

IEEE Std 802.5-1989
(Revision of ANSI/IEEE Std 802.5-1985)

LOCAL AREA NETWORKS

802.5

IEEE Standard

Token Ring
Access Method



Published by
The Institute of Electrical and
Electronics Engineers, Inc

IEEE Std 802.5-1989: Token Ring Access Method and Physical Layer Specifications

This standard specifies the formats and protocols used by the Token-Passing Ring medium access control (MAC) sublayer, the physical layer, and the means of attachment to the token-passing ring physical medium.

IEEE Std 802.5-1989 aids in the compatible interconnection of data processing equipment by way of a local area network using the token-passing ring access method.

It defines the frame format, including delimiters, addressing, and frame check sequence. It also defines MAC protocol, and introduces MAC frames, timers, and priority stacks. This standard describes the services provided by the MAC sublayer to the station management and the logical link control sublayer. It also describes the services provided by the physical layer to station management and the MAC sublayer. These services are defined in service primitives and associated parameters.

Also defined are:

- Physical layer functions of symbol encoding and decoding
- Symbol timing
- Latency buffering
- 1 Mb/s and 4 Mb/s, Shielded Twisted Pair attachment of the station to the medium

➡ **Important: ANSI/IEEE Std 802.2-1985 is the basic document in our LAN series. Make sure you have it, if you're ordering any of our other LAN standards.**

SH12609

IEEE Standards for
Local Area Networks:

**Token Ring Access Method and
Physical Layer Specifications**



Published by
The Institute of Electrical and Electronics Engineers, Inc

First Printing
September 1989

ISBN 1-55937-012-2
Library of Congress Catalog Card Number 89-045806

© Copyright 1989 by

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

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

September 29, 1989

SH12609

IEEE Std 802.5-1989
(Revision of ANSI/IEEE Std 802.5-1985)

**IEEE Standards for
Local Area Networks:**

**Token Ring Access Method and
Physical Layer Specifications**

Sponsor
**Technical Committee on Computer Communications
of the
IEEE Computer Society**

Approved June 2, 1989
IEEE Standards Board

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

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

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

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

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

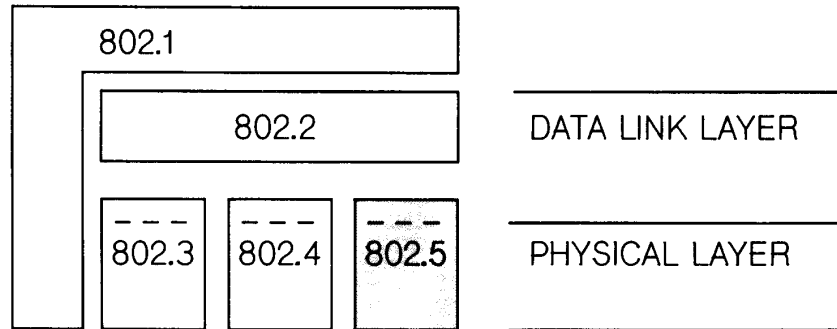
Secretary, IEEE Standards Board
345 East 47th Street
New York, NY 10017
USA

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

Foreword

(This Foreword is not a part of IEEE Std 802.5-1989, Token Ring Access Method and Physical Layer Specifications.)

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



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

- (1) ANSI/IEEE Std 802.3-1988 [ISO 8802-3], a bus utilizing CSMA/CD as the access method,
- (2) ANSI/IEEE Std 802.4-1985 [ISO 8802-4], a bus utilizing token passing as the access method,
- (3) IEEE Std 802.5-1989 [ISO 8802-5], a ring utilizing token passing as the access method.

Other access methods (for example, metropolitan area networks) are under investigation. ANSI/IEEE Std 802.2-1985, Logical Link Control protocol, is used in conjunction with the medium access standards.

A companion document, P802.1, describes the relationship among these standards and their relationship to the ISO Open Systems Interconnection Reference Model in more detail. This companion document will contain internetworking and network management issues.

