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1998-09-28

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

Part 12:
Demand-Priority access method, physical layer and repeater specifications

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

Partie 12: Méthode d'accès par priorité de la demande, et spécifications pour la couche physique et le répéteur

Reference number
ISO/IEC 8802-12:1998(E)
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Abstract: The media access control characteristics for the demand-priority access method are specified. The layer management, physical layers, and media that support this access method are also specified. Layer and sublayer interface specifications are aligned to the ISO Open Systems Interconnection Basic Reference Model and ISO/IEC 8802 models. Specifications for 100 Mb/s operation over 100 Ω balanced cable (twisted-pair) Categories 3 through 5, 150 Ω shielded balanced cable, and fibre-optic media are included. Optional implementation of redundant links to facilitate automatic recovery of network connectivity in case of link or repeater failure anywhere in the network path is specified. Rules for connecting redundant links within a network are defined.
Keywords: balanced cable, data processing, demand-priority access method, fault tolerance, fibre optic, information interchange, local area network, media access control, models, mode of data transmission, network interconnection, redundant link, repeater, star-topology local area network, twisted pair, network interconnection

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Information technology—
Telecommunications and information exchange between systems—
Local and metropolitan area networks—
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Part 12: Demand-Priority access method, physical layer and repeater specifications

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International Standard ISO/IEC 8802-12:1998(E)

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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 national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

International Standard ISO/IEC 8802-12 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

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

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

— *Part 2: Logical link control*

— *Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

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

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

— *Part 6: Distributed Queue Dual Bus (DQDB) access method and physical layer specifications*

— *Part 9: Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers*

— *Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications*

— *Part 12: Demand-Priority access method, physical layer and repeater specifications*

Annexes A to D form an integral part of this part of ISO/IEC 8802. Annexes E to G are for information only.

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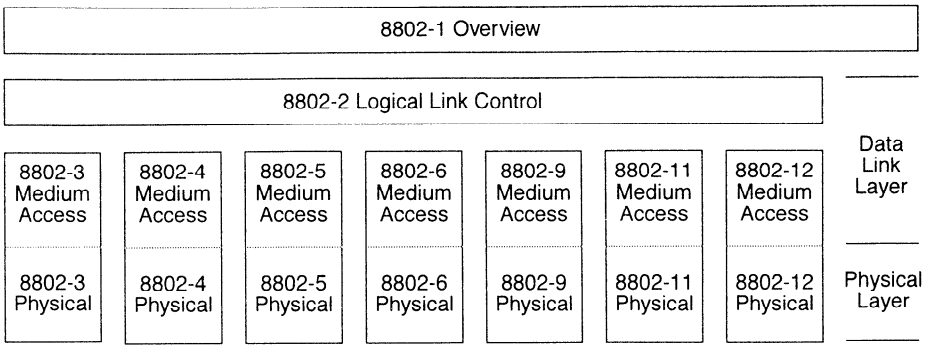
Foreword to International Standard ISO/IEC 8802-12: 1998

This International Standard is part of a family of International Standards for Local and Metropolitan Area Networks. The relationship between this International Standard and the other members of the family is shown below. (The numbers in the figure refer to ISO/IEC Standard numbers.)



This family of International Standards deals with the Physical and Data Link layers as defined by the ISO/IEC Open Systems Interconnection (OSI) Basic Reference Model (ISO/IEC 7498-1 : 1994). The access standards define seven types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The International Standards defining the access technologies are as follows:

a) ISO/IEC 8802-3, utilizing carrier sense multiple access with collision detection (CSMA/CD) as the access method.
b) ISO/IEC 8802-4, utilizing token passing bus as the access method.
c) ISO/IEC 8802-5, utilizing token passing ring as the access method.
d) ISO/IEC 8802-6, utilizing distributed queuing dual bus as the access method.
e) ISO/IEC 8802-9, a unified access method offering integrated services for backbone networks.
f) ISO/IEC 8802-11, a wireless LAN utilizing carrier sense multiple access with collision avoidance (CSMA/CA) as the access method.
g) ISO/IEC 8802-12, utilizing Demand Priority as the access method.

ISO/IEC TR 8802-1, *Overview of Local Area Network Standards*, provides an overview of the series of ISO/IEC 8802 standards.

ISO/IEC 8802-2, *Logical Link Control*, is used in conjunction with the medium access standards to provide the data link layer service to network layer protocols.

ISO/IEC 15802-1, *Medium Access Control (MAC) service definition*, specifies the characteristics of the common MAC Service provided by all IEEE 802 LAN MACs. The service is defined in terms of primitives that can be passed between peer service users, their parameters, their interrelationship and valid sequences, and the associated events of the service.

ISO/IEC 15802-2, *LAN/MAN Management*, defines an OSI management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.

ISO/IEC DIS 15802-3, *Media Access Control (MAC) Bridges*, specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the level of the logical link control protocol.

ISO/IEC 15802-4, *System Load Protocol*, specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.

ISO/IEC 15802-5, *Remote Media Access Control (MAC) bridging*, specifies extensions for the interconnection, using non-LAN communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.

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ANSI/IEEE Std 802.12, 1998 Edition

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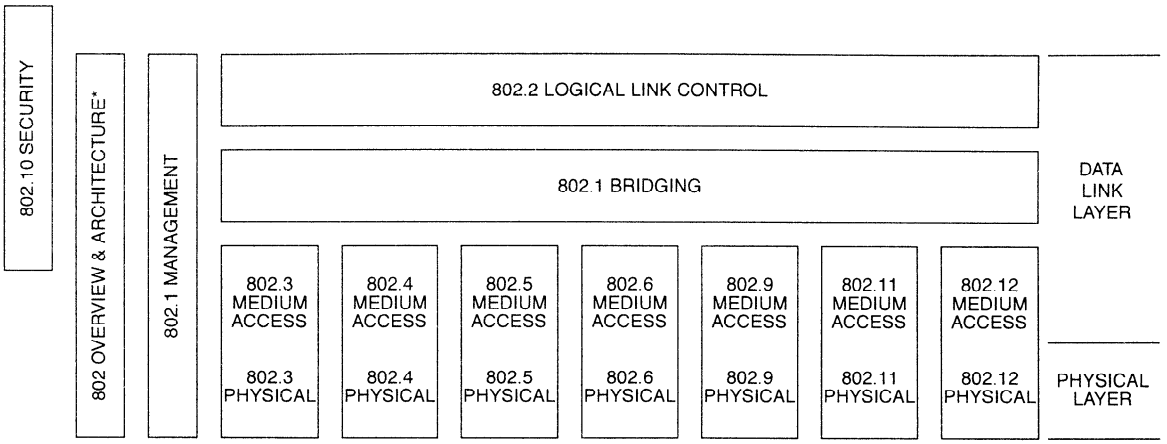
Introduction to ANSI/IEEE Std 802.12, 1998 Edition

[This is not part of ANSI/IEEE Std 802.12, 1998 Edition, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 12: Demand-Priority access method, physical layer and repeater specifications.]

This standard is part of a family of standards for local and metropolitan area networks. The relationship between the standard and other members of the family is shown below. (The numbers in the figure refer to IEEE standard numbers.)



* Formerly IEEE Std 802.1A.

This family of standards deals with the Physical and Data Link layers as defined by the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Basic Reference Model (ISO/IEC 7498-1 : 1994). The access standards define seven types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The standards defining the technologies noted above are as follows:

- IEEE Std 802 — *Overview and Architecture*. This standard provides an overview to the family of IEEE 802 Standards.
- ANSI/IEEE Std 802.1B and 802.1k [ISO/IEC 15802-2] — *LAN/MAN Management*. Defines an OSI management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.
- ANSI/IEEE Std 802.1D [ISO/IEC DIS 15802-3] — *Media Access Control (MAC) Bridges*. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.
- ANSI/IEEE Std 802.1E [ISO/IEC 15802-4] — *System Load Protocol*. Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.
- ANSI/IEEE Std 802.1F — *Common Definitions and Procedures for IEEE 802 Management Information*
- ANSI/IEEE Std 802.1G [ISO/IEC 15802-5] — *Remote Media Access Control (MAC) bridging*. Specifies extensions for the interconnection, using non-LAN communication technologies, of geographically separated IEEE 802 LANs below the level of the logical link control protocol.
- ANSI/IEEE Std 802.2 [ISO/IEC 8802-2] — *Logical link control*

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- ANSI/IEEE Std 802.3 [ISO/IEC 8802-3] — *CSMA/CD access method and physical layer specifications*
- ANSI/IEEE Std 802.4 [ISO/IEC 8802-4] — *Token passing bus access method and physical layer specifications*
- ANSI/IEEE Std 802.5 [ISO/IEC 8802-5] — *Token ring access method and physical layer specifications*
- ANSI/IEEE Std 802.6 [ISO/IEC 8802-6] — *Distributed Queue Dual Bus (DQDB) access method and physical layer specifications*
- ANSI/IEEE Std 802.9 [ISO/IEC 8802-9] — *Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers*
- ANSI/IEEE Std 802.10 — *Interoperable LAN/MAN Security*
- ANSI/IEEE Std 802.11 [ISO/IEC 8802-11] — *Wireless LAN Medium Access Control (MAC) and physical layer specifications*
- ANSI/IEEE Std 802.12 [ISO/IEC 8802-12] — *Demand-priority access method, physical layer and repeater specifications*

In addition to the family of standards, the following is a recommended practice for a common Physical Layer technology:

- IEEE Std 802.7 — *IEEE Recommended Practice for Broadband Local Area Networks*

The following additional working group has authorized standards projects under development:

- IEEE 802.14 — *Standard Protocol for Cable-TV Based Broadband Communication Network*

Conformance test methodology

An additional standards series, identified by the number 1802, has been established to identify the conformance test methodology documents for the 802 family of standards. Thus the conformance test documents for 802.3 are numbered 1802.3.

