre Juhász	Brian Kinnard	Richard LaCerte
Yasuhiro Hyakutake	Jason Julyan	Scott G. Kipp	Hans Lackner
David W. Hyer	Kwi-Yung Jung	Paul Kish	Gadi Lahat
Haruhiko Ichino	Dieter W. Junkers	Tadayoshi Kitayama	Kari Laihonon
Hiroki Ikeda	Paul Jury	Philippe Klein	Ashvin Lakshmikantha
Nicholas Ilyadis	David Kabal	Michael Klempa	Lowell D. Lamb
Jonathan Ingham	Jayant Kadambi	Avi Klinger	Lawrence J. Lamers
James Innis	Manabu Kagami	Richard Knight	Erik Lander
Romain Inslser	Vic Kairis	Curtis Knittle	D. Matthew Landry
Scott Irwin	Shinkyo Kaku	Dylan Ko	Brett Lane
Kazuhiko Ishibe	Omer Kal	Mike Ko	William Lane
Osamu Ishida	Mohan Kalkunte	Hiroshi Kobayashi	Gordon Langlands
Hideki Isono	Amrit Kalla	Shigeru Kobayashi	Daun Langston
Tom Issenhuth	Joel S. Kalman	Shoukei Kobayashi	Jeffrey Lapak
Hirotake Iwadata	Matt Kaltenbach	Satoshi Kodama	Ed Lare
Mitsuru Iwaoka	Puru Kamat	Daniel Koehler	Ferdinando Lari
Kenneth Jackson	Ron Kao	Henricus Koeman	Efstathios Larios
Steve Jackson	Hadriel Kaplan	David J. Koenen	Loren Larsen
Krista S Jacobsen	Rainer Kaps	Christine Koenig	Wayne Larsen
Michael R. Jacobson	Roger Karam	David E. Kohl	Donald C. Larson
Mike Jacobson	Abhay Karandikar	Keisuke Kojima	Ryan Latchman
Ajit Jadeja	Jaime Kardontchik	Srinivas Kola	Tony Lau
John M. Jaeger	Upen Kareti	Paul F. Kolesar	Mark Laubach
Brent Jaffa	Yuji Kasai	Steven Koller	Tony Lauck
Raj Jain	Allen Kasey	Tom Kolze	Bruce LaVigne
Rajeev Jain	Prakash Kashyap	Kishan Rao Konda	David J. Law
David V. James	Sanjay Kasturia	Masashi Kono	Eric Lawrence
Eric Jang	Toyoyuki Kato	David Kooistra	Michael Lawton
Woo-Hyuk Jang	Harold W. Katz	Derek Koonce	John Laynor
Stephen Janshego	Boris Katzenberg	Paul Kopera	Greg Le Cheminant
Jonathan Jedwab	Dave Kaufman	Keith Kosanovich	Yannick Le Goff
Tony Jeffree	Sumesh Kaul	Leonid Koshevoy	My Le
George D. Jelatis	Keisuke Kawahara	Josef Kosilek	Quang Le
Ernie Jensen	Yasuaki Kawatsu	Donald E. Kotas	Michael Lebar
John Jetzt	Kevin Kayser	William F. Kous	Greg LeCheminant
Jack L. Jewell	William Keasler	Tetsu Koyama	Arthur Lee
Pankaj Jha	James Keeley	Seiji Kozaki	Changoo Lee
Hongtao Jiang	Hal Keen	Josef Kozilek	Chun-Tsung Lee
Jessica Xin Jiang	Paul Kellam	Glen Koziuk	Dong-Soo Lee
Qiaofeng Jiang	N. Patrick Kelly	Glen Kramer	Eugene Lee
Wenbin Jiang	Michael Kelsen	Daniel Krent	Fu-Ho Lee
Ni Jie	Joe Kennedy	Subi Krishnamurthy	Han Hyub Lee
Andrew C. Jimenez	John J. Kenny	Lars Paul Krolner	Hyeong Ho Lee
Robert Jin	Scott Kesler	Joerg-R Kropp	Jack Lee
Thomas K. Joergensen	Dawson Kesling	Simon Kropveld	Kyusang Lee
Clarence Joh	Lior Khermosh	George Kubovcik	Michael Lee

Wesley Lee	Rick Loveless	Philip L. McCarron	Gabriel Montenegro
Ying Lee	Raul Lozano	Frank McCarthy	Juan Montojo
Vincent Lefebvre	Ken Lu	Mick McCarthy	Leo Montreuil
Richard Lefkowitz	Fred A. Lucas	C. Phillip McClay	Cindy Montstream
Amir Lehr	James A. Lucas	Brett McClellan	Paul Mooney
Hanan Leizerovich	Miklos Lukacs	Kelly McClellan	Charles Moore
Brian E. Lemoff	Meilissa R. Lum	Mike McConnell	Paul B. Moore
John Lemon	Andy J. Luque	John McCool	Robert Moore
Richard Lena	Kent Lusted	Michael S. McCormack	Andy Moorwood
Andreas Lenkisch	Sharon Lutz	Gary McCoy	Matthew Mora
Lisa Leo	Jeffrey Lynch	Thomas Mcdermott	Octavio Morales
Robert H. Leonowich	Mark Lynn	Andy McDonald	Kazuyuki Mori
Michael Lerer	Eric R. Lynskey	John McDonough	Shohei Moriwaki
Warayot Lertniphonphun	Ian Lyon	Jerry McDowell	Robert L. Morrell
Amir Leshem	Henning Lysdal	Jim McGrath	John Morris
Andre Lessard	Gael Mace	Chris McGugan	Robert Mortonson
Raymond W. K. Leung	Ben Mack-Crane	Alan McGuire	Simon Moseley
Tommy Leung	Brian MacLeod	James McIntosh	Jack Moses
Avinoam Levy	Kenneth MacLeod	Keith McKechnie	Steven Moustakas
Van Lewing	Sam Madani	Donna McMaster	Harald Mueller
David Lewis	Zahy Madgar	Larry McMillan	Thomas Mueller
Jon Lewis	Anthony Magee	Martin McNamey	Wayne A. Mueller
Richard Lewis	Joseph Maggiolino	Tim McShane	Robert Muir
Lei Li	Randall Magliozzi	Greg McSorley	Ron Muir
Mike Peng Li	Valerie Maguire	James D. McVey	Shankar Mukherjee
Shaohua Li	Ariel Maislos	Grahame Measor	Shimon Muller
Sam Liang	Rabih Makarem	Marcel Medina	Eric Multanen
Thomas Lichtenegger	Jeffery J. Maki	Mounir Meghelli	Carrie Munson
William P. Lidinsky	David Malicoat	Mukesh Mehta	Ken Murakami
Jane Lim	James Malkemus	Richard Y. Mei	Denis Murphy
Seyoun Lim	Yonatan Malkiman	Wolfgang Meier	Thomas Murphy
John O. Limb	Edwin Mallette	Vince Melendy	Brian Murray
Alex Lin	Trey Malpass	Richard Mellitz	Dale Murray
Chan-De Lin	Daniel Maltbie	Avraham Menachem	Narayan Murthy
George Lin	Jeff Mandin	Menucher Menuchery	Samba Murthy
Ray Lin	Jim Mangin	Mark Merrill	Angela Muscat
Ru Jian Lin	Bob Marchetti	John Messenger	Robert Musk
Yoseph L. Linde	Luciano Marchitto	Jo Beth Metzger	Jim Muth
Wayne Lindquist	Carlo Mariotti	Steve Metzger	Henry Muysshondt
Thomas A. Lindsay	Arthur Marris	Jeffrey Meyer	Yaron Nachman
Laurie Lindsey	Charles Marsh	Yossi Meyouhas	Gerard Nadeau
Robert Lingle	Robert Marshall	Amir Mezer	James Nadolny
Marina Lipshteyn	Robert A. Marsland	Tremont Miao	Takeshi Nagahori
Alexander Liu	Arlen Martin	Joseph Micallef	Ken Naganuma
Cathy Liu	Arlon Martin	Thomas Michaelis	Hari Naidu
Chang-Chi Liu	David W. Martin	Richard Michalowski	Wendell Nakamine
Dekun Liu	Jeff Martin	Colin Mick	Edward Nakamoto
Fengkun Liu	Chris Mash	Phil Miguelez	Karl Nakamura
Hai-Feng Liu	Koichiro Mashiko	Martin R. Milbury	Nersi Nazari
James liu	Scott Mason	Jim Millar	W. P. Neblett
Zhenyu Liu	Takeo Masuda	Bruce D. Miller	Erwan Nedellec
William D. Livingston	Kirsten Matheus	C. Kenneth Miller	Jay Neer
William Lo	Thomas Mathey	Larry D. Miller	Darcy Nelson
Martin Lobel	Ziad Albert Matni	Brian Misek	James Nelson
Terry Lockyer	Erdem Matoglu	Jacob (Kobi) Mizrahi	Kristian Nelson
Hugh Logan	Laurence Matola	Fanny Mlinarsky	Trung Nguyen
Moiz Lokhandwala	Naoki Matsuda	Reza Moattar	Thinh Nguyenphu
Larry Lomelino	Shougo Matsuda	Merrick Moeller	Henry T. Nicholas
Leland Long	Hideyuki Matsuo	Bryan Moffitt	Gary Nicholl
Sherry J. Lorei	Bob Matthys	Fred Mohamadi	Larry Nicholson
Jahan Lotfi	Bret A. Matz	Ardehshir Mohammadian	Allan Nielsen
James A. Lott	Bob Mayer	Dirk S. Mohl	Paul Nikolich
Dennis Lou	Joseph Mazor	Mart L. Molle	David Nim
Don Loughry	David S. McCallum	Ray Mompont	Glenn Nishida
Bob Love	Kent McCammon	John Monson	Susumu Nishihara

Shinji Nishimura	Earl Parsons	William Powell	Steven Robinson
George Noh	Elwood T. Parsons	Gideon Prat	Stuart Robinson
Kazuhiro Nojima	Glenn W. Parsons	Bernd Prediger	Timothy Rock
John Nolan	Vasu Parthasarathy	Robert S. Printis	Michael Rodensky
Kevin Nolish	Joel Paslaski	Max Pritikin	A. Rodriguez
Kevin Noll	Jerry Pate	Richard Prodan	Carlos Rodriguez
Takumi Nomura	Bhavesh Patel	John Proffitt	Josef Roese
Michael Nootbaar	Dipak M. Patel	Steve Pryor	Shawn Rogers
Ronald Nordin	Piyush Patel	Haoli Qian	Derek Rohde
Bob Norton	Pravin Patel	William Quackenbush	Dan Romascanu
Bob Noseworthy	Sandeep Patel	Holger Quast	Tume Römer
Ahmad Nouri	Shashi Patel	Tomas J. Quigley	Albrecht Rommel
Mark Nowell	Vijay Pathak	Jim Quilici	David Roos
Ivan Oakley	Martin Patoka	Patrick W. Quinn	Robert Rosenthal
Satoshi Obara	Aidan Paul	John Quirk	Floyd Ross
John Oberstar	Prasun K. Paul	Rick Rabinovich	Tam Ross
J. Michael O'Connor	Alex Pavlovsky	Jerry K. Radcliffe	Martin Rossbach
David Ofelt	John Payne	Ted Rado	Christopher Roth
Gourgen Oganessyan	Tony Peatfield	Sreen Raghavan	Michael Rothenberg
Ichiro Ogura	Anthony Peck	Saifur Rahman	Salvatore Rotolo
Stephen Oh	Neil Peers	Syed Rahman	Jessy Rouyer
Steven O'Hara	Jan P. Peeters-Weem	Jurgen Rahn	Tony Rowell
Peter Ohlén	Arkadiy Peker	Mohammad Rajabzadeh	Archana Roy
Raj Ojha	Joseph Pelissier	Purva Rajkotia	Larry Rubin
Mitsuji Okada	Jim Pelster	Shlomo Rakib	Paul F. Russo
Vladimir Oksman	Wanquan Peng	Naresh Raman	Bill Ryan
Guy P. Oliveira	Y. Lisa Peng	Brian Ramelson	Hyunsurk (Eric) Ryu
Chris Oliver	Petar Pepeljugoski	Brian J. Ramsey	Khosrow Sadeghi
Lloyd Oliver	Gerald Pepper	Adee Ran	Jonathan Sadler
David Olsen	Ruben Perez De Aranda Alonso	Karen Randall	Naoto Saeki
Bengt-Erik Olsson	Drew D. Perkins	Karen Randall	Dalit Sagi
Mike Oltmanns	Randy Perrie	William Randle	Ali Sajassi
Barry O'Mahony	Gerry Pesavento	Randy K. Rannow	Ed Sakaguchi
Padraig O'Mathuna	Michael Peters	Ram Rao	Toshiaki Sakai
Keith Onodera	William R. Peters	Sailesh K. Rao	Hisaya Sakamoto
Toshio Ooka	Brian Peterson	Jennifer G. Rasimas	Dolors Sala
Philip Orlik	David Peterson	Dan Rausch	Jorge Salinger
Aidan O'Rourke	John Petrilla	Peter Rautenberg	Peter Sallaway
Valy Ossman	Phong Pham	Eric Rawson	Peter Sallaway
Akihiro Otaka	Abhijit Phanse	Robert Reed	Joseph Salowey
Michael O'Toole	Thomas L. Phinney	Ivan Reede	Panagiotis Saltzidis
Tony O'Toole	Jean Picard	Alon Regev	Vineet Salunke
Michel Ouellette	David Piede	Dennis Rehm	Michael M. Salzman
George Oughton	David Piehler	Eugene Reilly	Moni Samaan
George Oulundsen	Roy Pierce	Jim Reinstedler	Sam Sambasivan
Pat Overs	Robert Pieters	Maurice Reintjes	Fred Sammartino
Kazuyuki Ozawa	Antti Pietilainen	Duane Remein	Henry Samuelli
Paul Pace	Christian Pietsch	Andreas Rendel	Anthony Sanders
Robert R. Pace	Velu C. Pillai	Lawrence Rennie	Gianluca Sanità
Charles Palanzo	Rick Pimpinella	Victor Renteria	Mark Sankey
Thomas Palkert	Neven Pischl	Tamir Reshef	Concita Saracino
Tom Palkert	Armin Pitzer	Michael Ressler	Arindam Sarkar
Hui Pan	Ed Pivonka	Pedro Reviriego	Bill Sarles
Sujan Pandey	Timothy R. Plunkett	Bill Reysen	F. Sarles
Sesha Panguluri	Rainer Poehmerer	Behrooz Rezvani	Akira Sasaki
Donald Pannell	David Poisner	June-Koo (Kevin) Rhee	Yasuo Sasaki
Bill Panos	Peter Pondillo	Jamal Riani	Stan Sassower
Gabriel D Papanreda	Petre Popescu	Dave Richkas	Ramesh Sastry
Carlos Pardo	Hayim Porat	Joseph Rickert	Satish Sathe
Keshab K. Parhi	Jeff Porter	Poldi (Pavlick) Rimboim	John Sauer
Jisang Park	Carl R. Posthuma	Poldi (Pavlick) Rimboim	Raj Savara
Moon Park	Bill Poston	John Ritger	Olindo Savi
Jim Parker	David Potter	Paul Rivett	T. Shannon Sawyer
Gavin Parnaby	Kimberly Pottratz	Ramez Rizk	Sabit Say-Otun
Bidyut Parruck	Scott R. Powell	Anthony Rizzolo	Edward Sayre
		Iain Robertson	J. David Schell
		Gary Robinson	

