INTERNATIONAL STANDARD

ISO/IEC 8802-4

ANSI/IEEE Std 802.4

First edition
1990-08-17

Information processing systems — Local area networks —

Part 4 : Token-passing bus access method and physical layer specifications

Systèmes de traitement de l'information — Réseaux locaux —

Partie 4 : Spécification pour la méthode d'accès et la couche physique relatives au bus à passage de jeton

Reference number
ISO/IEC 8802-4 : 1990 (E)
ANSI/IEEE
Std 802.4-1990

AVA Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Abstract: This Local Area Network (LAN) standard, ISO/IEC 8802-4 : 1990 [IEEE Std 802.4-1990], deals with all elements of the token-passing bus access method and its associated physical signaling and media technologies. To facilitate interconnection of stations by way of a LAN using the token-passing bus access method, this standard specifies the characteristics of the transmission medium; the signaling method used; the frame formats transmitted; the actions of a station upon receipt of a frame; the services provided at the conceptual interface between the Medium Access Control (MAC) sublayer and the Logical Link Control (LLC) sublayer; and the actions, entities, and values used by management. There are four medium characteristics and signaling methods: 5 and 10 Mb/s phase-coherent FSK; 1, 5, and 10 Mb/s broadband; 10 and 20 Mb/s fiber optic; and 1 Mb/s phase-continuous FSK.

First Printing

ISBN 1-55937-027-0
Library of Congress Catalog Card Number 90-082603

Copyright © 1990 by

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

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

August 17, 1990 *SH12948*

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

International Standard ISO/IEC 8802-4 : 1990
ANSI/IEEE Std 802.4-1990
(Revision of ANSI/IEEE Std 802.4-1985)

Information processing systems — Local area networks —

Part 4: Token-passing bus access method and physical layer specifications

Sponsor

Technical Committee on Computer Communications of the IEEE Computer Society

Approved February 27, 1990

IEEE Standards Board

Approved July 19, 1990

American National Standards Institute

Approved 1990 by the

International Organization for Standardization
and by the
International Electrotechnical Commission

Adopted as an International Standard by the International Organization for Standardization and by the International Electrotechnical Commission

Published by The Institute of Electrical and Electronics Engineers, Inc.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

International Standard ISO/IEC 8802-4 : 1990

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

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to the national bodies for approval before their acceptance as International Standards. They are approved in accordance with procedures requiring at least 75% approval by the national bodies voting.

In 1985, IEEE Std 802.4-1985 was adopted by ISO Technical Committee 97, *Information processing systems*, as draft International Standard ISO/DIS 8802-4. A further revision was subsequently approved by ISO/IEC JTC 1 in the form of this new edition, which is published as International Standard ISO/IEC 8802-4:1990.

For the purpose of assigning global addresses, the Institute of Electrical and Electronics Engineers, Inc., USA, has been designated by the ISO Council as the Registration Authority. Communications on this subject should be addressed to

Registration Authority for ISO/IEC 8802-4
c/o The Institute of Electrical and Electronics Engineers, Inc.
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

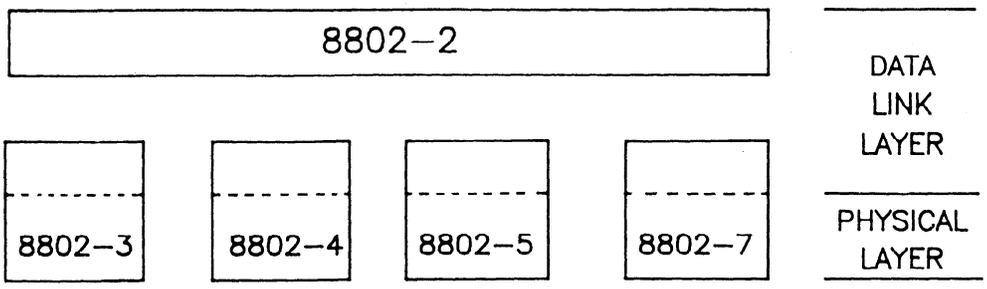
International Organization for Standardization/International Electrotechnical Commission
Case postale 56 • CH-1211 Genève 20 • Switzerland

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Foreword to International Standard ISO/IEC 8802-4 : 1990

This standard is part of a family of standards for Local Area Networks (LANs). The relationship between this standard and the other members of the family is shown below. (The numbers in the figure refer to ISO Standard numbers.)



This family of standards deals with the physical and data link layers as defined by the ISO Open Systems Interconnection Reference Model (ISO 7498 : 1984). The access standards define four types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. The standards defining these technologies are

(1) ISO 8802-3 [IEEE Std 802.3-1988], a bus utilizing CSMA/CD as the access method,
(2) ISO/IEC 8802-4 [IEEE Std 802.4-1990], a bus utilizing token passing as the access method,
(3) ISO 8802-7, a ring utilizing slotted ring as the access method.

ISO 8802-2 [IEEE Std 802.2-1989], Logical Link Control protocol, is used in conjunction with the medium access standards.

The reader of this document is urged to become familiar with the complete family of standards.

The main body of this standard serves for both the ISO/IEC 8802-4 : 1990 and IEEE 802.4-1990 standards, except for portions that specifically state that they are not a part of the ISO/IEC standard. Such portions apply to the IEEE standard only. ISO/IEC and IEEE each have unique foreword sections. The Appendixes serve as useful reference material to both standards.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

IEEE Std 802.4-1990

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE which have expressed an interest in participating in the development of the standard.

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

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

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

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

IEEE Standards documents are adopted by the Institute of Electrical and Electronics Engineers without regard to whether their adoption may involve patents on articles, materials, or processes. Such adoptions does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the standards documents.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Summary of Changes

This standard is a major revision of IEEE Std 802.4-1985 (ISO/DIS 8802/4). This revision incorporates the results of over four years of work by the IEEE 802.4 Working Group and by other organizations.

This section of the Foreword summarizes the changes for the reader's convenience.

The management sections, Sections 3 and 9, have been completely rewritten. These revised sections are now in conformance with the work of the IEEE 802 Committee and in alignment, to the extent possible, with other groups working on management standards.

The access control machine (ACM), the heart of the Medium Access Control (MAC) protocol, has been revised. Errors and ambiguities that existed in the previous version were corrected, and enhancements were made to improve error recovery. The intention in revising the ACM was to retain complete interoperability with the ACM described by the previous standard. We believe that intention has been realized.

The name of the request_with_response option has been changed from "immediate response" option to avoid conflicts with other uses of the phrase immediate response (see 6.1.1 and 6.6.2).

Additional MAC Capabilities (6.7) has been added to give implementors suggestions for providing extra MAC features and to give guidance to conformance testers.

The specification of an interface within the Physical Layer for a separate modem has been included as Section 10.

Section 11 has been reserved to retain compatible section numbers and for future additions.

The phase-coherent FSK Physical Layer and medium, described in Sections 12 and 13, underwent revision. Based on implementation experience, the working group found it necessary to make substantive technical changes to the standard. The transmit and receive levels were changed, the preamble pattern and length were changed, and a receiver blanking specification was added. The result of these changes is that the implementations of this revised standard will not interoperate with implementations of the previous standard.

The broadband Physical Layer and medium, described in Sections 14 and 15, underwent minor revisions to clarify the specification and to provide guidance for conformance testing.

A fiber optic Physical Layer and medium specification has been added as Sections 16 and 17.

The 1 Mb/s phase-continuous FSK Physical Layer and medium specification was moved from Sections 10 and 11 to Sections 18 and 19, to avoid renumbering the more commonly referenced Physical Layer and media sections. The coding of the end delimiter coding pattern was changed to increase the reliability (Hamming distance) of the protocol.

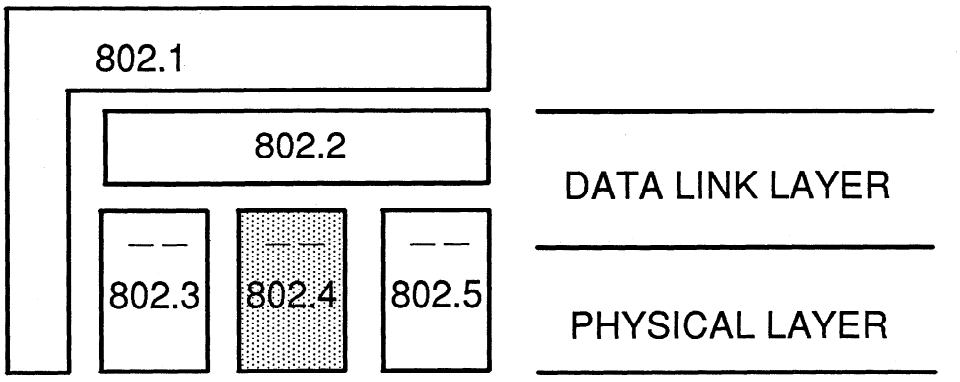
Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Foreword to IEEE Std 802.4-1990
(Revision of IEEE Std 802.4-1985)

(This Foreword is not a part of ISO/IEC 8802-4 : 1990 or of IEEE Std 802.4-1990.)

This standard is part of a family of standards for Local Area Networks (LANs). The relationship between this standard and other members of the family is shown below. (The numbers in the figure refer to IEEE Standard numbers.)



This family of standards deals with the physical and data link layers as defined by the ISO Open Systems Interconnection Basic Reference Model (ISO 7498 : 1984). The access standards define three types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. The standards defining these technologies are

(1) IEEE Std 802.3-1988 [ISO 8802-3], a bus utilizing CSMA/CD as the access method,
(2) IEEE Std 802.4-1990 [ISO/IEC 8802-4], a bus utilizing token passing as the access method,
(3) IEEE Std 802.5-1989, a ring utilizing token passing as the access method.

Other access methods (for example, metropolitan area networks and integrated voice-data networks) are under investigation.

IEEE Std 802.2-1989 [ISO 8802-2], the Logical Link Control standard, is used in conjunction with the medium access standards.

IEEE 802.1[1] (a series of related standards) describes the relationship among the family of 802 standards and their relationship to the ISO Open Systems Interconnection Basic Reference Model in more detail. IEEE 802.1 will also contain networking management standards and information on internetworking.

The reader of this standard is urged to become familiar with the complete family of standards.

[1] IEEE Std 802.1A-1990, Overview and Architecture of Network Standards; IEEE Std 802.1D-1990, MAC (Media Access Control) Bridges; and IEEE Std 802.1E-1990, System Load Protocol have been approved as IEEE Standards, but are not yet published. Other projects in the 802.1 series are currently under development.

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

This standard was submitted to ISO/IEC JTC1 for consideration as a revision and addendum to the previous edition of the token bus LAN standard, IEEE Std 802.4-1985 (ISO/DIS 8802/4). To facilitate processing of that document, portions that were not appropriate for an international standard were prefaced with a note enclosed in braces {...}.

These same portions contained within the current edition are not a part of the International Standard and are stated as such. These portions are peculiar to the IEEE version of this standard and consist of areas relating to

(1) References to national standards
(2) Recommended frequency allocations for North American CATV systems (see 14.8.4)
(3) Recommendations and guidelines related to safety concerns

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions to this standard may occur either to clarify existing material, to correct possible errors, or to incorporate new, related material.

