

**System Considerations for
Multisegment 10 Mb/s
Baseband Networks
(Section 13)**

**Twisted-Pair Medium
Attachment Unit (MAU)
and Baseband Medium,
Type 10BASE-T
(Section 14)**

IEEE Standards for
Local and Metropolitan Area Networks:

**Supplement to Carrier Sense Multiple Access with
Collision Detection (CSMA/CD) Access Method and
Physical Layer Specifications**

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10 Mb/s Baseband Networks (Section 13)**

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(MAU) and Baseband Medium, Type
10BASE-T (Section 14)**



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Abstract: This Local Area Network (LAN) standard, IEEE Std 802.3i-1990 (supplement to ISO/IEC 8802-3:1990 [ANSI/IEEE Std 802.3-1990 Edition]), specifies the Type 10BASE-T Medium Attachment Unit (MAU) and one specific unshielded twisted-pair medium for use with the MAU. This MAU is specified for use in a 10 Mb/s baseband CSMA/CD LAN. Guidelines for its application in a repeatered multisegment heterogeneous CSMA/CD network are included.

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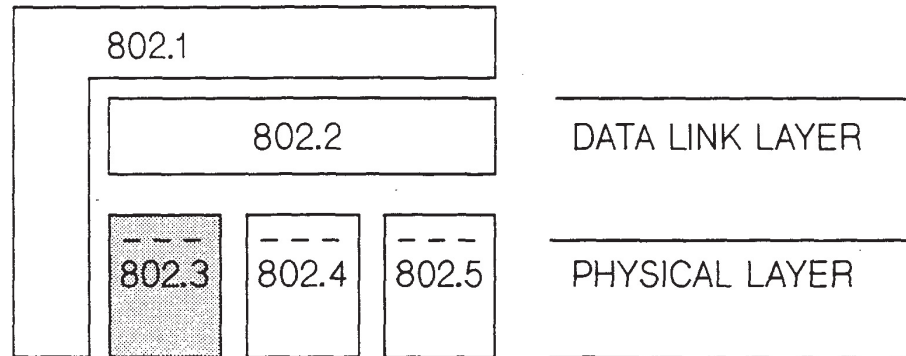
December 31, 1990

SH13763

Foreword

(This Foreword is not a part of IEEE Std 802.3i-1990.)

This supplement is part of a family of standards for Local and Metropolitan Area Networks. 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 as follows:

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

ISO 8802-2 [ANSI/IEEE Std 802.2-1989], the logical link control (LLC) standard, is used in conjunction with the medium access standards.

IEEE Std 802-1990* 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 Std 802.1D-1990 deals with media ac-

* The 802 Architecture and Overview Specification, originally known as IEEE Std 802.1A, has been renumbered as IEEE Std 802. This has been done to accommodate recognition of the base standard in a family of standards. References to IEEE Std 802.1A should be considered as references to IEEE Std 802.

cess control (MAC) bridging and IEEE Std 802.1E-1990 specifies a protocol for loading end systems (both to be published in early 1991). Other projects in the 802.1 series are currently under development.

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

The local area network access mechanism specified by this standard may include patented matter. The IEEE Standards Office calls attention to the fact that it is claimed that the process of the local area network access mechanism described throughout this standard is the subject of United States patent numbers 4 063 220 and 4 099 024 and corresponding patents of foreign countries owned by the Xerox Corporation. Although these patents appear to cover the access mechanism subject in this standard, the IEEE takes no position with respect to patent validity. The Xerox Corporation has assured the IEEE that it is willing to grant a license under these patents on reasonable and nondiscriminatory terms and conditions to anyone wishing to obtain such a license. The Xerox Corporation's undertakings in this respect are on file with the IEEE Standards Office and the license details may be obtained from the Office of General Counsel of Xerox Corporation, whose address is Post Office Box 1600, Stamford, Connecticut 06904, USA.

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are anticipated to this standard within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material.