Dieter W. Schicketanz	Nathan Silberman	Leonard Stencel	Katsuhisa Tawa
Frederick Schindler	Tim Simmons	Gary Stephens	Ken Taylor
Ronald Schmidt	Scott Simon	Claus Stetter	Mark Taylor
Matthew Schmitt	Jesse Simsarian	Ronald Steudler	Mehmet Tazebay
Tom Schmitt	Bharat Singh	Daniel Stevens	Tim Teckman
Stefan Schneelee	Charan J. Singh	Donald S. Stewart	Brian Teipen
Peter Schoenmaker	Paramjeet (P. J.) Singh	Heath Stewart	Antonio L. Teixeira
Frederick Scholl	Semir Sirazi	Dean M. Stoddart	Vivek Telang
Thomas Schramm	Ramesh Sivakolundu	Daniel P. Stokesberry	José Tellado
Thomas Schrans	Tom Skaar	Mario Stoltz	Patricia A. Thaler
Walter Schreuer	Joseph Skorupa	Robert Stone	R. Jonathan Thatcher
Ted Schroeder	James P. Skoutas	Christopher Stook	Sashisekaran Thiagarajan
Scott Schube	Jeff Slavick	Olaf Storaasli	Walter Thirion
Benjamin Schultz	Dinah Sloan	Steve Storozum	Geoffrey O. Thompson
Klaus Schulz	Tom Slykhouse	David Stover	Douglas Thomson
David Schwartz	Andrew Smith	Rick Strohmayer	Lars E. Thon
Peter Schwartz	Daniel Smith	Stephen Strong	David Thorne
Peter Scruton	David A. Smith	Richard Stuart	Ao Ting
Harvey R. Scull	Eric Smith	Thomas Suermann	Alan Tipper
Anthony Seaman	Grant Smith	Jun Sugawa	Nathan Tobol
Michael Seaman	Michael Smith	Alan Sugg	John Todd
Shawn Searles	Robert Smith	Robert Sultan	Bruce Tolley
Hossein Sedarat	Robert W. Smith	Ron Sulyma	Carlos A. Tomaszewski
Stephn Sedio	Steve Smith	Robert Summers	Peter Tomaszewski
Ted Seely	Robert Snyder	Ken F. Sumner	Pirooz Tooyserkani
Brian Seemann	Dror Sofer	Junqing Sun	Paul Torgerson
Khorvash (Kory) Sefidvash	Ran Soffer	Karthik Sundareshan	Luis Torres
Richard Seifert	Joe Solomon	Tetsuyuki Suzuki	Rick Townsend
Alexander Seiger	Gregory Somer	Hiroshi Suzuki	Hidehiro Toyoda
Katsutoshi Seki	Scott Sommers	Ken-ichi Suzuki	Mario Träber
Oren Sela	Yoshiaki Sone	Muneyoshi Suzuki	Nathan Tracy
Steve Selee	Jaeyeon Song	Naoki Suzuki	Mario Traeber
Lee Sendelbach	Jian Song	Daniel Svensson	Hiep Tran
Shoichiro Seno	Xiaolu Song	Steve Swanson	Matthew Traverso
Murat Serbay	Massimo Sorbara	Norman L. Swenson	David Tremblay
Naoshi Serizawa	David Sorensen	Andre Szczepanek	Francois Tremblay
Koichiro Seto	Michel Sorenson	Daniel Sze	Albert Tretter
Farhad Shafai	Walter Sotelo	William Szeto	Stephen J. Trowbridge
Haim Shafir	Stephen Soto	Tad Szostak	Thomas E. Truman
Amit Shah	Walt Soto	Richard Taborek	Wen-Cheng Tseng
Sunil Shah	Tom Souvignier	Dimitry Taich	Shinji Tsuji
Vadim Shain	Fulvio Spagna	Bharat Tailor	Yoshihiro Tsukamoto
Abhijit Shanbhag	Bryan Sparrowhawk	Akio Tajima	Eddie Tsumura
Megha Shanbhag	Ben Speiser	Takayuki Tajima	Mike Tu
Ron Shani	Gary Spencer	Tomoo Takahara	Zbigniew Turlej
Masood Shariff	Edward Sprague	Eiichi Takahashi	Brad Turner
Stephen Shellhammer	Michael Spratt	Hidenori Takahashi	Edward Turner
Bazhong Shen	Nurit Sprecher	Satoshi Takahashi	Wendell Turner
Sam Shen	Matthew B. Squire	Kiyoto Takahata	Bulent Tusiray
Ben Sheppard	Atul Srivastava	Noriyuki Takeda	Jacob Twersky
Paul Sherer	David Srodzinski	Martin Takessian	Bor-long Twu
Robbie Shergill	Matthew St Peter	Motoyuki Takizawa	Marcos Tzannes
Siddharth Sheth	Joseph St. Amand	Kohichi Tamura	Kiyoshi Uematsu
Masayuki Shigematsu	David N. Stacy	Alexander Tan	Alan Ugolini
Cheng-Chung Shih	Clayton Stanford	Keiji Tanaka	Herbert Uhl
Hyungsoo Shin	Thomas Staniec	Toshiki Tanaka	Jayshree Ullal
Jong-Yoon Shin	Patrick H. Stanley	Wen-Tsung Tang	John Ulm
Ramin Shirani	Kevin Stanton	Sandray Tarana	Steven Ulrich
Mizuki Shirao	Nick Stapleton	Victor J. Tarassov	Ed Ulrichs
Zion Shoheit	Graham Starkins	Peter Tarrant	Alexander Umnov
Larry Shorthill	Peter Stassar	Mike Tate	Gottfried Ungerboeck
Avadhani Shridhar	Peter Staub	Tsutomu Tatsuta	Musa Unmehopa
Kapil Shrikhande	Margit Stearns	Jim Tatum	Sterling A. Vaden
Martin Siegmund	Henk Steenman	James M. Tavacoli	Todd Vafiades
Som Sikdar	David E. Stein	Sadry Tavana	Stefano Valle

Magesh Valliappan	Robert Wang	Erica Williamson	Doug Yoder
Nicholas Van Bavel	Roy Wang	Robert S. Williamson	Tetsuya Yokomoto
David J. Van Goor	Tongtong Wang	Roger Wilmarth	Nobushige Yokota
Peter Van Laanen	Xiaofeng Wang	Joris Wils	Tae-Whan Yoo
Erik van Oosten	Xinyuan Wang	Izumi Wilson	Bin Yeong Yoon
Paul Z. Vanderlaan	Yun-Che Wang	Mike Wincn	Chong Ho Yoon
Schelto J. vanDoorn	Zhong Feng Wang	Mark Wingrove	Jason Yorks
Dono Van-Mierop	Ken Ward	Ludwig Winkel	Osamu Yoshihara
Andre VanSchyndel	Tim Warland	Darin Winterton	Takashi Yoshikawa
Nicola Varanese	David Warren	Mike Witkowski	George Young
Albert Vareljian	Jeff Warren	Kevin Witt	Ken Young
Kumaran Veerayah	Marc Warshaw	Andrew Witzner	Leonard Young
V. Kumar Venkatavaraton	Ted Washburn	John Wolcott	Nariman Yousefi
Ramakrishna Vepa	Yuji Watanabe	Jonghwa Won	Lennart Yseboodt
G�rard Vergnaud	Bruce Watson	King Won	Ben Yu
Bill Verheggen	Robert Watson	Shin-Hee Won	Hong Yu
Iain Verigin	Markus Weber	Ching Wong	Mark Yu
Robert Verne	Dong Wei	David Wong	Ting-Fa Yu
Anoop Vetteth	Yuehua Wei	Don Wong	Liquan Yuan
Nader Vijeh	Jason Weil	Edward Wong	Hayato Yuki
Ron Vilozny	Lyle Weiman	Leo Wong	Garold Yurko
John Visser	Nick Weiner	Percy Wong	Nick Zades
Balasubramanian Vittal	Brian Weis	Bill Woodruff	Nelson Zagalsky
Ionel Marius Vladan	Alan Weissberger	Paul Woodruff	Andrew Zambell
Yurii Vlasov	Andrew Weitzner	Ted K. Woodward	Meiyan Zang
David Vogel	Moti Weizman	Chien-Hsien Wu	Hank Zannini
Moshe Voloshin	Brian Welch	Choa-Ping Wu	Jamie Zartman
Brian Von Herzen	Jim Welch	Guangsheng Wu	Li Zeng
John von Voros	Yang Wen	Peter Wu	Huanlin Zhang
Manoj Wadekar	Matthias Wendt	Robert Wu	James Zhang
William Wager	Fred Weniger	Markus Wucher	Jin Zhang
Martin Wagner	Oded Wertheim	Stefan M. Wurster	Jing-fan Zhang
Robert Wagner	Jason Wertz	Dayin Xu	Wenyu Zhao
P. E. Wainwright	Willem Wery	Yu Xu	Lizhi Zhong
Ikuo Wakayama	Alan Wetzel	Ariel Yagil	Qiwen Zhong
Clinton Walker	David White	Michael Yam	Igor Zhovnirovsky
Dylan Walker	Hugh E. White	Masaki Yamada	Yan Zhuang
Rick Walker	Lawrence White	Hajime Yamashita	Martin Zielinski
Bill Wall	Martin White	Shuntaro Yamazaki	George Zimmerman
Edward Walter	Tony Whitlow	Howard Yang	Helge Zinner
Chang Jung Wang	Bill Wiedemann	Steven Yang	Pavel Zivny
Chenxi Wang	Joseph A. Wiencko	Yinglin (Frank) Yang	Bob Zona
Chiung Hung Wang	Natalie Wienckowski	Ronald Yara	Mo R. Zonoun
Greg Wang	Bert Wijnen	Masaki Yasukawa	Glen Zorn
Haifei Wang	Bruce Williams	Jun Yi	Gaoling Zou
Peter Wang	Richard Williams	Lee Chung Yiu	

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

Thomas Alexander	Christel Hunter	Michael Peters
Richard Alfvén	C. Huntley	David Piehler
Nobumitsu Amachi	Noriyuki Ikeuchi	Rick Pimpinella
Dale Amason	Sergiu Iordanescu	Adee Ran
Pete Anslow	Osamu Ishida	R.K. Rannow
Butch Anton	Atsushi Ito	Alon Regev
Stefan Aust	Raj Jain	James Reilly
Eric Baden	SangKwon Jeong	Maximilian Riegel
Christian Boiger	Peter Jones	Robert Robinson
Ralf-Peter Braun	Piotr Karocki	Alexander Rysin
Nancy Bravin	Stuart Kerry	Frank Schewe
Matthew Brown	Yongbum Kim	Kapil Shrikhande
Demetrio Jr Bucaneg	Jonathan King	Jeff Slavick
Gary Burrell	Mark Laubach	Daniel Smith
Jairo Bustos Heredia	David J. Law	Thomas Starai
William Byrd	Hyeong Ho Lee	Peter Stassar
Steven B. Carlson	Hanan Leizerovich	Heath Stewart
Juan Carreon	David Lewis	Walter Struppler
Chan Chen	Jon Lewis	Mitsutoshi Sugawara
Keith Chow	Kent Lusted	Kohichi Tamura
Keng Hua Chuang	Michael Lynch	David Tepen
Charles Cook	Elvis Maculuba	David Thompson
Rodney Cummings	Valerie Maguire	Geoffrey O. Thompson
Piers J. G. Dawe	Jeffery Maki	Michael Thompson
Michael Dudek	Roger Marks	David Tremblay
Sourav Dutta	Arthur Marris	Stephen Trowbridge
Jason Ellison	Michael Maytum	Mark-Rene Uchida
Andrew Fieldsend	Mick McCarthy	Paul Vanderlaan
Michael Fischer	Brett McClellan	Dmitri Varsanofiev
Avraham Freedman	Thomas Mcdermott	John Vergis
Matthias Fritsche	Richard Mellitz	George Vlantis
Yukihiro Fujimoto	John Messenger	Khurram Waheed
Zhigang Gong	Tremont Miao	Lisa Ward
Eric W Gray	Charles Moorwood	Keith Waters
Randall Groves	Rick Murphy	Scott Willy
Robert Grow	Henry Muyschondt	Andreas Wolf
Mark Gustlin	Michael Newman	Chun Yu Charles Wong
Stephen Haddock	NickS.A Nikjoo	Peter Wu
Adam Healey	Paul Nikolich	Jun Xu
Marco Hernandez	Tetsu Nishimura	Adrian Young
David Hess	Mark Nowell	Oren Yuen
Yasuo Hidaka	Satoshi Obara	Andrew Zambell
Werner Hoelzl	Robert O'Hara	George Zimmerman
Rita Horner	Bansi Patel	Pavel Zivny
	Ruben Perez De Aranda Alonso	

When the IEEE-SA Standards Board approved this standard on 14 June 2018, it had the following membership:

Jean-Philippe Faure, *Chair*
Gary Hoffman, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Ted Burse
Guido R. Hiertz
Christel Hunter
Joseph L. Koepfinger*
Thomas Koshy
Hung Ling
Dong Liu

Xiaohui Liu
Kevin Lu
Daleep Mohla
Andrew Myles
Paul Nikolich
Ronald C. Petersen
Annette D. Reilly

Robby Robson
Dorothy Stanley
Mehmet Ulema
Phil Wennblom
Philip Winston
Howard Wolfman
Jingyi Zhou

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 802.3-2018, IEEE Standard for Ethernet.