ANSI/IEEE Std 802.12, 1998 Edition (ISO/IEC 8802-12: 1998)

This standard defines the protocol and compatible interconnection of data communication equipment via a repeater-controlled, star-topology Local Area Network (LAN) using the demand-priority access method. It includes a 100 Mb/s implementation with Physical Layers for four-pair 100 Ω balanced cable Categories 3 through 5; two-pair 150 Ω shielded balanced cable; and fibre optic cable. Work is currently under way in the following areas: higher speed operation; two-pair Category 5 100 Ω balanced cable; and full-duplex operation. Optional implementation of redundant links to provide automatic recovery of network connectivity in case of link or repeater failure anywhere in the network path is specified. Rules and recommendations for connecting redundant links are provided.

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

Part 12: Demand-Priority access method, physical layer and repeater specifications

1. Overview

1.1 Scope

This International Standard defines the protocol and compatible interconnection of data communication equipment via a repeater-controlled, star-topology Local Area Network (LAN) using the demand-priority access method.

1.2 Purpose

The purpose of this protocol is to provide a higher speed LAN with deterministic access, priority, and optional filtering. Pursuant to this, the protocol will

a) Provide a minimum data rate of 100 Mb/s.

b) Provide smooth migration from ISO/IEC 8802-3 and ISO/IEC 8802-5 LANs.

c) Support either ISO/IEC 8802-3 or ISO/IEC 8802-5 frame format and MAC service interface to the LLC.

d) Support a cascaded star topology over twisted pair and fibre-optic generic building wiring.

e) Allow topologies of 2.5 km and greater with three levels of cascading.

f) Provide a Physical Layer Bit Error Rate (BER) of less than 10^{-8}.

g) Provide fair access and bounded latency.

h) Provide two priority levels: normal and high.

i) Provide a low-latency service through high priority for support of multimedia applications over extended networks.

j) Support an option for filtering individually addressed packets at the repeater to enhance privacy.

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k) Support network management to monitor network performance, isolate faults, and control network configuration.

l) Enable low-cost implementation and high levels of integration.

m) Provide for robust operation by testing the Physical Layer connection before allowing an end node to enter the network, and by removing disruptive nodes.

n) Support an option for redundant links that will enable automatic recovery of network connectivity in case of link or repeater failure anywhere in the network path.

1.3 Document organization

The clauses and annexes of this International Standard provide an overview and define the requirements of the demand-priority protocol and its supporting physical layers.

This International Standard is organized as follows:

Clauses 1 through 4 contain the overview, references, definitions, and abbreviations and acronyms, respectively.

Clause 5 (Notation) defines the various notations that are used within this International Standard.

Clause 6 (Introduction to the protocol) shows the relationship of the protocol to the IEEE 802 family of standards and defines the architectural structure of the network end nodes and repeaters. An overview of the operation of a demand-priority LAN is also provided.

Clause 7 (MAC service specifications) defines the interface services provided by the Medium Access Control (MAC) sublayer to the Logical Link Control (LLC) sublayer.

Clause 8 (PMI service specifications) defines the interface services provided by the Physical Medium Independent (PMI) sublayer to the MAC and Repeater Medium Access Control (RMAC) entities.

Clause 9 (PMD service specifications) defines the interface services provided by the Physical Medium Dependent (PMD) sublayer to the PMI.

Clause 10 (MAC frame format structure) defines the MAC frame formats, including addressing conventions, data-length restrictions, Frame Check Sequence (FCS) generation, and training frame requirements.

Clause 11 (MAC protocol) defines the MAC protocol. Finite state machines and pseudo code descriptions are supplemented with prose annotations. MAC-based operational counters, error counters, and timers are described. Link initiation and training are specified.

Clause 12 (RMAC protocol) defines the functional control requirements and services of the RMAC sublayer in the network repeater. Fault detection, training, and recovery procedures for operation in single and multiple repeater networks are described.

Clause 13 (Layer management functions and services) defines the functional requirements and recommendations for the optional Layer Management Entity (LME), including direct and indirect interrogation of operation and error counters, and maintenance of operational and error statistics.

Clause 14 (PMI specifications) specifies the PMI portion of the Physical Layer. This includes data-symbol scrambling, descrambling, encoding, and decoding requirements for the PMI. Four-channel bit-stream formats are defined.

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Clause 15 (MII specifications) defines the functional characteristics of the Medium Independent Interface (MII) and, additionally, provides electrical specifications for an optional, physically exposed MII.

Clause 16 (4-UTP PMD, MDI, and link specifications) defines the 4-UTP PMD functional requirements, including timing, signal conditioning, and control signal recognition for link configurations with 100 Ω balanced cable. The electrical and mechanical requirements of the physically exposed 4-UTP Medium Dependent Interface (MDI) are defined.

Clause 17 (Dual simplex STP PMD, MDI, and link specifications) defines the STP PMD functional requirements, including timing, signal conditioning, and control signal recognition for link configurations with two-pair 150 Ω balanced cable. The electrical and mechanical requirements of the physically exposed STP MDI are defined.

Clause 18 (Dual simplex fibre-optic PMD, MDI, and link specifications) defines the fibre-optic PMD functional requirements, including timing, signal conditioning, and control signal recognition for link configurations with two optical fibre links. The optical, electrical, and mechanical requirements of the physically exposed fibre-optic MDI are defined.

Clause 19 (2-TP PMD, MDI, and link specifications), the specification of a PMD to support two twisted pair links, is reserved for future study.

Annex A (PICS proforma) provides a Protocol Implementation Conformance Statement (PICS) proforma in compliance with the relevant requirements, and in accordance with the relevant guidance, given in ISO/IEC 9646-2:1994[1] (normative).

Annex B (General environmental and safety specifications) defines the general environmental and safety requirements for the various network configurations (normative).

Annex C (GDMO specifications for demand-priority managed objects) defines the Guidelines for the Definition of Managed Objects (GDMO) notation used for layer management objects (normative if the optional LME is implemented).

Annex D (Allocation of object identifier values) contains a summary of all object identifier values that have been allocated for layer management purposes (normative if the optional LME is implemented).

Annex E (Network topology rules) defines topology rules for ISO/IEC 8802-12 networks (normative).

Annex F (Use of cabling systems with a differential characteristic impedance of 120 Ω nominal for 4-UTP links) provides information on an alternate balanced cable (informative).

Annex G (Bibliography) contains a bibliography that can supply additional information regarding specific subclauses of this standard (informative).

1.4 Application areas

The applications environment for the demand-priority LAN is intended to be commercial and light industrial.

[1] Information on references can be found in Clause 2.

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1.5 Conformance requirements

Annex A contains PICS proforma definitions for demand-priority network components.

1.5.1 End node PICS proforma

The supplier of an end-node implementation that is claimed to conform to this standard shall complete a copy of the relevant PICS proforma in Annex A, including the information necessary to identify both the supplier and the implementation.

1.5.2 Repeater PICS proforma

The supplier of a repeater implementation that is claimed to conform to this standard shall complete a copy of the relevant PICS proforma in Annex A, including the information necessary to identify both the supplier and the implementation.

1.5.3 PMD PICS proforma

The supplier of a PMD implementation that is claimed to conform to this standard shall complete a copy of the relevant PICS proforma in Annex A, including the information necessary to identify both the supplier and the implementation.

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2. Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of ISO and IEC maintain registers of currently valid International Standards.

CISPR 22:1993, Limits and methods of measurement of radio disturbance characteristics of information technology equipment.[2]

IEC 60060-1:1989, High-voltage test techniques—Part 1: General definitions and test requirements.[3]

IEC 60874-1:1993, Connectors for optical fibres and cables—Part 1: Generic specification.

IEC 60950:1991, Safety of information technology equipment, including electrical business equipment.

IEEE Std 802-1990, IEEE Standards for Local and Metropolitan Area Networks: Overview and Architecture (ANSI).[4]

ISO 4902:1989, Information technology—Data communication—37-pole DTE/DCE interface connector and contact number assignments.[5]

ISO TR 8509:1987, Information processing systems—Open Systems Interconnection—Service conventions.

ISO/IEC 7498-1:1984, Information technology—Open Systems Interconnection—Basic Reference Model—Part 1: The Basic Model.

ISO/IEC 7498-4:1989, Information processing systems—Open Systems Interconnection—Basic Reference Model—Part 4: Management framework.

