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**Telecommunications and exchange
between information technology
systems — Requirements for local and
metropolitan area networks —**

**Part 3:
Standard for Ethernet**

*Télécommunications et échange entre systèmes informatiques —
Exigences pour les réseaux locaux et métropolitains —*

Partie 3: Norme pour Ethernet



Reference number
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ISO/IEC/IEEE 8802-3 was prepared by the LAN/MAN of the IEEE Computer Society (as IEEE Std 8802-3: 2018) and drafted in accordance with its editorial rules. It was adopted, under the "fast-track procedure" defined in the Partner Standards Development Organization cooperation agreement between ISO and IEEE, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

This third edition cancels and replaces the second edition (ISO/IEC/IEEE 8802-3:2017), which has been technically revised. It also incorporates the Amendments ISO/IEC/IEEE 8802-3:2017/Amd 1:2017, ISO/IEC/IEEE 8802-3:2017/Amd 2:2017, ISO/IEC/IEEE 8802-3:2017/Amd 3:2017, ISO/IEC/IEEE 8802-3:2017/Amd 4:2017, ISO/IEC/IEEE 8802-3:2017/Amd 5:2017, ISO/IEC/IEEE 8802-3:2017/Amd 6:2018, ISO/IEC/IEEE 8802-3:2017/Amd 7:2017, ISO/IEC/IEEE 8802-3:2017/Amd 8:2018, ISO/IEC/IEEE 8802-3:2017/Amd 9:2018, ISO/IEC/IEEE 8802-3:2017/Amd 9:2018, ISO/IEC/IEEE 8802-3:2017/Amd 10:2019, ISO/IEC/IEEE 8802-3:2017/Amd 11:2019 and the Technical Corrigendum ISO/IEC/IEEE 8802-3:2017/Cor 1:2018.

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ISO/IEC/IEEE 8802-3:2021(E)

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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 via 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; medium dependent 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

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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.

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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*
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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 , <i>Working Group Chair</i>
IEEE Std 802.3b-1985 (Clause 11), 10 Mb/s Broad-band MAU, 10BROAD36	19 September 1985	Donald C. Loughry , <i>Working Group Chair</i> Menachem Abraham , <i>Task Force Chair</i>
IEEE Std 802.3a-1988 (Clause 10), 10 Mb/s MAU 10BASE2	15 November 1985	Donald C. Loughry , <i>Working Group Chair</i> Alan Flatman , <i>Task Force Chair</i>
IEEE Std 802.3c-1985 (9.1–9.8), 10 Mb/s Baseband Repeater	12 December 1985	Donald C. Loughry , <i>Working Group Chair</i> Geoffrey O. Thompson , <i>Task Force Chair</i>
IEEE Std 802.3e-1987 (Clause 12), 1 Mb/s MAU and Hub 1BASE5	11 June 1987	Donald C. Loughry , <i>Working Group Chair</i> Robert Galin , <i>Task Force Chair</i>
IEEE Std 802.3d-1987 (9.9), 10 Mb/s Fiber MAU, FOIRL	10 December 1987	Donald C. Loughry , <i>Working Group Chair</i> Steven Moustakas , <i>Task Force Chair</i>
IEEE Std 802.3h-1990 (Clause 5), 10 Mb/s Layer Management, DTEs	28 September 1990	Donald C. Loughry , <i>Working Group Chair</i> Andy J. Luque , <i>Task Force Chair</i>
IEEE Std 802.3i-1990 (Clauses 13 and 14), 10 Mb/s UTP MAU, 10 BASE-T	28 September 1990	Donald C. Loughry , <i>Working Group Chair</i> Patricia Thaler , <i>Task Force Chair (initial)</i> Richard Anderson , <i>Task Force Chair (final)</i>
IEEE Std 802.3k-1993 (Clause 19), 10 Mb/s Layer Management, Repeaters	17 September 1992	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 802.3l-1992 (14.10), 10 Mb/s PICS Proforma 10BASE-T MAU	17 September 1992	Patricia Thaler , <i>Working Group Chair</i> Mike Armstrong , <i>Task Force Chair and Editor</i> Paul Nikolich , <i>Vice Chair</i> William Randle , <i>Editorial Coordinator</i>