Readers wishing to know the state of revisions should contact the

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

The following were voting members of the IEEE 802.4 Token-Passing Bus Access Method Working Group at the time of approval of this standard:

Paul S. Eastman, *Chair* **Louis F. Wojnaroski,** *Vice Chair*
Rhonda Alexis-Dirvin, *Secretary*

Ernest E. Bergmann
Clyde A. Boenke
Shalom Bresticker
Charles Brill
Mike Bukowski
Mike Bush
Hsin-Hwai Chen
Jade Y. Chien
Robert S. Crowder
C. David Daly
Sanjay Dhawan
H. N. "Hank" Dorris
Robert H. Douglas
Daniel Dove
Richard B. Formeister
Anatoly V. Fridland
Darrell Furlong
T. R. (Tom) Gandhi
Maris Graube
David J. Greenstein
Gerhard Hammer
Richard F. Hunter
Dittmar Janetzky
Lawrence R. Johnson
Walter Kammerer
Bradford S. Kellar
Robert W. Kilgore
William H. Kind
Michael T. Klein
Simon Korotwitz
Leonid Koshevoy
Detlev Leisengang
Daniel N. LeBlanc
Bruce A. Loyer
Wayne A. Mack
Charles H. March
Gunther J. Martin
Michael A. Masleid
Stephen G. McChrystal
Dale D. Murry
David L. Nicholson
Toshio Ogawa
Ilan Pardo
Michael J. Perkins
Thomas L. Phinney
Fred Rhine
David W. Riley
Ken Ross
Chandos A. Rypinski
Toshio Saito
Walter Schreuer
Rich Seifert
Yehuda Shvager
Daniel P. Stokesberry
Orest Lev Storoshchuk
Catherine F. Summers
Chuck Thurwachter
Lourens Van Der Jagt
Earl J. Whitaker
Roger Wilmarth
Yong W. Yi

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Special thanks to the following task group chairmen whose task groups contributed to this revision:

802.4A, Broadband	—	**Donald J. Loughry**
802.4B, Carrier Band	—	**Michael T. Klein**
802.4C, MAC Management	—	**Robert H. Douglas**
802.4D, Physical Management	—	**Michael J. Perkins**
802.4F, MAC Revision	—	**Louis F. Wojnaroski**
and past Chair	—	**Richard M. Collins**
802.4G, DTE-DCE Interface	—	**Clyde A. Boenke**
802.4H, Fiber Optic Media	—	**Robert S. Crowder**
802.4J, Conformance Testing	—	**Paul S. Eastman**
and past Chair	—	**Robert L. Husak** (deceased)

Special thanks to our past chairman, 1983–87, under whose guidance we developed the current draft and reached committee consensus:

Robert H. Douglas, *past Chair*

The following persons were on the balloting committee that approved this document for submission to the IEEE Standards Board:

William B. Adams
J. Ashok
Kit Athul
William E. Ayen
Ali Bahrololoomi
Michael Benedek
Peter I. P. Boulton
G. S. Carson
Chih-Tsai Chen
Lap Yan Cheung
Kilnam Chon
Michael H. Coden
A. F. Conrad
R. A. Conser
Richard J. Corley
Robert S. Crowder
Andrew I. Davidson
R. T. Denton
M. G. Duncan
Paul Eastman
John E. Emrich
Philip H. Enslow
J. W. Fendrich
Harold Folts
Harvey A. Freeman
Patrick S. Gonia
Julio Gonzalez-Sanz
Maris Graube
Stephen Harris
J. Scott Haugdahl
Anne B. Horton
Chris Hsieh
Richard J. Iliff
Raj Jain
Duncan P. Johnson
G. Juanloe
S. L. Junker
M. Kezunovic
Samuel Kho
T. M. Kurihara
Anthony B. Lake
Mike Lawler
E. Y. Lee
Sateesh B. Lele
F. C. Lim
R. S. Little
William Livingston
Donald C. Loughry
J. F. P. Luhukay
Wo-Shun Luk
Andy J. Luque
George Mattathil
P. S. McIntosh
Gilbert Melanson
David S. Millman
John E. Montague
Luis F. M. de Moraes
M. A. F. Morganti
Kinji Mori
David Morris
Steven Moustakas
Gerry Nadler
R. R. Nelson
Arne A. Nilsson
J. D. Northcutt
C. Oestereicher
Young Oh
Ari Ollikainen
Thomas L. Phinney
Rafat Pirzada
Udo Pooch
Robert S. Printis
Keith Alan Rhodes
John Riganati
G. Robinson
D. J. Rypka
S. I. Samoylenko
George Sanderson
Ambatipudi R. Sastry
N. F. Schneidewind
D. A. Sheppard
Steve Showalter
L. Sintonen
Ing Alex Soceanu
H. P. Solomon
Robert K. Southhard
John Spragins
T. Stack
Michael J. Stephenson
C. M. Stillebroer
F. J. Strauss
P. Sugar
E. D. Sykas
A. N. Tantawi
Nathan Tobol
Wei-Tek Tsai
L. D. Umbaugh
Thomas A. Varetoni
J. T. Vorhies
Donald F. Weir
William J. Wenker
Earl J. Whitaker
Michael Willett
David Wood
George B. Wright
Oren Yuen

AVA Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

The final conditions for approval of this standard were met on February 27, 1990. This standard was conditionally approved by the IEEE Standards Board on February 15, 1990, with the following membership:

Marco W. Migliaro, *Chair* **James M. Daly,** *Vice Chair*
Andrew G. Salem, *Secretary*

Paul L. Borrill
Fletcher J. Buckley
Allen L. Clapp
Stephen R. Dillon
Donald C. Fleckenstein
Jay Forster*
Thomas L. Hannan
Kenneth D. Hendrix
John W. Horch
Joseph L. Koepfinger*
Michael A. Lawler
Donald C. Loughry
John E. May, Jr.
Lawrence V. McCall
L. Bruce McClung
Donald T. Michael*
Stig Nilsson
Roy T. Oishi
Gary S. Robinson
Terry R. Whittemore
Donald W. Zipse

*Member Emeritus

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

This page intentionally left blank

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Contents

SECTION PAGE

1. Introduction and Overview 17
   1.1 Scope 18
   1.2 Definitions 18
   1.3 References 18
   1.4 Conformance 20
   1.5 Overview of the Token Method 20
   1.6 MAC Sublayer Internal Structure 22
   1.7 PLE and Medium 23
   1.8 Access Method Characteristics 28
   1.9 Standard Organization 29

2. LLC-MAC Interface Service Specifications 31
   2.1 Overview of the LLC-MAC Service 31
   2.2 Detailed Interactions with the LLC Entity 32

3. MAC Sublayer Management 35
   3.1 Overview 36
   3.2 MAC Management Facilities 36

4. Frame Formats 43
   4.1 Frame Components 44
   4.2 Enumeration of Frame Types 50
   4.3 Appendix—Recommendation for a Hierarchical Structure for Locally Administered Addresses 52

5. Elements of MAC Sublayer Operation 55
   5.1 Basic Operation 56
   5.2 Access Control Machine (ACM) States 64
   5.3 Interface Machine (IFM) Description 70
   5.4 Receive Machine (RxM) Description 71
   5.5 Transmit Machine (TxM) Description 75
   5.6 Regenerative Repeater Machine (RRM) Description 75

6. MAC Sublayer Definitions and Requirements 77
   6.1 MAC Definitions 77
   6.2 Transmission Order 78
   6.3 Delay Labeling 80
   6.4 Miscellaneous Requirements 80
   6.5 Use of Address Bits in Contention Algorithms 82
   6.6 Options within MAC Sublayer 83
   6.7 Additional MAC Capabilities 84
   6.8 Delegation of Right to Transmit 86

7. Access Control Machine (ACM) Description 87
   7.1 Variables and Functions 87
   7.2 Access Control Machine (ACM) Formal Description 97

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

SECTION PAGE

8. MAC Sublayer-Physical Layer Interface Service Specification 133
   8.1 Overview of the LAN Physical Layer Service 133
   8.2 Detailed Specifications 134

9. Physical Layer Entity (PLE) Management 139
   9.1 Overview 140
   9.2 Physical Management Facilities 140
   9.3 Additional Management 144

10. Exposed DTE-DCE Interface 145
   10.1 Overview of DTE-DCE Interface 146
   10.2 PHY-UNITDATA Request and Indication 146
   10.3 DCE Management 149
   10.4 Electrical Characteristics 156
   10.5 Mechanical Characteristics 160
   10.6 Appendix—Clarification of Management Mode 164

11. RESERVED 167

12. Single-Channel Phase-Coherent-FSK Bus Physical Layer Entity (PLE) ... 169
   12.1 Nomenclature 170
   12.2 Object 171
   12.3 Compatibility Considerations 171
   12.4 Medium Overview 171
   12.5 PLE Overview 171
   12.6 Application of Management 173
   12.7 Functional, Electrical, and Mechanical Specifications 173
   12.8 Environmental Specifications 181
   12.9 Labeling 181

13. Single-Channel Phase-Coherent-FSK Bus Medium 183
   13.1 Nomenclature 184
   13.2 Object 185
   13.3 Compatibility Considerations 185
   13.4 Overview 185
   13.5 Functional, Electrical, and Mechanical Specifications 186
   13.6 Environmental Specifications 189
   13.7 Transmission_path_delay Considerations 190
   13.8 Documentation 190
   13.9 Network Sizing 190
   13.10 Appendix—Guidelines for Configuring the Medium 191

14. Broadband Bus Physical Layer Entity (PLE) 195
   14.1 Nomenclature 196
   14.2 Object 197
   14.3 Compatibility Considerations 197
   14.4 Operational Overview of Single-Cable Medium 198
   14.5 Operational Overview of a Dual-Cable Medium 198

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

SECTION PAGE

14.6 General Overview 199
14.7 Application of Management 201
14.8 Functional, Electrical, and Mechanical Specifications 201
14.9 Environmental Specifications 215
14.10 Labeling 216
14.11 Appendix—Provisions of Two MAC-Symbol/PHY-Symbol Signaling 216
14.12 Appendix—Detailed Scrambling and Descrambling Process 220

15. Broadband Bus Medium 221
15.1 Nomenclature 222
15.2 Object 224
15.3 Compability Considerations 224
15.4 Overview 224
15.5 Functional, Electrical, and Mechanical Specifications 226
15.6 Environmental Specifications 228
15.7 Transmission_path_delay Considerations 229
15.8 Documentation 229
15.9 Network Sizing 229

16. Fiber Optic Physical Layer Entity (PLE) 231
16.1 Nomenclature 232
16.2 Object 234
16.3 Compatibility Considerations 234
16.4 Operational Overview 235
16.5 Physical Layer Overview 235
16.6 Application of Management 236
16.7 Functional, Optical, Electrical, and Mechanical Specifications 236
16.8 Environmental Specifications 242
16.9 Labeling 242
16.10 Appendix—Alternative Fiber Optic Medium 243
16.11 Appendix—Comparison of Parameter Values of Standard and Alternative Fiber Optic Medium 244

17. Fiber Optic Medium 245
17.1 Nomenclature 246
17.2 Object 248
17.3 Compatibility Considerations 248
17.4 Overview 249
17.5 Functional, Optical, and Mechanical Specifications 249
17.6 Safety Requirements 251
17.7 Transmission_path_delay Considerations 251
17.8 Documentation 251
17.9 Appendix—Alternative Fiber Optic Medium 252
17.10 Appendix—Comparison of Parameter Values of Standard and Alternative Fiber Optic Medium 252

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

SECTION PAGE

17.11 Appendix—Network Size and Configuration 253

18. Single-Channel Phase-Continuous-FSK Bus Physical Layer Entity (PLE) .. 255
18.1 Nomenclature 256
18.2 Object 257
18.3 Compatibility Considerations 257
18.4 Medium Overview 257
18.5 Physical Layer Overview 258
18.6 Application of Management 259
18.7 Functional, Electrical, and Mechanical Specifications 259
18.8 Environmental Specifications 263
18.9 Labeling 264

19. Single-Channel Phase-Continuous-FSK Bus Medium 265
19.1 Nomenclature 266
19.2 Object 267
19.3 Compatibility Considerations 267
19.4 General Overview 268
19.5 Functional, Electrical, and Mechanical Specifications 268
19.6 Environmental Specifications 270
19.7 Transmission_path_delay Considerations 270
19.8 Documentation 271
19.9 Network Sizing 271
19.10 Appendix—Guidelines for Configuring the Medium 271