ISO/IEC 8802-2:1998 [ANSI/IEEE Std 802.2, 1998 Edition], Information technology—Telecommunications and information exchange between systems—Local and Metropolitan area networks—Specific requirements—Part 2: Logical link control.[6]

ISO/IEC 8802-3:1996 [ANSI/IEEE Std 802.3, 1996 Edition], Information technology—Telecommunications and information exchange between systems—Local and Metropolitan area networks—Part 3:

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[2]CISPR documents are available from the International Electrotechnical Commission, 3, rue de Varembé, Case Postale 131, CH-1211, Genève 20, Switzerland/Suisse. CISPR documents are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[3]IEC publications are available from IEC Sales Department, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[4]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[5]ISO and ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[6]This publication and other ISO/IEC [ANSI/IEEE] publications are available from the ISO Central Secretariat as well as from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

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Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.

ISO/IEC 8802-5:1998 [ANSI/IEEE Std 802.5, 1998 Edition], Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Part 5: Token ring access method and physical layer specifications.

ISO/IEC 8824:1990, Information technology—Open Systems Interconnection—Specification of Abstract Syntax Notation One (ASN.1).

ISO/IEC 8877:1992, Information technology—Telecommunications and information exchange between systems—Interface connector and contact assignments for ISDN Basic Access Interface located at reference points S and T.

ISO/IEC 9646-1:1994, Information technology—Open Systems Interconnection—Conformance testing methodology and framework—Part 1: General concepts.

ISO/IEC 9646-2:1994, Information technology—Open Systems Interconnection—Conformance testing methodology and framework—Part 2: Abstract Test Suite specification.

ISO/IEC 10040:1992, Information technology—Open Systems Interconnection—Systems management overview.

ISO/IEC 10165-2:1992, Information technology—Open System Interconnection—Structure of management information: Definition of management information.

ISO/IEC 10165-4:1992, Information technology—Open System Interconnection—Structure of management information—Part 4: Guidelines for the definition of managed objects.

ISO/IEC 11801:1995, Information technology—Generic cabling for customer premises.

ISO/IEC 15802-1:1995 Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 1: Medium Access Control (MAC) service definition.

ISO/IEC 15802-2:1995 [ANSI/IEEE Std 802.1B, 1995 Edition], Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 2: LAN/MAN management.

ISO/IEC DIS 15802-3 [ANSI/IEEE Std 802.1D, 1998 Edition[7]], Information technology—Telecommunications and information exchange between systems—Local area networks—Media access control (MAC) bridges.

ISO/IEC TR 11802-2:1995, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Technical reports and guidelines—Part 2: Standard Group MAC Addresses.

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[7] IEEE Std 802.1D-1998 was approved by the IEEE Standards Board on 30 June 1998 but was not yet published at the time this standard went to press. The draft standard is, however, available from the IEEE. The anticipated publication date is October 1998, when it will be published as ISO/IEC 15802-3:1998 [ANSI/IEEE Std 802.1D, 1998 Edition]. For status information, contact the IEEE Standards Department at 1 (732) 562-3800.

Note—Footnotes 8 and 9 are intentionally left blank in order to maintain consistency with footnote numbering in IEEE 802.12c:1998, the recently published full-duplex supplement to this standard.

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3. Definitions

For purposes of this International Standard, the following definitions apply:

3.1 4-UTP: Four-pair 100 Ω balanced cable meeting or exceeding the Category 3 specifications in ISO/IEC 11801:1995.

3.2 5B6B encoding: A method whereby data quintets are mapped (encoded) as code sextets.

3.3 balanced cable: A cable consisting of one or more metallic symmetrical cable elements (twisted pairs or quads).

3.4 baud: A unit of signaling speed equal to the number of discrete conditions or signal events per second, or the reciprocal of the time of the shortest signal element in a character.

3.5 broadcast address: A special address consisting of all 1's indicating all end nodes on the network.

3.6 BT: The time required for one data bit to cross the Medium Independent Interface (MII)—Bit Time = 1/TxClk.

3.7 bundled cable: A cable consisting of multiple twisted pairs. Bundled cable in this standard indicates a cable with 25 unshielded copper twisted pairs, Category 3 or better, that may contain up to six 4-UTP links.

3.8 cascade: A multilevel repeater topology in which higher-level repeaters are connected through their local ports to the cascade port of lower-level repeaters.

3.9 cascade port: The repeater port that enables a cascade connection to a higher-level repeater.

3.10 clear: The action that removes the outgoing signal from a link (i.e., clears the link) and prepares the Physical Medium Dependent (PMD) to receive a packet.

3.11 common-mode voltage: The instantaneous algebraic mean of two signals applied to a balanced circuit, where both signals are referred to a common reference.

3.12 cross-connect: A group of connection points, often wall- or rack-mounted in a wiring closet, used to mechanically terminate and interconnect twisted-pair building wiring.

3.13 demand priority: A round-robin arbitration method to provide LAN access based on message priority level.

3.14 destination address (DA): A field in the packet format identifying the end node(s) to which the packet is being sent.

3.15 differential mode voltage: The instantaneous algebraic difference of two signals applied to a balanced circuit, where both signals are referred to a common reference.

3.16 downlink: The transmission medium between a repeater and a connected end node or lower level repeater, as viewed from the local repeater. *Contrast with:* **uplink**.

3.17 dual simplex: A link segment configuration containing two simultaneous signal paths, one in each direction. (STP and fibre optic links are configured as dual simplex.)

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3.18 elasticity buffer: A first-in-first-out (FIFO) buffer in the network repeater that can provide temporary storage for a message packet during retransmission delays. The buffer acts as a shift register or delay line, and does not need to hold an entire, full-length packet. *See also:* **store-and-forward buffer**.

3.19 enable high only: A link control signal from an upper repeater to a lower repeater pre-empting a lower repeater's normal-priority round-robin control cycle.

3.20 end node: A physical device that may be attached to a LAN link segment for the purpose of transmitting and receiving information on that link medium. For example, an end node may be a user station, a bridge, or a LAN analyzer. It is identified by a unique 48-bit address.

3.21 end of stream delimiter (esd): Patterns that identify the end of an MII data stream.

3.22 extension bits: One to four bits that are appended to the last octet of a MAC frame to complete the last data quintet.

3.23 fibre-optic cable: A cable containing one or more optical fibres.

3.24 fibre-optic link: A link segment configured from fibre optic cables and two attached Medium Dependent Interface (MDI) connectors.

3.25 fibre pair: Optical fibres interconnected to provide two continuous light paths terminated at both ends in an optical connector.

3.26 filler: Three- or six-bit reserved code patterns that are appended to the end of individual MII channel data streams to equalize the stream lengths in all four channels.

3.27 frame: The logical organization of control and data fields (e.g., addresses, data, error check sequences) defined for a MAC sublayer. In this standard, the term *frame* refers to a MAC frame unless otherwise indicated. *See also:* **MAC frame**.

3.28 frame check sequence (FCS): A Cyclic Redundancy Check (CRC) used by the transmit and receive algorithms to detect errors in the bit sequence of a MAC frame.

3.29 full duplex: A link segment capable of transferring signals in both directions simultaneously.

3.30 functional address (FA): A bit-significant address used in the ISO/IEC 8802-5 MAC format to identify well-known functional groups.

3.31 grant: A link control signal or link condition indicating that the receiving entity has been given permission to send a packet.

3.32 half duplex: A link segment capable of transferring signals in either direction along the link, but not in both directions simultaneously. Requires line turnaround to change signal direction. (4-UTP links are full duplex in control mode, but only half duplex in data mode.)

3.33 idle: (Idle_Up, Idle_Down) A link control signal indicating that the sending entity currently has no traffic pending for the entity connected to the other end of the link.

3.34 incoming: A link control signal indicating that a packet may soon be sent to the receiving entity.

3.35 individual address: The unique address identifying an individual end node.

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3.36 invalid frame: A frame that is marked with an Invalid Packet Marker (IPM) or that has been identified by the MAC, Repeater Medium Access Control (RMAC), or lower sublayers as containing errors.

3.37 invalid packet marker (IPM): A pattern used by a repeater that is substituted for the end of stream delimiter (esd) in the MII channel transmission frames to identify a packet that was received with transmission errors.

3.38 layer management entity (LME): The logical portion of the repeater responsible for collection of operational and error statistics and for management of the network.

3.39 level n repeater: A repeater that is (n−1) link segments below the root repeater in a cascade.

3.40 link is clear: A condition in which there is no incoming energy on the link. *See also*: **clear**.

3.41 link segment: The physical interconnection between two repeaters or between a repeater and an end node. A link segment includes the link medium (twisted pairs or optical fibres) and its two attached Medium Dependent Interface (MDI) connectors.

3.42 local port: The repeater port that allows connection to a lower-level entity (e.g., end node, repeater, bridge, LAN analyzer).

3.43 logical link control (LLC) sublayer: That part of the Data Link Layer that supports medium independent data link functions, and uses the services of the MAC to provide services to the Network Layer.

3.44 MAC frame: The logical organization of control and data fields (e.g., addresses, data, error check sequences) defined for the MAC sublayer. The MAC frame may be constructed in either ISO/IEC 8802-3 or ISO/IEC 8802-5 format. *See also*: **frame**.