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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>
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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> Imre 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>
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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>

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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. McCormack , <i>Task Force Editor (Phase 1)</i> John J. Jetzt , <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>
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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>
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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>

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IEEE Std 802.3ap-2007, Ethernet Operation over Electrical Backplanes	22 March 2007	Robert M. Grow , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice-Chair</i> Wael W. Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i> Adam Healey , <i>Task Force Chair</i> Schelto vanDoorn , <i>Task Force Editor-in-Chief (Phase 1)</i> Ilango S. Ganga , <i>Task Force Editor-in-Chief (Phase 2)</i>
IEEE Std 802.3-2005/Cor 2-2007 (IEEE 802.3aw), 10GBASE-T corrigendum	7 June 2007	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> Bradley Booth , <i>Working Group Treasurer</i>
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 , <i>Working Group Chair</i> David J. Law , <i>Working Group Vice Chair, Task Force Chair, and Task Force Editor</i> Wael William Diab , <i>Working Group Secretary</i> Steven B. Carlson , <i>Working Group Executive Secretary</i> Bradley Booth , <i>Working Group Treasurer</i>
IEEE Std 802.3at-2009 Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements	11 September 2009	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> Bradley Booth , <i>Working Group Treasurer</i> Mike McCormack , <i>Task Force Chair</i> D. Matthew Landry , <i>Task Force Chief Editor</i>
IEEE Std 802.3av-2009 Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks	11 September 2009	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> Bradley Booth , <i>Working Group Treasurer</i> Glen Kramer , <i>Task Force Chair</i> Duane Remein , <i>Task Force Chief Editor</i>
IEEE Std 802.3bc-2009 Ethernet Organizationally Specific Type, Length, Value (TLVs)	11 September 2009	David J. Law , <i>Working Group Chair and Task Force Editor</i> Wael W. Diab , <i>Working Group Vice Chair and Task Force 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>
IEEE Std 802.3-2008/Cor 1-2009 (IEEE 802.3bb) Pause Reaction Delay Corrigendum.	9 December 2009	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>

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	<p>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></p>
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	<p>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></p>
IEEE Std 802.3by-2016 Media Access Control Parameters, Physical Layers, and Management Parameters for 25 Gb/s Operation	30 June 2016	<p>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></p>
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	<p>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></p>
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	<p>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></p>
IEEE Std 802.3br-2016 Specification and Management Parameters for Interspersing Express Traffic	30 June 2016	<p>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></p>
IEEE Std 802.3bn-2016 Physical Layer Specifications and Management Parameters for Ethernet Passive Optical Networks Protocol over Coax	22 September 2016	<p>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></p>
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	<p>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></p>
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	<p>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></p>

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>

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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

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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 optic 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 optic 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.

1.1.2.1 Half duplex operation

In half duplex mode, the CSMA/CD media access method is the means by which two or more stations share a common transmission medium. To transmit, a station waits (defers) for a quiet period on the medium (that is, no other station is transmitting) and then sends the intended message in bit-serial form. If, after initiating a transmission, the message collides with that of another station, then each transmitting station intentionally transmits for an additional predefined period to ensure propagation of the collision throughout the system. The station remains silent for a random amount of time (backoff) before attempting to transmit again. Each aspect of this access method process is specified in detail in subsequent clauses of this standard.

Half duplex operation can be used with certain media types and configurations as defined by this standard. For allowable configurations, see 4.4.2.

1.1.2.2 Full duplex operation

Full duplex operation allows simultaneous communication between a pair of stations using point-to-point media (dedicated channel). Full duplex operation does not require that transmitters defer, nor do they monitor or react to receive activity, as there is no contention for a shared medium in this mode. Full duplex mode can only be used when all of the following are true:

- a) The physical medium is capable of supporting simultaneous transmission and reception without interference.
- b) There are exactly two stations connected with a full duplex point-to-point link. Since there is no contention for use of a shared medium, the multiple access (i.e., CSMA/CD) algorithms are unnecessary.
- c) Both stations on the LAN are capable of, and have been configured to use, full duplex operation.