FIGURES

Fig 1-1 Relationship of Adjacent Protocol Layers 17
Fig 1-2 Logical Ring on Physical Bus 21
Fig 1-3 MAC Sublayer Functional Partitioning 22
Fig 2-1 Relation to LAN Model 31
Fig 3-1 Relation to LAN Model 35
Fig 5-1 Relation to LAN Model 55
Fig 5-2 Token Rotation Time "Priority" Example 63
Fig 5-3 MAC Finite State Machine Diagram 65
Fig 5-4 Receive Machine 72
Fig 5-5 sil/act Detector Finite State Machine 73
Fig 5-6 SD Detector Finite State Machine 73
Fig 5-7 ED Detector Finite State Machine 74
Fig 5-8 NB/BQ Finite State Machine 75
Fig 5-9 Bus Repeater 76
Fig 6-1 MAC Protocol_data_unit Transmission Order 79
Fig 6-2 Logical Token-Passing Ring 81
Fig 8-1 Relation to LAN Model 133
Fig 9-1 Relation to LAN Model 139
Fig 10-1 Relation to LAN Model 145
Fig 10-2 Single-ended Interface Connection 157

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

FIGURE PAGE

Fig 10-3 Indication Channel Timing 158
Fig 10-4 Request Channel Timing Using TXCLK 158
Fig 10-5 Typical Driver—Differential Interface 159
Fig 10-6 Typical Receivers—Differential Interface 159
Fig 10-7 Request Channel Timing Using RETURNCLK 160
Fig 10-8 Typical Derivation of RETURNCLK 160
Fig 10-9 Cable Detection Circuits 161
Fig 10-10 Single-ended Interface Connector Receptacle 161
Fig 10-11 Typical Station Management 164
Fig 10-12 Writing to a Register 165
Fig 10-13 Typical Modem Failure Sequence 166
Fig 12-1 Relation to LAN Model 169
Fig 12-2 Physical Hardware Partitioning 170
Fig 12-3 MAC-Symbol Encodings 174
Fig 12-4 Eye Patterns 176
Fig 12-5 Receiver Blanking 179
Fig 13-1 Relation to LAN Model 183
Fig 13-2 Physical Hardware Partitioning 184
Fig 13-3 Limits for Percent PDD 188
Fig 14-1 Relation to LAN Model 195
Fig 14-2 Physical Hardware Partitioning 196
Fig 14-3 Limits for Amplitude Distortion 209
Fig 14-4 Transmit Spectrum Mask 210
Fig 14-5 $1 + X^{-6} + X^{-7}$ Scrambler 220
Fig 14-6 Exemplary Scrambler/Descrambler Circuitry 220
Fig 15-1 Relation to LAN Model 221
Fig 15-2 Physical Hardware Partitioning 222
Fig 16-1 Relation to LAN Model 231
Fig 16-2 Physical Hardware Partitioning 232
Fig 16-3 Optical Wave Shape Template 238
Fig 17-1 Relation to LAN Model 245
Fig 17-2 Physical Hardware Partitioning 246
Fig 17-3 n by m Splitter/Combiner Primitive 249
Fig 17-4 Star Topology 254
Fig 18-1 Relation to LAN Model 255
Fig 18-2 Physical Hardware Partitioning 256
Fig 19-1 Relation to LAN Model 265
Fig 19-2 Physical Hardware Partitioning 266

TABLES

Table 10-1 Request Channel Encoding—MAC Mode 148
Table 10-2 Indication Channel Encoding—MAC Mode 149
Table 10-3 Request Channel Encoding—Management Mode 152
Table 10-4 Indication Channel Encoding—Management Mode 152

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

TABLE PAGE

Table 10-5 Single-ended Connector Pinout 162
Table 10-6 Differential Connector Pinout 163
Table 12-1 Data Rate Versus Signaling Frequencies 175
Table 14-1 Relative Power Level Reporting 201
Table 14-2 Baseband Pulse Coding Rules 204
Table 14-3 Usual North American Mid-split Channels—Nomenclature and Pairing 206
Table 14-4 Required Transmit Level 207
Table 14-5 Breakpoints of Amplitude Distortion Limits 208
Table 14-6 Required Noise Floor and In-band Signal Power 212
Table 14-7 Minimum Length of *Pad_idle* Preamble 212
Table 16-1 Data Rate Versus Media Transmission Rate 237
Table 16-2 Alternate Test Fiber Parameter Values 243
Table 16-3 Parameter Values for Standard and Alternate Test Fiber 244
Table 17-1 Alternate Test Fiber Parameter Values 252
Table 17-2 Parameter Values for Standard and Alternate Test Fiber 253
Table 17-3 Passive Star Power Loss Budget 254

APPENDIX

A A Model Used for the Service Specification 275
A1. Service Hierarchy 275
A2. N-Layer Interface 275
A3. Specification of Services 276
A4. Classification of N-Layer Service Primitives 276
A5. Interaction Behavior 276

APPENDIX FIGURES

Fig A1 Service Hierarchy Relationships 275
Fig A2 Service Primitive Interactions 276

INDEX 277

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

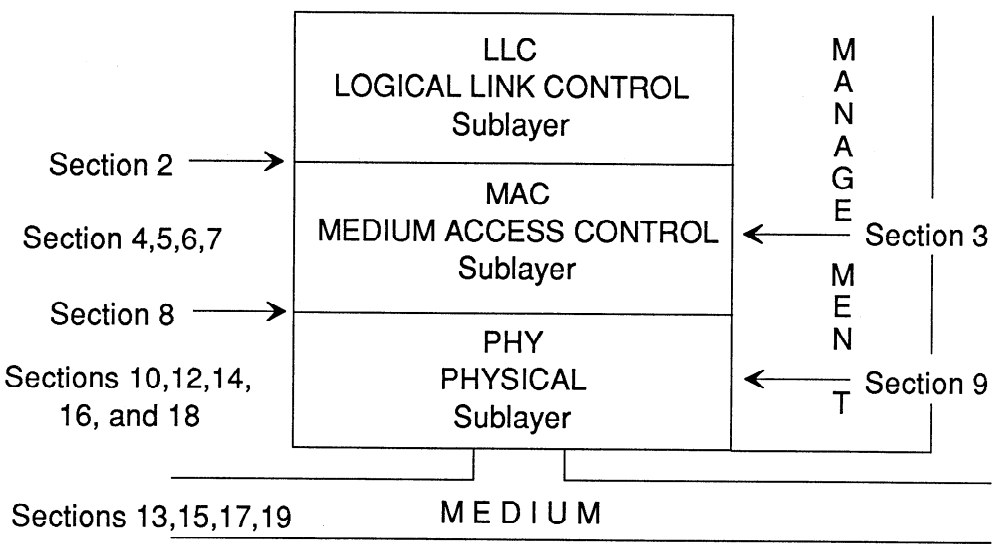
Information processing systems — Local area networks —

Part 4: Token-passing bus access method and physical layer specifications

1. Introduction and Overview

This portion of the Local Area Network (LAN) standards deals with all elements of the token-passing bus access method and its associated physical signaling and media technologies. The access function coordinates the use of the shared medium among the attached stations and has the relationship to the other protocol functions given by Fig 1-1.

Fig 1-1
Relationship of Adjacent Protocol Layers



Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

1.1 Scope. For the purpose of compatible interconnection of stations by way of a LAN using the token-passing bus access method this standard

(1) Specifies the electrical and/or optical and physical characteristics of the transmission medium,
(2) Specifies the electrical or optical signaling method used,
(3) Specifies the frame formats transmitted,
(4) Specifies the actions of a station upon receipt of a frame,
(5) Specifies the services provided at the conceptual interface between the Medium Access Control (MAC) sublayer and the Logical Link Control (LLC) sublayer above it,
(6) Specifies the actions, entities, and values used to manage the MAC sublayer and Physical Layer Entity (PLE).

Within this standard the operation of a station is specified in terms of the layered model shown in Fig 1-1 and described in ISO 7498 : 1984 [13].[2]

Additional information on the 802 family of LAN standards can be found in IEEE Std 802.1A [9].

Figure 1-1 also shows which sections of the standard specify interfaces between layers and which sections specify the operation of the layers themselves.

Recommendations for frequency allocations for community antenna television (CATV) systems are subjects for national standardization and are outside the scope of this International Standard.

1.2 Definitions. The definitions used in this standard are consistent with ISO 2382-9 : 1984 [12]. A more specific information processing vocabulary pertaining to LAN systems is in development as WP 2382/25.

1.3 References.[3] When the following standards referred to in this standard are superseded by an approved revision, the latest revision shall apply.

References to IEEE and ISA standards are not a part of this International Standard.

[1] ANSI/ISA-S72.01-1986, PROWAY-LAN Industrial Data Highway.[4]

[2] CCITT Recommendation X.150, Principles of Maintenance Testing for Public Data Networks Using Data Terminal Equipment (DTE) Data Circuit-Terminating (DCE) Test Loops. In Vol. VIII.3 of the *CCITT Blue Books*—Data communication network transmission, signaling and switching, network aspects, maintenance and administrative arrangements. Geneva: International Telecommunications Union, 1989.[5]

[2] The numbers in brackets correspond to those of the references listed in 1.3.

[3] See Index to locate citations in the text of the following publications.

[4] ISA documents are available from the Instrument Society of America, Standards Dept., 67 Alexandria Drive, P.O. Box 12277, Research Triangle Park, NC 27709.

[5] CCITT documents are available in the US from the US Dept. of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161. CCITT documents are also available from CCITT General Secretariat, International Telecommunications Union (ITU), Sales Section, Place des Nations, CH-1211, Genève 20, Switzerland/Suisse.

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

[3] CISPR Publication 22 (1985), Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.[6]

[4] IEC Publication 169-8 (1978), Radio Frequency Connectors, Part 8: RF Coaxial Connectors with Inner Diameter of Outer Conductor 6.5 mm (0.256 in) with Bayonet Lock and Characteristic Impedance of 50 Ω (type BNC).

[5] IEC Publication 807-2 (1985), Detailed Specification for a Range of Connectors and Round Contacts (Fixed Solder Contact Types).

[6] IEC Publication 825 (1984), Radiation Safety of Laser Products, Equipment Classification, Requirements and User's Guide.

[7] IEC Publication 950 (1986), Safety of Information Technology Equipment, Including Electrical Business Equipment (Amendment 1, 1988).

[8] IEEE C37.90.1-1989, IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems (ANSI).[8]

[9] IEEE Std 802.1A-1990, IEEE Standard for Local Area Networks and Metropolitan Area Networks: Overview and Architecture of Network Standards.

[10] Reserved for future use.[7]

[11] IEEE Std 802.7-1989, IEEE Recommended Practices for Broadband Local Area Networks (ANSI).

[12] ISO 2382-9 : 1984, Data processing—Vocabulary—Part 09: Data communication.[9]

[13] ISO 7498 : 1984, Information processing systems—Open systems interconnection—Basic reference model.

[14] ISO/IEC 7498-4 : 1989, Information processing systems—Open systems interconnection—Basic reference model—Part 4: Management framework.

[15] ISO 8022-2 : 1989 (IEEE Std 802.2-1989), Information processing systems—Local area networks—Part 2: Logical link control.

[16] ISO 8824 : 1987, Information processing systems—Open systems interconnection—Specification of abstract syntax notation one (ASN.1).

---

[6] CISPR and IEC documents are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018. These documents are also available from International Electrotechnical Commission, 3 rue de Varembé, Case postale 131, CH-1211, Genève 20, Switzerland/Suisse.

[7] When the following IEEE project is approved and published, it will become a part of this reference section: P802.1B, Local Area Networks and Metropolitan Networks Management.

[8] IEEE documents are available from the Service Center, Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

[9] ISO documents are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018. ISO documents are also available from the ISO Office, 1 rue de Varembé, Case postale 56, CH-1211, Genève 20, Switzerland/Suisse.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

[17] Reserved for future use.[10]

[18] Reserved for future use.[11]

[19] Reserved for future use.[12]

[20] Reserved for future use.[13]

1.4 Conformance. Implementations that claim conformance with this standard shall

(1) Offer the mandatory LLC-MAC interface services specified in Section 2,
(2) Support the mandatory layer management actions, entities, and values specified in Sections 3 and 9,
(3) Generate, transmit, receive, and recognize the frames and sequences specified in Section 4,
(4) Support the mandatory capabilities, constraints, and behavior of the medium access protocol specified in Sections 6 and 7,
(5) Offer the mandatory MAC sublayer-Physical Layer interface services specified in Section 8,
(6) Support the mandatory capabilities, features, and constraints of at least one of the specified PLEs and medium specifications defined in Sections 12 and 13, 14 and 15, 16 and 17, and 18 and 19,
(7) Support at least one of the data rates specified for the chosen PLE, and
(8) Support the capabilities, behavior, or values defined for all options claimed to be supported by the implementation.