IEEE Std 802.3™ was first published in 1985. Since the initial publication, many projects have added functionality or provided maintenance updates to the specifications and text included in the standard. Each IEEE 802.3 project/amendment is identified with a suffix (e.g., IEEE Std 802.3ba™-2010).

The half duplex Media Access Control (MAC) protocol specified in IEEE Std 802.3-1985 is Carrier Sense Multiple Access with Collision Detection (CSMA/CD). This MAC protocol was key to the experimental Ethernet developed at Xerox Palo Alto Research Center, which had a 2.94 Mb/s data rate. Ethernet at 10 Mb/s was jointly released as a public specification by Digital Equipment Corporation (DEC), Intel and Xerox in 1980. Ethernet at 10 Mb/s was approved as an IEEE standard by the IEEE Standards Board in 1983 and subsequently published in 1985 as IEEE Std 802.3-1985. Since 1985, new media options, new speeds of operation, and new capabilities have been added to IEEE Std 802.3. A full duplex MAC protocol was added in 1997.

Some of the major additions to IEEE Std 802.3 are identified in the marketplace with their project number. This is most common for projects adding higher speeds of operation or new protocols. For example, IEEE Std 802.3u™ added 100 Mb/s operation (also called Fast Ethernet), IEEE Std 802.3z added 1000 Mb/s operation (also called Gigabit Ethernet), IEEE Std 802.3ae added 10 Gb/s operation (also called 10 Gigabit Ethernet), IEEE Std 802.3ah™ specified access network Ethernet (also called Ethernet in the First Mile) and IEEE Std 802.3ba added 40 Gb/s operation (also called 40 Gigabit Ethernet) and 100 Gb/s operation (also called 100 Gigabit Ethernet). These major additions are all now included in and are superseded by IEEE Std 802.3-2015 and are not maintained as separate documents.

At the date of IEEE Std 802.3-2018 publication, IEEE Std 802.3 is composed of the following documents:

IEEE Std 802.3-2018

Section One—Includes Clause 1 through Clause 20 and Annex A through Annex H and Annex 4A. Section One includes the specifications for 10 Mb/s operation and the MAC, frame formats and service interfaces used for all speeds of operation.

Section Two—Includes Clause 21 through Clause 33 and Annex 22A through Annex 33E. Section Two includes management attributes for multiple protocols and speed of operation as well as specifications for providing power over twisted pair cabling for multiple operational speeds. It also includes general information on 100 Mb/s operation as well as most of the 100 Mb/s Physical Layer specifications.

Section Three—Includes Clause 34 through Clause 43 and Annex 36A through Annex 43C. Section Three includes general information on 1000 Mb/s operation as well as most of the 1000 Mb/s Physical Layer specifications.

Section Four—Includes Clause 44 through Clause 55 and Annex 44A through Annex 55B. Section Four includes general information on 10 Gb/s operation as well as most of the 10 Gb/s Physical Layer specifications.

Section Five—Includes Clause 56 through Clause 77 and Annex 57A through Annex 76A. Clause 56 through Clause 67 and Clause 75 through Clause 77, as well as associated annexes, specify subscriber access and other Physical Layers and sublayers for operation from 512 kb/s to 10 Gb/s, and defines services and protocol elements that enable the exchange of IEEE Std 802.3 format frames between stations in a subscriber access network. Clause 68 specifies a 10 Gb/s Physical Layer specification. Clause 69 through Clause 74 and associated annexes specify Ethernet operation over electrical backplanes at speeds of 1000 Mb/s and 10 Gb/s.

Section Six—Includes Clause 78 through Clause 95 and Annex 83A through Annex 93C. Clause 78 specifies Energy-Efficient Ethernet. Clause 79 specifies IEEE 802.3 Organizationally Specific Link Layer Discovery Protocol (LLDP) type, length, and value (TLV) information elements. Clause 80 through Clause 95 and associated annexes include general information on 40 Gb/s and 100 Gb/s operation as well as 40 Gb/s and 100 Gb/s Physical Layer specifications. Clause 90 specifies Ethernet support for time synchronization protocols.

Section Seven—Includes Clause 96 through Clause 115 and Annex 97A through Annex 115A. Clause 96 through Clause 98, Clause 104, and associated annexes, specify Physical Layers and optional features for 100 Mb/s and 1000 Mb/s operation over a single twisted pair. Clause 100 through Clause 103, as well as associated annexes, specify Physical Layers for the operation of the EPON protocol over coaxial distribution networks. Clause 105 through Clause 114 and associated annexes include general information on 25 Gb/s operation as well as 25 Gb/s Physical Layer specifications. Clause 99 specifies a MAC merge sublayer for the interspersing of express traffic. Clause 115 and its associated annex specify a Physical Layer for 1000 Mb/s operation over plastic optical fiber.

Section Eight—Includes Clause 116 through Clause 126 and Annex 119A through Annex 120E. Clause 116 through Clause 124 and associated annexes include general information on 200 Gb/s and 400 Gb/s operation as well as 200 Gb/s and 400 Gb/s Physical Layer specifications. Clause 125 and Clause 126 include general information on 2.5 Gb/s and 5 Gb/s operation as well as 2.5 Gb/s and 5 Gb/s Physical Layer specifications.

A companion document IEEE Std 802.3.1 describes Ethernet management information base (MIB) modules for use with the Simple Network Management Protocol (SNMP). IEEE Std 802.3.1 is updated to add management capability for enhancements to IEEE Std 802.3 after approval of the enhancements.

IEEE Std 802.3 will continue to evolve. New Ethernet capabilities are anticipated to be added within the next few years as amendments to this standard.

Acknowledgments

Grateful acknowledgment is made for portions of this standard reprinted with permission from Broadcom Corporation, OPEN Alliance BroadR-Reach® (OABR) Physical Layer Transceiver Specification For Automotive Applications V3.2, June 24, 2014, © 2014.

Grateful acknowledgment is made for portions of this standard reprinted with permission from Data-Over-Cable Service Interface Specifications DOCSIS® 3.1 Physical Layer Specification CM-SP-PHYv3.1-I01-131029 (Cable Television Laboratories, Inc. 2013), © 2013.

Portions of the material contained herein are reprinted with permission from Maxim Integrated Products, Inc., DS18B20 “Programmable Resolution 1-Wire Digital Thermometer” Data Sheet, Rev. 042208, © 2008.

IEEE Standard for Ethernet

SECTION ONE

This section includes Clause 1 through Clause 20, Annex A through Annex H, and Annex 4A.

Contents

1. Introduction.....	55
1.1 Overview.....	55
1.1.1 Scope.....	55
1.1.2 Basic concepts.....	55
1.1.2.1 Half duplex operation	56
1.1.2.2 Full duplex operation	56
1.1.3 Architectural perspectives.....	56
1.1.3.1 Architectural rationale	57
1.1.3.2 Compatibility interfaces.....	57
1.1.4 Layer interfaces.....	60
1.1.5 Application areas	60
1.2 Notation	60
1.2.1 State diagram conventions	60
1.2.2 Service specification method and notation	62
1.2.2.1 Classification of service primitives.....	62
1.2.3 Physical Layer and media notation	63

1.2.4	Physical Layer message notation	63
1.2.5	Hexadecimal notation	63
1.2.6	Accuracy and resolution of numerical quantities	63
1.2.7	Qm.n number format.....	63
1.2.8	Em dash (—) in a table cell	63
1.3	Normative references	64
1.4	Definitions	73
1.5	Abbreviations.....	108
2.	Media Access Control (MAC) service specification	114
2.1	Scope and field of application	114
2.2	Overview of the service	114
2.2.1	General description of services provided by the layer.....	114
2.2.2	Model used for the service specification	114
2.2.3	Overview of interactions.....	114
2.2.4	Basic services.....	115
2.3	Detailed service specification	115
2.3.1	MA_DATA.request	115
2.3.1.1	Function	115
2.3.1.2	Semantics of the service primitive.....	115
2.3.1.3	When generated	115
2.3.1.4	Effect of receipt	115
2.3.1.5	Additional comments.....	115
2.3.2	MA_DATA.indication.....	116
2.3.2.1	Function	116
2.3.2.2	Semantics of the service primitive.....	116
2.3.2.3	When generated	116
2.3.2.4	Effect of receipt	117
2.3.2.5	Additional comments.....	117
3.	Media Access Control (MAC) frame and packet specifications	118
3.1	Overview.....	118
3.1.1	Packet format	118
3.1.2	Service interface mappings.....	119
3.2	Elements of the MAC frame and packet.....	119
3.2.1	Preamble field.....	119
3.2.2	Start Frame Delimiter (SFD) field.....	119
3.2.3	Address fields	119
3.2.3.1	Address designation.....	120
3.2.4	Destination Address field.....	120
3.2.5	Source Address field.....	121
3.2.6	Length/Type field	121
3.2.7	MAC Client Data field.....	121
3.2.8	Pad field	122
3.2.9	Frame Check Sequence (FCS) field.....	122
3.2.10	Extension field	122
3.3	Order of bit transmission	123
3.4	Invalid MAC frame.....	123
4.	Media Access Control.....	124
4.1	Functional model of the MAC method	124

4.1.1	Overview.....	124
4.1.2	CSMA/CD operation	125
4.1.2.1	Normal operation	125
4.1.2.1.1	Transmission without contention.....	125
4.1.2.1.2	Reception without contention	126
4.1.2.2	Access interference and recovery	126
4.1.3	Relationships to the MAC client and Physical Layers	127
4.2	CSMA/CD Media Access Control (MAC) method: Precise specification.....	127
4.2.1	Introduction.....	127
4.2.2	Overview of the procedural model	127
4.2.2.1	Ground rules for the procedural model.....	128
4.2.2.2	Use of Pascal in the procedural model.....	128
4.2.2.3	Organization of the procedural model	129
4.2.2.4	Layer management extensions to procedural model.....	129
4.2.3	Packet transmission model.....	130
4.2.3.1	Transmit data encapsulation	135
4.2.3.2	Transmit media access management.....	135
4.2.3.2.1	Deference	135
4.2.3.2.2	Interpacket gap.....	136
4.2.3.2.3	Collision handling (half duplex mode only)	136
4.2.3.2.4	Collision detection and enforcement (half duplex mode only).....	136
4.2.3.2.5	Collision backoff and retransmission (half duplex mode only).....	136
4.2.3.2.6	Full duplex transmission.....	137
4.2.3.2.7	Packet bursting (half duplex mode only).....	137
4.2.3.3	Minimum frame size.....	138
4.2.3.4	Carrier extension (half duplex mode only).....	138
4.2.4	Frame reception model	138
4.2.4.1	Receive data decapsulation.....	138
4.2.4.1.1	Address recognition	138
4.2.4.1.2	Frame check sequence validation	139
4.2.4.1.3	Frame disassembly.....	139
4.2.4.2	Receive media access management	139
4.2.4.2.1	Framing.....	139
4.2.4.2.2	Collision filtering.....	140
4.2.5	Preamble generation	140
4.2.6	Start frame sequence	140
4.2.7	Global declarations	140
4.2.7.1	Common constants, types, and variables	140
4.2.7.2	Transmit state variables	142
4.2.7.3	Receive state variables.....	143
4.2.7.4	State variable initialization	143
4.2.8	Frame transmission	144
4.2.9	Frame reception	151
4.2.10	Common procedures	155
4.3	Interfaces to/from adjacent layers.....	155
4.3.1	Overview.....	155
4.3.2	MAC service	155
4.3.2.1	MAC client transmit interface state diagram.....	156
4.3.2.1.1	Variables	156
4.3.2.1.2	Functions.....	156
4.3.2.1.3	Messages	156
4.3.2.1.4	MAC client transmit interface state diagram.....	156
4.3.2.2	MAC client receive interface state diagram	156
4.3.2.2.1	Variables	156