The most common configuration envisioned for full duplex operation consists of a central bridge (also known as a switch) with a dedicated LAN connecting each bridge port to a single device. Repeaters as defined in this standard are outside the scope of full duplex operation.

Full duplex operation constitutes a proper subset of the MAC functionality required for half duplex operation.

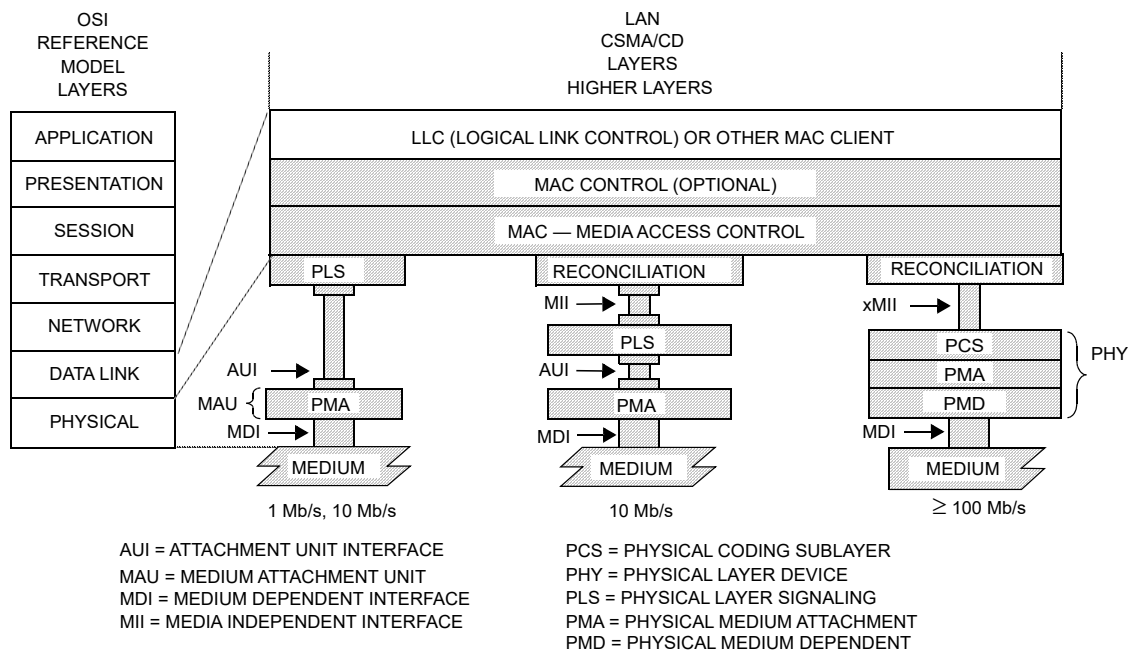
1.1.3 Architectural perspectives

There are two important ways to view network design corresponding to the following:

- a) *Architecture*. Emphasizing the logical divisions of the system and how they fit together.
- b) *Implementation*. Emphasizing actual components, their packaging, and interconnection.

This standard is organized along architectural lines, emphasizing the large-scale separation of the system into two parts: the Media Access Control (MAC) sublayer of the Data Link Layer and the Physical Layer. These layers are intended to correspond closely to the lowest layers of the ISO/IEC Model for Open Systems Interconnection (see Figure 1–1). (See ISO/IEC 7498-1:1994.¹) The Logical Link Control (LLC) sublayer and MAC sublayer together encompass the functions intended for the Data Link Layer as defined in the OSI model.

¹For information about references, see 1.3.



NOTE—In this figure, the xMII is used as a generic term for the Media Independent Interfaces for implementations of 100 Mb/s and above. For example: for 100 Mb/s implementations this interface is called MII; for 1 Gb/s implementations it is called GMII; for 10 Gb/s implementations it is called XGMII; etc.

Figure 1–1—IEEE 802.3 standard relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model

1.1.3.1 Architectural rationale

An architectural organization of the standard has two main advantages:

- a) *Clarity.* A clean overall division of the design along architectural lines makes the standard clearer.
- b) *Flexibility.* Segregation of medium-dependent aspects in the Physical Layer allows the LLC and MAC sublayers to apply to a family of transmission media.