3.45 medium: The physical material from which the link is constructed.

3.46 medium access control (MAC) sublayer: The portion of the Data Link Layer that controls access to the medium. The MAC sublayer is required in end nodes.

3.47 medium dependent interface (MDI): The physically exposed interface between the link segment medium and the PMD of the end node or repeater, for which all mechanical, electrical or optical, and transmitted signal requirements are specified.

3.48 medium independent interface (MII): The logical interface between the Physical Medium Independent (PMI) and PMD in an end node or repeater. Optionally, the MII may be implemented as a physically exposed interface with specified signaling timing and electrical characteristics.

3.49 multicast address: A special address indicating a specific group of end nodes.

3.50 null address: An all zero address that does not identify any network end node. The null address may be used as the destination address in training packets being sent from an end node or lower-level repeater to an upper-level repeater. The null address may be used in the Source Address (SA) field of training frames to verify link operation between an end node and the connected repeater. The null address may also be used in void frames. Packets with the null address are forwarded by the receiving repeater to all promiscuous ports.

3.51 octet: A group of eight adjacent bits.

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3.52 packet: The total information transmitted over the link medium, including the preamble, the MAC frame, and the start of stream and end of stream delimiters. *See also:* **frame**.

3.53 pad: Any combination of octets used to extend the end of the data field of the ISO/IEC 8802-3 MAC frame so that it will meet minimum length requirements.

3.54 physical medium dependent (PMD) sublayer: The medium dependent portion of the Physical Layer.

3.55 physical medium independent (PMI) sublayer: The medium independent portion of the Physical Layer.

3.56 primitive: A definition of a service provided by a sublayer to the sublayer immediately above. Primitives may be initiated by either the upper or lower sublayer.

3.57 privacy mode: A mode in which an end node receives only those packets specifically addressed to it.

3.58 promiscuous mode: A mode in which a repeater port or an end node receives all message traffic transmitted on the network.

3.59 Protocol Implementation Conformance Statement (PICS): A statement of which capabilities and options have been implemented for a given interconnection protocol.

3.60 quintet: A contiguous string of five bits.

3.61 redundant link: A second link from an end node or from the cascade port of a repeater that provides an alternative path to maintain network connectivity in case of a repeater or link failure.

3.62 repeater: A device used to extend the length, topology, and interconnectivity of the physical medium beyond that imposed by a single segment. Demand-priority repeaters perform the functions of restoring signal amplitude, waveform, and timing. They also arbitrate access to the network from connected end nodes and optionally collect statistics regarding network operations.

3.63 repeater medium access control (RMAC) sublayer: The sublayer in the repeater that arbitrates packet sequencing and controls packet routing.

3.64 request: (Request_Normal, Request_High) A link control signal indicating that a lower entity has traffic pending for the network.

3.65 return: A secondary link control signal indicating that the pre-empted normal-priority round-robin cycle in a lower repeater is not complete.

3.66 root repeater: The level 1 (topmost) repeater in a cascade.

3.67 service: The capabilities and action provided by one layer for another.

3.68 sextet: A contiguous string of six bits.

3.69 simplex: A link segment configuration capable of transferring signals in one direction only.

3.70 source address (SA): A field in the message packet format identifying the sending end node.

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3.71 start of stream delimiter (ssd): Reserved code patterns that identify the beginning of the MII channel transmission frame. The ssd indicates the transmission priority of the packet.

3.72 store-and-forward buffer: A first-in-first-out (FIFO) buffer in the network repeater that can provide temporary storage for an entire message packet prior to retransmission. The buffer acts as a shift register and must hold an entire, full-length packet. *See also:* **elasticity buffer**.

3.73 STP: A 150 Ω shielded balanced cable meeting the specifications in ISO/IEC 11801:1995.

3.74 symbol rate: The number of symbols transmitted per second and expressed in baud (e.g., 1 Mbd = 1 000 000 symbols per second).

3.75 training: (Training_Up, Training_Down) A link control signal indicating that the sending entity is either requesting or giving permission to train (initialize) the link.

3.76 twisted pair: Two continuous, insulated copper conductors twisted around each other in a helical manner. Twisted-pair cable may be unshielded (UTP) or shielded (STP).

3.77 twisted-pair cable: A group of two or four twisted pairs within a single sheath.

3.78 twisted-pair cable binder group: A group of twisted pairs within a cable that are bound together.

3.79 twisted-pair link: A link segment consisting of a twisted-pair cable and two attached MDI connectors.

3.80 unicast address: An individual address identifying an individual end node.

3.81 uplink: The transmission medium between an end node or repeater and a connected higher-level repeater, as viewed from the local entity. *Contrast with:* **downlink**.

3.82 UTP: A 100 Ω unshielded balanced cable meeting the specifications in ISO/IEC 11801:1995.

3.83 weight 2/4 code alternation: A rule requiring successive unbalanced-code symbols in a data stream to be alternately chosen between weight-2 and weight-4 code groups.

3.84 weight-2 code: An unbalanced code sextet containing exactly two 1's.

3.85 weight-4 code: An unbalanced code sextet containing exactly four 1's.

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4. Abbreviations and acronyms

The following abbreviations and acronyms are used in this standard:

AC	ISO/IEC 8802-5 format Access Control field
AI	Active Optical Input
AO	Active Optical Output
BER	Bit error rate
BT	Bit Time
CRC	Cyclic Redundancy Check
CRS	Configuration Report Server
CS	Control Signal
DA	Destination Address
esd	end of steam delimiter
FA	Functional Address
FAI	Functional Address Indicator
FC	ISO/IEC 8802-5 format Frame Control field
FCS	Frame Check Sequence
FIFO	First In First Out
FWHM	Full Width at Half Maximum
GDMO	Guidelines for the Development of Managed Objects
HCS	Half Control Signal
I/G	Individual/Group
IPM	Invalid Packet Marker
L	Length of ISO/IEC 8802-3 format data
LAN	Local Area Network
LED	Light Emitting Diode
LLC	Logical Link Control

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LME	Layer Management Entity
LSB	Least Significant Bit
LTH	ISO/IEC 8802-5 format RI field Length
MAC	Medium Access Control
MDI	Medium Dependent Interface
mesd	multiplexed end of stream delimiter
MII	Medium Independent Interface
mpreamble	multiplexed preamble
MSB	Most Significant Bit
msdu	MAC service data unit
mssd	multiplexed start of stream delimiter
NEXT	Near-End Crosstalk
NRZ	Non-Return-to-Zero
OSI	Open System Interconnection
PDU	Protocol Data Unit
PICS	Protocol Implementation Conformance Statement
PMD	Physical Medium Dependent
PMI	Physical Medium Independent
PVC	Polyvinyl Chloride
RCS	Receiver Control State
REM	Ring Error Monitor
RI	ISO/IEC 8802-5 format Routing Information field
RII	Routing Information Indicator
RMAC	Repeater Medium Access Control
RPS	Ring Parameter Server
RxClk	Receive Clock
RxEn	Receive Enable

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SA	Source Address
SAP	Service Access Point
ssd	start of stream delimiter
TCS	Transmit Control State
TPIO	Twisted Pair Input/Output circuit
TxClk	Transmit Clock
TxEn	Transmit Enable
Vdd	power supply voltage
Vih	Voltage, input high
Vil	Voltage, input low
Voh	Voltage, output high
Vol	Voltage, output low

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5. Notation

This standard uses service primitives, finite state machines, state tables, and pseudo code, supplemented by prose descriptions and illustrative diagrams, to define the requirements of the protocol.

5.1 Service definition method and notation

Services in this specification are described in an abstract manner using the method and naming conventions of the ISO/IEC Open Systems Interconnection Service Conventions defined in ISO TR 8509:1987. The services of an (n-1) layer are the capabilities that it offers to an (n)-user in the next higher (n) layer. In order to provide its service, the (n-1) layer builds its functions on the services that it requires from the next lower layer. Figure 5-1 illustrates the layer service model.

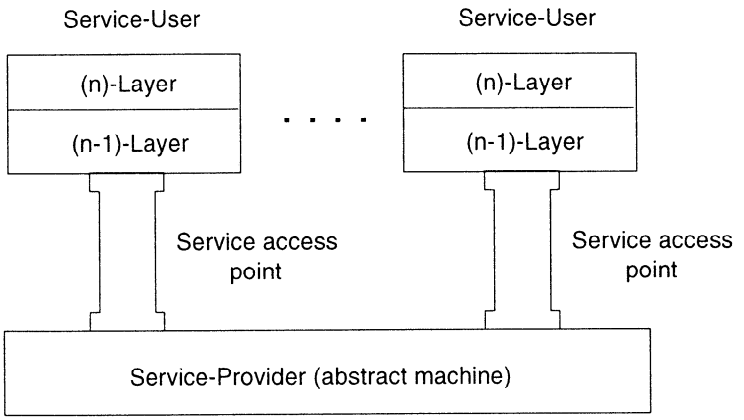

Figure 5-1—Layer service model

Services are specified by describing the information flow between the service user and the next lower layer. This information flow is modeled by discrete, instantaneous events that characterize the provision of service. Each event consists of passing a service primitive from one layer to another. User layers communicate with peer user layers by passing primitives through one or more Service Access Points (SAPs) to service providers associated with the identified peer user(s).