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

NOTE: This IEEE Std 802.5-1989 specifies that each octet of the information field shall be transmitted most significant bit (MSB) first. This convention is reversed from that used in ANSI/IEEE Std 802.3-1988 and ANSI/IEEE Std 802.4-1985, standards that are least significant bit (LSB) first transmission. While the transmission of MSB first is used for the IEEE 802.5-1989 token ring, this does not imply that MSB transmission is preferable for any other type of local area network. Anyone considering the interconnection of the IEEE 802.5-1989 token ring with other IEEE standard networks should keep in mind the need to perform bit reordering in the gateway between networks.

Voting members of the 802.5 Working Group who participated in developing this standard were as follows:

Robert A. Donnan, *Chairman*

H. Abramowicz	Dave Kollm	Don Roworth
Steven C. Andersen	Stan Kopec	Howard C. Salwen
A. Philip Arneth	Robert Krebs	W. L. Schumacker
Nicholas Beale	Robert Krzyzanowski	Tim Shafer
Alan Beardsley	Eiji Kuge	David Sheehy
Randall Blair	David Laffitte	Naoshi Shima
Daniel Boudreau	Bob Lapointe	Marc Shoquist
Charles Brill	Katie D. Lee	W. S. Shung
Werner Bux	Laurie Lindsey	Somsubhra Sikdar
Michael H. Coden	Robert D. Love	Michael J. Sobieski
Guy Crauwels	Alan C. Marshall	Bob Southard
Gunnar Forsberg	Jeffrey V. Marshik	Andre Szczepanek
Nathan Fritts	Kelly P. McClellan	D. T. W. Sze
Yoshihiko Fujii	John Messenger	Paul Tan
R. W. Gibson	Arthur Miller	V. Tarassov
Harry Gold	John E. Montague	Lars Thernsjo
Richard H. Gompertz	Narayan Murthy	Nathan Tobol
Lisa Goulet	Shigekatsu Nakao	Art Torino
Fred Greim	W. B. Neblett	Paul A. Trudgett
Siegmar Gross	James Nelson	Bo Viklund
Robert Grow	Olle Nilsson	John Q. Walker
Tom Gulick	Brian O'Connell	Frank Wang
Lee C. Haas	Atul Pandya	Ian Watson
Nobuhiro Hamada	Guy Parker	Jim Weisert
Claire Hamner	Michael W. Patrick	R. O. Westlake
Takeshi Harakawa	Dave Pfahler	Kevin White
Lloyd Hasley	Jeffery Pickering	Izumi Y. Wilson
Bryan Hatfield	John Rance	Jacalyn Winkler
Tricia Hill	Everett O. Rigsbee III	Albert Wong
Tetsuo Isayama	Robert Rosenthal	Howard D. Wright
Jiro Kashio	Floyd Ross	Kazuhiko Yamada
Carrell Killebrew	John Rovner	H. A. Zannini
Makoto Kohno		Mo Zonoun