Partitioning the Data Link Layer allows various media access methods within the family of LAN standards.

The architectural model is based on a set of interfaces that may be different from those emphasized in implementations. One critical aspect of the design, however, shall be addressed largely in terms of the implementation interfaces: compatibility.

1.1.3.2 Compatibility interfaces

The following important compatibility interfaces are defined within what is architecturally the Physical Layer.

- a) *Medium Dependent Interfaces (MDI).* To communicate in a compatible manner, all stations shall adhere rigidly to the exact specification of physical media signals defined in the appropriate clauses in this standard, and to the procedures that define correct behavior of a station. The medium-independent aspects of the LLC sublayer and the MAC sublayer should not be taken as detracting from this point; communication in an Ethernet Local Area Network requires complete compatibility at the Physical Medium interface (that is, the physical cable interface).

- b) *Attachment Unit Interface (AUI)*. Some DTEs are located some distance from their connection to the physical cable. A small amount of circuitry will exist in the Medium Attachment Unit (MAU) directly adjacent to the physical cable, while the majority of the hardware and all of the software will be placed within the DTE. The AUI is defined as a second compatibility interface. While conformance with this interface is not strictly necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing MAUs and DTEs. The AUI may be optional or not specified for some implementations of this standard that are expected to be connected directly to the medium and so do not use a separate MAU or its interconnecting AUI cable. The PLS and PMA are then part of a single unit, and no explicit AUI implementation is required.
- c) *Media Independent Interface (MII)*. It is anticipated that some DTEs will be connected to a remote PHY, and/or to different medium dependent PHYs. The MII is defined as a third compatibility interface. While conformance with implementation of this interface is not strictly necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs. The MII is optional.
- d) *Gigabit Media Independent Interface (GMII)*. The GMII is designed to connect a 1 Gb/s capable MAC or repeater unit to a 1 Gb/s PHY. While conformance with implementation of this interface is not strictly necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 1 Gb/s speeds. The GMII is intended for use as a chip-to-chip interface. No mechanical connector is specified for use with the GMII. The GMII is optional.
- e) *Ten-bit Interface (TBI)*. The TBI is provided by the 1000BASE-X PMA sublayer as a physical instantiation of the PMA service interface. The TBI is recommended for 1000BASE-X systems, since it provides a convenient partition between the high-frequency circuitry associated with the PMA sublayer and the logic functions associated with the PCS and MAC sublayers. The TBI is intended for use as a chip-to-chip interface. No mechanical connector is specified for use with the TBI. The TBI is optional.
- f) *10 Gigabit Media Independent Interface (XGMII)*. The XGMII is designed to connect a 2.5 Gb/s, 5 Gb/s, or 10 Gb/s capable MAC to a PHY of the same rate. While conformance with implementation of this interface is not necessary to ensure communication, it allows maximum flexibility in intermixing PHYs and DTEs at 2.5 Gb/s, 5 Gb/s, and 10 Gb/s speeds. The XGMII is intended for use as a chip-to-chip interface. No mechanical connector is specified for use with the XGMII. The XGMII is optional.
- g) *10 Gigabit Attachment Unit Interface (XAUI)*. The XAUI is designed to extend the connection between a 10 Gb/s capable MAC and a 10 Gb/s PHY. While conformance with implementation of this interface is not necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 10 Gb/s speeds. The XAUI is intended for use as a chip-to-chip interface. No mechanical connector is specified for use with the XAUI. The XAUI is optional.
- h) *10 Gigabit Sixteen-Bit Interface (XSBI)*. The XSBI is provided as a physical instantiation of the PMA service interface for 10GBASE-R and 10GBASE-W PHYs. While conformance with implementation of this interface is not necessary to ensure communication, it provides a convenient partition between the high-frequency circuitry associated with the PMA sublayer and the logic functions associated with the PCS and MAC sublayers. No mechanical connector is specified for use with the XSBI. The XSBI is optional.
- i) *25 Gigabit Media Independent Interface (25GMII)*. The 25GMII is designed to connect a 25 Gb/s capable MAC to a 25 Gb/s PHY. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in intermixing PHYs and DTEs at 25 Gb/s speeds. The 25GMII is a logical interconnection intended for use as an intra-chip interface. No mechanical connector is specified for use with the 25GMII. The 25GMII is optional.
- j) *25 Gigabit Attachment Unit Interface (25GAUI)*. The 25GAUI is a physical instantiation of the PMA service interface to extend the connection between 25 Gb/s capable PMAs. While conformance with implementation of this interface is not necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 25 Gb/s