Services are described through the use of service primitives and parameters that characterize each service. A service may have one or more related primitives that constitute the activity related to the particular service. Each service primitive may have zero or more parameters that convey the information required to provide the service.

Service primitives convey the information required to provide a particular service. These service primitives are an abstraction in that they specify only the service provided rather than the means by which it is provided. Further, this definition is independent of any particular interface implementation. There is no direct conformance of equipment to these service definitions. Clauses 10 through 19 and the associated normative annexes specify the requirements for the functional behavior of equipment.

Two generic types of primitives are used in this specification:

a) *Request primitive.* This primitive is passed by the (n)-layer to the (n-1)-layer to request that a service be initiated. Request primitives generated by a layer may result in one or more primitives being generated by the next lower layer.

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b) *Indication primitive.* This primitive is passed from the (n-1)-layer to the (n)-layer to indicate an event that is significant to the (n)-layer. This event may be logically related to a remote service request, or may be caused by an event internal to the (n-1)-layer.

Some of the possible relationships among primitives are illustrated by the time-sequence diagrams in Figure 5-2. Primitives that occur earlier in time and that are connected by dotted lines are the logical antecedents of subsequent primitives. Figures 5-2a) through 5-2d) show possible relationships within an individual device. Figure 5-2e) shows a typical relationship between the connected entities at each end of a link. If there is no specific relationship between events, where it is impossible to predict which will occur first, but where both must occur within a finite period of time, then a tilde (~) is used. This possibility is shown in Figure 5-2f). An example might be the indication of a failure in the link between a repeater and the end node—it would be impossible to know which entity would be the first to detect the failure.

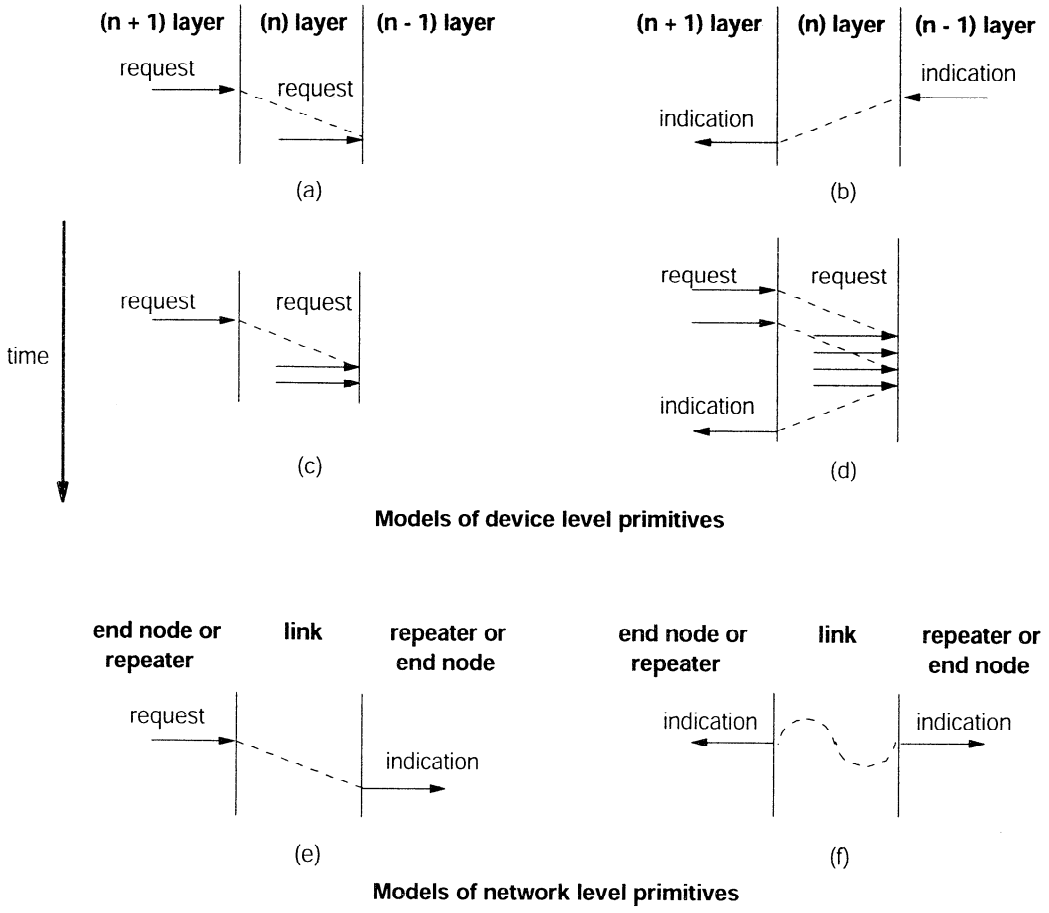

Figure 5-2—Primitive time-sequence examples

5.2 State diagram notation

The operation of a protocol can be described by subdividing the protocol into a number of interrelated functions. The operation of a function can be described by state machines. Each machine represents the domain of a function and consists of a group of connected, mutually exclusive states. Only one state of a function may be active at any one time; however, several functions may be active at the same time.

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Each state that a function can assume is represented by a rectangle as shown in Figure 5-3. State names are shown above the dotted lines in the rectangle; actions or operations to be accomplished in the state are shown below the double line.

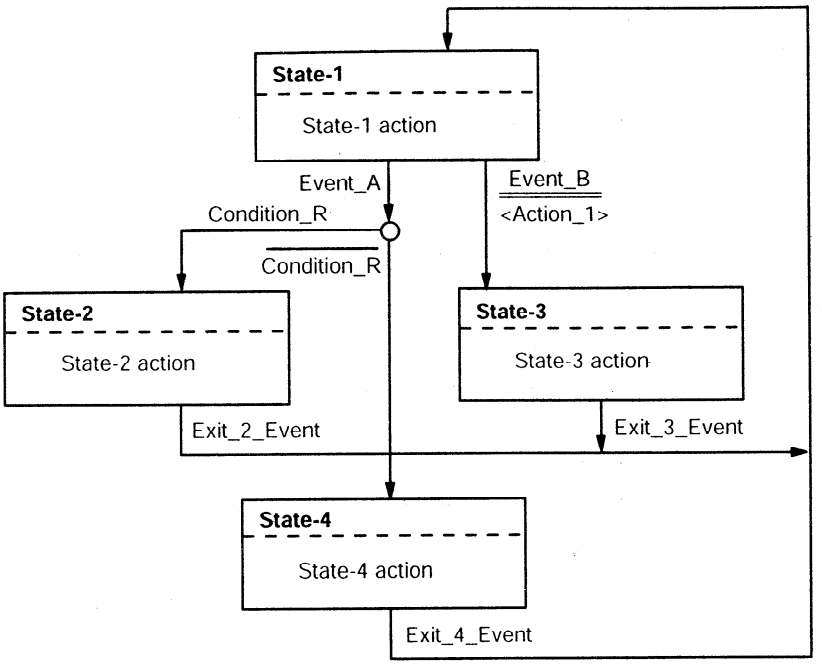

Figure 5-3—Example state machine diagram

State machines are event driven and can be in any defined state. They remain in the current state until an event occurs that would cause them to change states. Transitions are presumed to be instantaneous.

The possible transitions between the states are represented by arrows from one state to the next. If multiple states have transition paths to a common destination (States 2, 3, and 4 in the example all have transition paths to State-1), the path may be shown as a transition from the state to a common path. Transition paths that cross each other without joining arrows are presumed to be independent.

Events or conditions that cause the particular transition are shown next to the transition path at the exit point of the state. Transition arrows that fork (indicated by a small circle) require the logical AND of the labeled transition conditions. For example, transition from State-1 to State-4 would require that Event_A occur AND that Condition_R be false.

Actions or operations that are to be performed during a transition are enclosed in < > and are shown below a double line under the condition required for the transition. For example, the transition from State-1 to State-3 would require that Event_B occur and that Action_1 be taken.

5.3 Pseudo code state description

The structure of a state machine is commonly defined in the state machine diagram. The operation of the state machine may be defined either by prose annotation or by coded constructs, such as a pseudo code. For some state machines (e.g., MAC, RMAC), this standard uses prose annotation to provide an overview of each state of a state machine, and pseudo code to define the operations accomplished by that state. If there are any perceived differences in the interpretation of the prose annotation and the pseudo code description, the pseudo code shall take precedence.

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5.3.1 Pseudo code constructs and key words

The pseudo code used in this standard is a variant of PASCAL. It uses PASCAL constructs and key words; however, the operation differs somewhat from PASCAL. Execution of any pseudo code construct or code segment is considered to be instantaneous, regardless of the number of statements or the number of iterations involved.