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

Marshall D. Abrams	M. Kezunovic	Robert Rosenthal
William B. Adams	Samuel Kho	Gian Paolo Rossi
S.R. Ahuja	Robert Klessig	David J. Rypka
Kit Athul	David Kollm	S.I. Samaylenko
William Ayen	Hirayr M. Kudyan	Norman F. Schneidewind
Eduardo W. Bergamini	Takahiko Kuki	Omri Serlin
H.F. Boley	Wai-Sum Lai	D.A. Sheppard
Paul W. Campbell, Jr.	Lanse M. Leach	J.B. Sinclair
George S. Carson	Edward Y. Lee	Stephen H. Soto
Po Chen	F.C. Lim	Tom Stack
L.Y. Cheung	Ming T. Liu	Carel M. Stillebroer
Kilnam Chon	William D. Livingston	Fred Strauss
Michael Coden	K.D. Loughner	Bart W. Stuck
A.F. Conrad	Don C. Loughry	Tatsuya Suda
Ira Cotton	Joseph F.P. Luhukay	P. Sugar
Peter J. Crotty	Wo-Shun Luk	Efstathios D. Sykas
Robert S. Crowder	Joseph Massi	Daniel T.W. Sze
M.G. Duncan	Darrel B. McIndoe	Ahmed N. Tantawi
Philip Enslow, Jr.	P.S. McIntosh	H.C. Torng
Judith Estrin	Marco Meli	D.F. Towsley
John W. Fendrich	David S. Millman	Wei-Tek Tsai
Harvey A. Freeman	Aditya N. Mishra	Masahiro Tsuchiya
Robert J. Gagliano	David E. Morgan	Stanko Turk
Patrick S. Gonia	Mike Morganti	L. David Umbaugh
A. Goyal	Kanji Mori	Pearl S.C. Wang
Maris Graube	David Morris	Don Weir
Joseph L. Hammond	J.D. Northcut	Alan J. Weissburger
Stephen Harris	Charles Oestereicher	W.J. Wenker
J. Scott Haugdahl	Young Oh	R.O. Westlake
Paul Hutton	George Parowski	Earl J. Whitaker
Richard Illiff	Thomas L. Phinney	Michael Willett
E.D. Jensen	David Potter	David C. Wood
Guy Juanole	C.S. Raghavenendra	Oren Yuen
S.L. Junker		S.G. Zaky

When the IEEE Standards Board approved this standard on June 1, 1989, it had the following membership:

Dennis Bodson, *Chairman* **Marco W. Migliaro, *Vice Chairman***
Andrew G. Salem, *Secretary*

Arthur A. Blaisdell	Kenneth D. Hendrix	John E. May, Jr.
Fletcher J. Buckley	Theodore W. Hissey, Jr.	Lawrence V. McCall
Allen L. Clapp	John W. Horch	L. Bruce McClung
James M. Daly	David W. Hutchins	Donald T. Michael*
Stephen R. Dillon	Frank D. Kirschner	Richard E. Mosher
Donald C. Fleckenstein	Frank C. Kitzantides	Stig Nilsson
Eugene P. Fogarty	Joseph L. Koepfinger*	L. John Rankine
Jay Forster*	Edward Lohse	Gary S. Robinson
Thomas L. Hannan		Donald W. Zipse

*Member Emeritus

Contents

SECTION	PAGE
1. General	13
1.1 Scope.....	13
1.2 Definitions	14
1.3 Abbreviations	16
1.4 References.....	18
2. General Description.....	19
3. Formats and Facilities.....	23
3.1 Formats.....	23
3.1.1 Token Format.....	23
3.1.2 Frame Format.....	23
3.1.3 Fill.....	24
3.2 Field Descriptions	24
3.2.1 Starting Delimiter (SD).....	24
3.2.2 Access Control (AC)	24
3.2.3 Frame Control (FC).....	25
3.2.4 Destination and Source Address (DA and SA) Fields.....	26
3.2.5 Information (INFO) Field.....	28
3.2.6 Frame Check Sequence (FCS).....	30
3.2.7 Ending Delimiter (ED)	31
3.2.8 Frame Status (FS).....	31
3.3 Medium Access Control (MAC) Frames	32
3.3.1 Vector Description	32
3.3.2 Subvector Descriptions	35
3.3.3 Table of MAC Frames.....	37
3.4 Timers.....	40
3.4.1 Timer, Return to Repeat (TRR).....	40
3.4.2 Timer, Holding Token ((THT).....	40
3.4.3 Timer, Queue PDU (TQP).....	40
3.4.4 Timer, Valid Transmission (TVX).....	40
3.4.5 Timer, No Token (TNT)	40
3.4.6 Timer, Active Monitor (TAM).....	40
3.4.7 Timer, Standby Monitor (TSM).....	40
3.4.8 Timer, Error Report (TER).....	40
3.4.9 Timer, BCN Transmit (TBT).....	40
3.4.10 Timer, BCN Receive (TBR).....	41
3.5 Flags	41
3.5.1 I Flag.....	41
3.5.2 SFS Flag	41
3.5.3 MA Flag.....	41
3.5.4 SMP Flag	41
3.5.5 NN Flag.....	41
3.5.6 BR Flag	41