4.3.2.2.2	Functions.....	157
4.3.2.2.3	Messages.....	157
4.3.2.2.4	MAC client receive interface state diagram	158
4.3.3	Services required from the Physical Layer	158
4.4	Specific implementations.....	160
4.4.1	Compatibility overview	160
4.4.2	MAC parameters.....	161
4.4.3	Configuration guidelines.....	162
5.	Layer Management	163
5.1	Introduction.....	163
5.1.1	Systems Management overview	163
5.1.2	Layer Management model	163
5.1.3	Packages.....	164
5.1.4	Conformance requirements.....	164
5.2	Management facilities.....	164
5.2.1	Introduction.....	164
5.2.2	DTE MAC Sublayer Management facilities.....	164
5.2.2.1	DTE MAC sublayer attributes	166
5.2.2.1.1	aMACID	166
5.2.2.1.2	aFramesTransmittedOK.....	166
5.2.2.1.3	aSingleCollisionFrames	166
5.2.2.1.4	aMultipleCollisionFrames	166
5.2.2.1.5	aFramesReceivedOK	167
5.2.2.1.6	aFrameCheckSequenceErrors	167
5.2.2.1.7	aAlignmentErrors.....	167
5.2.2.1.8	aOctetsTransmittedOK	167
5.2.2.1.9	aFramesWithDeferredXmissions.....	168
5.2.2.1.10	aLateCollisions	168
5.2.2.1.11	aFramesAbortedDueToXSColls	168
5.2.2.1.12	aFramesLostDueToIntMACXmitError	168
5.2.2.1.13	aCarrierSenseErrors	169
5.2.2.1.14	aOctetsReceivedOK.....	169
5.2.2.1.15	aFramesLostDueToIntMACRcvError	169
5.2.2.1.16	aPromiscuousStatus	169
5.2.2.1.17	aReadMulticastAddressList	170
5.2.2.1.18	aMulticastFramesXmittedOK	170
5.2.2.1.19	aBroadcastFramesXmittedOK	170
5.2.2.1.20	aFramesWithExcessiveDeferral.....	170
5.2.2.1.21	aMulticastFramesReceivedOK	171
5.2.2.1.22	aBroadcastFramesReceivedOK	171
5.2.2.1.23	aInRangeLengthErrors.....	171
5.2.2.1.24	aOutOfRangeLengthField.....	171
5.2.2.1.25	aFrameTooLongErrors.....	172
5.2.2.1.26	aMACEnableStatus.....	172
5.2.2.1.27	aTransmitEnableStatus	172
5.2.2.1.28	aMulticastReceiveStatus	172
5.2.2.1.29	aReadWriteMACAddress	173
5.2.2.1.30	aCollisionFrames	173
5.2.2.2	DTE MAC Sublayer actions	173
5.2.2.2.1	acInitializeMAC.....	173
5.2.2.2.2	acAddGroupAddress.....	173
5.2.2.2.3	acDeleteGroupAddress	174

5.2.2.2.4	acExecuteSelfTest.....	174
5.2.2.3	ResourceTypeID Managed Object Class	174
5.2.2.3.1	ResourceTypeID	174
5.2.3	DTE Physical Sublayer Management facilities	174
5.2.3.1	DTE Physical Sublayer attributes	174
5.2.3.1.1	aPHYID	174
5.2.3.1.2	aSQETestErrors	174
5.2.4	DTE Management procedural model.....	175
5.2.4.1	Common constants and types	175
5.2.4.2	Transmit variables and procedures	175
5.2.4.3	Receive variables and procedures.....	177
5.2.4.4	Common procedures	179
6.	Physical Signaling (PLS) service specifications.....	180
6.1	Scope and field of application	180
6.2	Overview of the service	180
6.2.1	General description of services provided by the layer.....	180
6.2.2	Model used for the service specification	180
6.2.3	Overview of interactions.....	180
6.2.4	Basic services and options	181
6.3	Detailed service specification	181
6.3.1	Peer-to-peer service primitives	181
6.3.1.1	PLS_DATA.request.....	181
6.3.1.1.1	Function	181
6.3.1.1.2	Semantics of the service primitive.....	181
6.3.1.1.3	When generated	181
6.3.1.1.4	Effect of receipt	181
6.3.1.2	PLS_DATA.indication	182
6.3.1.2.1	Function	182
6.3.1.2.2	Semantics of the service primitive.....	182
6.3.1.2.3	When generated	182
6.3.1.2.4	Effect of receipt	182
6.3.2	Sublayer-to-sublayer service primitives	182
6.3.2.1	PLS_CARRIER.indication	182
6.3.2.1.1	Function	182
6.3.2.1.2	Semantics of the service primitive.....	182
6.3.2.1.3	When generated	182
6.3.2.1.4	Effect of receipt	182
6.3.2.2	PLS_SIGNAL.indication.....	183
6.3.2.2.1	Function	183
6.3.2.2.2	Semantics of the service primitive.....	183
6.3.2.2.3	When generated	183
6.3.2.2.4	Effect of receipt	183
6.3.2.3	PLS_DATA_VALID.indication.....	183
6.3.2.3.1	Function	183
6.3.2.3.2	Semantics of the service primitive.....	183
6.3.2.3.3	When generated	183
6.3.2.3.4	Effect of receipt	183
7.	Physical Signaling (PLS) and Attachment Unit Interface (AUI) specifications	184
7.1	Scope.....	184
7.1.1	Definitions	184

7.1.2	Summary of major concepts	184
7.1.3	Application.....	185
7.1.4	Modes of operation	185
7.1.5	Allocation of function.....	185
7.2	Functional specification.....	185
7.2.1	PLS–PMA (DTE–MAU) Interface protocol.....	185
7.2.1.1	PLS to PMA messages.....	186
7.2.1.1.1	output message.....	186
7.2.1.1.2	output_idle message.....	187
7.2.1.1.3	normal message.....	187
7.2.1.1.4	isolate message (optional).....	187
7.2.1.1.5	mau_request message (optional).....	187
7.2.1.2	PMA to PLS interface.....	189
7.2.1.2.1	input message.....	189
7.2.1.2.2	input_idle message.....	191
7.2.1.2.3	signal_quality_error message	191
7.2.1.2.4	mau_available message.....	191
7.2.1.2.5	mau_not_available message (optional).....	191
7.2.2	PLS interface to MAC and management entities.....	192
7.2.2.1	PLS–MAC interface	192
7.2.2.1.1	OUTPUT_UNIT	192
7.2.2.1.2	OUTPUT_STATUS.....	192
7.2.2.1.3	INPUT_UNIT	192
7.2.2.1.4	CARRIER_STATUS	192
7.2.2.1.5	SIGNAL_STATUS.....	193
7.2.2.1.6	DATA_VALID_STATUS.....	193
7.2.2.2	PLS–management entity interface	193
7.2.2.2.1	RESET_REQUEST	193
7.2.2.2.2	RESET_RESPONSE	194
7.2.2.2.3	MODE_CONTROL.....	194
7.2.2.2.4	SQE_TEST	194
7.2.3	Frame structure	194
7.2.3.1	Silence.....	195
7.2.3.2	Preamble	195
7.2.3.3	Start of Frame Delimiter (SFD).....	195
7.2.3.4	Data.....	195
7.2.3.5	End of transmission delimiter.....	195
7.2.4	PLS functions.....	195
7.2.4.1	Reset and Identify function.....	196
7.2.4.2	Mode function.....	196
7.2.4.3	Output function	197
7.2.4.4	Input function.....	197
7.2.4.5	Error Sense function	197
7.2.4.6	Carrier Sense function	198
7.3	Signal characteristics	198
7.3.1	Signal encoding.....	198
7.3.1.1	Data encoding	198
7.3.1.2	Control encoding.....	202
7.3.2	Signaling rate	203
7.3.3	Signaling levels.....	203
7.4	Electrical characteristics	203
7.4.1	Driver characteristics	203
7.4.1.1	Differential output voltage, loaded	203
7.4.1.2	Requirements after idle.....	205

7.4.1.3	AC common-mode output voltage.....	205
7.4.1.4	Differential output voltage, open circuit.....	205
7.4.1.5	DC common-mode output voltage.....	205
7.4.1.6	Fault tolerance.....	206
7.4.2	Receiver characteristics	206
7.4.2.1	Receiver threshold levels	206
7.4.2.2	AC differential input impedance.....	207
7.4.2.3	AC common-mode range	207
7.4.2.4	Total common-mode range	207
7.4.2.5	Idle input behavior	208
7.4.2.6	Fault tolerance.....	208
7.4.3	AUI cable characteristics	208
7.4.3.1	Conductor size	209
7.4.3.2	Pair-to-pair balanced crosstalk.....	209
7.4.3.3	Differential characteristic impedance	209
7.4.3.4	Transfer impedance.....	209
7.4.3.5	Attenuation.....	209
7.4.3.6	Timing jitter	209
7.4.3.7	Delay	209
7.5	Functional description of interchange circuits.....	210
7.5.1	General.....	210
7.5.2	Definition of interchange circuits	210
7.5.2.1	Circuit DO–Data Out	211
7.5.2.2	Circuit DI–Data In	211
7.5.2.3	Circuit CO–Control Out (optional).....	211
7.5.2.4	Circuit CI–Control In.....	211
7.5.2.5	Circuit VP–Voltage Plus.....	212
7.5.2.6	Circuit VC–Voltage Common	212
7.5.2.7	Circuit PG–Protective Ground	212
7.5.2.8	Circuit shield terminations.....	212
7.6	Mechanical characteristics	212
7.6.1	Definition of mechanical interface	212
7.6.2	Line interface connector	212
7.6.3	Contact assignments	213
8.	Medium Attachment Unit and baseband medium specifications, type 10BASE5	216
8.1	Scope.....	216
8.1.1	Overview.....	216
8.1.1.1	Medium Attachment Unit	216
8.1.1.2	Repeater unit	217
8.1.2	Definitions	217
8.1.3	Application perspective: MAU and MEDIUM objectives	217
8.1.3.1	Object.....	217
8.1.3.2	Compatibility considerations	217
8.1.3.3	Relationship to PLS and AU interface.....	218
8.1.3.4	Modes of operation	218
8.2	MAU functional specifications	218
8.2.1	MAU Physical Layer functions	218
8.2.1.1	Transmit function requirements.....	218
8.2.1.2	Receive function requirements	219
8.2.1.3	Collision Presence function requirements	220
8.2.1.4	Monitor function requirements (optional)	220
8.2.1.5	Jabber function requirements.....	221

8.2.2	MAU interface messages	221
8.2.2.1	DTE Physical Layer to MAU Physical Layer messages	221
8.2.2.2	MAU Physical Layer to DTE Physical Layer	222
8.2.2.2.1	input message.....	222
8.2.2.2.2	input_idle message.....	222
8.2.2.2.3	mau_available message.....	222
8.2.2.2.4	signal_quality_error message	222
8.2.3	MAU state diagrams	223
8.3	MAU–medium electrical characteristics	223
8.3.1	MAU-to-coaxial cable interface	223
8.3.1.1	Input impedance.....	223
8.3.1.2	Bias current	224
8.3.1.3	Coaxial cable signaling levels.....	224
8.3.1.4	Transmit output levels symmetry	230
8.3.1.5	Collision detect thresholds.....	230
8.3.2	MAU electrical characteristics.....	230
8.3.2.1	Electrical isolation	230
8.3.2.2	Power consumption.....	231
8.3.2.3	Reliability.....	231
8.3.3	MAU–DTE electrical characteristics.....	231
8.3.4	MAU–DTE mechanical connection.....	231
8.4	Characteristics of the coaxial cable	231
8.4.1	Coaxial cable electrical parameters	231
8.4.1.1	Characteristic impedance	231
8.4.1.2	Attenuation.....	231
8.4.1.3	Velocity of propagation	232
8.4.1.4	Edge jitter, untapped cable.....	232
8.4.1.5	Transfer impedance.....	232
8.4.1.6	Cable dc loop resistance	232
8.4.2	Coaxial cable properties.....	233
8.4.2.1	Mechanical requirements	233
8.4.2.1.1	General construction	233
8.4.2.1.2	Center conductor	233
8.4.2.1.3	Dielectric material.....	233
8.4.2.1.4	Shielding system	233
8.4.2.1.5	Overall jacket.....	233
8.4.2.2	Jacket marking	234
8.4.3	Total segment dc loop resistance	234
8.5	Coaxial trunk cable connectors.....	234
8.5.1	Inline coaxial extension connector	234
8.5.2	Coaxial cable terminator.....	235
8.5.2.1	Termination.....	235
8.5.2.2	Earthing.....	235
8.5.3	MAU-to-coaxial cable connection.....	235
8.5.3.1	Electrical requirements	235
8.5.3.2	Mechanical requirements	236
8.5.3.2.1	Connector housing	236
8.5.3.2.2	Contact reliability	236
8.5.3.2.3	Shield probe characteristics	237
8.6	System considerations.....	237
8.6.1	Transmission system model.....	237
8.6.2	Transmission system requirements	238
8.6.2.1	Cable sectioning.....	238
8.6.2.2	MAU placement.....	238

8.6.2.3	Trunk cable system grounding.....	238
8.6.3	Labeling	239
8.7	Environmental specifications.....	239
8.7.1	General safety requirements	239
8.7.2	Network safety requirements	239
8.7.2.1	Installations	239
8.7.2.2	Grounding	240
8.7.2.3	Safety	240
8.7.2.4	Breakdown path	240
8.7.2.5	Isolation boundary	240
8.7.2.6	Installation and maintenance guidelines	240
8.7.3	Electromagnetic environment.....	241
8.7.3.1	Susceptibility levels	241
8.7.3.2	Emission levels	241
8.7.4	Temperature and humidity.....	241
8.7.5	Regulatory requirements.....	241
8.8	Protocol implementation conformance statement (PICS) proforma for Clause 8, Medium Attachment Unit and baseband medium specifications, type 10BASE5.....	242
8.8.1	Overview.....	242
8.8.2	Abbreviations and special symbols.....	242
8.8.2.1	Status symbols	242
8.8.2.2	Abbreviations.....	242
8.8.3	Instructions for completing the PICS proforma.....	242
8.8.3.1	General structure of the PICS proforma	242
8.8.3.2	Additional information	243
8.8.3.3	Exception information	243
8.8.3.4	Conditional items.....	243
8.8.4	Identification.....	244
8.8.4.1	Implementation identification.....	244
8.8.4.2	Protocol summary.....	244
8.8.5	Global statement of conformance	244
8.8.6	PICS proforma tables for MAU.....	245
8.8.6.1	MAU compatibility.....	245
8.8.6.2	Transmit function	245
8.8.6.3	Receive function	246
8.8.6.4	Collision function	247
8.8.6.5	Monitor function	247
8.8.6.6	Jabber function	248
8.8.6.7	MAU to coaxial cable interface	249
8.8.6.8	MAU electrical characteristics	250
8.8.6.9	MAU-DTE requirements	250
8.8.6.10	MAU to coaxial cable connection	251
8.8.6.11	Safety requirements	251
8.8.7	PICS proforma tables for MAU AUI characteristics.....	252
8.8.7.1	Signal characteristics	252
8.8.7.2	DI and CI driver characteristics	252
8.8.7.3	DO receiver characteristics	253
8.8.7.4	CO receiver characteristics	254
8.8.7.5	Circuit termination.....	254
8.8.7.6	Mechanical characteristics	255
8.8.8	PICS proforma tables for 10BASE5 coaxial cable.....	256
8.8.8.1	10BASE5 coaxial cable characteristics	256
9.	Repeater unit for 10 Mb/s baseband networks.....	258