=		Is equal to -- For example, the statement: If (A = B) would be interpreted as testing for the condition: is A equal to B? If A equals B, the statement would be set to true, otherwise it would be false.
<>		Is not equal to -- For example, the statement: If (A <> B) would be interpreted as testing for the condition: is A not equal to B? If A does not equal B, the statement would be set to true, otherwise it would be false.
:=		The replacement operator --For example, the statement: A := B means replace the current value of A with the value of B.
{ }		Defines a non-executable comment. When used within the body of the code, it encloses an annotation or comment. Pseudo code comments in this standard are shown in bold face type (for example, see 5.3.2).
[ ]		Refers to elements with multiple instantiations, for example, ADDRESS_MATCH [X] refers to the Xth element of the array ADDRESS_MATCH.
And		The logical AND operator.
Begin	End	Marks the BEGINning and END of a code section
Case	Of	A concise form of multiple If statements (see example in 5.3.2)
For	Do	A method of defining bounds for a code loop. For example, the construct: For variable <u>vvv</u> = value_1 to value_2, Do statement <u>bbb</u> would execute statement <u>bbb</u> for all integer values of variable <u>vvv</u> beginning with value_1 and ending with value_2.
Forever	Do	A method of defining a code segment that executes continuously, for example, every clock cycle.

If Then	Else	A method of testing for a condition and then executing alternate statements. For example, the construct:
		If (statement <u>aaa</u>)
		Then
		statement <u>bbb</u>
		Else
		statement <u>ccc</u>

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	true,	would TEST the value of the statement aaa, and THEN, if aaa were bbb would be executed; ELSE, if aaa were false, ccc would be executed.
Or		The logical OR operator.
Repeat	Until	A method for defining a code segment that is executed repeatedly until some defined condition is true. For example, the code segment: Repeat statement aaa statement bbb ... statement nnn Until (condition sss) would cause statements aaa through nnn to be repeatedly executed until the condition sss became true.
Wait		Suspend execution for the period of time specified. For example, the construct: Wait (duration) would suspend operation for a period of time equal to the value of duration.
Wait_Until		Suspend execution until the named event occurs. For example, the construct: Wait_Until (some_event) would suspend execution until the event: some_event occurred.
With var	Do	Execute the statements following this construct using the contents of the field specified by var. For example, the code segment: With ALLOWED_CONFIGURATION_FIELD Do Statement aaa Statement bbb End would cause the contents of ALLOWED_CONFIGURATION_FIELD to
	be	subjected to the operations specified in statements aaa and bbb.

5.3.2 Pseudo code example

Consider an example of how the pseudo code is interpreted. Suppose that the state machine in Figure 5-3 is in STATE_1, that both condition-1 and condition-2 can never be true at the same time, and that the pseudo code for STATE_1 is:

```
STATE_1: INITIAL_STATE
   Begin {execute the initial operations that are to be performed on entering the state}
      aaa;
      bbb;
   End;  {end of initial operations}

   Case TRANSITION_CONTROL of: {poll for possible state transition conditions}
```


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```
    CONDITION_1:   {condition-1 is true; test for condition-3 to determine the next
state}
        Begin
          IF (CONDITION_3 = TRUE) then  {condition-3 is true; transition to state-2}
            NEXT_STATE := STATE_2
          else {condition-3 is false; transition to state-4}
            NEXT_STATE := STATE_4;
        End {condition-1}

    CONDITION_2 : {condition-2 is true; execute action-1 and transition to state-3}
        Begin
          ACTION_1
          NEXT_STATE := STATE_3
        End {condition-2}

  End;  {case of transition control}
```

The operations defined under the current state that can be performed are performed immediately. Then operations that test for the existence of transition conditions (defined here in a case construct) are polled continuously.

a) If condition-1 occurs before condition-2, transition is made to either state-2 (if condition-3 is true) or state-4 (if condition-3 is false).

b) If condition-2 occurs first, action-1 is performed and then transition is made to state-3.

These actions and transitions are conditional on the existence of the indicated event being detected, and are not carried out if some other event occurs.

NEXT_STATE indicates the destination state of the transition. It may be a global variable and may be available to several state machines. Changing the value of NEXT_STATE may cause state transitions and/or actions to be taken in other state machines as well.

5.3.3 Pseudo code functions and procedures

The pseudo code state definitions may call special, commonly used routines known as functions or procedures. Functions and procedures are distinguished by the function or procedure name, followed by either:

a) Parameters in brackets, such as in: CHANGE_CASCADE_PORT_TONE (REQ_H), or

b) Brackets without parameters, such as in: POWER_ON ( ).

5.3.3.1 Functions

Functions are frequently used code segments that may carry out actions and that return values to the calling routine. The function may or may not utilize parameters to transfer data between itself and the calling routine. For example, a pseudo code function call might be:

```
VARIABLE := EXAMPLE_FUNCTION (parameter_1, parameter_2)
```

where parameter_1 and parameter_2 are values that the calling routine wishes EXAMPLE_FUNCTION to act upon or supply (they may be either constants or variables).

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The function EXAMPLE_FUNCTION(v_in, v_out) is defined as a separate routine that accepts one value from, and returns two values to, the calling routine.