SECTION	PAGE
3.6 Priority Registers and Stacks.....	41
3.6.1 Pr and Rr Registers	41
3.6.2 Sr and Sx Stacks	41
3.7 Latency Buffer	41
3.8 Counters.....	42
3.8.1 Line Error	42
3.8.2 Internal Error.....	42
3.8.3 Burst Error.....	42
3.8.4 AC Error	42
3.8.5 Abort Delimiter Transmitted (AD_TRANS).....	42
3.8.6 Lost Frame Error (LOST_FR)	42
3.8.7 Receive Congestion Error (RCV_CON).....	42
3.8.8 Frame Copied Error (FR_COPIED)	42
3.8.9 Frequency Error (FREQ).....	42
3.8.10 Token Error	42
3.8.11 Frame Count (FR_CNT).....	43
4. Token Ring Protocols.....	45
4.1 Overview.....	45
4.1.1 Frame Transmission.....	45
4.1.2 Token Transmission.....	45
4.1.3 Stripping.....	45
4.1.4 Frame Reception.....	45
4.1.5 Priority Operation	46
4.1.6 Beaconing and Neighbor Notification	47
4.1.7 Error Reporting.....	49
4.1.8 Administration of Ring Parameters.....	49
4.1.9 Configuration Control.....	49
4.1.10 Early Token Release (ETR).....	49
4.2 Specification.....	49
4.2.1 Receive Actions	50
4.2.2 Operational Finite-State Machine.....	52
4.2.3 Standby Monitor Finite-State Machine	57
4.2.4 Active Monitor Finite-State Machine	61
5. Physical Layer.....	65
5.1 Symbol Encoding.....	65
5.2 Symbol Decoding	66
5.3 Data Signalling Rates	67
5.4 Symbol Timing.....	67
5.5 Latency Buffer	67
5.5.1 Assured Minimum Latency.....	67
5.5.2 Phase Jitter Compensation.....	67
6. Service Specifications.....	69
6.1 MAC to LLC Service	69

SECTION	PAGE
6.1.1 Interactions.....	69
6.1.2 Detailed Service Specifications.....	70
6.2 PHY to MAC Service.....	72
6.2.1 Interactions.....	72
6.2.2 Detailed Service Specifications.....	72
6.3 MAC to SMT Service.....	73
6.3.1 Overview of MAC Services.....	74
6.3.2 MAC Attributes.....	74
6.3.3 MAC Transients.....	77
6.4 PHY to SMT Service.....	79
6.4.1 Overview of PHY Management Service.....	79
6.4.2 PHY Transients.....	80
7. Station Attachment Specifications.....	81
7.1 Scope.....	81
7.2 Overview.....	81
7.3 Coupling of the Station to the Ring.....	82
7.4 Ring Access Control.....	82
7.4.1 Current and Voltage Limits.....	82
7.4.2 Insertion/Bypass Transfer Timing.....	84
7.5 Signal Characteristics.....	84
7.5.1 The Transmitter.....	84
7.5.2 The Channel.....	85
7.5.3 The Receiver.....	86
7.5.4 Error Rate.....	89
7.6 Reliability.....	89
7.7 Safety Requirements.....	89
7.8 Electromagnetic Emanation.....	89
7.9 Medium Interface Connector (MIC).....	89
7.9.1 Medium Interface Connector—Contactor Detail.....	90
7.9.2 Medium Interface Connector—Locking Mechanism Detail.....	90

FIGURES

Fig 2-1 Relation of the OSI Reference Model to the LAN Model.....	19
Fig 2-2 Token Ring Configuration.....	20
Fig 2-3 Relationship of Data Stations, Servers, and System Manager.....	21
Fig 3-1 MAC Frame Information Field Structure.....	29
Fig 4-1 An Example of a Failure Domain.....	48
Fig 4-2 Receive Action Table.....	51
Fig 4-3 Operational Finite-State Machine.....	53
Fig 4-4 Repeat State Loop Table.....	54
Fig 4-5 Standby Monitor Finite-State Machine.....	58
Fig 4-6 Standby State Transition Loop Table.....	60
Fig 4-7 Active Monitor Finite-State Machine.....	63
Fig 5-1 Example of Symbol Encoding.....	66