- speeds. The 25GAUI is intended for use as a chip-to-chip or a chip-to-module interface. No mechanical connector is specified for use with the 25GAUI. The 25GAUI is optional.
- k) *40 Gb/s Media Independent Interface (XLGMII)*. The XLGMII is designed to connect a 40 Gb/s capable MAC to a 40 Gb/s PHY. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in intermixing PHYs and DTEs at 40 Gb/s speeds. The XLGMII is a logical interconnection intended for use as an intra-chip interface. No mechanical connector is specified for use with the XLGMII. The XLGMII is optional.
 - l) *40 Gb/s Attachment Unit Interface (XLAUI)*. The XLAUI is a physical instantiation of the PMA service interface to extend the connection between 40 Gb/s capable PMAs. While conformance with implementation of this interface is not necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 40 Gb/s speeds. The XLAUI is intended for use as a chip-to-chip or a chip-to-module interface. No mechanical connector is specified for use with the XLAUI. The XLAUI is optional.
 - m) *40 Gb/s Parallel Physical Interface (XLPPPI)*. The XLPPPI is provided as a physical instantiation of the PMD service interface for 40GBASE-SR4 and 40GBASE-LR4 PMDs. The XLPPPI has four lanes. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in connecting the 40GBASE-SR4 or 40GBASE-LR4 PMDs. The XLPPPI is intended for use as a chip-to-module interface. No mechanical connector is specified for use with the XLPPPI. The XLPPPI is optional.
 - n) *100 Gb/s Media Independent Interface (CGMII)*. The CGMII is designed to connect a 100 Gb/s capable MAC to a 100 Gb/s PHY. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in intermixing PHYs and DTEs at 100 Gb/s speeds. The CGMII is a logical interconnection intended for use as an intra-chip interface. No mechanical connector is specified for use with the CGMII. The CGMII is optional.
 - o) *100 Gb/s Attachment Unit Interface (CAUI-n)*. The CAUI-n is a physical instantiation of the PMA service interface to extend the connection between 100 Gb/s capable PMAs. While conformance with implementation of this interface is not necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 100 Gb/s speeds. The CAUI-n is intended for use as a chip-to-chip or a chip-to-module interface. Two widths of CAUI-n are defined: a ten-lane version (CAUI-10) in Annex 83A and Annex 83B, and a four-lane version (CAUI-4) in Annex 83D and Annex 83E. No mechanical connector is specified for use with the CAUI-n. The CAUI-n is optional.
 - p) *100 Gb/s Parallel Physical Interface (CPPI)*. The CPPI is provided as a physical instantiation of the PMD service interface for 100GBASE-SR10 PMDs. The CPPI has ten lanes. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in connecting the 100GBASE-SR10 PMDs. The CPPI is intended for use as a chip-to-module interface. No mechanical connector is specified for use with the CPPI. The CPPI is optional.
 - q) *200 Gb/s Media Independent Interface (200GMII)*. The 200GMII is designed to connect a 200 Gb/s capable MAC to a 200 Gb/s PHY. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in intermixing PHYs and DTEs at 200 Gb/s speeds. The 200GMII is a logical interconnection intended for use as an intra-chip interface. No mechanical connector is specified for use with the 200GMII. The 200GMII is optional.
 - r) *200 Gb/s Attachment Unit Interface (200GAUI-n)*. The 200GAUI-n is a physical instantiation of the PMA service interface to extend the connection between 200 Gb/s capable PMAs. While conformance with implementation of this interface is not necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 200 Gb/s speeds. The 200GAUI-n is intended for use as a chip-to-chip or a chip-to-module interface. Two widths of 200GAUI-n are defined: an eight-lane version (200GAUI-8) in Annex 120B and Annex 120C, and a four-lane version (200GAUI-4) in Annex 120D and Annex 120E. No mechanical connector is specified for use with the 200GAUI-n. The 200GAUI-n is optional.