```
EXAMPLE_FUNCTION(v_in, v_out)
    Begin;
        If v_in <> some_value
            then
                EXAMPLE_FUNCTION := return_value_1
            else
                EXAMPLE_FUNCTION := return_value_2;
        mmm
        nnn
        v_out := computed_value
    End;
```

In this case, the calling routine supplies the value of parameter_1, which is accepted as the value of v_in in the function. Inclusion of EXAMPLE_FUNCTION as the destination variable of a replacement statement in the function definition allows it to return a direct replacement value for VARIABLE in the calling statement. The value of v_out (computed_value in this example) is returned to parameter_2 in the calling routine.

5.3.3.2 Procedures

Procedures are frequently used routines that carry out actions, but do not return a value to the calling routine. The procedure may or may not utilize parameters to transfer data from the calling routine to the procedure.

5.4 Numerical representation

Numerical values may be represented in binary, decimal, or hexadecimal notation.

Binary values are represented by the binary digits 0, 1, or x, and are indicated by the letter B followed by the binary value enclosed in apostrophes wherever it is not obvious from the context (e.g., a logical value). The lowercase x represents a digit that may be either 0 or 1. An example binary number is B'001xxx'. An example logical value is RCS [2:0] = 010.

Hexadecimal values are represented by the hexadecimal digits 0–9, A–F, or x, and are indicated by the uppercase letter X followed by the hexadecimal value enclosed in apostrophes. The lowercase x represents a digit that may be any hexadecimal value. An example hexadecimal value is X'01 6F xx'.

The actual numerical value of an octet within a MAC frame field depends on the particular format being used (see 10.1.1).

5.5 Time-space diagrams

Operational sequences are often depicted in time-space diagrams as shown in Figure 5-4. The space between the horizontal lines represents the link between the repeater and the connected end nodes (or repeaters). Control signals between the repeater and the end node are shown as single arrows indicating the direction of the signal. (For clarity, signals sent by the end node are shown solid; signals sent by the repeater are shown dashed.) The specific control signal is identified by the indicated signal name; the duration of the signal is identified by the horizontal arrow. The different spacing between the repeater and

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the end nodes indicates the possibility of different link distances. The slope of the transmitted control signals and data packets depicts the propagation delay in the link.

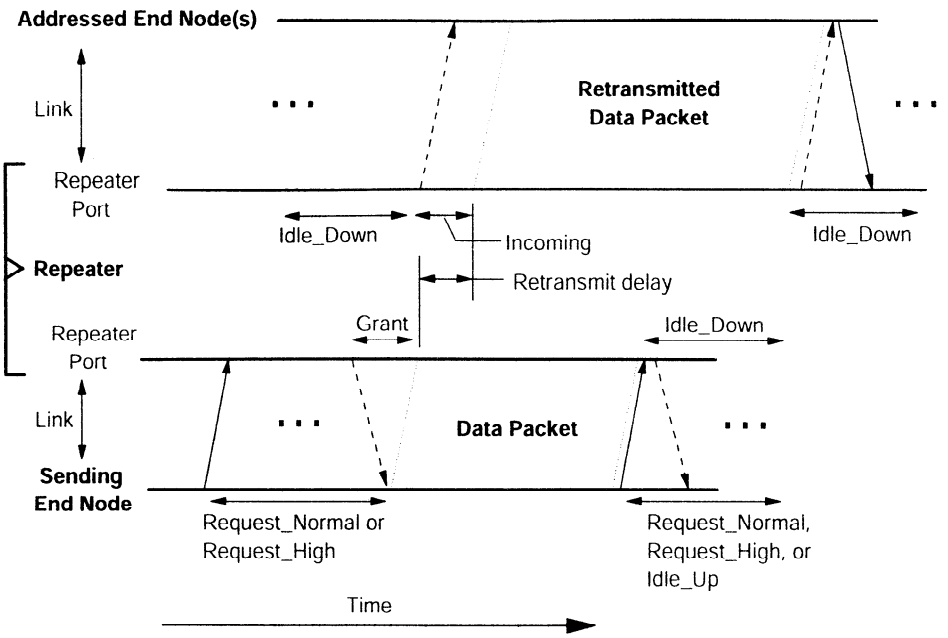

Figure 5-4—Example time-space diagram

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6. Introduction to the protocol

The demand-priority medium access protocol provides a means by which stations (end nodes) can communicate with each other over a centrally controlled LAN that offers a choice of several different link media including: 100 Ω balanced cable (4-UTP and 2-TP), 150 Ω shielded balanced cable (STP), and optical fibres.

6.1 Network topology

The demand-priority access method has been defined to allow considerable flexibility in the network topology.

6.1.1 Network components

The demand-priority LAN architecture utilizes three principal structural components: end nodes, repeaters, and network links.

a) End nodes are typically personal or larger computers, user workstations, peripherals, or file servers. They might also be special devices (such as LAN analyzers), or they might be bridges to other LANs.

b) Repeaters are the network controllers and are configured with two or more local ports to allow connection to end nodes or other repeaters. They can also be configured with an optional cascade port, which is reserved for connection to repeaters only.

c) Link segments provide the interconnection medium between a repeater and its connected end nodes or other repeaters.

6.1.2 Network structure

The network can be structured with single or multiple repeater levels.

6.1.2.1 Single repeater networks

The simplest network structure contains one repeater and two or more end nodes as shown in Figure 6-1.

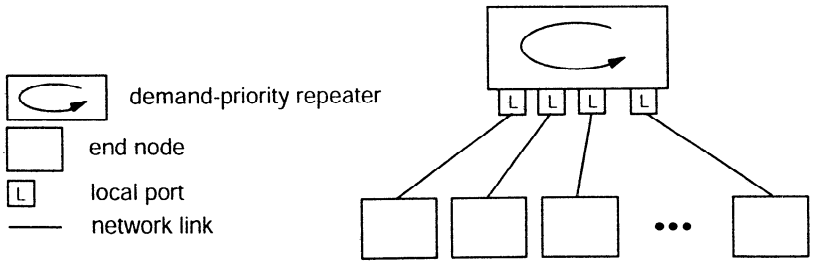

Figure 6-1—A single-repeater network topology

6.1.2.2 Cascaded networks

Larger topologies can contain several levels of repeaters interconnected in a cascade as shown in Figure 6-2. Each repeater will typically be connected to one or more end nodes, and can be connected to one or more repeaters. Lower-level repeaters and end nodes are connected to local ports. Higher-level repeaters must be connected to a cascade port. Interconnection between two repeaters using only local ports is not allowed.

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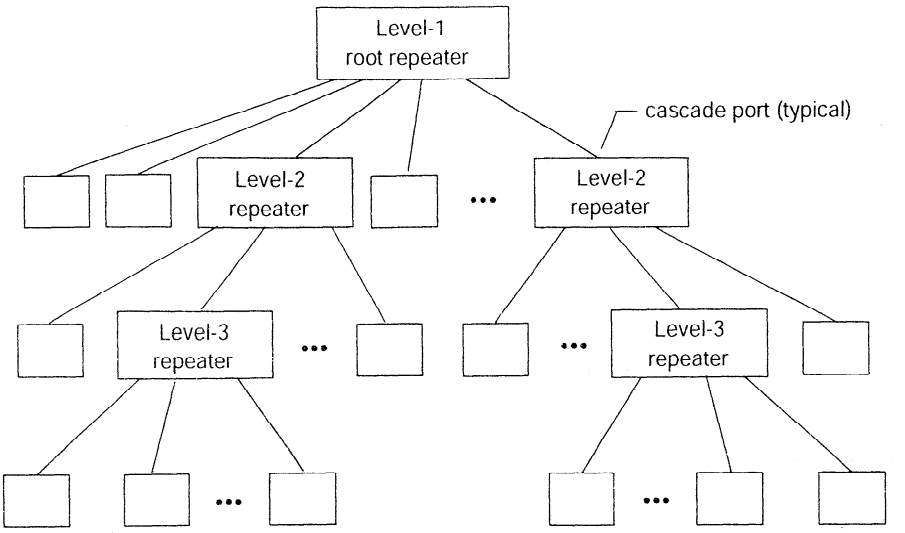

Figure 6-2—A multilevel cascaded topology

The topmost repeater in the cascade is designated as the Level-1 repeater. Repeaters in each succeeding lower level in the cascade are designated by the number of links between them and the root repeater by the equation:

repeater level = (number of link segments away from the root repeater) + 1 (1)

All repeaters on the same level are designated with the same level number.

6.1.2.3 Connection to other LANs

Connection of a demand-priority network to other LANs is shown in Figure 6-3. Each bridge is connected to a local port on the demand-priority repeater, and is treated as though it were an end node on the network.

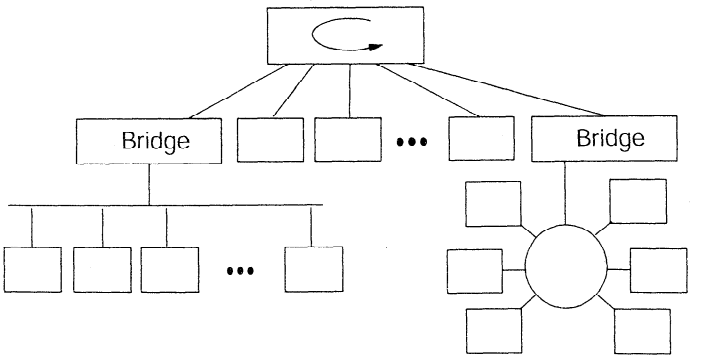

Figure 6-3—A demand-priority network interconnected with other LANs

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6.1.3 Link configuration

Packets can be sent to an individual end node, to groups of end nodes (group addressing), or to all end nodes on the network (broadcast addressing). Repeater ports connected to end nodes can be configured to support either of two addressing modes:

a) Privacy mode, in which packets are sent to addressed end nodes only, or
b) Promiscuous mode, in which the port transmits all traffic.

Local ports connected to lower-level repeaters, bridges, or network analyzers should always be configured for promiscuous-transmission mode. Packets with broadcast and multicast addresses are sent to all ports.

End nodes can request the repeater port to be configured to receive packets in either privacy or promiscuous mode; however, promiscuous-mode requests can be denied by the network manager. Repeater support for privacy mode is optional.

6.1.4 Link media

The links between repeater local ports and their connected end nodes can be 4-pair 100 Ω balanced cable (4-UTP and 2-TP), 2-pair 150 Ω balanced cable (STP), or two optical fibres.

For 4-UTP repeater-to-end node links, the recommended configuration is 4-pair cable. Bundled cable (25-pair binder-groups) is allowed, but requires repeaters with privacy mode and store-and-forward capability because excessive crosstalk could occur with simultaneous transmission of a packet to multiple ports on the same bundled cable as the sending end node.

Bundled cable must not be used in repeater-to-repeater, repeater-to-bridge, or repeater-to-end node links where the end node is allowed to receive all network traffic. See Annex E for additional information and topology rules and recommendations for ISO/IEC 8802-12 networks.

6.1.5 Redundant links

Both end nodes and repeater cascade ports may optionally be equipped with a second (redundant) link to maintain network connectivity in case of individual link or repeater failure in the network connection path. Specific requirements for implementing redundant links are given in Clause 11 for end nodes and in Clause 12 for repeaters. Rules for connecting redundant links and recommendations for interconnecting redundant-link repeaters and end nodes in a network containing one or more repeaters that do not have redundant-link capability are defined in Annex E.

6.2 Basic operational concepts