Unless otherwise stated herein, all specifications shall apply over the entire operating environmental range for which the manufacturer claims conformance.

A number of options are specified in this standard. An implementation shall indicate which, if any, of these options are supported.

1.5 Overview of the Token Method

1.5.1 The Essence of the Token Access Method

(1) A *token* controls the right of access to the physical medium; the station which holds (possesses) the token has momentary control over the medium.

---

[10] When the following ISO/IEC project is completed, approved, and published, it will become a part of this reference section: JTC1 DIS 9314-3, Information processing systems — Fibre distributed data interface (FDDI) — Part 3: Physical layer medium dependent (PMD) requirements.

[11] When the following ISO/IEC project is completed, approved, and published, it will become a part of this reference section: JTC1 DIS 9595, Information processing systems — Open systems interconnection — Management information service definition.

[12] When the following ISO/IEC project is completed, approved, and published, it will become a part of this reference section: JTC1 DIS 9596, Information processing systems — Open Systems Interconnection — Management information protocol specification.

[13] When the following ISO/IEC project is completed, approved, and published, it will become a part of this reference section: JTC1 DIS 10039, Information technology — Telecommunications and information exchange between systems — Medium access control service definition.

AVA Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

(2) The token is passed by stations residing on the medium. As the token is passed from station to station a logical ring is formed.
(3) Steady state operation consists of a data transfer phase and a token transfer phase.
(4) Ring maintenance functions within the stations provide for ring initialization, lost token recovery, new station addition to the logical ring, and general housekeeping of the logical ring. The ring maintenance functions are replicated among all the token-using stations on the network.

Shared media generally can be categorized into two major types. These types are *broadcast* and *sequential*. This standard deals exclusively with the broadcast type. On a broadcast medium, every station may receive all signals transmitted. Media of the broadcast type are usually configured as a physical bus.

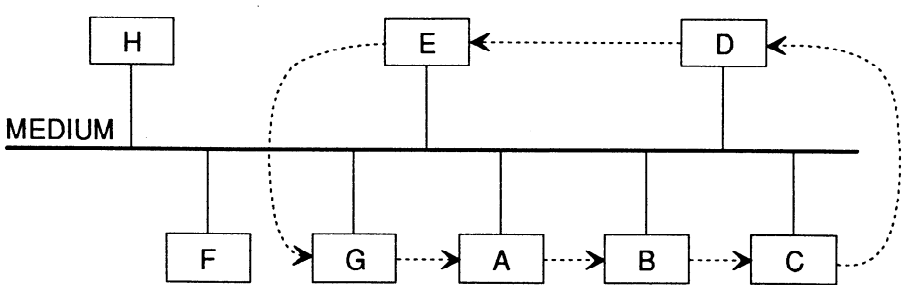
In Fig 1-2, note that the token medium access method is always sequential in a logical sense. That is, during normal, steady state operation, the right to access the medium passes from station to station. Furthermore, note that the physical connectivity has little impact on the order of the logical ring and that stations can respond to a query from the token holder even without being part of the logical ring. (For example, stations H and F can receive frames and could respond but cannot initiate a transmission since they will never be sent the token.)

The MAC sublayer provides sequential access to the shared bus medium by passing control of the medium from station to station in a logically circular fashion. The MAC sublayer determines when the station has the right to access the shared medium by recognizing and accepting the token from the predecessor station, and it determines when the token shall be passed to the successor station.

1.5.2 General Sublayer Functions

(1) Lost token timer
(2) Distributed initialization
(3) Token holding timer
(4) Limited data buffering
(5) Node address recognition
(6) Frame encapsulation (including token preparation)
(7) Frame check sequence (FCS) generation and checking

Fig 1-2
Logical Ring on Physical Bus



Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

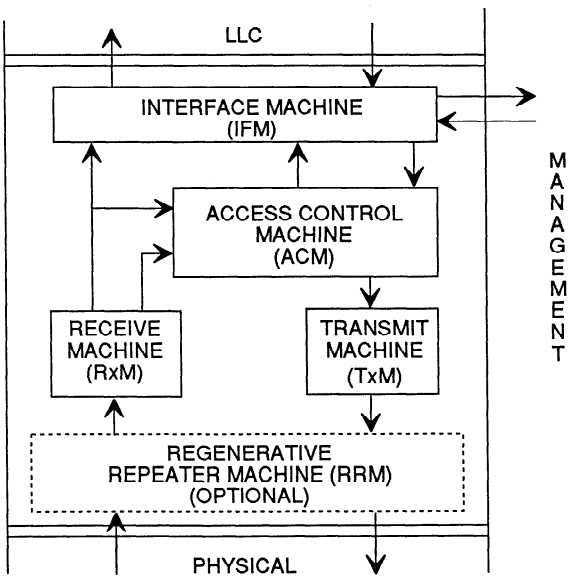
(8) Valid token recognition
(9) Ring member addition/deletion
(10) Node failure error recovery

1.6 MAC Sublayer Internal Structure. The MAC sublayer performs several functions that are loosely coupled. The descriptions and specifications of the MAC sublayer in this standard are organized in terms of one of several possible partitionings of these functions. The partitioning used here is illustrated in Fig 1-3, which shows five asynchronous logical "machines," each of which handles some of the MAC functions, as discussed in 1.6.1 through 1.6.5.

Of these five machines, the access control machine (ACM) is the most critical and the most complex; it is the key control mechanism for the token-passing bus access method, and it cooperates closely with ACMs in other stations given only limited information regarding the state of the network. Because of its importance, and because much of its operation is not easily inferred from its functional requirements, the explanation and specification of the ACM are the major concerns of Sections 5, 6, and 7.

The interface machine (IFM) and receive machine (RxM) participate heavily in the operation of the MAC sublayer protocol. They are, however, discussed only in sufficient detail so that the reader will understand their role in the MAC sublayer in support of the ACM. The level of discussion was chosen to avoid any ambiguities which might compromise the coexistence of conformant stations on a single bus.

Fig 1-3
MAC Sublayer Functional Partitioning



Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

1.6.1 Interface Machine (IFM). This machine acts as an interface and buffer between the LLC and MAC sublayers and between network management and the MAC sublayer. It interprets all incoming MA-UNITDATA and other service primitives and generates appropriate outgoing service primitives. This machine handles the mapping of "quality of service" parameters from the LLC view to the MAC view, where this is necessary. It handles queuing of service requests, for example, requests to send an LLC protocol data unit (PDU). Finally, it performs the "address recognition" function on received data frames, accepting only those addressed to this station.

1.6.2 Access Control Machine (ACM). This machine cooperates with the ACMs of all other stations on the bus in handling the token to control transmission access to the shared bus. The ACM may (optionally) manage multiple MAC access_classes so as to provide different levels of "quality of service" to the LLC sublayer. The ACM is also responsible for initialization and maintenance of the logical ring, including the admission of new stations. Finally, it has responsibility for the detection of and, where possible, recovery from faults and failures in the token-passing bus network.

1.6.3 Receive Machine (RxM). This machine accepts atomic_symbol inputs from the Physical Layer and assembles them into frames which it validates and passes to the IFM and ACM. The RxM accomplishes this by recognizing the frame start and the frame end delimiters (SD and ED), checking the FCS and validating the frame's structure. The RxM also identifies and indicates the reception of *noise_bursts* and the *bus_quiet* condition.

1.6.4 Transmit Machine (TxM). This machine generally accepts a frame from the ACM and transmits it, as a sequence of atomic_symbols in the proper format, to the PLE. The TxM builds a MAC protocol-data-unit by prefacing each frame with the required preamble and SD, and appending the FCS and ED. When operating with a Regenerative Repeater Machine (RRM), the TxM's operation may be somewhat different.

1.6.5 Regenerative Repeater Machine (RRM). This machine is an optional MAC component that is present only in special "repeater" stations, for example, a broadband remodulator. In such repeater stations, the RRM, when appropriate, repeats the incoming atomic_symbol stream, from the PLE, back to the PLE for retransmission; in such cases the PLE is understood to be connected to at least two different segments of a single bus. The RxM and TxM may cooperate with the RRM in such repeating operations.

1.7 PLE and Medium. The broad outlines for the PLE sections of this standard and also an introduction to the various physical signaling techniques and media defined for LANs using the token-passing MAC protocol are given here.

Four bus media and corresponding PLEs are specified for use with the token-passing MAC protocol.

Each PLE and corresponding bus medium is described in a pair of consecutive sections (that is, Sections 12 and 13, Sections 14 and 15, Sections 16 and 17, and Sections 18 and 19), consisting of the following:

AVA Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

(1) A section specifying a specific PLE, including how the generic management objects (Section 9) in that PLE are particularized, and
(2) A section specifying the medium appropriate to that PLE.

Four different PLEs with corresponding media suitable for use with the token-passing bus MAC protocol are specified in this standard. They are distinguished primarily by the different forms of media and signaling specified for each type of PLE. The remainder of this subsection outlines the salient points of each type of PLE and corresponding medium.

1.7.1 Summary of Phase-Coherent Frequency Shift Keying (FSK)

Topology. Omnidirectional bus

Cable. 75 Ω coaxial cable, such as RG-11 type or semirigid

Connector at Station. 75 Ω female F-series, to be specified by IEC (see NOTES in 13.5.1)

Recommended Cable Configuration. CATV trunk of either RG-11 type or semi-rigid and flexible drop cables of up to 50 m in length

Trunk Connection Unit. 75 Ω nondirectional 20 dB passive impedance-matching tap

Repeaters. Active regenerative repeaters used for high-fanout branching and extension of the system beyond the limits of a single segment of the cable

Transmit Level. +63 to +66 dB (1 mV, 75 Ω) [dBmV]

Receiver Sensitivity. +10 dBmV to +66 dBmV

Data Rates. 5 Mb/s and 10 Mb/s

Signaling. Direct encoding of *data* and *non_data* symbols, each as an integral number of cycles of constant frequency, with frequency changes only at the zero crossings of the waveforms. Two frequencies are used:
(1) The lower is 1 Hz/(b/s) (that is, 5 MHz at 5 Mb/s, 10 MHz at 10 Mb/s)
(2) The higher is 2 Hz/(b/s) (that is, 10 MHz at 5 Mb/s, 20 MHz at 10 Mb/s)
The symbol representations are
zero—two full cycles of the higher frequency
one—one full cycle of the lower frequency
pairs of *non_data*—one full cycle of the higher frequency, one full cycle of the lower frequency, and another one full cycle of the higher frequency

Pad_idle. Alternating *one* and *zero* symbols, starting with *one*

Clock Recovery. From zero crossings in the received signal

Transmit Data Timing. Phase-locked to transmit frequencies. All ports of a regenerative repeater use the same transmit data timing and, hence, identical transmit frequencies.

AVA Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

1.7.2 Summary of Multilevel Duobinary Amplitude Modulation/Phase Shift Keying (AM/PSK)

Topology. Directional bus with active repeater

Cable. 75 Ω coaxial cable, such as RG-6 type or semirigid

Connector at Station. 75 Ω female F-series, to be specified by IEC (see NOTE in 15.5.1)

Recommended Cable Configuration. CATV-like semirigid trunk and flexible drop cable

Trunk Connection Unit. 75 Ω directional passive impedance-matching tap

Repeaters. Regenerative repeater used as system data-rate clock source, as central assessor of contention and noise, and to retransmit all signaling received on the directional medium

Amplifiers. Standard CATV bidirectional (or unidirectional for dual-cable configuration) broadband amplifiers used for extension of the system beyond the basic signal loss budget

Channel Bandwidths. 1.5 MHz, 6 MHz, and 12 MHz

Transmit Level

In 1.5 MHz bandwidth, +41 dB (1 mV, 75 Ω) [dBmV]
In 6 MHz bandwidth, +47 dB (1 mV, 75 Ω) [dBmV]
In 12 MHz bandwidth, +50 dB (1 mV, 75 Ω) [dBmV]

Receiver Sensitivity

In 1.5 MHz, -13 to +4 dB (1 mV, 75 Ω) [dBmV]
In 6 MHz, -7 to +10 dB (1 mV, 75 Ω) [dBmV]
In 12 MHz, -4 to +13 dB (1 mV, 75 Ω) [dBmV]

Data Rates. 1 Mb/s in 1.5 MHz, 5 Mb/s in 6 MHz, 10 Mb/s in 12 MHz

Channel Frequency Assignments. Channel frequency assignments are a subject for national standardization. The following North American recommended channel assignments are included for information only. They are not a part of this International Standard.