- s) *400 Gb/s Media Independent Interface (400GMII)*. The 400GMII is designed to connect a 400 Gb/s capable MAC to a 400 Gb/s PHY. While conformance with implementation of this interface is not necessary to ensure communication, it allows flexibility in intermixing PHYs and DTEs at 400 Gb/s speeds. The 400GMII is a logical interconnection intended for use as an intra-chip interface. No mechanical connector is specified for use with the 400GMII. The 400GMII is optional.
- t) *400 Gb/s Attachment Unit Interface (400GAUI-n)*. The 400GAUI-n is a physical instantiation of the PMA service interface to extend the connection between 400 Gb/s capable PMAs. While conformance with implementation of this interface is not necessary to ensure communication, it is recommended, since it allows maximum flexibility in intermixing PHYs and DTEs at 400 Gb/s speeds. The 400GAUI-n is intended for use as a chip-to-chip or a chip-to-module interface. Two widths of 400GAUI-n are defined: a sixteen-lane version (400GAUI-16) in Annex 120B and Annex 120C, and an eight-lane version (400GAUI-8) in Annex 120D and Annex 120E. No mechanical connector is specified for use with the 400GAUI-n. The 400GAUI-n is optional.

1.1.4 Layer interfaces

In the architectural model used here, the layers interact by way of well-defined interfaces, providing services as specified in Clause 2 and Clause 6. In general, the interface requirements are as follows:

- a) The interface between the MAC sublayer and its client includes facilities for transmitting and receiving frames, and provides per-operation status information for use by higher-layer error recovery procedures.
- b) The interface between the MAC sublayer and the Physical Layer includes signals for framing (carrier sense, receive data valid, transmit initiation) and contention resolution (collision detect), facilities for passing a pair of serial bit streams (transmit, receive) between the two layers, and a wait function for timing.

These interfaces are described more precisely in 4.3. Additional interfaces are necessary to provide for MAC Control services, and to allow higher level network management facilities to interact with these layers to perform operation, maintenance, and planning functions. Network management functions are described in Clause 30.

1.1.5 Application areas

Use of this standard is not restricted to any specific environments or applications.

In the context of this standard, the term “LAN” is used to indicate all networks that utilize the IEEE 802.3 (Ethernet) protocol for communication. These may include (but are not limited to) LANs and MANs.

1.2 Notation

1.2.1 State diagram conventions

The operation of a protocol can be described by subdividing the protocol into a number of interrelated functions. The operation of the functions can be described by state diagrams. Each diagram represents the domain of a function and consists of a group of connected, mutually exclusive states. Only one state of a function is active at any given time (see Figure 1–2).

Each state that the function can assume is represented by a rectangle. These are divided into two parts by a horizontal line. In the upper part the state is identified by a name in capital letters. The lower part contains the name of any ON signal that is generated by the function. Actions are described by short phrases and enclosed in brackets.