Demand-priority access is a priority-based, round-robin arbitration method in which the central network controller (the repeater) regularly polls[10] its connected ports to determine which have transmission requests pending, and whether the transmission request is normal priority (e.g., for data files) or high priority (e.g., for real-time voice, video, or data). The following overview concentrates on the operation of the protocol between the repeater and its connected end nodes. The full description of round-robin arbitration and port selection in single and multiple repeater networks is provided in Clause 12.

[10]The particular method of determining whether or not a repeater port has a transmission request pending is an implementation decision. The requirement is for each port to be interrogated at least once each packet time.

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6.2.1 Round-robin polling

Round-robin polling provides all end nodes with access to the network during each round-robin cycle. The repeater maintains two next-port pointers, one for normal-priority and one for high-priority requests, that keep track of the next ports to be serviced. All ports are polled at least once per packet transmission to determine which have requests pending.

A high-priority request allows an end node to obtain permission to send sooner than its normal-priority cycle position. High-priority requests are serviced before normal-priority requests, but do not cause a normal-priority transmission in progress to be interrupted.

In the repeater, timers monitor the normal-priority requests at each port to ensure that abnormally large high-priority traffic levels do not preclude normal-priority traffic. Normal-priority requests that have been pending for approximately 250 ms are automatically elevated to high priority and are serviced in port order as indicated by the high-priority next-port pointer. Priority promotion is not intended to occur during normal network operation. When an abnormal situation occurs (e.g., an end node continuously making high-priority requests), priority promotion allows normal-priority requests to be serviced until network management locates and isolates the source of the problem.

6.2.2 Data transmission

Packet transmission follows a request/grant sequence in which the request is initiated by the sending end node and the issuance of the grant is controlled by the repeater. When packet transmission is occurring:

a) The repeater polls all local ports to determine which end nodes or lower-level repeaters are requesting to send a packet and whether the request is normal priority or high priority. If an end node has a packet ready to send, it transmits either a Request_Normal or Request_High control signal. Otherwise, the end node transmits the Idle_Up control signal.

b) Once the repeater has finished transmitting the packet, it selects the next end node with a request pending (the next port closest to the next-port-pointer value) by sending Grant to the selected end node. Idle_Down is sent to all other end nodes. Packet transmission begins when the end node detects the grant.

c) The repeater then alerts all end nodes (other than the sender) on the network of a possible incoming packet (by transmitting an Incoming control signal) and decodes the destination address as it is being received.

d) When an end node receives the Incoming control signal, it prepares to receive a packet.

e) After the repeater has decoded the destination address, the packet is sent to the addressed end node(s) and to any promiscuous ports. Communication to nonaddressed, nonpromiscuous ports is inhibited during packet transmission (the repeater sends Idle_Down to these ports during packet transmission).

Figure 6-4 shows a conceptual time-space diagram of a transmission (from an end node connected to port 8 to an end node connected to port 3) in a single-level repeater topology. Elasticity buffering of the packet is provided in the repeater to compensate for delays required to decode the destination address and to begin packet retransmission to the designated end node.

6.2.3 Round-robin transmission example

Figure 6-5 shows an example that would result with round-robin polling in an 8-station, single-repeater network, assuming that the network was idle at t = 0. The normal-priority request from port 2 is selected by the repeater's RMAC and packet transmission begins. During this time, high-priority requests are received from ports 5 and 1, but they are not acted upon until the current packet transmission is complete. The repeater then selects and processes the high-priority request with the closest port in port order to the

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high-priority next-port pointer (port 1 in this example). The high-priority request from port 5 is serviced next. Since there are no additional high-priority requests pending after port 5, the repeater returns to normal-priority requests and processes these, in port order (ports 3, 6, and 7), as indicated by the normal-request next-port pointer. Another high-priority request is received from port 1 and is serviced before the remaining normal-priority requests can be satisfied. These are then processed in the order indicated by the normal-priority next-port pointer.

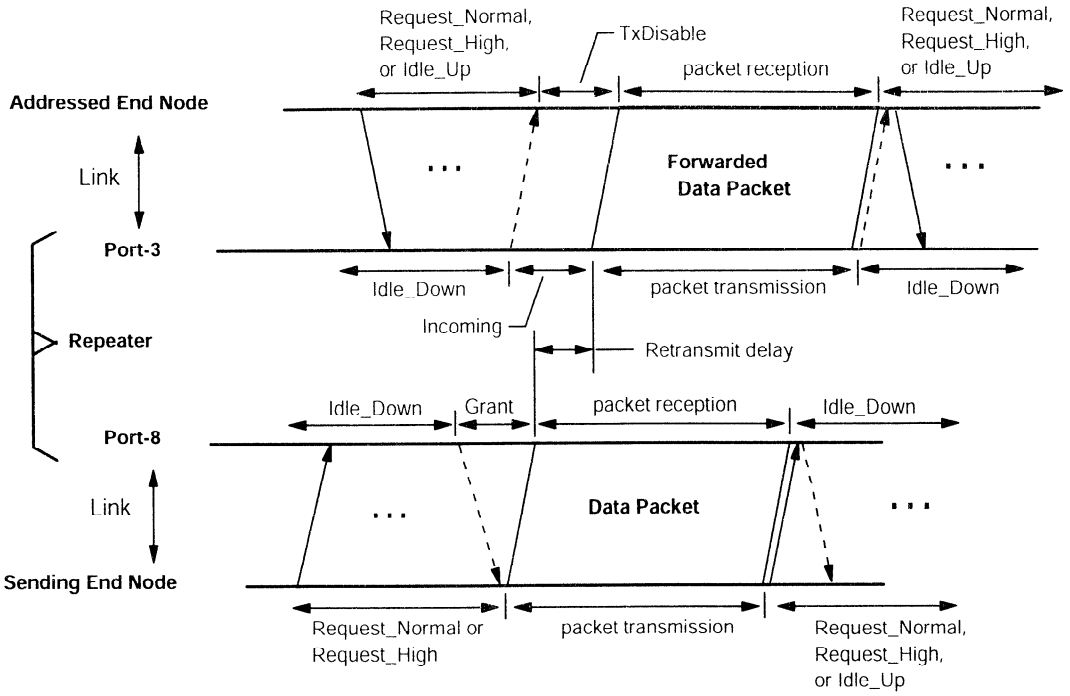

Figure 6-4—Packet transmission time-space diagram

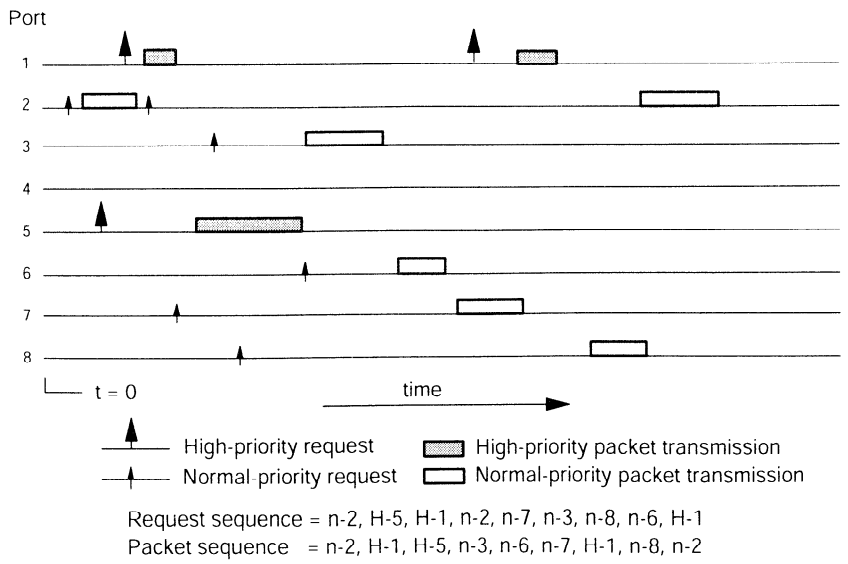

Figure 6-5—An example packet sequence in a single-repeater network

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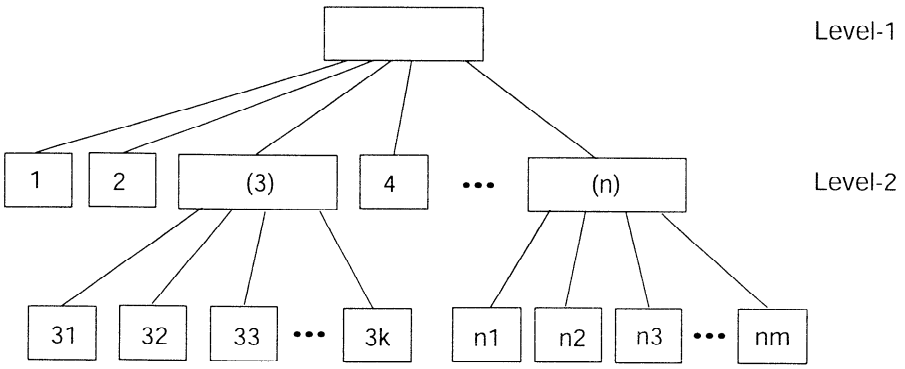
6.3 Operations in cascaded networks

Transmission in cascaded networks follows a similar procedure to operations in a single-repeater network. The interconnected repeaters act essentially the same as a single large repeater. All traffic is sent to each repeater, and each repeater polls its active ports for requests at least once per packet transmission.

The Level-1 (root) repeater has primary control of the packet sequencing. Lower-level repeaters with requests pending issue requests to the next higher-level repeater in the same manner as an end node.

Request selection begins at the root repeater. If the next port to be serviced is connected to an end node, the request is handled essentially in the same way as described in 6.2. All repeaters and other end nodes on the network are alerted of a possible incoming packet. The destination address is decoded as the packet is being received. If the address indicates an end node on a repeater's port address list, the packet is forwarded to that end node and to any promiscuous ports. The packet is always forwarded to all other repeaters on the network.

If the next port (with a pending request) in the root-repeater selection sequence is connected to a lower-level repeater, the request selection responsibility is granted to the lower-level repeater, and that repeater keeps the selection authority for one complete round-robin cycle. Requests from succeeding ports in the root-repeater result in a single packet transmission if the link is connected to an end node, or in a complete round-robin cycle if the link is connected to a repeater. The effect is a network that acts as though it has a single large repeater with port ordering as shown in the example of Figure 6-6.



Port Order = 1, 2, 31, 32, 33, ..., 3k, 4, ..., n1, n2, n3, ..., nm

Figure 6-6—Effective port ordering in a network with two repeater levels

High-priority requests from any port in a network with more than one repeater level are processed before normal-priority requests. If a high-priority request is received before completion of a normal-priority round-robin in a lower-level repeater, the root repeater pre-empts the remainder of the round-robin cycle by sending the Enable_High_Only control signal to the lower repeater. After the high-priority request has been satisfied, the lower-level repeater is allowed to complete the normal-priority round-robin cycle. Figure 6-7 shows an example request sequence and the resulting packet order for the network of Figure 6-6, assuming that a normal-priority packet is being transmitted at time = t, and that no high-priority requests are pending.

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