For 10 Mb/s, channels 3′ and 4′ (59.75 - 71.75 MHz) and P and Q (252 - 264 MHz)

For 5 Mb/s, channels 3′ (59.75 - 65.75 MHz) and P (252 - 258 MHz), or 4′ (65.75 - 71.75 MHz) and Q (258 - 264 MHz)

For 1 Mb/s, any of the eight equally spaced 1.5 MHz subchannels of reverse channels 3′ and 4′, paired with the corresponding forward channels P and Q

Scrambler. A self-sync scrambler with a generator polynomial of $1+X^{-6}+X^{-7}$ is applied to all framed data prior to encoding for transmission, both to increase the average number of transitions within a transmission and to randomize spectral components of the transmitted modulation.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Signaling. *Data* and *non_data* symbols are encoded so as to specify the amplitude of the eventual modulation. A single form is defined in this standard: One MAC-symbol per PHY-symbol, together with compatibility considerations for an additional form described in 14.11.

In both forms of signaling, the middle level is used only to signal the *non_data* symbols found in frame delimiters and reported *silence*, and to break up long sequences of a single other signaling level (see 14.8.2.1 (4) (c)). Such long sequences are unlikely since a scrambler is applied to framed data before it is encoded for transmission.

For one MAC-symbol per PHY-symbol signaling, the symbol representations at the receiver are

{*0*} = *zero*—zero amplitude
{*4*} = *one*—"maximum" amplitude
{*2*} = *non_data*—"middle" amplitude of one half "maximum"

Modulation. Multilevel duobinary AM/PSK

Pad_idle. Alternating {*4*} and {*0*} symbols, starting with {*4*}

Reported *Silence*. The repeated sequence of symbols transmitted by the remodulator to report that it is not receiving any signaling. The sequence has a period of four symbols and the repetition may break off after any symbol of the sequence. Listening modems can set their automatic gain control (AGC), and can determine the signaling mode of the system by the sequence used.

For one MAC-symbol per PHY-symbol signaling, the sequence is:

{*2*} {*2*} {*0*} {*4*}

For a possible future two MAC-symbols per PHY-symbol signaling mode, the following sequence is reserved:

{*2*} {*2*} {*4*} {*0*}

Implementations that detect this reserved repeating sequence should either switch to the enhanced mode of operation or inhibit transmission.

Clock Recovery. From level transitions within the received signaling

Transmit Data Timing. Sourced by remodulator; frequency-locked to received data timing at all other stations

1.7.3 Summary of Fiber Optic Media

Topology. Directional bus using active or passive stars

Cable. The standard assumes a silica fiber optic waveguide with the following nominal characteristics: a core diameter of 62.5 μm, outside diameter of 125 μm, and an effective numerical aperture of 0.275.

NOTE: Operation using a 50 μm alternate test fiber is described in Appendixes 16.10 and 17.9.

Connector at Station. The cable plant interface connector (CPIC) is a duplex connector as defined in ISO/IEC 9314-3 [16].

Repeaters. Active regenerative repeaters used for high-fanout star topologies

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

Transmit Characteristics. -7 to -11 dBm effective optical launch power with center wavelength between 800 and 910 nm

Receiver Sensitivity
Moderate sensitivity: -11 to -31 dBm effective power with silence level of -40 dBm
High sensitivity: -21 to -41 dBm effective power with silence level of -50 dBm

Data Rates. 5 Mb/s, 10 Mb/s, and 20 Mb/s

Signaling. Manchester encoding of *data* and *non_data* symbols
The symbol representations are
{*H L*} = *zero*
{*L H*} = *one*
{*L L H H*} and {*H H L L*} = pairs of *non_data* symbols

Pad_idle. Alternating *one* and *zero* symbols, starting with *one*

Clock Recovery. From transitions generated by the Manchester encoding

Transmit Data Timing. Phase-locked to transmit frequencies. All ports of a regenerative repeater use the same transmit data timing and, hence, identical transmit frequencies.

1.7.4 Summary of Phase-Continuous FSK

Topology. Omnidirectional bus

Trunk Cable. 75 Ω coaxial cable, such as types RG-6, RG-11, and semirigid

Drop Cable. 35-50 Ω coaxial cable stub, less than 350 mm long

Connector at Station. 50 Ω male BNC-series, see IEC 169-8 (1978) [4]

Recommended Cable Configuration. Long unbranched trunk cable with very short "stub" drop cables

Trunk Connection Unit. 75 Ω tee connector

Repeaters. Active regenerative repeaters used for branching and extension of the system beyond the basic signal loss budget

Transmit Level. +54 to +60 dB (1 mV, 37.5 Ω)

Receiver Sensitivity. +24 dB (1 mV, 37.5 Ω)

Data Rate. 1 Mb/s

Signaling. Manchester encoding of *data* and *non_data* symbols
The symbol representations are
{*H L*} = *zero*—initial high, final low level
{*L H*} = *one*—initial low, final high level
{*L L H H*} and {*H H L L*} = pairs of *non_data* symbols, initial pair of low level followed by a final pair of high level or vice versa

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Modulation. Phase-continuous FSK (a form of frequency modulation), with Manchester representation:

(1) Frequency of high level = 6.25±0.08 MHz
(2) Frequency of low level = 3.75±0.08 MHz

Pad_idle. Alternating *one* and *zero* symbols, starting with *one*

Clock Recovery. From transitions generated by the Manchester encoding

1.7.5 Alternate Physical Layer and Medium for Industrial Control. Alternate Physical Layers and media for industrial control are specified in ANSI/ISA-S72.01-1986 [1]. These alternate Physical Layers and media are compatible at the MAC sublayer-Physical Layer interface.

1.8 Access Method Characteristics. An understanding of the basic characteristics of the token-passing access method is useful, so as to better understand where and when a token-passing bus is an appropriate LAN technology.

Some of the important features of this medium access method are as follows:

(1) The method is efficient in the sense that, under high offered load, the coordination of the stations requires only a small percentage of the medium's capacity.
(2) The method is fair in the sense that it offers each station an equal share of the medium's capacity. It does not, however, require any station to use its full share.
(3) The method permits multiple classes of service.
(4) The method coordinates the stations' transmissions so that they minimize and control their interference with each other.
(5) The method imposes no additional requirements on the medium or the PLE's capabilities over those necessary for transmission and reception of multibit, multiframe sequences at the specified bit error rate.
(6) In the absence of system noise, the method provides computable, deterministic, worst-case bounds on access delay for the highest priority class of service for any given network and loading configuration.
(7) Periods of controlled interference are distinguishable; system noise measurements are possible during the remaining periods.
(8) The method places minimal constraints on how a station that momentarily controls the medium may use its share of the medium's capacity.
(9) The method efficently supports the proposed LLC Type 3 Service by allowing the token holding station to wait for the receiving station to respond to the token holder's transmission.
(10) Though not specified by this standard, the method permits the presence of large numbers of low-cost, reduced-function stations in the network, together with one or more full-function stations. (At least one full-function station is needed to make the system operational.) An example of a reduced function station is one that does not contain access control logic.

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

1.9 Standard Organization. This standard is organized in 19 sections, which are summarized below.

Section 1 (this section) begins with a general discussion of the token-passing bus access method. The MAC sublayer functional partitioning used in subsequent discussions is introduced here. The PLE and media options are also surveyed. Finally, features of the token-passing bus access method are reviewed.

Section 2 details the logical interfaces between the LLC sublayer and the MAC sublayer, and the services and command interfaces (such as sending a frame) provided to the LLC sublayer.

Section 3 details the management parameters, actions, and events within the MAC sublayer.

Section 4 details the general MAC frame structure, including delimiters, addressing, and the FCS. All of the frame formats that the MAC handles, including MAC control frames, are enumerated.

Section 5 discusses the basic concepts of the access protocol and provides an informal description of the actions in each state of the ACM. The other state machines of the MAC sublayer are also described in Section 5.

Section 6 contains definitions of essential MAC terms and components.

Section 7 specifies the MAC ACM by means of a state machine model. This is the definitive specification of the token-passing bus MAC operation. Section 7 also describes the MAC sublayer variables, functions, and procedures used in the state machine.

Section 8 details the logical interface between the MAC sublayer and the Physical Layer. Included here are descriptions of the interface symbols, requests, and responses.

Section 9 details the management parameters, actions, and events within the PLE.

Section 10 defines the logical, electrical, and mechanical interface within the PLE between the station and a separated modem.

Section 11 is reserved.

Sections 12 and 13 detail the PLE and medium, respectively, for a single-channel (that is, omnidirectional) phase-coherent-FSK coaxial cable bus at 5 Mb/s or 10 Mb/s.

Sections 14 and 15 detail the PLE and medium, respectively, for a dual-channel (that is, head-ended) broadband duobinary AM/PSK coaxial cable bus at 1 Mb/s, 5 Mb/s, or 10 Mb/s.

Sections 16 and 17 detail the PLE and medium, respectively, for a fiber optic bus at 5 Mb/s, 10Mb/s, or 20 Mb/s.

Sections 18 and 19 detail the PLE and medium, respectively, for a single-channel (that is, omnidirectional) phase-continuous-FSK coaxial cable bus at 1 Mb/s.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

This page intentionally left blank

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

2. LLC-MAC Interface Service Specification

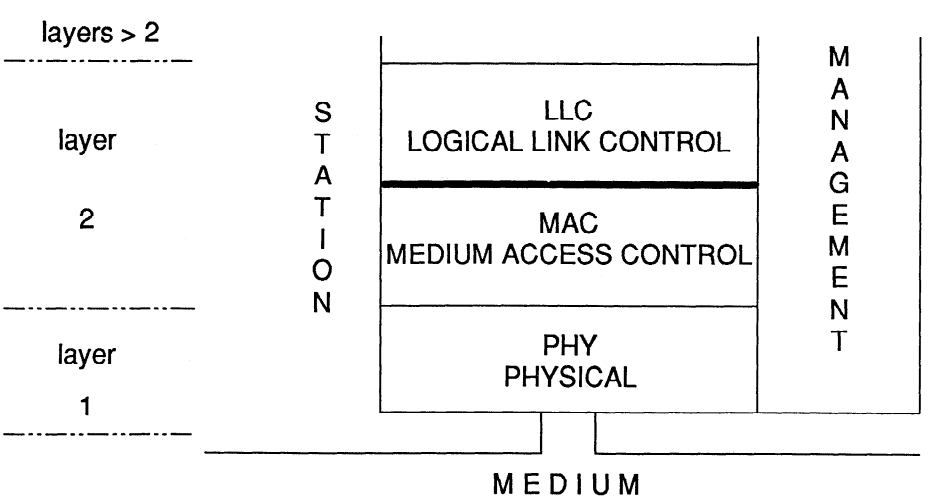
This section specifies the services provided to the Logical Link Control (LLC) sublayer, and to the alternative sublayer specified in ANSI/ISA-S72.01-1986 [1], at the boundary between the LLC functions and the Medium Access Control (MAC) sublayer of the Data Link Layer of the reference model. This standard specifies these services in an abstract way. It does not specify or constrain the implementation entities and interfaces within a computer system. The relationship of this section to other sections of this standard and to LAN specifications is illustrated in Fig 2-1.

NOTES: (1) The exact relationship of the layers described in this standard to the layers defined by the Open Systems Interconnection (OSI) Basic Reference Model (ISO 7498 : 1984 [13]) is for future study.
(2) Work is in process to produce a single service specification that is common to all the MAC sublayers; see ISO/IEC 10039 [20]. When that standard is completed, approved, and published, Section 2 will be deleted.