9.1	Overview.....	258
9.2	References.....	259
9.3	Definitions	259
9.4	Compatibility interface	259
9.4.1	AUI compatibility.....	259
9.4.2	Mixing segment compatibility.....	259
9.4.2.1	Direct coaxial cable attachment compatibility.....	259
9.4.2.2	“N” connector compatibility.....	259
9.4.2.3	BNC compatibility.....	259
9.4.2.4	BFOC/2.5 (10BASE-FP) compatibility.....	259
9.4.3	Link segment compatibility	260
9.4.3.1	Vendor-dependent IRL	260
9.4.3.2	Fiber optic FOIRL compatibility	260
9.4.3.3	Twisted-pair jack compatibility.....	260
9.4.3.4	Fiber optic 10BASE-FB and 10BASE-FL compatibility.....	260
9.5	Basic functions.....	260
9.5.1	Repeater set network properties.....	260
9.5.2	Signal amplification.....	260
9.5.3	Signal symmetry	260
9.5.4	Signal retiming.....	261
9.5.5	Data handling.....	261
9.5.5.1	Start-of-packet propagation delays	261
9.5.5.2	Start-of-packet variability	261
9.5.6	Collision handling.....	262
9.5.6.1	Collision presence.....	262
9.5.6.2	Jam generation	262
9.5.6.3	Collision-jam propagation delays	262
9.5.6.4	Transmit recovery time.....	263
9.5.6.5	Carrier recovery time	263
9.5.7	Electrical isolation	263
9.6	Detailed repeater functions and state diagrams	264
9.6.1	State diagram notation	264
9.6.2	Data and collision handling	267
9.6.3	Preamble regeneration	267
9.6.4	Fragment extension.....	267
9.6.5	MAU Jabber Lockup Protection.....	268
9.6.6	Auto-Partitioning/Reconnection (optional)	268
9.6.6.1	Overview.....	268
9.6.6.2	Detailed auto-partition/reconnection algorithm state diagram	268
9.7	Electrical isolation	271
9.7.1	Environment A requirements.....	271
9.7.2	Environment B requirements	271
9.8	Reliability.....	271
9.9	Medium attachment unit and baseband medium specification for a vendor-independent FOIRL	272
9.9.1	Scope.....	272
9.9.1.1	Overview.....	272
9.9.1.2	Application perspective: FOMAU and medium objectives.....	274
9.9.1.3	Compatibility considerations	274
9.9.1.4	Relationship to AUI.....	274
9.9.1.5	Mode of operation.....	274
9.9.2	FOMAU functional specifications.....	274
9.9.2.1	Transmit function requirements.....	275
9.9.2.2	Receive function requirements	276

9.9.2.3	Collision Presence function requirements	276
9.9.2.4	Jabber function requirements.....	277
9.9.2.5	Low Light Level Detection function requirements.....	277
9.9.2.6	Repeater Unit to FOMAU Physical Layer messages.....	278
9.9.2.7	FOMAU Physical Layer to repeater unit messages.....	278
9.9.2.7.1	input message.....	278
9.9.2.7.2	input_idle message.....	278
9.9.2.7.3	fomau_available message	278
9.9.2.7.4	signal_quality_error message	278
9.9.2.8	FOMAU state diagrams	279
9.9.3	FOMAU electrical characteristics	280
9.9.3.1	Electrical isolation	280
9.9.3.2	Power consumption.....	280
9.9.3.3	Reliability.....	281
9.9.3.4	FOMAU/Repeater unit electrical characteristics	281
9.9.3.5	FOMAU/Repeater unit mechanical connection.....	281
9.9.4	FOMAU/Optical medium interface	281
9.9.4.1	Transmit optical parameters.....	281
9.9.4.1.1	Wavelength	281
9.9.4.1.2	Spectral width	281
9.9.4.1.3	Optical modulation	281
9.9.4.1.4	Optical idle signal	281
9.9.4.1.5	Transmit optical logic polarity.....	281
9.9.4.1.6	Optical rise and fall times	283
9.9.4.1.7	Transmit optical pulse edge jitter.....	283
9.9.4.1.8	Peak coupled optical power	284
9.9.4.2	Receive optical parameters	284
9.9.4.2.1	Receive peak optical power range	284
9.9.4.2.2	Receive optical pulse edge jitter	284
9.9.4.2.3	Receive optical logic polarity	284
9.9.5	Characteristics of the optical fiber cable link segment	284
9.9.5.1	Optical fiber medium	285
9.9.5.2	Optical medium connector plug and socket.....	285
9.9.6	System requirements.....	285
9.9.6.1	Optical transmission system considerations	285
9.9.6.2	Timing considerations.....	286
9.9.7	Environmental specifications.....	287
9.9.7.1	Safety requirements	287
9.9.7.1.1	Electrical safety.....	287
9.9.7.1.2	Optical source safety.....	287
9.9.7.2	Electromagnetic environment	287
9.9.7.2.1	Susceptibility levels	287
9.9.7.2.2	Emission levels	287
9.9.7.3	Temperature and humidity	288
10.	Medium attachment unit and baseband medium specifications, type 10BASE2	289
10.1	Scope.....	289
10.1.1	Overview.....	289
10.1.1.1	Medium attachment unit (normally contained within the data terminal equipment [DTE]).....	290
10.1.1.2	Repeater unit	290
10.1.2	Definitions	290
10.1.3	Application perspective: MAU and medium objectives.....	290

10.1.3.1	Object.....	290
10.1.3.2	Compatibility considerations	291
10.1.3.3	Relationship to PLS and AUI	291
10.1.3.4	Mode of operation.....	291
10.2	References.....	291
10.3	MAU functional specifications	291
10.3.1	MAU Physical Layer functional requirements	292
10.3.1.1	Transmit function requirements.....	292
10.3.1.2	Receive function requirements	293
10.3.1.3	Collision Presence function requirements	293
10.3.1.4	Jabber functional requirements	294
10.3.2	MAU interface messages	294
10.3.2.1	DTE to MAU messages	294
10.3.2.2	MAU to DTE messages	294
10.3.2.2.1	input message.....	296
10.3.2.2.2	input_idle message.....	296
10.3.2.2.3	mau_available message.....	296
10.3.2.2.4	signal_quality_error (SQE) message	296
10.3.3	MAU state diagrams	296
10.4	MAU–medium electrical characteristics	297
10.4.1	MAU-to-coaxial cable interface	297
10.4.1.1	Input impedance.....	297
10.4.1.2	Bias current	297
10.4.1.3	Coaxial cable signaling levels.....	297
10.4.1.4	Transmit output levels symmetry	299
10.4.1.5	Collision detect thresholds.....	299
10.4.2	MAU electrical characteristics.....	299
10.4.2.1	Electrical isolation	299
10.4.2.2	Power consumption.....	299
10.4.2.3	Reliability.....	300
10.4.3	MAU–DTE electrical characteristics.....	300
10.5	Characteristics of coaxial cable system	300
10.5.1	Coaxial cable electrical parameters	300
10.5.1.1	Characteristic impedance	300
10.5.1.2	Attenuation.....	300
10.5.1.3	Velocity of propagation	300
10.5.1.4	Edge jitter; entire segment without DTEs attached	300
10.5.1.5	Transfer impedance.....	301
10.5.1.6	Cable dc loop resistance	301
10.5.2	Coaxial cable physical parameters.....	301
10.5.2.1	Mechanical requirements	301
10.5.2.1.1	General construction	302
10.5.2.1.2	Center conductor	302
10.5.2.1.3	Dielectric material.....	302
10.5.2.1.4	Shielding system	302
10.5.2.1.5	Overall jacket.....	302
10.5.2.2	Jacket marking	302
10.5.3	Total segment dc loop resistance	302
10.6	Coaxial trunk cable connectors	303
10.6.1	In-line coaxial extension connector	303
10.6.2	Coaxial cable terminator.....	304
10.6.3	MAU-to-coaxial cable connection.....	304
10.7	System considerations.....	304
10.7.1	Transmission system model.....	304

10.7.2	Transmission system requirements	306
10.7.2.1	Cable sectioning.....	306
10.7.2.2	MAU placement.....	306
10.7.2.3	Trunk cable system earthing	306
10.7.2.4	Static discharge path	306
10.7.2.4.1	Installation environment	306
10.8	Environmental specifications.....	307
10.8.1	Safety requirements	307
10.8.1.1	Installations	307
10.8.1.2	Earthing.....	307
10.8.2	Electromagnetic environment	307
10.8.2.1	Susceptibility levels	307
10.8.2.2	Emission levels	307
10.8.3	Regulatory requirements.....	307
11.	Broadband medium attachment unit and broadband medium specifications, type 10BROAD36	308
11.1	Scope.....	308
11.1.1	Overview.....	308
11.1.2	Definitions	310
11.1.3	MAU and medium objectives	310
11.1.4	Compatibility considerations	311
11.1.5	Relationship to PLS and AUI	311
11.1.6	Mode of operation.....	311
11.2	MAU functional specifications	311
11.2.1	MAU functional requirements	311
11.2.1.1	Transmit function requirements.....	311
11.2.1.2	Receive function requirements	312
11.2.1.3	Collision Detection function requirements	312
11.2.1.3.1	Collision enforcement transmitter requirements.....	313
11.2.1.3.2	Collision enforcement detection requirements	313
11.2.1.4	Jabber function requirements.....	313
11.2.2	DTE PLS to MAU and MAU to DTE PLS messages	314
11.2.2.1	DTE Physical Layer to MAU Physical Layer messages	314
11.2.2.2	MAU Physical Layer to DTE Physical Layer messages	314
11.2.2.2.1	input message.....	314
11.2.2.2.2	input_idle message.....	314
11.2.2.2.3	mau_available message.....	314
11.2.2.3	signal_quality_error message	314
11.2.3	MAU state diagrams	315
11.2.3.1	MAU state diagram messages.....	315
11.2.3.2	MAU state diagram signal names.....	315
11.3	MAU characteristics	318
11.3.1	MAU-to-coaxial cable interface	318
11.3.1.1	Receive interface.....	318
11.3.1.1.1	Receive input impedance	318
11.3.1.1.2	Receiver squelch requirements	318
11.3.1.1.3	Receive level requirements.....	319
11.3.1.1.4	Receiver selectivity and linearity requirements.....	319
11.3.1.1.5	Receive input mechanical requirements	319
11.3.1.2	Transmit interface	319
11.3.1.2.1	Transmit output impedance	319
11.3.1.2.2	Transmitted RF packet format	319
11.3.1.2.3	Transmit spectrum and group delay characteristics.....	320

11.3.1.2.4	Transmit out-of-band spectrum	322
11.3.1.2.5	Transmit level requirements	322
11.3.1.2.6	Nontransmitting signal leakage requirement	322
11.3.1.2.7	Transmit spurious output requirement	322
11.3.1.2.8	Collision enforcement signal leakage requirement.....	323
11.3.1.2.9	Transmit output mechanical requirements.....	323
11.3.2	MAU frequency allocations.....	323
11.3.2.1	Single-cable systems frequency allocations	323
11.3.2.2	Dual-cable systems frequency allocations.....	324
11.3.3	AUI electrical characteristics.....	324
11.3.3.1	Electrical isolation requirements	324
11.3.3.2	Current consumption.....	324
11.3.3.3	Driver and receiver requirements	325
11.3.3.4	AUI mechanical connection.....	325
11.3.4	MAU transfer characteristics	325
11.3.4.1	AUI to coaxial cable framing characteristics.....	325
11.3.4.1.1	Scrambler and differential encoding requirements.....	326
11.3.4.2	Coaxial cable to AUI framing characteristics.....	327
11.3.4.3	Circuit DO to circuit DI framing characteristics	328
11.3.4.4	AUI to coaxial cable delay characteristics.....	328
11.3.4.4.1	Circuit DO to RF data signal delay.....	328
11.3.4.4.2	Circuit DO to CE RF output delay.....	328
11.3.4.4.3	Transmit postamble to SQE test signal delay	328
11.3.4.4.4	SQE test signal length.....	328
11.3.4.5	Coaxial cable to AUI delay characteristics.....	328
11.3.4.5.1	Received RF to circuit DI delay	329
11.3.4.5.2	Received RF to CE RF output and circuit CI delay.....	329
11.3.4.5.3	Collision enforcement to circuit CI delay.....	329
11.3.4.5.4	Receive data to SQE test delay	329
11.3.4.6	Delay from circuit DO to circuit DI.....	330
11.3.4.7	Interpacket gap requirement	331
11.3.4.8	Bit error ratio	331
11.3.5	Reliability.....	331
11.4	System considerations.....	332
11.4.1	Delay budget and network diameter	332
11.4.2	MAU operation with packets shorter than 512 bits	332
11.5	Characteristics of the coaxial cable system	333
11.5.1	Electrical requirements	333
11.5.2	Mechanical requirements.....	333
11.5.3	Delay requirements	333
11.6	Frequency translator requirements for the single-cable version	334
11.6.1	Electrical requirements	334
11.6.2	Mechanical requirements.....	334
11.7	Environmental specifications.....	334
11.7.1	Safety requirements	334
11.7.2	Electromagnetic environment.....	335
11.7.2.1	Susceptibility levels	335
11.7.2.2	Emission levels	335
11.7.3	Temperature and humidity.....	335
12.	Physical signaling, medium attachment, and baseband medium specifications, type 1BASE5	336
12.1	Introduction.....	336