Readers wishing to know the state of revisions should contact
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When the IEEE 802.3 Working Group approved IEEE Std 802.3i-1990 (Sections 13 and 14), it had the following membership:

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Patricia Thaler, *Chair, Type 10BASE-T Task Force*†

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IEEE Std 802.3i-1990
(Supplement to ISO/IEC 8802-3:1990 [ANSI/IEEE Std 802.3-1990 Edition])

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Revisions to ISO/IEC 8802-3:1990 [ANSI/IEEE Std 802.3-1990 Edition]

(These changes and additions are part of IEEE Std 802.3i-1990.)

The following changes add references to 10BASE-T and specifications for 10BASE-T to the appropriate places in ISO/IEC 8802-3:1990 [ANSI/IEEE Std 802.3-1990 Edition]. The changes do not alter the specifications for existing systems.

1.3 References

Add this reference to list of references:

[16] ISO 8877:1987, Information processing systems—Interface connector and contact assignments for ISDN basic access interface located at reference points S and T.

4.4.2.1 Parameterized Values

In first sentence, delete "(type 10BASE5)".

8.6.1 Transmission System Model

Replace current item (2) with the following:

"(2) A point-to-point link constitutes a link segment. A link segment may contain a maximum end-to-end propagation delay of 2570 ns."

9.1 Overview

In the first sentence, change "10BASE5 and 10BASE2" to "10BASE5, 10BASE2, and 10BASE-T".

13. System Considerations for Multisegment 10 Mb/s Baseband Networks

13.1 Overview. This section provides information on building multisegment 10 Mb/s baseband networks within a single collision domain. The proper operation of a CSMA/CD network requires network size to be limited to control round-trip propagation delay to meet the requirements of 4.2.3.2.3 and 4.4.2.1, and the number of repeaters between any two Data Terminal Equipments (DTEs) to be limited in order to limit the shrinkage of the interpacket gap as it travels through the network. This section applies to networks that contain 10BASE-T segments.

NOTE: Information on 10BASE-T is included to begin the process of developing this section. It is intended that 8.6.1 and 10.7.1 be merged into this section in the future and that any new 10BASE segments be added to this section.

13.2 Definitions. Terminology used in Section 13, and not previously defined, is defined here:

collision domain. A single CSMA/CD network. If two or more Media Access Control (MAC) sublayers are within the same collision domain and both transmit at the same time, a collision will occur. MAC sublayers separated by a repeater are within the same collision domain. MAC sublayers separated by a bridge are within different collision domains.

link segment. The point-to-point full duplex medium connection between two and only two Medium-Dependent Interfaces (MDIs).

segment. The medium connection, including connectors, between MDIs in a CSMA/CD LAN.

13.3 Transmission System Model. The physical size of a 10BASE-T network, or mixed-media network containing 10BASE-T link segments, is constrained by the limits of individual network components. These limits include the following:

- (1) Cable length and its associated propagation time delay.
- (2) Delay of repeater units (start-up and steady-state).
- (3) Delay of MAUs (start-up and steady-state).
- (4) Interpacket gap shrinkage.
- (5) Delays within the DTE associated with the CSMA/CD access method.

The following table summarizes the delays for the various network media segments:

Media Segment Type	Maximum Number of MAUs per Segment	Maximum Segment Length (m)	Minimum Medium Propagation Velocity*	Maximum Medium Delay per Segment (ns)
Coax				
10BASE5	100	500	0.77 c	2165
10BASE2	30	185	0.65 c	950
Link				
FOIRL	2	1000	0.66 c	5000
10BASE-T	2	100 [†]	0.59 c	1000
AUI [‡]	1 DTE/1 MAU	50	0.65 c	257

* $c = 3 \times 10^8$ m/s

[†] Actual maximum segment length depends on cable characteristics; see 14.1.1.3.

[‡] AUI is not a segment.

In addition, Table 14-1 summarizes the delays for the 10BASE-T MAU; Section 8, the delays for the 10BASE5 MAU; Section 10, the delays for the 10BASE2 MAU; and Section 9, the delays of the fiber optic inter-repeater link (FOIRL) and the repeater.