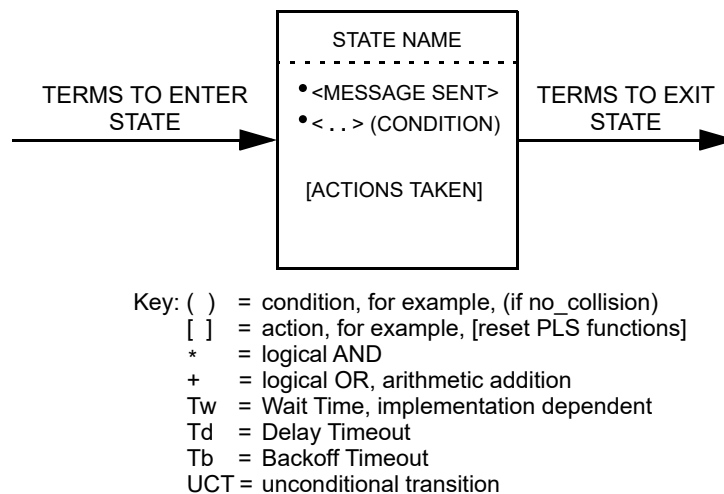


Figure 1–2—State diagram notation example

All permissible transitions between the states of a function are represented graphically by arrows between them. A transition that is global in nature (for example, an exit condition from all states to the IDLE or RESET state) is indicated by an open arrow. Labels on transitions are qualifiers that must be fulfilled before the transition will be taken. The label UCT designates an unconditional transition. Qualifiers described by short phrases are enclosed in parentheses.

State transitions and sending and receiving of messages occur instantaneously. When a state is entered and the condition to leave that state is not immediately fulfilled, the state executes continuously, sending the messages and executing the actions contained in the state in a continuous manner.

Some devices described in this standard (e.g., repeaters) are allowed to have two or more ports. State diagrams that are capable of describing the operation of devices with an unspecified number of ports require a qualifier notation that allows testing for conditions at multiple ports. The notation used is a term that includes a description in parentheses of which ports must meet the term for the qualifier to be satisfied (e.g., ANY and ALL). It is also necessary to provide for term-assignment statements that assign a name to a port that satisfies a qualifier. The following conventions are used to describe a term-assignment statement that is associated with a transition:

- a) The character “:” (colon) is a delimiter used to denote that a term assignment statement follows.
- b) The character “←” (left arrow) denotes assignment of the value following the arrow to the term preceding the arrow.

The state diagrams contain the authoritative statement of the functions they depict; when apparent conflicts between descriptive text and state diagrams arise, the state diagrams are to take precedence. This does not override, however, any explicit description in the text that has no parallel in the state diagrams.

The models presented by state diagrams are intended as the primary specifications of the functions to be provided. It is important to distinguish, however, between a model and a real implementation. The models are optimized for simplicity and clarity of presentation, while any realistic implementation may place heavier emphasis on efficiency and suitability to a particular implementation technology. It is the functional behavior of any unit that must match the standard, not its internal structure. The internal details of the model are useful only to the extent that they specify the external behavior clearly and precisely.

1.2.2 Service specification method and notation

The service of a layer or sublayer is the set of capabilities that it offers to a user in the next higher (sub)layer. Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition of service is independent of any particular implementation (see Figure 1–3).

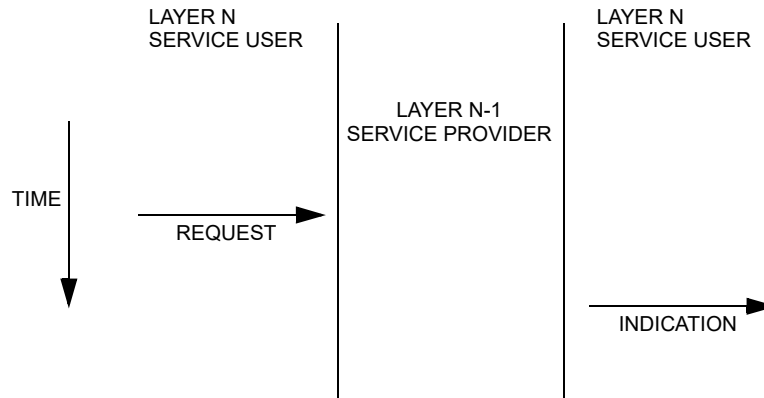


Figure 1–3—Service primitive notation

Specific implementations may also include provisions for interface interactions that have no direct end-to-end effects. Examples of such local interactions include interface flow control, status requests and indications, error notifications, and layer management. Specific implementation details are omitted from this service specification both because they will differ from implementation to implementation and because they do not impact the peer-to-peer protocols.

1.2.2.1 Classification of service primitives

Primitives are of two generic types:

- a) **REQUEST.** The request primitive is passed from layer N to layer N-1 to request that a service be initiated.
- b) **INDICATION.** The indication primitive is passed from layer N-1 to layer N to indicate an internal layer N-1 event that is significant to layer N. This event may be logically related to a remote service request, or may be caused by an event internal to layer N-1.