2.1 Overview of the LLC-MAC Service

2.1.1 General Description of Services Provided. This section informally describes the services provided to the LLC sublayer by the token-passing MAC sublayer, both of the Data Link Layer. These services provide only connectionless data

Fig 2-1
Relation to LAN Model



Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

transfer services between peer LLC entities. They provide the means by which LLC entities can exchange MAC service data units (M_SDU) without the establishment of an underlying point-to-point connection. The data transfer can be point-to-point or multipoint, unacknowledged or acknowledged.

2.1.2 Model Used for the Service Specification. The model and descriptive method are detailed in Appendix A.

2.1.3 Overview of Interactions. The primitives associated with this connectionless data transfer service are

(1) MA-UNITDATA request
(2) MA-UNITDATA indication
(3) MA-UNITDATA confirm

An MA-UNITDATA request primitive is passed to the MAC sublayer to request that an M_SDU be sent. (All M_SDUs are sent using connectionless procedures.) An MA-UNITDATA indication primitive is passed from the MAC sublayer to indicate the arrival of an M_SDU. An MA-UNITDATA confirm primitive is passed from the MAC sublayer to indicate the status of the previous associated MA-UNITDATA request primitive.

2.1.4 Basic Services and Options. All services are mandatory and are required in all implementations.

2.2 Detailed Interactions with the LLC Entity. This subsection describes in detail the primitives and parameters associated with the connectionless data transfer services provided to LLC by MAC. Note that the parameters are specified in an abstract sense. The parameters specify the information that shall be available to the receiving entity. A specific implementation is not constrained in the method of making this information available. For example, the M_SDU parameter associated with some of the data transfer service primitives may be provided by actually passing the MAC service data unit, by passing a descriptor, or by other means. The values of some selection parameters may be implied by an implementation.

2.2.1 MA-UNITDATA request

2.2.1.1 Function. This primitive is the service request primitive for the connectionless data transfer service.

2.2.1.2 Semantics. The primitive shall provide parameters as follows:

```
MA-UNITDATA request (
                     destination_address,
                     source_address,
                     M_SDU,
                     desired_quality
                     )
```

The destination_address parameter specifies either an individual or a group MAC-entity address. The source_address parameter specifies the originating MAC-entity address, typically the local station. The M_SDU parameter specifies the MAC service data unit to be transmitted by the MAC sublayer entity for the requesting LLC sublayer entity.

AVA Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

The desired_quality parameter specifies the desired quality of service. The semantics of this parameter include both MAC-level priority, with a range of 0 (lowest) to 7 (highest) (see 6.6.1.2), and MAC-level delivery confirmation service, with values of request_with_no_response, request_with_response, and response.

2.2.1.3 When Generated. This primitive is passed from the LLC sublayer entity to the MAC sublayer entity to request that the MAC sublayer entity compose and transmit the specified frame at the desired quality of service on the LAN.

2.2.1.4 Effect on Receipt. Receipt of this primitive causes the MAC sublayer entity to attempt to compose and transmit the specified frame.

2.2.1.5 Additional Comments. A value of request_with_response for the delivery-confirmation component of the quality parameter indicates that the next MA-UNITDATA indication should itself have a quality parameter specifying response, in which case that next MA-UNITDATA indication shall be associated with this MA-UNITDATA request.

A value of response for the delivery-confirmation component of the quality parameter indicates that the immediately prior MA-UNITDATA indication shall itself have had a quality parameter specifying request_with_response.

A group destination_address should not be used when specifying request_with_response.

2.2.2 MA-UNITDATA indication

2.2.2.1 Function. This primitive is the service indication primitive for the connectionless data transfer service.

2.2.2.2 Semantics. The primitive shall provide parameters as follows:

```
MA-UNITDATA indication  (
                         destination_address,
                         source_address,
                         M_SDU,
                         quality
                         )
```

The destination_address and source_address parameters specify the DA and SA fields of a frame (see Section 4) as received by the local MAC entity, and thus the MAC entities purportedly involved in the communication. The M_SDU parameter specifies the MAC service data unit as received by the local MAC sublayer entity.

The quality parameter specifies the delivered quality of service. The semantics of this parameter include both MAC-level priority, with a range of 0 (lowest) to 7 (highest) (see 6.6.1.2), and MAC-level delivery-confirmation service, with values of request_with_no_response, request_with_response, and response.

2.2.2.3 When Generated. This primitive is passed from the MAC sublayer entity to the LLC sublayer entity to indicate the arrival of a data frame from the Physical Layer entity (PLE). Such frames are reported only when they are free of detected errors and their (individual or group) destination address designates the local MAC entity.

2.2.2.4 Effect on Receipt. The effect of receipt of this primitive by the LLC entity is specified in ISO 8802-2 : 1989 (IEEE Std 802.2-1989) [15].

2.2.2.5 Additional Comments. In the absence of undetected errors, the con-

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

tents of the M_SDU parameter are logically complete and unchanged relative to the M_SDU parameter in the associated MA-UNITDATA request at the sending station.

NOTE: This is a guarantee of transparency.

A value of request_with_response for the delivery-confirmation component of the quality parameter indicates that the receiving LLC sublayer entity should immediately respond with an MA-UNITDATA request which itself has a quality parameter specifying response.

A value of response for the delivery-confirmation component of the quality parameter indicates that this MA-UNITDATA indication may be associated with a prior MA-UNITDATA request which itself had a quality parameter specifying request_with_response, and which was issued by the same LLC sublayer entity.

2.2.3 MA-UNITDATA confirm

2.2.3.1 Function. This primitive provides the LLC sublayer with status information for the previous associated MA-UNITDATA request primitive.

2.2.3.2 Semantics. The primitive shall provide parameters as follows:

```
MA-UNITDATA confirm (
                     destination_address,
                     source_address,
                     status,
                     provided_quality
                     )
```

The destination_address and source_address parameters specify the destination address and source address fields of the associated MA-UNITDATA request primitive. The status parameter indicates the status of the service provided for a previous associated MA-UNITDATA request primitive.

The provided_quality parameter specifies the quality of service actually provided for the previous request. The semantics of this parameter include both MAC-level priority, with a range of 0 (lowest) to 7 (highest) (see 6.6.1.2), and MAC-level delivery confirmation service.

2.2.3.3 When Generated. This primitive is passed from the MAC sublayer entity to the LLC sublayer entity to indicate the status of the service provided for the previous associated LLC data transfer request.

A success indication is passed when the request has been completed successfully, either because no response was requested or because the requested response was received. A failure indication is passed upon local failure or when a requested response is not received, even after the specified number of retries. When the quality parameter of that request specifies request_with_response, a failure indication is also passed if the allowed number of retries has occurred with no response.

2.2.3.4 Effect on Receipt. The effect of receipt of this primitive by the LLC sublayer entity is specified in ISO 8802-2 : 1989 (IEEE Std 802.2-1989) [15].

2.2.3.5 Additional Comments. It is assumed that sufficient information is available to the LLC sublayer to associate the status with the appropriate request.

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

3. MAC Sublayer Management

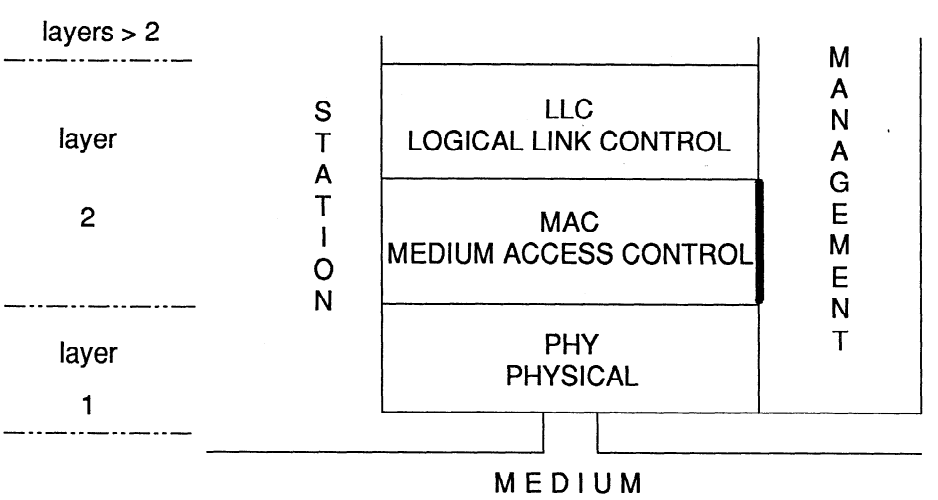
This section specifies the abstract entities (parameters, events, and actions) used in managing the Medium Access Control (MAC) sublayer. The relationship of this section to other sections of this standard and to Local Area Network (LAN) specifications is illustrated in Fig 3-1.

There are two ways to manage a MAC sublayer: locally or remotely.

Local management is required to initially configure a MAC and to operate it when remote management is not available. Since the operation of local MAC management, other than the need to manage the entities described in this section, does not affect station interoperability, the specification of local management is outside the scope of this standard.

This standard uses the concept of remote management as defined in the Open Systems Interconnection (OSI) Management Framework described in ISO/IEC 7498-4 : 1989 [14]. Remote management uses a communications protocol to manipulate and observe the managed entities. This section is designed to be used with the companion remote management standard described by IEEE P802.1B [9].

Fig 3-1
Relation to LAN Model



Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Other protocols, such as described by ISO/IEC 9595 [18] and ISO/IEC 9596 [19], may also be used.

To implement a remote management protocol, the identification and value representation of the managed entities must be defined. Such a definition is given by a layer management interface (LMI) protocol.

NOTE: The definition of a MAC sublayer LIM protocol is under study. An addendum to this standard is planned that will contain this protocol.

Within this document the general term "management" is used to refer to either local or remote management, unless otherwise indicated.

3.1 Overview. This section describes the entities communicable via the LMI, shown as a thick line in Fig 3-1. The MAC sublayer entities described in this section consist of

(1) Parameters within the MAC sublayer written and read by the management entity,
(2) Actions initiated by the management entity that cause changes within the MAC sublayer,
(3) Events within the MAC sublayer entity that are passed to the management entity.

The notation used to specify the entities defined in this section is the Abstract Transfer Syntax and Notation (ASN.1), defined in ISO 8824 : 1987 [16]. This syntax differs from that used in Sections 4 through 7 to describe the token bus MAC. The difference is in the spelling of the entity names. The ASN.1 notation does not allow the underscore character, "_", and uses a combination of uppercase and lowercase characters to improve readability.

For example, this section defines a parameter *inRing*. Section 7 defines a parameter *in_ring*. While the syntax of the names is different, the parameters are equivalent.

3.2 MAC Management Facilities. This subsection contains a description of use of the management parameters, actions, and events within the token-passing bus MAC sublayer.

3.2.1 Organization. There are three types of management entities:

(1) Parameters
(2) Actions
(3) Events

The MAC sublayer parameters accessible by the management entity are described first. These parameters are organized into groups. The groups not only collect the variables, they also define collections of parameters that can be accessed in a common manner.

NOTE: In implementing control of access to parameters, the intent of this standard is to implement the granularity of access control only to the group level. Thus, all parameters within a group share a common access level.

Any or all of the parameters in a group may be passed in a single remote management request. The semantics and grouping of the parameters so communicated are specified in the following subsections.

AVA Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

3.2.2 ResourceTypeID. This subsection discusses the parameters of the MAC sublayer LMI that are common to any layer. These parameters create a "nameplate" that identifies the basic attributes of the MAC sublayer.

The ResourceTypeID is common to all MAC sublayers. Implementation of this group shall be required. The ResourceTypeID group is defined in IEEE P802.1B [9].

3.2.2.1 resourceType. This parameter identifies the resource as a MAC sublayer.

3.2.2.2 standardRevision. This parameter identifies the revision of this standard implemented by the MAC sublayer.

3.2.2.3 lmeOptions. This parameter identifies the options supported by the implementation. The options defined by this standard are priority and request_with_response.

3.2.3 MAC Characteristics Group. The MAC characteristics group defines attributes of the MAC sublayer that are specific to a token-passing bus MAC sublayer. The implementation of the parameters in the MAC characteristics group shall be optional except for maxSDUSize, which is required. All parameters shall be read-only.