The following network topology constraints apply for 10BASE-T networks as well as mixed-media networks containing 10BASE-T link segments:

- (1) Repeater sets are required for all segment interconnection.
- (2) MAUs that are part of repeater sets count toward the maximum number of MAUs on a segment.
- (3) The transmission path permitted between any two DTEs may consist of up to five segments, four repeater sets (including optional AUIs), two MAUs, and two AUIs.
- (4) When a network path consists of four repeater sets and five segments, up to three of the segments may be coax and the remainder must be link segments (Figs 13-1 and 13-2). When five segments are present, each FOIRL link segment should not exceed 500 m.
- (5) When a network path consists of three repeater sets and four segments, the maximum allowable length of the FOIRL segments is 1000 m each, as specified in 9.9 (Fig 13-3).

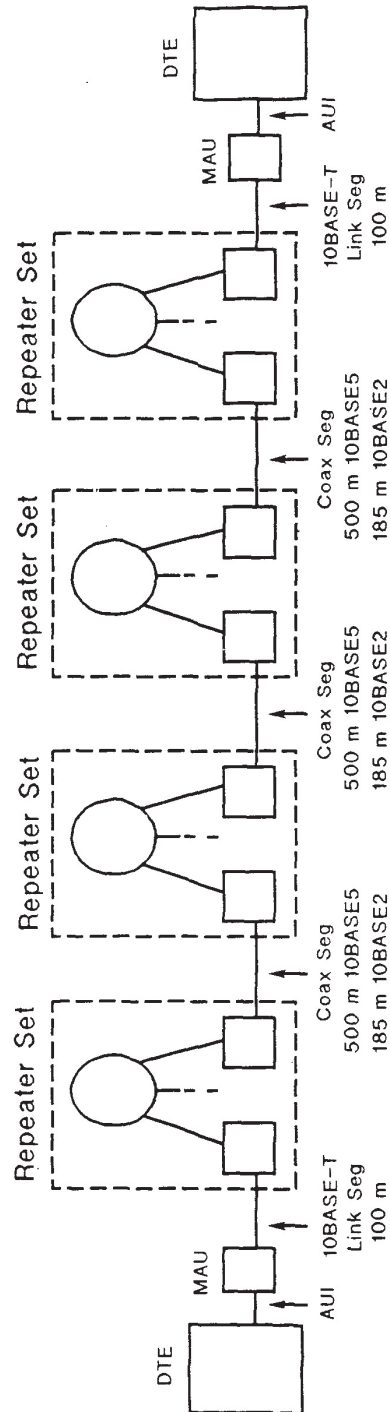


Fig 13-1
Maximum Transmission Path with Three Coax Segments

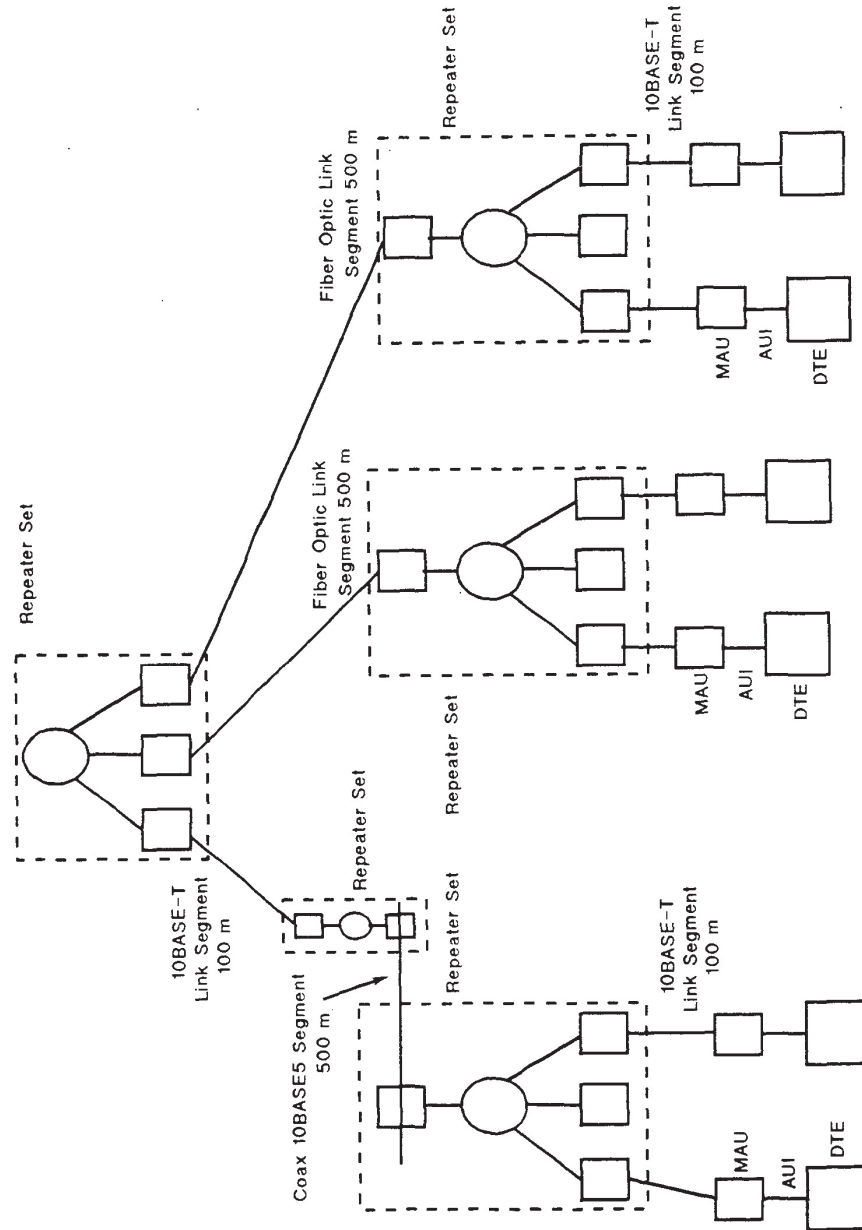


Fig 13-2
Example of Maximum Transmission Path Using Coax Segments,
10BASE-T Link Segments, and Fiber Optic Link Segments