The service primitives are an abstraction of the functional specification and the user-layer interaction. The abstract definition does not contain local detail of the user/provider interaction. For instance, it does not indicate the local mechanism that allows a user to indicate that it is awaiting an incoming call. Each primitive has a set of zero or more parameters, representing data elements that shall be passed to qualify the functions invoked by the primitive. Parameters indicate information available in a user/provider interaction; in any particular interface, some parameters may be explicitly stated (even though not explicitly defined in the primitive) or implicitly associated with the service access point. Similarly, in any particular protocol specification, functions corresponding to a service primitive may be explicitly defined or implicitly available.

1.2.3 Physical Layer and media notation

Users of this standard need to reference which particular implementation is being used or identified. Therefore, a means of identifying each implementation is given by a simple, three-field, type notation that is explicitly stated at the beginning of each relevant clause. In general, the Physical Layer type is specified by these fields:

<data rate> <modulation type> <additional distinction>

The data rate, if only a number, is in Mb/s, and if suffixed by a “G”, is in Gb/s. The modulation type (e.g., BASE) indicates how encoded data is transmitted on the medium. The additional distinction may identify characteristics of transmission or medium and, in some cases, the type of PCS encoding used (examples of additional distinctions are “T” for twisted pair, “B” for bidirectional optics, and “X” for a block PCS coding used for that speed of operation). Expansions for defined Physical Layer types are included in 1.4.

1.2.4 Physical Layer message notation

Messages generated within the Physical Layer, either within or between PLS and the MAU (that is, PMA circuitry), are designated by an italic type to designate either form of physical or logical message used to execute the Physical Layer signaling process (for example, *input_idle* or *mau_available*).

1.2.5 Hexadecimal notation

Numerical values designated by the 0x prefix indicate a hexadecimal interpretation of the corresponding number. For example: 0x0F represents an 8-bit hexadecimal value of the decimal number 15; 0x00000000 represents a 32-bit hexadecimal value of the decimal number 0; etc.

Numerical values designated with a 16 subscript indicate a hexadecimal interpretation of the corresponding number. For example: 0F₁₆ represents an 8-bit hexadecimal value of the decimal number 15.

1.2.6 Accuracy and resolution of numerical quantities

Unless otherwise stated, numerical limits in this standard are to be taken as exact, with the number of significant digits and trailing zeros having no significance.

1.2.7 Qm.n number format

The Qm.n number format is a fixed-point number format where the number of fractional bits is specified by n and optionally the number of integer bits is specified by m. For example, a Q14 number has 14 fractional bits; a Q2.14 number has 2 integer bits and 14 fractional bits. Preceding the “Q” with a “U” indicates an unsigned number.

1.2.8 Em dash (—) in a table cell

A table cell containing an em-dash (—) indicates a lack of data for that cell, or:

- For a units cell, that there is no unit for that parameter
- For a maximum cell, that there is no requirement on the maximum value of that parameter
- For a minimum cell, that there is no requirement on the minimum value of that parameter

1.3 Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this standard. Standards may be subject to revision, and parties subject to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid international standards. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI INCITS 230-1994 (R1999), Information Technology—Fibre Channel—Physical and Signaling Interface (FC-PH) [formerly ANSI X3.230-1994 (R1999)].²

ANSI INCITS 263-1995 (S2010), Fibre Distributed Data Interface (FDDI)—Token Ring Twisted Pair Physical Layer Medium Dependent (TP-PMD) [formerly INCITS 263-1995 (R2005)].

ANSI/TIA-568-C.0 (February 2009), Generic Telecommunications Cabling for Customer Premises.³

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IEEE Std 802.3-2018, IEEE Standard for Ethernet
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IEEE Std 802.3-2018, IEEE Standard for Ethernet
SECTION ONE

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NOTE—Local and national standards such as those supported by ANSI, EIA, MIL, NFPA, and UL are not a formal part of this standard except where no international standard equivalent exists. A number of local and national standards are referenced as resource material; these bibliographical references are located in the bibliography in Annex A.²⁴