3.2.3.1 maxSDUSize. The maximum size service data unit that the sublayer implementation is capable of accepting.

The value of maxSDUSize is between 516 (to allow 512 octet frames) and 8191 octets.

3.2.3.2 transmitTimeDelay. The estimated maximum delay incurred by the MAC in sending a data frame, including the time in the MAC transmit queue. The value of this parameter is for use by higher layers in computing a time-out delay to use in detecting lost frames. The type is an array of time values indexed by MAC service class (see 6.6.1.2).

The units of this parameter and methods of computing the values are for future study.

3.2.4 MAC Management Group. The MAC management parameters describe the current state of the MAC sublayer. The implementation of access by the management entity to these parameters shall be optional. Access by the management entity to these parameters shall be read-only to prevent unpredictable changes to MAC operation. In order to change the value of one of these parameters, the management entity must change the corresponding value in the initialization group (see 3.2.7) and then perform the reset action to force the station to reinitialize.

3.2.4.1 state. MAC sublayer state. The current state of the MAC entity. The MAC state is changed by management actions (see 3.2.11) and events within the MAC access control machine (ACM) (see Section 7).

The range of values of the state parameter is offline, tokenBus, tokenBusBridge, and tokenBusRepeater.

NOTE: The operation of a station in the token-passing bus bridge mode is for future study. Bridge operation is envisioned to include acceptance of frames addressed to stations on networks other than the one to which the station is connected.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

3.2.4.2 testStatus. The status of a previously initiated test. Negative, implementation-dependent values shall be treated as "failure" by entities that lack further information on the implementation-dependent meaning.

See 7.1.1 for a detailed description of the following parameters of the MAC management group.

3.2.4.3 ts. This station's address.

3.2.4.4 slotTime. The network slot_time.

3.2.4.5 minPostSilencePreambleLength. The minimum number of octets of preamble to prefix to a frame after silence. The value is obtained from the PLE and used by the transmit machine (TxM).

3.2.5 Station Performance Group. These parameters affect the operation of the station and the station's performance in the network. Management may read and write the station performance parameters in order to alter network operation without having to re-initialize the station. The implementation of access by the management entity to these parameters shall be optional.

See 7.1.1 for a detailed description of the parameters of the station performance group.

3.2.5.1 maxInterSolicitCount

3.2.5.2 maxRetryLimit

3.2.5.3 hiPriTokenHoldTime

3.2.5.4 targetRotationTime

3.2.5.5 ringMaintenanceTimerInitialValue

3.2.5.6 inRingDesired

3.2.6 Station Monitoring Group. These parameters reflect the current status of the network and the station's status with respect to the network.

The implementation of access by the management entity to these parameters shall be optional. The station monitoring parameters shall be read-only with the exception of maxTokenRotationTime, which shall be read-write.

See 7.1.6 for a description of the parameters of the station monitoring group not discussed in the following paragraphs.

3.2.6.1 ns. The address of the next station in the logical ring.

3.2.6.2 ps. The address of the previous station in the logical ring.

3.2.6.3 nsKnown

3.2.6.4 inRing

3.2.6.5 soleActiveStation

3.2.6.6 lastTokenRotationTime. The observed token rotation time for the last token rotation, timed from token arrival to token arrival. Units are octet times.

A value of zero indicates that the value is not currently available; for example, possibly when the station is not a member of the logical ring. A negative value indicates a range overflow.

3.2.6.7 maxTokenRotationTime. The maximum token rotation time. The value is created by comparing the old value of maxTokenRotationTime with the value of lastTokenRotationTime whenever the token is received. If the old maxTokenRotationTime value is less then the lastTokenRotationTime, the value of maxTokenRotationTime is set equal to the value of lastTokenRotationTime. Units are octet times.

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

The value of this parameter may be set to zero by the management entity to begin a time interval over which the maximum token rotation time is to be measured.

A value of zero indicates that the value is not currently available. A negative value indicates a range overflow.

The creation of other statistics from the maximum and instantaneous token rotation time variables is for future study.

3.2.6.8 approximateRingSize. The approximate number of stations in the logical ring.

A possible method of obtaining the value of approximateRingSize is for the station to count the number of valid token frames that it hears between sending and receiving the token. Such a simplistic approach is prone to error when tokens are repeated or heard in error. Implementors can improve the approximation with more sophisticated techniques if desired.

A value of zero means the value is currently unavailable, for example, possibly when the station is not a member of the logical ring. A negative value indicates a range overflow.

3.2.7 Initialization Group. The initialization parameters are copied to the MAC sublayer operational parameters when the station is initialized. The initialization parameters shall be required in implementations where the corresponding operational parameters exist. The initialization parameters shall be readable and writeable by the management entity.

See 7.1.7 for a detailed description of the parameters of the initialization group.

3.2.7.1 initTS
3.2.7.2 initSlotTime
3.2.7.3 initMaxInterSolicitCount
3.2.7.4 initMaxRetryLimit
3.2.7.5 initHiPriTokenHoldTime
3.2.7.6 initTargetRotationTime
3.2.7.7 initRingMaintenanceTimerInitialValue
3.2.7.8 initInRingDesired

3.2.8 Interface Machine (IFM) Counters Group. These parameters monitor the operation of the IFM. In counting frame length, octets in a frame are counted between the start delimiter and the end delimiter, exclusively. Service class to access class correspondence is specified in 6.6.1.2.

The implementation of the IFM counters and access by the management entity shall be optional. Access by the management entity to these parameters shall be read-only.

3.2.8.1 messagesSent. The number of data frames sent at the corresponding access class.

3.2.8.2 octetsSent. The number of octets in data frames sent at the corresponding access class, including control fields and excluding delimiters.

3.2.8.3 messagesReceived. The number of valid data frames received and accepted at the corresponding access class.

3.2.8.4 octetsReceived. The number of octets of valid data frames received and accepted at the corresponding access class, including control fields and excluding delimiters.

AVA Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

NOTES: (1) This standard does not include a count of frames discarded at the MAC-LLC interface due to lack of buffer space. The presumption is that the LLC sublayer is responsible for buffer management and discarding frames for lack of space.

(2) It is possible to have underruns while transmitting frames and/or overruns while receiving frames. Implementations may have counters that record the occurrence of these events. It is recommended that these counters be included in private management parameters of the IFM counters group.

3.2.9 Access Control Machine (ACM) Counters Group. These parameters monitor the operation of the ACM. The implementation of the ACM counters and access by the management entity shall be optional.

Implementation of a threshold facility associated with each counter shall be treated as a separate option. Thus, one of three conditions exist: No implementation, 32-bit counters without threshhold, or 32-bit counters with threshold. If implemented, access by the management entity to these parameters shall be read-only, except for the portions associated with the threshold mechanism. (The threshold facility can be used to generate an event to the management entity when the value of a counter exceeds a specified value.)

NOTE: The condition described in 6.7.4 can cause the token_pass_failure, who_follows_query, and solicit_any counters to increment during correct operation of the network.

3.2.9.1 whoFollowsQuery. The number of occurrences of the ACM who_follows_query state transition. (See 7.2.3.8.)

3.2.9.2 tokenPassFailed. The number of occurrences of the ACM token_pass_failed state transition when pass_state equals pass_token.

3.2.9.3 solicitAny. The number of occurrences of the ACM solicit_any state transition not due to the ACM do_solicit_any state transition.

3.2.9.4 noSuccessor. The number of occurrences of the ACM no_successor_8 state transition.

3.2.9.5 unexpectedFrame. The number of occurrences of the ACM unexpected_frame_6 and unexpected_frame_10 state transitions.

3.2.9.6 claimToken. The number of occurrences of the ACM no_token state transition.

3.2.10 Receiver Machine (RxM) Counters Group. These parameters monitor the operation of the RxM. The implementation of the RxM counters and access by the management entity shall be optional. Thus the implementation of the MAC variable noise_expected discussed in the next paragraph, shall also be optional. Access to the RxM counters shall be read-only, except for the portions associated with the optional threshold mechanism.

The MAC variable noise_expected is used only in the definition of the RxM counters and is not described elsewhere in this standard. The noise_expected variable attempts to track the state of the network so that errors reported by the modem can be classified.

Errors reported by the modem may actually be induced by "collisions" when multiple stations transmit during times when contention can occur. By tracking the state of the network, the ACM attempts to predict the times of possible contention. The variable noise_expected conveys this information.

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

To simplify the explanation, the ACM state tables in 7.2 do not include the variable noise_expected. If required to implement the counters defined in this subsection, noise_expected shall be reset whenever the ACM

(1) Receives or sends a valid token frame
(2) Receives or sends a valid data frame

The noise_expected variable shall be set whenever the ACM

(a) Traverses the initialize arc
(b) Receives or sends a solicit_successor_1 frame
(c) Receives or sends a solicit_successor_2 frame
(d) Receives or sends a resolve_contention frame
(e) Receives or sends a who_follows frame
(f) Receives or sends a claim_token frame

Implementation of a threshold facility associated with each counter except validFrames shall be treated as a separate option. Thus, one of three conditions exist: No implementation, simple 32-bit counters, or thresholded 32-bit counters. If implemented, access by the management entity to these parameters shall be read-only, except for the portions associated with the threshold mechanism.

3.2.10.1 validFrames. The number of valid frames received of all types, including MAC control frames. (See 4.1.)

3.2.10.2 modemErrors. The number of noise bursts that occur when noise_expected is reset. modemErrors is a count of noise bursts that are probably caused by errors in the PLE or as the result of noise introduced on the medium.

The following counters are defined in order to aid in diagnosing the cause of errors reported in modemErrors. The value of modemErrors is the sum of the values of the following counters:

(1) **fcsErrors.** The number of frames received with incorrect frame check sequence (FCS) and E-bit reset when noise_expected is reset. (This value represents a count of FCS errors not previously detected by a remodulator or other repeater.)
(2) **eBitErrors.** The number of frames received with the E-bit set and the FCS invalid when noise_expected is reset. (This value represents a count of FCS errors previously detected by a remodulator or other repeater.)
(3) **nonSilence.** The number of occurrences of non-silence followed by silence in which a start delimiter was not detected when noise_expected is reset. (This error is possibly caused by a noise "hit" on the start delimiter.)
(4) **frameFragments.** The number of occurrences of a start delimiter followed by a start delimiter, invalid symbol sequence, or silence without an intervening end delimiter. frameFragments is only incremented when noise_expected is reset. (This error is probably caused by premature termination of a frame by an abort sequence.)

The treatment of frames that are received with the correct FCS and the E-bit set is not specified by this standard. However, if such frames are discarded by the MAC as invalid, the count of such discarded frames shall be included in eBitErrors.

3.2.11 Action Definitions. Actions are requests by the management entity to perform some activity. The reset and initialize with a value of initializeTokenBus actions shall be required locally. All other actions shall be optional.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

3.2.11.1 reset Action. This action causes the MAC sublayer to go to the OFFLINE state. The MAC sublayer shall remain in this state until a local initialize action occurs. A remote initialize action shall be ignored following a remote reset action.

The action may be used to disable the MAC sublayer if it is suspected of malfunctioning.

3.2.11.2 initialize Action. This action resets the MAC sublayer and then causes the station's ACM to traverse the initialize arc and enter the IDLE state in accordance with the action request parameter. A remote initialize action shall be ignored if the MAC sublayer is already in the OFFLINE state. The action request parameter may assume the values tokenBus, tokenBusBridge, or tokenBusRepeater.

Following an initialize action, the values of the counters specified in 3.2.8 through 3.2.10 are unspecified.

3.2.11.3 initiateTest Action. The initiateTest action commences an internal test of the MAC sublayer if the station is in the OFFLINE state. The result of the most recently initiated test is reported in the parameter testStatus. (See 3.2.4.2.)

The effect of the initiateTest action when the station is not in the OFFLINE state is for future study.

3.2.12 Event Definitions. Events are spontaneously reported by the sublayer to the management entity. Remote reporting of events shall be optional.