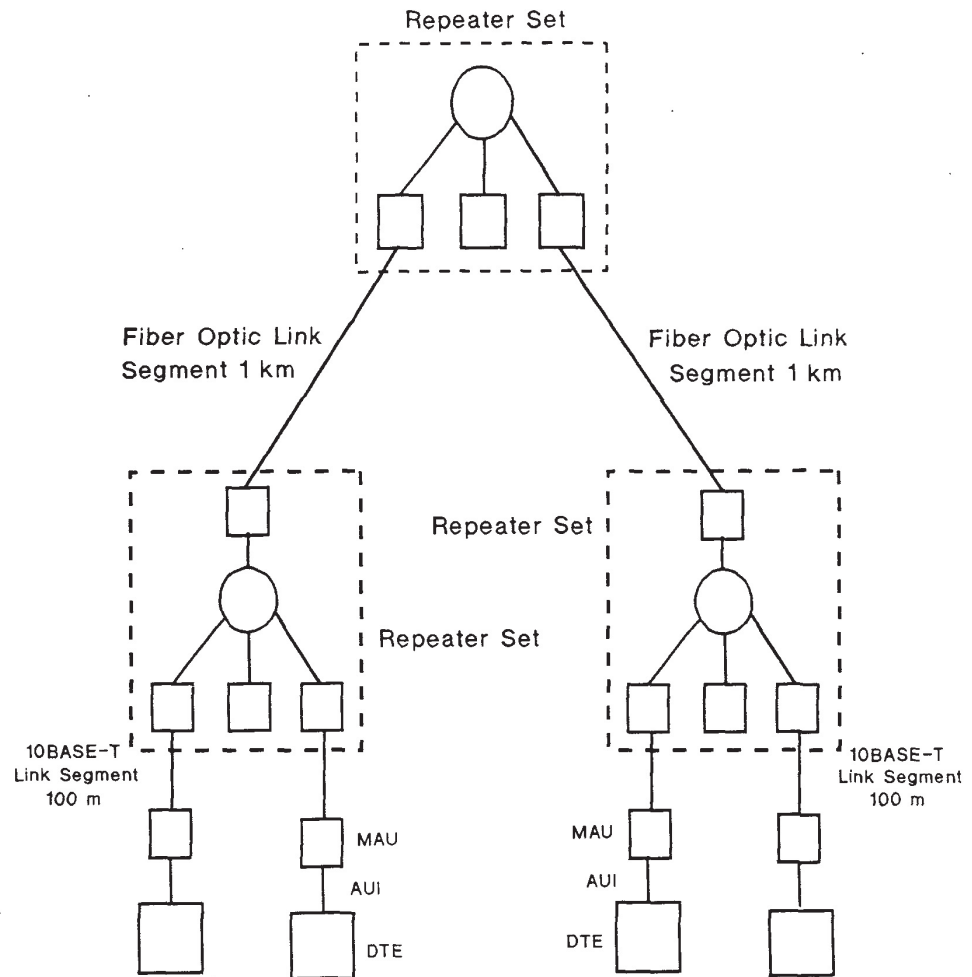


Fig 13-3
Example of Maximum Transmission Path with Three Repeater Sets,
Four Link Segments (Two are 100 m 10BASE-T and Two are 1 km Fiber)

14. Twisted-Pair Medium Attachment Unit (MAU) and Baseband Medium, Type 10BASE-T

14.1 Scope

14.1.1 Overview. Section 14 defines the functional, electrical, and mechanical characteristics of the Type 10BASE-T MAU and one specific medium for use with that MAU. The relationship of this specification to the entire ISO/IEC 8802-3 CSMA/CD Local Area Network Specification is shown in Fig 14-1. The purpose of the MAU is to provide a simple, inexpensive, and flexible means of attaching devices to the medium.

This MAU and medium specification is aimed primarily at office applications where twisted-pair cable is often installed. Installation and reconfiguration simplicity is allowed by the type of cable and connectors used.

The 10BASE-T specification builds upon Sections 1 through 7 and Section 9 of this standard.

14.1.1.1 Medium Attachment Unit (MAU). The MAU has the following general characteristics:

- (1) Enables coupling the Physical Signaling (PLS) sublayer by way of the Attachment Unit Interface (AUI) to the baseband twisted-pair link defined in Section 14.
- (2) Supports message traffic at a data rate of 10 Mb/s.
- (3) Provides for operating over 0 to at least 100 m (328 ft) of twisted pair without the use of a repeater.
- (4) Permits the Data Terminal Equipment (DTE) or repeater to confirm operation of the MAU and availability of the medium.
- (5) Supports network configurations using the CSMA/CD access method defined in ISO/IEC 8802-3:1990 with baseband signaling.
- (6) Supports a point-to-point interconnection between MAUs and, when used with repeaters having multiple ports, supports a star wiring topology.
- (7) Allows incorporation of the MAU within the physical bounds of a DTE or repeater.

14.1.1.2 Repeater Unit. The repeater unit is used to extend the physical system topology and provides for coupling two or more segments. Repeaters are an integral part of all 10BASE-T networks with more than two DTEs (see Figs 13-1 and 13-2). The repeater unit is defined in Section 9. Multiple repeater units are permitted within a single collision domain to provide the maximum connection path length specified in Section 13. The repeater unit is not a DTE and therefore has slightly different requirements for its attached MAUs, as defined in 9.4.1. Repeater sets with 10BASE-T MAUs are required to provide the auto-partition/reconnection algorithm on those ports, as specified in 9.6.6.2.