12.1.1	Overview.....	336
12.1.2	Scope.....	336
12.1.3	Definitions	336
12.1.4	General characteristics	336
12.1.5	Compatibility	337
12.1.6	Objectives of type 1BASE5 specification	337
12.2	Architecture	337
12.2.1	Major concepts.....	337
12.2.2	Application perspective	338
12.2.3	Packet structure.....	338
12.2.3.1	Silence.....	339
12.2.3.2	Preamble	339
12.2.3.3	Start-of-frame delimiter	340
12.2.3.4	Data	340
12.2.3.5	End-of-transmission delimiter	340
12.3	DTE physical signaling (PLS) specification.....	341
12.3.1	Overview.....	341
12.3.1.1	Summary of major concepts	341
12.3.1.2	Application perspective	341
12.3.2	Functional specification.....	342
12.3.2.1	PLS-PMA interface.....	342
12.3.2.1.1	output message.....	342
12.3.2.1.2	output_idle message.....	342
12.3.2.1.3	input message.....	342
12.3.2.1.4	input_idle message.....	342
12.3.2.2	PLS-MAC interface	343
12.3.2.2.1	OUTPUT_UNIT	343
12.3.2.2.2	OUTPUT_STATUS.....	343
12.3.2.2.3	INPUT_UNIT	343
12.3.2.2.4	CARRIER_STATUS	343
12.3.2.2.5	SIGNAL_STATUS.....	343
12.3.2.3	PLS functions.....	344
12.3.2.3.1	State diagram variables.....	344
12.3.2.3.2	Output function	344
12.3.2.3.3	Input function.....	345
12.3.2.3.4	Error Sense function	345
12.3.2.3.5	Carrier Sense function	346
12.3.2.4	Signal encoding.....	346
12.3.2.4.1	Data transmission rate.....	346
12.3.2.4.2	Data symbol encoding	346
12.3.2.4.3	Collision presence encoding	346
12.3.2.4.4	Idle line encoding.....	347
12.4	Hub specification	348
12.4.1	Overview.....	348
12.4.1.1	Summary of major concepts	349
12.4.1.2	Application perspective	349
12.4.2	Hub structure.....	349
12.4.2.1	Upward side	349
12.4.2.2	Downward side	349
12.4.3	Hub PLS functional specification	350
12.4.3.1	Hub PLS to PMA interface	350
12.4.3.2	Hub PLS functions.....	350
12.4.3.2.1	State diagram variables.....	350
12.4.3.2.2	Upward Signal Transfer function	351

12.4.3.2.3	Jabber function.....	351
12.4.3.2.4	Downward Signal Transfer function.....	352
12.4.3.2.5	Retiming (jitter removal)	354
12.4.3.2.6	Header hub wrap-around	354
12.4.3.2.7	Collision presence startup.....	354
12.4.3.3	Reliability.....	355
12.5	Physical medium attachment (PMA) specification	355
12.5.1	Overview.....	355
12.5.2	PLS–PMA interface.....	355
12.5.3	Signal characteristics	356
12.5.3.1	Transmitter characteristics.....	356
12.5.3.1.1	Differential output voltage.....	356
12.5.3.1.2	Output timing jitter	359
12.5.3.1.3	Transmitter impedance balance	359
12.5.3.1.4	Common-mode output voltage	360
12.5.3.1.5	Common-mode tolerance.....	360
12.5.3.1.6	Transmitter fault tolerance.....	361
12.5.3.2	Receiver characteristics	361
12.5.3.2.1	Differential input voltage.....	361
12.5.3.2.2	Input timing jitter	361
12.5.3.2.3	Idle input behavior	361
12.5.3.2.4	Differential input impedance	362
12.5.3.2.5	Common-mode rejection	362
12.5.3.2.6	Noise immunity.....	363
12.5.3.2.7	Receiver fault tolerance	363
12.6	Medium Dependent Interface (MDI) specification	363
12.6.1	Line interface connector	363
12.6.2	Connector contact assignments.....	364
12.6.3	Labeling	364
12.7	Cable medium characteristics	365
12.7.1	Overview.....	365
12.7.2	Transmission parameters	365
12.7.2.1	Attenuation.....	365
12.7.2.2	Differential characteristic impedance	365
12.7.2.3	Medium timing jitter.....	365
12.7.2.4	Dispersion	366
12.7.3	Coupling parameters	366
12.7.3.1	Pair-to-pair crosstalk.....	366
12.7.3.2	Multiple-disturber crosstalk.....	366
12.7.3.3	Balance.....	367
12.7.4	Noise environment.....	367
12.7.4.1	Impulse noise	367
12.7.4.2	Crosstalk	368
12.8	Special link specification	368
12.8.1	Overview.....	368
12.8.2	Transmission characteristics	368
12.8.3	Permitted configurations.....	368
12.9	Timing.....	368
12.9.1	Overview.....	368
12.9.2	DTE timing	369
12.9.3	Medium timing	369
12.9.4	Special link timing	369
12.9.5	Hub timing	369
12.10	Safety	370

12.10.1	Isolation	370
12.10.2	Telephony voltages	371
13.	System considerations for multisegment 10 Mb/s baseband networks	372
13.1	Overview	372
13.1.1	Repeater usage	373
13.2	Definitions	373
13.3	Transmission System Model 1	373
13.4	Transmission System Model 2	380
13.4.1	Round-trip collision delay	380
13.4.1.1	Worst-case path delay value (PDV) selection	380
13.4.1.2	Worst-case PDV calculation	380
13.4.2	Interpacket gap (IPG) shrinkage	381
13.4.2.1	Worst-case path variability value (PVV) selection	382
13.4.2.2	Worst-case path variability value (PVV) calculation	382
13.5	Full duplex topology limitations	382
14.	Twisted-pair medium attachment unit (MAU) and baseband medium, type 10BASE-T including type 10BASE-Te	383
14.1	Scope	383
14.1.1	Overview	383
14.1.1.1	Medium Attachment Unit (MAU)	383
14.1.1.2	Repeater unit	384
14.1.1.3	Twisted-pair media	384
14.1.2	Definitions	384
14.1.3	Application perspective	385
14.1.3.1	Objectives	385
14.1.3.2	Compatibility considerations	386
14.1.3.3	Modes of operation	386
14.1.4	Relationship to PLS and AUI	386
14.2	MAU functional specifications	386
14.2.1	MAU functions	387
14.2.1.1	Transmit function requirements	388
14.2.1.2	Receive function requirements	388
14.2.1.3	Loopback function requirements (half duplex mode only)	389
14.2.1.4	Collision Presence function requirements (half duplex mode only)	389
14.2.1.5	signal_quality_error Message (SQE) Test function requirements	389
14.2.1.6	Jabber function requirements	389
14.2.1.7	Link Integrity Test function requirements	390
14.2.1.8	Auto-Negotiation	391
14.2.2	PMA interface messages	391
14.2.2.1	PLS to PMA messages	391
14.2.2.1.1	PMA to PLS messages	391
14.2.2.2	PMA to twisted-pair link segment messages	392
14.2.2.3	Twisted-pair link segment to PMA messages	392
14.2.2.4	Interface message time references	392
14.2.3	MAU state diagrams	392
14.2.3.1	State diagram variables	392
14.2.3.2	State diagram timers	398
14.3	MAU electrical specifications	398
14.3.1	MAU-to-MDI interface characteristics	398
14.3.1.1	Isolation requirement	398

14.3.1.2	Transmitter specifications	399
14.3.1.2.1	Differential output voltage	400
14.3.1.2.2	Transmitter differential output impedance	403
14.3.1.2.3	Output timing jitter	404
14.3.1.2.4	Transmitter impedance balance	404
14.3.1.2.5	Common-mode output voltage	404
14.3.1.2.6	Transmitter common-mode rejection.....	405
14.3.1.2.7	Transmitter fault tolerance.....	405
14.3.1.3	Receiver specifications	406
14.3.1.3.1	Receiver differential input signals	406
14.3.1.3.2	Receiver differential noise immunity	406
14.3.1.3.3	Idle input behavior	407
14.3.1.3.4	Receiver differential input impedance.....	407
14.3.1.3.5	Common-mode rejection	407
14.3.1.3.6	Receiver fault tolerance	407
14.3.2	MAU-to-AUI specification.....	407
14.3.2.1	MAU-AUI electrical characteristics	407
14.3.2.2	MAU-AUI mechanical connection	408
14.3.2.3	Power consumption.....	408
14.4	Characteristics of the simplex link segment	409
14.4.1	Overview.....	409
14.4.2	Transmission parameters	409
14.4.2.1	Insertion loss	409
14.4.2.2	Differential characteristic impedance	409
14.4.2.3	Medium timing jitter.....	409
14.4.2.4	Delay	410
14.4.3	Coupling parameters	410
14.4.3.1	Differential near-end crosstalk (NEXT) loss	410
14.4.3.1.1	Twenty-five-pair cable and twenty-five-pair binder groups.....	410
14.4.3.1.2	Four-pair cable.....	410
14.4.3.1.3	Other cables	410
14.4.3.2	Multiple-disturber NEXT (MDNEXT) loss	410
14.4.4	Noise environment.....	411
14.4.4.1	Impulse noise	411
14.4.4.2	Crosstalk noise.....	411
14.5	MDI specification	411
14.5.1	MDI connectors	411
14.5.2	Crossover function.....	412
14.6	System considerations.....	413
14.7	Environmental specifications.....	414
14.7.1	General safety	414
14.7.2	Network safety.....	414
14.7.2.1	Installation	414
14.7.2.2	Grounding.....	414
14.7.2.3	Installation and maintenance guidelines	414
14.7.2.4	Telephony voltages	414
14.7.3	Environment.....	415
14.7.3.1	Electromagnetic emission	415
14.7.3.2	Temperature and humidity.....	415
14.8	MAU labeling	415
14.9	Timing summary.....	416
14.10	Protocol implementation conformance statement (PICS) proforma for Clause 14, Twisted-pair medium attachment unit (MAU) and baseband medium, type 10BASE-T and type 10BASE-Te	417

14.10.1	Introduction.....	417
14.10.1.1	Scope.....	417
14.10.1.2	Reference	417
14.10.1.3	Definitions	417
14.10.1.4	Conformance.....	417
14.10.2	Identification of implementation	418
14.10.2.1	Supplier information	418
14.10.2.2	Implementation information	418
14.10.3	Identification of the protocol	418
14.10.4	PICS proforma for 10BASE-T	419
14.10.4.1	Abbreviations.....	419
14.10.4.2	PICS Completion instructions and implementation statement	419
14.10.4.3	Additional information	419
14.10.4.4	References.....	419
14.10.4.5	PICS proforma tables for MAU.....	420
14.10.4.5.1	MAU functions	420
14.10.4.5.2	Transmit function.....	421
14.10.4.5.3	Receive function	421
14.10.4.5.4	Loopback function	422
14.10.4.5.5	Collision Detect function	422
14.10.4.5.6	signal_quality_error Message Test function.....	423
14.10.4.5.7	Jabber function.....	423
14.10.4.5.8	Link Integrity Test function.....	424
14.10.4.5.9	MAU state diagram requirements.....	425
14.10.4.5.10	AUI requirements	425
14.10.4.5.11	Isolation requirements.....	425
14.10.4.5.12	Transmitter specification	426
14.10.4.5.13	Receiver specification.....	427
14.10.4.5.14	MDI requirements.....	428
14.10.4.5.15	Safety requirements	428
14.10.4.6	PICS proforma tables for MAU AUI characteristics.....	429
14.10.4.6.1	Signal characteristics	429
14.10.4.6.2	DI and CI driver characteristics	429
14.10.4.6.3	DO receiver characteristics.....	430
14.10.4.6.4	Power consumption.....	430
14.10.4.6.5	Circuit termination.....	431
14.10.4.6.6	Mechanical characteristics.....	431
14.10.4.7	PICS proforma tables for 10BASE-T link segment.....	432
14.10.4.7.1	10BASE-T link segment characteristics	432
14.10.4.8	PICS proforma tables for Auto-Negotiation able MAUs	433
15.	Fiber optic medium and common elements of medium attachment units and star, type 10BASE-F.....	434
15.1	Scope.....	434
15.1.1	Overview.....	434
15.1.1.1	Fiber optic medium attachment units (MAUs).....	434
15.1.1.2	Fiber optic passive star	434
15.1.1.3	Repeater unit	435
15.1.2	Definitions	436
15.1.3	Applications perspective: MAUs, stars, and fiber optic medium	436
15.1.3.1	Objectives	436
15.1.3.2	Compatibility considerations	436
15.1.3.3	Relationship to PLS and AUI	437