Local support of the thresholdReached event is required when thesholded counters are implemented. Support of the newSuccessor event shall be optional. Passing of the new successor's address shall be optional. Support of the no-Successor event shall be optional. Local support of the duplicateAddressFault and faultyTransmitterFault events shall be required.

NOTE: In implementing routing of events, the intent of this standard is to provide a unique routing path for each event.

3.2.12.1 thresholdReached. A thresholded counter has passed the threshold value. The event value shall be the counter's parameter identifier.

3.2.12.2 newSuccessor. The station's successor has changed. The event value shall be the new successor address.

3.2.12.3 noSuccessor. The station now considers itself the sole member or not a member of the ring.

3.2.12.4 duplicateAddressFault. The station has detected another station with the same MAC address. The state transition causing this event is duplicate_address_1. (See 6.7.1 for possible additional detection methods.)

3.2.12.5 faultyTransmitterFault. The station has decided that it may have a faulty transmitter. The state transitions associated with such a decision are

(1) end_all_contention
(2) no_future

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

4. Frame Formats

This section defines the required Medium Access Control (MAC) frame formats. This includes all allowed frame formats and the arrangement of all frame subfields. The term frame as used here refers to the protocol data units (PDUs) exchanged by MAC sublayer entities. The MAC service data units received from the Logical Link Control (LLC) sublayer are contained within some of these MAC frames. The frame components and formats used by medium access control are also described in this section.

The MAC frames and abort sequences are described in the following subsections. First, the components of the frames are discussed, followed by the definition of the valid frame formats. All frames sent or received by the MAC sublayer shall conform to the following general format:

PREAMBLE	SD	FC	DA	SA	DATA_UNIT ...	FCS	ED

```
where
   PREAMBLE = pattern sent to set receiver's modem clock and level
              (1 or more octets)
         SD = start delimiter (1 octet)
         FC = frame control (1 octet)
         DA = destination address (2 or 6 octets)
         SA = source address (2 or 6 octets)
  DATA_UNIT = information (0 or more octets)
        FCS = frame check sequence (4 octets)
         ED = end delimiter (1 octet)
```

The number of octets between SD and ED, exclusive, of a data frame (see 4.1.3.2) shall be 8191 octets or fewer.

The abort sequence shall conform to the following format:

SD	ED

```
where
  SD = start delimiter (1 octet)
  ED = end delimiter (1 octet)
```


AVA Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

Within this section the following acronyms are used for the addresses of the station under discussion, its successor and its predecessor in the logical ring:

TS — this station's address
NS — next station's address
PS — previous station's address

4.1 Frame Components. This subsection describes the frame components that are shown in the previous illustrations in greater detail.

A valid frame consists of preamble, a start delimiter, a frame control octet, destination and source addresses, possibly a data_unit, a valid FCS, and an end delimiter, and does not meet any of the criteria of an invalid frame as described in 4.2.3. This definition excludes abort sequences from the set of valid frames.

4.1.1 Preamble. The preamble pattern preceeds every transmitted frame. Preamble is sent by the MAC sublayer entity as an appropriate number of *pad_idle* symbols. Preamble may be decoded by the receiver as arbitrary data symbols that occur outside frame delimiters. Preamble is primarily used by the receiving modem to acquire signal level and phase lock by using a known pattern. The preamble pattern is chosen for each modulation scheme and data rate for this purpose. The parameter min_post_silence_preamble_length specifies the minimum amount of preamble on the first frame transmitted after a period of "transmitted" *silence.* See 7.1.1 for use of the parameter within the MAC sublayer. See 12.6, 14.7, 16.6, and 18.6 for the specification of the different physical layers.

A secondary purpose for the preamble is to guarantee a minimum ED to SD time period to allow stations to process the frame previously received. The minimum amount of preamble transmitted is a function of both the data rate and the modulation scheme. The standard requires that the duration of the preamble shall be at least 2 μs, regardless of data rate, and that an integral number of octets shall be sent. Thus, at a data rate of 1 Mb/s, one octet of preamble is required to meet the integral number of octet requirements, and at a data rate of 10 Mb/s, three octets are required to meet the minimum time requirement.

The maximum amount of preamble is constrained by the "jabber" control in the PLE. Additionally, for claim_token frames, all stations shall use the minimum number of preamble octets to ensure that all frames are of uniform specified length.

4.1.2 Start Delimiter (SD). The frame structure requires an SD, which begins the frame. The SD consists of signaling patterns that are always distinguishable from data.

The SD is coded as follows (see 12.7, 14.8, 14.11, 16.7, and 18.7 for representations of the symbol coding as present on the medium):

```
                          ┌── first MAC-symbol transmitted

start delimiter (SD):     | N N 0 N N 0 0 0 |

                          1 2 3 4 5 6 7 8 ← bit
                                            positions
```


Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

```
where
  N = non_data MAC-symbol
  0 = zero MAC-symbol
  1 = one MAC-symbol
```

4.1.3 Frame Control (FC) Field. The FC octet determines what class of frame is being sent from among the following general categories:

(1) MAC control
(2) LLC data

The FC format for each of these categories is illustrated by the following:

4.1.3.1 MAC Control Frame

```
        ┌──────── first MAC-symbol transmitted
      ┌─────────┬─────────────────┐
      │ 0 0     │ C C C C C C     │
      └─────────┴─────────────────┘
        1 2       3 4 5 6 7 8     ← bit positions
where
  CCCCCC = type of MAC_control frame as follows:
  C C C C C C
 ──────────────
 3 4 5 6 7 8   ← bit positions
 ──────────────
 0 0 0 0 0 0   claim_token
 0 0 0 0 0 1   solicit_successor_1 (has 1 response window)
 0 0 0 0 1 0   solicit_successor_2 (has 2 response windows)
 0 0 0 0 1 1   who_follows         (has 3 response windows)
 0 0 0 1 0 0   resolve_contention  (has 4 response windows)
 0 0 1 0 0 0   token
 0 0 1 1 0 0   set_successor
```

4.1.3.2 Data frames

```
        ┌──────── first MAC-symbol transmitted
      ┌─────────┬─────────┬─────────┐
      │ F F     │ M M M   │ P P P   │
      └─────────┴─────────┴─────────┘
        1 2       3 4 5     6 7 8   ← bit positions
where
   F F = frame type:
  (1 2 ← bit positions)
   ───
   0 1 = LLC_data_frame
   1 0 = reserved (former management)
   1 1 = reserved (further study)
```


Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

```
 M M M = MAC-action:
(3 4 5 ← bit positions)
 ------
 0 0 0 =  request_with_no_response
 0 0 1 =  request_with_response   (see 6.6.2)
 0 1 0 =  response                (see 6.6.2)

 P P P =  priority:
(6 7 8 ← bit positions)
 ------
 1 1 1 = highest priority
 1 1 0
 1 0 1
 1 0 0
 0 1 1
 0 1 0
 0 0 1
 0 0 0 = lowest priority
```

NOTE: The use of the "10" in the frame type field to indicate frames destined for the management entity is not recommended and is included only to retain backwards compatibility with previous versions of this standard.

Other bit patterns in the FC octet are reserved for future study. The action of a station upon receiving an FC value not defined in this standard is not specified.

4.1.4 Address Fields. Each frame shall contain two address fields: The destination address field and the source address field, in that order. Addresses shall be either 16 bits or 48 bits in length. All addresses on a given Local Area Network (LAN) shall be of the same length.

4.1.4.1 Destination Address Field. The following illustration shows the possible representations of destination addresses:

(1) 16-bit address form

```
┌── first MAC-symbol transmitted
┌──────────────────────┐
│ I/G │  15-bit address │
└──────────────────────┘
                        └── most significant
                            bit of address
```

(2) 48-bit locally administered form

```
┌── first MAC-symbol transmitted
┌──────────────────────────────────────┐
│ I/G │ 1 │          46-bit address    │
└──────────────────────────────────────┘
                                       └── most significant
                                           bit of address
```


Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990

(3) 48-bit universally administered form

```
┌── first MAC-symbol transmitted
```

I/G	0	46-bit address

```
                                    └── most significant
                                        bit of address
```

where
I/G = individual/group address bit

The first MAC-symbol transmitted of the destination address (the I/G bit) distinguishes individual addresses from group addresses:

0 = individual address
1 = group address

For 48-bit addresses, the second MAC-symbol transmitted of source or destination addresses (the local/universal or L/U bit) distinguishes locally administered addresses from universally administered, unique addresses.

Individual Addresses. An individual address identifies a particular station on the LAN and shall be distinct from all other individual station addresses on the same LAN.

Group Addresses. A group address is used to address a frame to multiple destination stations. Group addresses may be associated with zero, one, or more stations on a given LAN. In particular, a group address is an address associated by convention with a group of logically related stations.

Broadcast Addresses. The group address consisting of all *ones* (that is, 16 or 48 *ones* for two- or six-octet addressing, respectively) shall constitute a broadcast address, denoting the set of all stations on the given LAN.

NOTE: For some of the frame types used by the token-passing bus MAC procedures, the contents of the destination address field are irrelevant. In such cases, the originating station's own address or any other individual addresses may be sent in this field.

Address Administration (48-bit addresses only). There are two methods of administering the set of 48-bit station addresses: locally or through a universal authority. The second bit transmitted of the destination address indicates whether the address has been assigned by a universal or local administrator.

0 = universally administered
1 = locally administered

Universal Administration. With this method, all individual addresses are distinct from the individual addresses of all other LAN stations on a universal basis. The procedure for administration of these addresses is not specified in this standard.

NOTE: Information concerning the Registration Authority and its procedures may be obtained on request to the Secretary General, ISO Central Secretariat, 1 rue de Varembé, Case postale 56, CH1211, Genève, Switzerland/Suisse, quoting the number of this International Standard.

Documents
Document Sharing Hub

Full document details: ISO_IEC 8802-4_1990

For information on universal address administration contact the Secretary, IEEE Standards Board, Institute of Electrical and Electronics Engineers, Inc., P.O. Box 1331, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA.

Local Administration. Individual station addresses are administered by a local (to the LAN) authority. (This is the only method allowed for 16-bit addresses.)

NOTE: Appendix 4.3 contains a suggested method for hierarchical structuring of locally administered addresses.

4.1.4.2 Source Address Field. The source address identifies the station originating the frame and has the same format and length as the destination address in a given frame, except that the I/G bit shall be set to 0; the significance of it being set to 1 is a subject for future study.

4.1.4.3 Numerical Interpretation of Addresses. Strictly speaking, addresses are bit strings which serve as unique station identifiers or group identifiers. For the purpose of the MAC address comparison within the token bus MAC sublayer, as used in ordering the logical ring and as expressed in the formal access control machine of 7.2.3, each MAC-address bit string is interpreted as if it were an unsigned integer value sent least significant bit first, and thus as if the last bit transmitted had the highest numeric significance.

NOTE: This interpretation does not extend beyond the logical ring ordering operations of the token-passing bus MAC sublayer.

Additionally, the address bits are used in determining delays in the contention process and transmission lengths in the token claiming process. These processes start with the most significant address bits, under the above interpretation, using two bits at a time. Thus the internal processing order is reversed from the serial transmission order on the medium.

4.1.5 MAC Data_Unit Field. Depending on the bit pattern specified in the frame's FC octet, the MAC data_unit field can contain either an LLC protocol data_unit as specified in ISO 8802-2 : 1989 (IEEE Std 802.2-1989) [15], or a value specific to one of the MAC control frames.

In the case where the MAC data_unit field contains a LLC PDU, the MAC data_unit field shall be transmitted to the Physical Layer in the same bit order as received from the LLC sublayer. Likewise, the MAC data unit field shall be delivered to the LLC sublayer in the same bit order as received from the Physical Layer.

4.1.6 Frame Check Sequence (FCS) Field. The FCS is a 32-bit frame checking sequence, based upon the following standard generator polynomial of degree 32:

$$X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^{8} + X^{7} + X^{5} + X^{4} + X^{2} + X + 1$$

The FCS is the one's complement of the sum (modulo 2) of

(1) The remainder of

$$X^{K} * (X^{31} + X^{30} + X^{29} + \ldots + X^{2} + X + 1)$$

Documents
Document Sharing Hub
Full document details: ISO_IEC 8802-4_1990