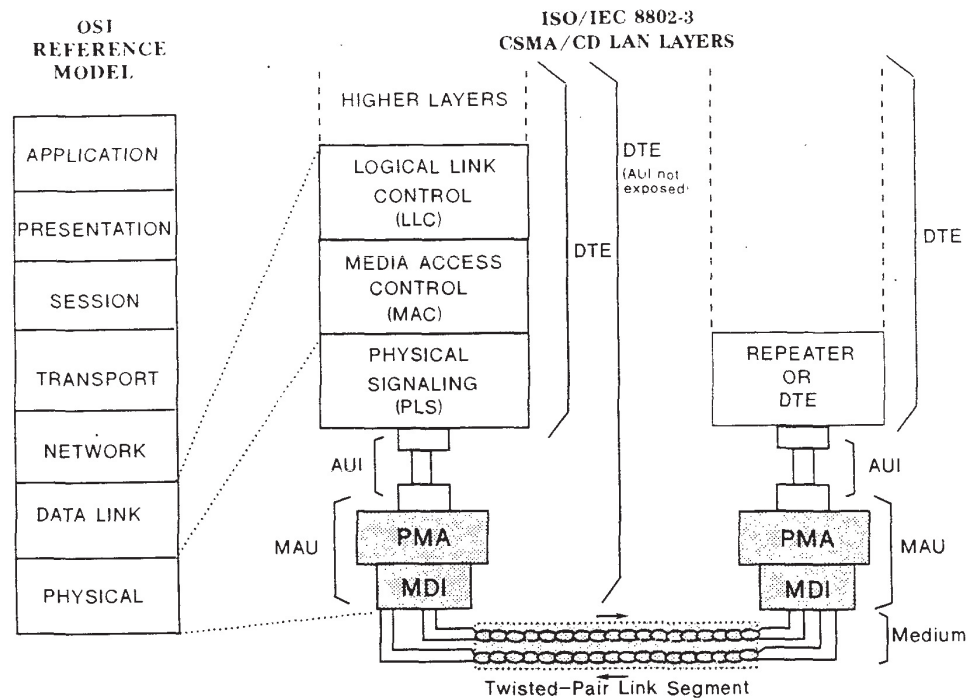


Fig 14-1
10BASE-T Relationship to OSI and CSMA/CD LAN

14.1.1.3 Twisted-Pair Media. The medium for 10BASE-T is twisted-pair wire. The performance specifications of the simplex link segment are contained in 14.4. This wiring normally consists of 0.4 to 0.6 mm diameter [26 to 22 AWG] unshielded wire in a multipair cable. The performance specifications are generally met by 100 m of 0.5 mm telephone twisted pair. Longer lengths are permitted providing the simplex link segment meets the requirements of 14.4. A length of 100 m, the design objective, will be used when referring to the length of a twisted-pair link segment.

14.1.2 Definitions. This section defines the terminology specific to Type 10BASE-T MAUs and their application to repeater units.

bit time (BT). The duration of one bit symbol ($1/BR$).

collision. A condition that results from concurrent transmissions from multiple signal sources.

common-mode voltage. The instantaneous algebraic average of two signals applied to a balanced circuit, both signals referred to a common reference. Also called longitudinal voltage.

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.

differential-mode voltage. The instantaneous algebraic difference between two signals applied to a balanced circuit, both signals referred to a common reference. Also called metallic voltage.

Medium-Dependent Interface (MDI). The mechanical and electrical interface between the twisted-pair link segment and the MAU.

Physical Medium Attachment (PMA) sublayer. The portion of the MAU that contains the functional circuitry.

Physical Signaling (PLS) sublayer. The portion of the Physical Layer, contained within the DTE, that provides the logical and functional coupling between the MAU and the Data Link Layer.

simplex link segment. A two-wire path between two MAUs including the terminating connectors, consisting of one or more twisted pairs joined serially with appropriate connection devices, for example, patch fields and wall plates (Fig 14-2).

twisted pair. Two continuous insulated conductors helically twisted around one another (Fig 14-2).

twisted-pair cable. A group of twisted pairs within a single protective sheath, often four or twenty-five.

twisted-pair cable binder group. A group of twisted pairs within a cable that are bound together. Large telephone cables have multiple binder groups with high interbinder group near-end crosstalk loss.