15.1.3.4	Guidelines for implementation of systems	438
15.1.3.5	Modes of operation	438
15.2	MDI optical characteristics	439
15.2.1	Transmit optical parameters.....	439
15.2.1.1	Center wavelength	439
15.2.1.2	Spectral width	439
15.2.1.3	Optical modulation extinction ratio	439
15.2.1.4	Optical Idle Signal amplitude	439
15.2.1.5	Optical transmit pulse logic polarity.....	439
15.2.1.6	Optical transmit pulse rise and fall times.....	439
15.2.1.7	Optical transmit pulse overshoot and undershoot.....	439
15.2.1.8	Optical transmit pulse edge jitter	439
15.2.1.9	Optical transmit pulse duty cycle distortion	441
15.2.1.10	Optical transmit average power range	441
15.2.1.11	Optical transmit signal templates.....	441
15.2.1.11.1	10BASE-FP optical transmit signal template	442
15.2.1.11.2	10BASE-FB optical transmit signal template.....	443
15.2.1.11.3	10BASE-FL Optical transmit signal template	445
15.2.2	Receive optical parameters	446
15.2.2.1	Optical receive average power range.....	446
15.2.2.2	Optical receive pulse edge jitter.....	446
15.2.2.3	Optical receive pulse logic polarity	446
15.2.2.4	Optical receive pulse rise and fall times	447
15.3	Characteristics of the fiber optic medium	447
15.3.1	Optical fiber and cable	447
15.3.1.1	Attenuation.....	447
15.3.1.2	Modal bandwidth	447
15.3.1.3	Propagation delay	447
15.3.2	Optical medium connector plug and socket.....	447
15.3.2.1	Optical connector insertion loss.....	448
15.3.2.2	Optical connector return loss	448
15.3.3	Fiber optic medium insertion loss.....	448
15.3.3.1	10BASE-FP segment insertion loss.....	448
15.3.3.2	10BASE-FB and 10BASE-FL segment insertion loss	449
15.3.4	Electrical isolation	449
15.4	MAU reliability.....	449
15.5	MAU–AUI specification.....	449
15.5.1	MAU–AUI electrical characteristics	449
15.5.2	MAU–AUI mechanical connections.....	449
15.5.3	Power consumption.....	449
15.5.4	MAU–AUI messages	450
15.5.4.1	PLS to PMA messages.....	450
15.5.4.2	PMA to PLS messages.....	450
15.5.4.2.1	signal_quality_error message	450
15.6	Environmental specifications.....	451
15.6.1	Safety requirements	451
15.6.2	Electromagnetic environment	451
15.6.3	Other environmental requirements	451
15.7	MAU labeling	452
15.7.1	10BASE-FP star labeling.....	452
15.8	Protocol implementation conformance statement (PICS) proforma for Clause 15, Fiber optical medium and common elements of medium attachment units and star, type 10BASE-F.....	453
15.8.1	Introduction.....	453

15.8.2	Abbreviations and special symbols.....	453
15.8.2.1	Status symbols	453
15.8.2.2	Abbreviations.....	453
15.8.3	Instructions for completing the PICS proforma.....	453
15.8.3.1	General structure of the PICS proforma	453
15.8.3.2	Additional information	454
15.8.3.3	Exception information	454
15.8.3.4	Conditional items	455
15.8.4	Identification.....	455
15.8.4.1	Implementation identification.....	455
15.8.4.2	Protocol summary	455
15.8.5	Major capabilities/options.....	456
15.8.6	PICS Proforma for the fiber optic medium.....	456
15.8.6.1	Characteristics of the fiber optic medium.....	456
15.8.6.2	Optical medium connector plug and socket.....	457
15.8.6.3	Fiber optic medium insertion loss.....	457
15.8.6.4	Electrical isolation requirements	457
16.	Fiber optic passive star and medium attachment unit, type 10BASE-FP.....	458
16.1	Scope.....	458
16.1.1	Overview.....	458
16.1.1.1	10BASE-FP medium attachment unit.....	458
16.1.1.2	10BASE-FP Star	458
16.1.1.3	Repeater unit	458
16.2	PMA interface messages.....	459
16.2.1	PMA-to-MDI interface signal encodings	459
16.2.2	PMA-to-MDI OTD messages	459
16.2.2.1	OTD_output.....	459
16.2.2.2	OTD_idle	459
16.2.2.3	OTD_manch_violation.....	460
16.2.3	MDI ORD-to-PMA messages.....	460
16.2.3.1	ORD_input.....	460
16.2.3.2	ORD_idle	461
16.2.3.3	ORD_crv.....	461
16.3	10BASE-FP MAU functional specifications.....	461
16.3.1	Transmit function requirements.....	461
16.3.1.1	Preamble encoding.....	462
16.3.1.1.1	Synchronization pattern	462
16.3.1.1.2	Packet header code rule violation	462
16.3.1.1.3	Unique word	462
16.3.1.2	Data transmit.....	462
16.3.1.3	Collision encoding (unique word jam)	463
16.3.2	Receive function requirements	463
16.3.2.1	Preamble reconstruction and alignment.....	463
16.3.2.2	Data receive	463
16.3.2.3	Signal presence during collision.....	463
16.3.3	Loopback function requirements	463
16.3.4	Collision presence function requirements.....	464
16.3.4.1	CI Circuit signaling.....	464
16.3.4.2	Collision detection	464
16.3.4.3	End of collision.....	465
16.3.5	signal_quality_error Message (SQE) Test function requirements.....	465
16.3.6	Jabber function requirements.....	465

16.3.7	Link fault detection and low light function requirements.....	466
16.3.8	Interface message time references	467
16.3.9	MAU state diagram.....	467
16.3.9.1	MAU state diagram variables	467
16.3.9.2	MAU state diagram timers.....	469
16.3.9.3	MAU state diagram counters	470
16.4	Timing summary.....	475
16.5	10BASE-FP Star functional specifications.....	475
16.5.1	Star functions	475
16.5.1.1	Number of ports	475
16.5.1.2	Optical power division.....	475
16.5.1.3	Configuration	476
16.5.1.4	Reliability.....	476
16.5.2	Star optical characteristics	476
16.5.2.1	Star insertion loss.....	476
16.5.2.2	Star single output port uniformity.....	476
16.5.2.3	Star directivity.....	476
16.6	Protocol implementation conformance statement (PICS) proforma for Clause 16, Fiber optic passive star and medium attachment unit, type 10BASE-FP	477
16.6.1	Introduction.....	477
16.6.2	Abbreviations and special symbols.....	477
16.6.2.1	Status symbols	477
16.6.2.2	Abbreviations.....	477
16.6.3	Instructions for completing the PICS proforma.....	477
16.6.3.1	General structure of the PICS proforma	477
16.6.3.2	Additional information	478
16.6.3.3	Exception information	478
16.6.3.4	Conditional items	479
16.6.4	Identification.....	479
16.6.4.1	Implementation identification.....	479
16.6.4.2	Protocol summary	479
16.6.5	Major capabilities/options.....	480
16.6.6	PICS proforma for the type 10BASE-FP MAU	480
16.6.6.1	Compatibility considerations	480
16.6.6.2	Optical transmit parameters.....	481
16.6.6.3	Optical receive parameters.....	482
16.6.6.4	Optical medium connector plug and socket.....	482
16.6.6.5	MAU functions	482
16.6.6.6	PMA interface messages.....	482
16.6.6.7	PMA to MDI OTD messages.....	483
16.6.6.8	MDI ORD to PMA messages	483
16.6.6.9	Transmit functions	483
16.6.6.10	Collision Encoding (Unique Word Jam) function	484
16.6.6.11	Receive functions.....	484
16.6.6.12	Preamble reconstruction and alignment function	485
16.6.6.13	Data receive function	485
16.6.6.14	Signal presence during collision.....	485
16.6.6.15	Loopback function	486
16.6.6.16	Collision presence function	486
16.6.6.17	signal_quality_error Message (SQE) test function.....	487
16.6.6.18	Jabber function.....	487
16.6.6.19	Link Fault Detect function.....	487
16.6.6.20	MAU state diagram requirements	488
16.6.6.21	MAU-to-AUI signal characteristics.....	488

16.6.6.22	MAU-to-AUI DI and CI driver characteristics	488
16.6.6.23	AUI-to-MAU DO receiver characteristics.....	489
16.6.6.24	MAU-to-AUI circuit termination.....	489
16.6.6.25	MAU-to-AUI mechanical connections	490
16.6.6.26	MAU reliability.....	490
16.6.6.27	Power consumption.....	491
16.6.6.28	PLS–PMA requirements	491
16.6.6.29	signal_quality_error message (SQE)	491
16.6.6.30	Environmental requirements.....	492
16.6.6.31	MAU labeling	492
16.6.7	PICS proforma tables for 10BASE-FP stars.....	492
16.6.7.1	Star basic functions.....	492
16.6.7.2	Star optical characteristics	493
16.6.7.3	Star environmental requirements	493
16.6.7.4	10BASE-FP star labeling.....	493
17.	Fiber optic medium attachment unit, type 10BASE-FB.....	494
17.1	Scope.....	494
17.1.1	Overview.....	494
17.1.1.1	Medium attachment unit	494
17.1.1.2	Relationship to repeater	494
17.1.1.3	Remote diagnostic messages	494
17.1.2	Relationship to AUI.....	494
17.2	PMA interface messages.....	495
17.2.1	PMA-to-MDI interface signal encodings	495
17.2.2	PMA-to-MDI OTD messages	495
17.2.2.1	OTD_output.....	496
17.2.2.2	OTD_sync_idle.....	496
17.2.2.3	OTD_remote_fault.....	496
17.2.3	MDI ORD-to-PMA messages.....	496
17.2.3.1	Status decoding	496
17.2.3.2	ORD_input.....	496
17.2.3.3	ORD_sync_idle.....	496
17.2.3.4	ORD_remote_fault.....	497
17.2.3.5	ORD_invalid_data	497
17.2.4	Transitions between signals	497
17.2.5	Signaling rate	497
17.3	MAU functional specifications	497
17.3.1	Transmit function requirements.....	497
17.3.1.1	Data transmit.....	498
17.3.1.2	Synchronous idle.....	498
17.3.1.3	Fault signaling.....	498
17.3.2	Receive function requirements	498
17.3.2.1	Data receive	498
17.3.2.2	Remote status message handling	498
17.3.3	Collision function requirements.....	498
17.3.3.1	Collision detection	498
17.3.3.2	End of collision.....	499
17.3.4	Loopback function requirements	499
17.3.5	Fault-handling function requirements.....	499
17.3.6	Jabber function requirements	499
17.3.7	Low light level detection function requirements	500
17.3.8	Synchronous qualification function requirements	500

17.3.9	Interface message time references	501
17.3.10	MAU state diagrams	501
17.3.10.1	MAU state diagram variables	501
17.3.10.2	MAU state diagram timers.....	502
17.4	Timing summary.....	505
17.5	Protocol implementation conformance statement (PICS) proforma for Clause 17, Fiber optical medium attachment unit, type 10BASE-FB	506
17.5.1	Introduction.....	506
17.5.2	Abbreviations and special symbols.....	506
17.5.2.1	Status symbols	506
17.5.2.1.1	Abbreviations.....	506
17.5.3	Instructions for completing the PICS proforma.....	506
17.5.3.1	General structure of the PICS proforma	506
17.5.3.2	Additional information	507
17.5.3.3	Exception information	507
17.5.3.4	Conditional items.....	508
17.5.4	Identification.....	508
17.5.4.1	Implementation identification.....	508
17.5.4.2	Protocol summary	508
17.5.5	PICS proforma for the type 10BASE-FB MAU.....	508
17.5.6	PICS proforma for the type 10BASE-FB MAU.....	509
17.5.6.1	Compatibility considerations	509
17.5.6.2	Optical transmit parameters	509
17.5.6.3	Optical receive parameters	510
17.5.6.4	Optical medium connector plug and socket.....	510
17.5.6.5	MAU functions	511
17.5.6.6	PMA-to-MDI OTD messages and signaling	511
17.5.6.7	MDI ORD-to-PMA messages and signaling	512
17.5.6.8	Transitions between signals	512
17.5.6.9	Signaling rate	512
17.5.6.10	Transmit functions	513
17.5.6.11	Receive functions.....	513
17.5.6.12	Data receive function	514
17.5.6.13	Remote status message handling	514
17.5.6.14	Collision function requirements.....	514
17.5.6.15	End of collision.....	515
17.5.6.16	Loopback function	515
17.5.6.17	Fault-handling function.....	515
17.5.6.18	Jabber-handling function	516
17.5.6.19	Low light detection	516
17.5.6.20	Synchronous qualification	517
17.5.6.21	MAU state diagram requirements.....	517
17.5.6.22	MAU reliability.....	517
17.5.6.23	PLS-PMA requirements.....	518
17.5.6.24	signal_quality_error message (SQE)	518
17.5.6.25	Environmental requirements.....	518
17.5.6.26	MAU labeling	518
18.	Fiber optic medium attachment unit, type 10BASE-FL.....	519
18.1	Scope.....	519
18.1.1	Overview.....	519
18.1.1.1	10BASE-FL medium attachment unit (MAU)	519
18.1.1.2	Repeater unit	519

18.2	PMA interface messages.....	519
18.2.1	PMA to fiber optic link segment messages	520
18.2.1.1	OTD_output.....	520
18.2.1.2	OTD_idle	520
18.2.2	Fiber optic link segment to PMA messages.....	520
18.2.2.1	ORD_input.....	520
18.2.2.2	ORD_idle.....	520
18.2.3	Interface message time references	521
18.3	MAU functional specifications	521
18.3.1	MAU functions	521
18.3.1.1	Transmit function requirements.....	522
18.3.1.2	Receive function requirements	523
18.3.1.3	Loopback function requirements (half duplex mode only)	523
18.3.1.4	Collision Presence function requirements (half duplex mode only).....	523
18.3.1.5	signal_quality_error Message (SQE) Test function requirements.....	524
18.3.1.6	Jabber function requirements.....	524
18.3.1.7	Link Integrity Test function requirements	524
18.3.1.8	Auto-Negotiation	525
18.3.2	MAU state diagrams	525
18.3.2.1	MAU state diagram variables	525
18.3.2.2	MAU state diagram timers.....	527
18.4	Timing summary.....	532
18.5	Protocol implementation conformance statement (PICS) proforma for Clause 18, Fiber optical medium attachment unit, type 10BASE-FL	533
18.5.1	Introduction.....	533
18.5.2	Abbreviations and special symbols.....	533
18.5.2.1	Status symbols	533
18.5.2.2	Abbreviations.....	533
18.5.3	Instructions for completing the PICS proforma.....	534
18.5.3.1	General structure of the PICS proforma	534
18.5.3.2	Additional information	534
18.5.3.3	Exception information	534
18.5.3.4	Conditional items.....	535
18.5.4	Identification.....	535
18.5.4.1	Implementation identification.....	535
18.5.4.2	Protocol summary	535
18.5.5	Major capabilities/options.....	536
18.5.6	PICS proforma tables for the type 10BASE-FL MAU.....	536
18.5.6.1	Compatibility considerations	536
18.5.6.2	Optical transmit parameter	537
18.5.6.3	Optical receive parameters	538
18.5.6.4	Optical medium connector plug and socket.....	538
18.5.6.5	MAU functions	539
18.5.6.6	PMA interface messages.....	539
18.5.6.7	PMA-to-MDI OTD messages.....	539
18.5.6.8	MDI ORD-to-PMA messages.....	539
18.5.6.9	Transmit function	540
18.5.6.10	Receive function	540
18.5.6.11	Loopback function	541
18.5.6.12	Collision Presence function	541
18.5.6.13	signal_quality_error Message (SQE) Test function.....	541
18.5.6.14	Jabber function.....	542
18.5.6.15	Link Integrity Test function.....	542
18.5.6.16	MAU state diagram requirements.....	544