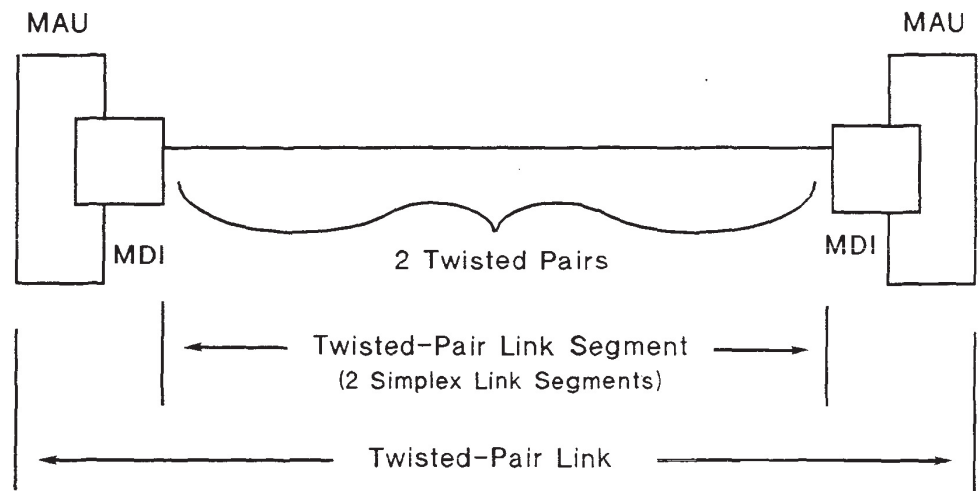
twisted-pair link. A twisted-pair link segment and its two attached MAUs (Fig 14-2).

twisted-pair link segment (duplex link segment). Two simplex link segments for connecting two MAUs (Fig 14-2).

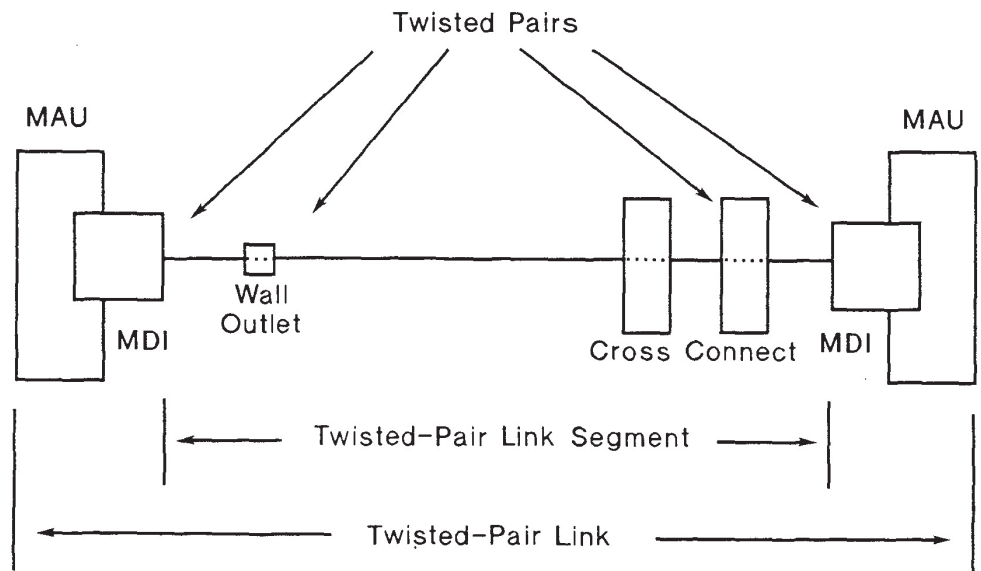
14.1.3 Application Perspective. This section states the broad objectives and assumptions underlying the specifications defined throughout Section 14.

14.1.3.1 Objectives

- (1) Provide the physical means for communication between LAN Data Link Layer Entities.
- (2) Ensure compatibility of independently developed physical and electrical interfaces.
- (3) Provide a communication channel with a mean bit error rate, at the physical layer service interface of less than one part in 10^8 .
- (4) Provide for ease of installation and service.
- (5) Ensure that fairness of DTE access is not compromised.
- (6) Provide for low-cost networks, as related to both equipment and cabling.
- (7) Make use of telephone twisted-pair building wiring and telephony wiring practices.



(a)



(b)

Fig 14-2
Twisted-Pair Link

IEEE Standards for Local and Metropolitan Area Networks

The availability of a full-range of competitively priced, state-of-the-art information processing hardware and software—developed to meet particular requirements—has led to the predominance of multi-vendor systems environments. This development has fostered the demand for multi-vendor connectivity, distributed processing, and electronic exchange of information between incompatible mainframes, workstations, and peripherals. In response, Local Area Networks (LANs) and Metropolitan Area Networks (MANs) have emerged.

IEEE LAN/MAN Standards provide the latest technological information on LAN/MAN architectures and access methods appropriate for particular applications and system objectives. If you manage, administer, or design Local and Metropolitan Area Networks, make sure you have the complete set of LAN/MAN standards published by the IEEE.

■ Overview and Architecture

(ISBN 1-55937-052-1)

IEEE Std 802-1990 (ANSI)

Product Number: SH13557

Serves as the foundation standard for the family of LAN/MAN standards published by the IEEE. It contains descriptions of the networks considered as well as a reference model for protocol standards.

■ Information Processing Systems —

Local Area Networks — Part 2: Logical Link Control (ISBN 1-55937-019-X)

ISO 8802-2 : 1989 (ANSI/IEEE Std 802.2-1989)

Product Number: SH12930

Describes the functions, features, protocol, and services of the Logical Link Control (LLC) sublayer in the ISO 8802 LAN Protocol.

■ Information Processing Systems—

Local Area Networks—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications (ISBN 1-55937-005-X)

ISO/IEC 8802-3 : 1990

(ANSI/IEEE Std 802.3-1990)

Product Number: SH11726

Specifies an Ethernet-like LAN medium, the Physical Layer, and Media Access Control (MAC) protocols. Section 9 is now comprised of the ISO/IEC-approved versions of IEEE Std 802.3c-1985 and IEEE Std 802.3d-1987.

■ Supplements to CSMA/CD

(ISBN 1-55937-013-0)

IEEE Std 802.3b, c, d, e-1989 Edition (ANSI)

Product Number: SH12351

The companion document to ISO/IEC 8802-3 : 1990.

■ Supplement to CSMA/CD:

System Considerations for Multisegment 10 Mb/s Baseband Networks (Section 13) and Twisted-Pair Medium Attachment Unit (MAU) and Baseband Medium, Type 10BASE-T (Section 14) (ISBN 1-55937-070-X)

IEEE Std 802.3i-1990

Product Number: SH13763

Defines the functional, electrical, and mechanical characteristics of Type 10BASE-T MAU.

■ Token-Passing Bus Access Method and Physical Layer Specifications

(ISBN 1-55937-027-0)

ISO/IEC 8802-4 : 1990

(ANSI/IEEE Std 802.4-1990)

Product Number: SH12948

Deals with all elements of the Token-Passing Bus Access Method and its associated physical signaling and media technologies.

■ Token Ring Access Method and Physical Layer Specifications (ISBN 1-55937-012-2)

IEEE Std 802.5-1989 (ANSI)

Product Number: SH12609

Specifies a Twisted-Pair Medium, the Physical Layer, and the Media Access Control (MAC) protocols for a star-configured ring topology.

■ Broadband Local Area Networks

(ISBN 1-55937-021-1)

IEEE Std 802.7-1989 (ANSI)

Product Number: SH12955

Specifies the physical, electrical, and mechanical characteristics of a properly designed IEEE 802.7 broadband cable medium.

ISBN 1-55937-070-X