18.5.6.17	MAU-to-AUI signal characteristics.....	544
18.5.6.18	MAU-to-AUI DI and CI driver characteristics.....	545
18.5.6.19	AUI-to-MAU DO receiver characteristics.....	545
18.5.6.20	AUI circuit termination.....	546
18.5.6.21	MAU-to-AUI mechanical connections.....	546
18.5.6.22	MAU reliability.....	547
18.5.6.23	Power consumption.....	547
18.5.6.24	PLS–PMA requirements.....	547
18.5.6.25	signal_quality_error message (SQE).....	547
18.5.6.26	Environmental requirements.....	548
18.5.6.27	MAU labeling.....	548
19.	Layer Management for 10 Mb/s baseband repeaters.....	549
19.1	Introduction.....	549
19.1.1	Scope.....	549
19.1.2	Relationship to objects in IEEE Std 802.1F-1993.....	549
19.1.3	Definitions.....	549
19.1.4	Symbols and abbreviations.....	549
19.1.5	Management model.....	550
19.2	Managed objects.....	551
19.2.1	Introduction.....	551
19.2.2	Overview of managed objects.....	551
19.2.2.1	Text description of managed objects.....	551
19.2.2.2	Port functions to support management.....	551
19.2.2.3	Containment.....	553
19.2.2.4	Naming.....	554
19.2.2.5	Packages and capabilities.....	554
19.2.3	Repeater managed object class.....	556
19.2.3.1	Repeater attributes.....	556
19.2.3.1.1	aRepeaterID.....	556
19.2.3.1.2	aRepeaterGroupCapacity.....	556
19.2.3.1.3	aGroupMap.....	556
19.2.3.1.4	aRepeaterHealthState.....	556
19.2.3.1.5	aRepeaterHealthText.....	557
19.2.3.1.6	aRepeaterHealthData.....	557
19.2.3.1.7	aTransmitCollisions.....	557
19.2.3.2	Repeater actions.....	557
19.2.3.2.1	acResetRepeater.....	557
19.2.3.2.2	acExecuteNonDisruptiveSelfTest.....	558
19.2.3.3	Repeater notifications.....	558
19.2.3.3.1	nRepeaterHealth.....	558
19.2.3.3.2	nRepeaterReset.....	559
19.2.3.3.3	nGroupMapChange.....	559
19.2.4	ResourceTypeID Managed Object Class.....	559
19.2.5	Group managed object class.....	559
19.2.5.1	Group attributes.....	559
19.2.5.1.1	aGroupID.....	559
19.2.5.1.2	aGroupPortCapacity.....	560
19.2.5.1.3	aPortMap.....	560
19.2.5.2	Group Notifications.....	560
19.2.5.2.1	nPortMapChange.....	560
19.2.6	Port managed object class.....	560
19.2.6.1	Port Attributes.....	560

19.2.6.1.1	aPortID.....	560
19.2.6.1.2	aPortAdminState.....	561
19.2.6.1.3	aAutoPartitionState.....	561
19.2.6.1.4	aReadableFrames.....	561
19.2.6.1.5	aReadableOctets.....	561
19.2.6.1.6	aFrameCheckSequenceErrors.....	562
19.2.6.1.7	aAlignmentErrors.....	562
19.2.6.1.8	aFramesTooLong.....	562
19.2.6.1.9	aShortEvents.....	562
19.2.6.1.10	aRunts.....	563
19.2.6.1.11	aCollisions.....	563
19.2.6.1.12	aLateEvents.....	563
19.2.6.1.13	aVeryLongEvents.....	564
19.2.6.1.14	aDataRateMismatches.....	564
19.2.6.1.15	aAutoPartitions.....	564
19.2.6.1.16	aLastSourceAddress.....	564
19.2.6.1.17	aSourceAddressChanges.....	565
19.2.6.2	Port Actions.....	565
19.2.6.2.1	acPortAdminControl.....	565
20.	Layer Management for 10 Mb/s baseband medium attachment units.....	566
20.1	Introduction.....	566
20.1.1	Scope.....	566
20.1.2	Management model.....	566
20.2	Managed objects.....	566
20.2.1	Text description of managed objects.....	566
20.2.1.1	Naming.....	566
20.2.1.2	Containment.....	567
20.2.1.3	Packages.....	567
20.2.2	MAU Managed object class.....	568
20.2.2.1	MAU attributes.....	568
20.2.2.1.1	aMAUID.....	568
20.2.2.1.2	aMAUType.....	568
20.2.2.1.3	aMediaAvailable.....	569
20.2.2.1.4	aLoseMediaCounter.....	569
20.2.2.1.5	aJabber.....	569
20.2.2.1.6	aMAUAdminState.....	570
20.2.2.1.7	aBbMAUXmitRcvSplitType.....	570
20.2.2.1.8	aBroadbandFrequencies.....	570
20.2.2.2	MAU actions.....	571
20.2.2.2.1	acResetMAU.....	571
20.2.2.2.2	acMAUAdminControl.....	571
20.2.2.3	MAU notifications.....	571
20.2.2.3.1	nJabber.....	571
Annex A (informative)	Bibliography.....	572
Annex B (informative)	System guidelines.....	576
B.1	Baseband system guidelines and concepts, 10 Mb/s.....	576
B.1.1	Overall system objectives.....	576
B.1.2	Analog system components and parameter values.....	576
B.1.3	Minimum frame length determination.....	578

B.1.4	System jitter budgets.....	579
B.1.4.1	Nominal jitter values.....	579
B.1.4.2	Decoder evaluation	580
B.1.5	Systems consideration calculations	581
B.1.5.1	Overview.....	581
B.1.5.2	Maximum collision fragment size	581
B.1.5.2.1	Left-end base SDV.....	582
B.1.5.2.2	Mid-base SDV	583
B.1.5.2.3	Right-end base SDV	583
B.1.5.3	Interpacket Gap (IPG) shrinkage	584
B.1.5.3.1	Transmitting end segment variability value.....	584
B.1.5.3.2	Mid-segment variability value.....	585
B.1.5.4	Timing parameters for round-trip delay and variability calculations	585
B.1.5.4.1	MAU parameters.....	585
B.1.5.4.2	Repeater parameters.....	586
B.1.5.4.3	Media parameters.....	586
B.1.5.4.4	DTE parameters	586
B.2	System parameters and budgets for 1BASE5	588
B.2.1	Delay budget	588
B.2.2	Minimum frame length determination	589
B.2.3	Jitter budget.....	590
B.3	Example crosstalk computation for multiple disturbers, balanced-pair cable	591
B.4	10BASE-T guidelines	593
B.4.1	System jitter budget	593
B.4.2	Filter characteristics	593
B.4.3	Notes for conformance testing	593
B.4.3.1	Notes for 14.3.1.2.1 on differential output voltage.....	593
B.4.3.2	Note for 14.3.1.2.2 on transmitter differential output impedance	594
B.4.3.3	Note for 14.3.1.2.3 on output timing jitter.....	594
B.4.3.4	General note on common-mode tests.....	595
B.4.3.5	Note for 14.3.1.3.4 on receiver differential input impedance.....	595
B.4.3.6	Note for 14.3.1.3.3 on receiver idle input behavior.....	595
B.4.3.7	Note for 14.3.1.3.5 on receiver common-mode rejection.....	595
B.5	10BASE-F.....	596
B.5.1	System jitter budget	596
B.5.2	10BASE-FP fiber optic segment loss budget	596
Annex C (informative) State diagram, MAC sublayer		599
Annex D (informative) Application context, selected medium specifications		600
D.1	Introduction.....	600
D.2	Type 10BASE5 applications.....	600
D.3	Type 10BASE2 applications.....	600
D.4	Type FOIRL and 10BASE-F applications; alternative fiber optic medium applications	601
D.4.1	Alternative fiber types	601
D.4.1.1	Theoretical coupling losses.....	601
D.4.1.2	Maximum launch power	602
D.4.2	Type 10BASE-FP applications using 50/125 μm fiber	603
D.4.2.1	Coupled transmit power.....	603
D.4.2.2	Star coupler loss.....	603
D.4.2.3	Collision detection	604
D.5	10BASE-T use of cabling systems with a nominal differential characteristic impedance of 120 Ω	604

D.6	10BASE-T use of cabling systems with a nominal differential characteristic impedance of 150 Ω	605
	Annex E (informative) Receiver wavelength design considerations (FOIRL).....	607
	Annex F (normative) Additional attributes required for systems	608
F.1	Introduction	608
F.1.1	Scope.....	608
F.2	Objects/Attributes/Actions/Notifications.....	608
F.2.1	TimeSinceSystemReset attribute	608
F.2.2	RepeaterResetTimeStamp attribute	609
F.2.3	ResetSystemAction action	609
	Annex G (normative) Additional material required for conformance testing	610
G.1	Introduction	610
G.1.1	Material in support of the aDataRateMismatches attribute	610
	Annex H (normative) GDMO specifications for CSMA/CD managed objects	611
	Annex 4A (normative) Simplified full duplex media access control	612
4A.1	Functional model of the MAC method	612
4A.1.1	Overview.....	612
4A.1.2	Full duplex operation	613
4A.1.2.1	Transmission.....	613
4A.1.2.2	Reception	613
4A.1.3	Relationships to the MAC client and Physical Layers	614
4A.2	Media access control (MAC) method: precise specification	614
4A.2.1	Introduction.....	614
4A.2.2	Overview of the procedural model	614
4A.2.2.1	Ground rules for the procedural model.....	614
4A.2.2.2	Use of Pascal in the procedural model.....	615
4A.2.2.3	Organization of the procedural model	615
4A.2.2.4	Layer management extensions to procedural model.....	620
4A.2.3	Packet transmission model.....	620
4A.2.3.1	Transmit data encapsulation	620
4A.2.3.2	Transmit media access management.....	620
4A.2.3.2.1	Deference	620
4A.2.3.2.2	Interpacket gap.....	621
4A.2.3.2.3	Transmission.....	621
4A.2.3.2.4	Minimum frame size	621
4A.2.4	Frame reception model	621
4A.2.4.1	Receive data decapsulation	621
4A.2.4.1.1	Address recognition	621
4A.2.4.1.2	Frame check sequence validation	622
4A.2.4.1.3	Frame disassembly.....	622
4A.2.4.2	Receive media access management	622
4A.2.5	Preamble generation	622
4A.2.6	Start frame sequence.....	622
4A.2.7	Global declarations	623
4A.2.7.1	Common constants, types, and variables	623
4A.2.7.2	Transmit state variables	624

4A.2.7.3	Receive state variables.....	624
4A.2.7.4	State variable initialization	624
4A.2.8	Frame transmission	625
4A.2.9	Frame reception	628
4A.2.10	Common procedures	631
4A.3	Interfaces to/from adjacent layers	631
4A.3.1	Overview.....	631
4A.3.2	MAC service	631
4A.3.2.1	MAC client transmit interface state diagram.....	631
4A.3.2.1.1	Variables	631
4A.3.2.1.2	Functions.....	632
4A.3.2.1.3	Messages	632
4A.3.2.1.4	MAC client transmit interface state diagram.....	632
4A.3.2.2	MAC client receive interface state diagram	633
4A.3.2.2.1	Variables	633
4A.3.2.2.2	Functions.....	633
4A.3.2.2.3	Messages	633
4A.3.2.2.4	MAC client receive interface state diagram	634
4A.3.3	Services required from the Physical Layer	634
4A.4	Specific implementations	635
4A.4.1	Compatibility overview	635
4A.4.2	MAC parameters.....	636

IEEE Standard for Ethernet

Section One: This section includes Clause 1 through Clause 20, Annex A through Annex H, and Annex 4A.

1. Introduction

1.1 Overview

This is an international standard for Local and Metropolitan Area Networks (LANs and MANs), employing CSMA/CD as the shared media access method and the IEEE 802.3 (Ethernet) protocol and frame format for data communication. This international standard is intended to encompass several media types and techniques for a variety of MAC data rates as shown in Figure 1–1 and in 4.4.2.

1.1.1 Scope

This standard defines Ethernet local area, access and metropolitan area networks. Ethernet is specified at selected speeds of operation; and uses a common media access control (MAC) specification and management information base (MIB). The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) MAC protocol specifies shared medium (half duplex) operation, as well as full duplex operation. Speed specific Media Independent Interfaces (MIIs) provide an architectural and optional implementation interface to selected Physical Layer entities (PHY). The Physical Layer encodes frames for transmission and decodes received frames with the modulation specified for the speed of operation, transmission medium and supported link length. Other specified capabilities include: control and management protocols, and the provision of power over selected twisted pair PHY types.

1.1.2 Basic concepts

This standard provides for two distinct modes of operation: half duplex and full duplex. A given IEEE 802.3 instantiation operates in either half or full duplex mode at any one time. The term “CSMA/CD MAC” is used throughout this standard synonymously with “802.3 MAC,” and may represent an instance of either a half duplex or full duplex mode data terminal equipment (DTE), even though full duplex mode DTEs do not implement the CSMA/CD algorithms traditionally used to arbitrate access to shared-media LANs.