FIGURES	PAGE
Fig 7-1 Partitioning of PHY and Medium.....	81
Fig 7-2 Example of Station Connection to the Medium	83
Fig 7-3 Receive Signal Eye Pattern	87
Fig 7-4 Medium Interface Connector—Isometric View.....	90
Fig 7-5 Medium Interface Connector—Contactor Detail.....	91
Fig 7-6 Medium Interface Connector—Locking Mechanism Detail.....	92
APPENDIXES	
Appendix A Address Structuring	93
Appendix B LLC Type 3 Support	95

IEEE Standards for Local Area Networks: **Token Ring Access Method and Physical Layer Specifications**

1. General

1.1 Scope. For the purpose of compatible interconnection of data processing equipment via a local area network using the token-passing ring access method, this standard

- (1) Defines the frame format, including delimiters, addressing, and frame check sequence, and introduces medium access control (MAC) frames, timers, and priority stacks (see Section 3);
- (2) Defines the MAC protocol. The finite-state machine and state tables are supplemented with a prose description of the algorithms (see Section 4);
- (3) Defines the physical layer (PHY) functions of symbol encoding and decoding, symbol timing, and latency buffering (see Section 5);
- (4) Describes the services provided by the MAC to the station management (SMT) and the logical link control sublayer (LLC) and the services provided by the PHY to SMT and the MAC. These services are defined in terms of service primitives and associated parameters (see Section 6);
- (5) Defines the 4 and 16 Mbit/s, shielded twisted pair attachment of the station to the medium including the definition of the medium interface connector (MIC) (see Section 7). The previously specified 1 Mbit/s mode of operation is not covered by this standard. Users and implementers of 1 Mbit/s should refer to ANSI/IEEE Std 802.5-1985, under which it is allowed.

The definition of suitable media (twisted pair, coaxial cable, and optical fiber) for connecting stations that meet the attachment standard specified herein is a subject for future consideration. Until such time as specific media are specified, the specifications in Section 7 shall define the performance bounds to which an operating network, including media and trunk coupling unit(s) TCUs, shall conform.

A particular emphasis of this standard is to specify the homogeneous exter-

nally visible characteristics needed for interconnection compatibility, while avoiding unnecessary constraints upon and changes to internal design and implementation of the heterogeneous processing equipment to be interconnected.

The applications environment for the Local Area Network is intended to be commercial and light industrial. The use of token ring LANs in home and heavy industrial environments, while not precluded, has not been considered in the development of this standard.

1.2 Definitions

abort sequence. A sequence that terminates the transmission of a frame prematurely.

accumulated jitter. The jitter measured against the clock of the active monitor. Like alignment jitter, this is not a type of jitter but a way to measure total jitter growth throughout the ring. It is normally used to determine the required size of the elastic buffer.

alignment jitter. The jitter measured against the clock of the upstream adapter. This is not a type of jitter per se; rather, it is a way to measure jitter. When “zero transferred jitter” is specified, the jitter measured is alignment jitter.

broadcast transmission. A transmission addressed to all stations.

channel. The channel is the transmission path from the MIC at the transmitter to the first MIC at the receiver. It may include trunk coupling units (TCUs) and connectors in addition to transmission line.

configuration report server (CRS). A function that controls the configuration of the ring. It receives configuration information from the stations on the ring, and either forwards them to the network manager, or uses them to maintain a configuration of the ring. It can also, when requested by the network manager, check the status of stations on the ring, change operation parameters of stations on the ring, and remove stations from the ring.

correlated jitter. The portion of the total jitter that is related to the data pattern. Since every adapter receives the same *pattern*, this jitter is *correlated* among all adapters and therefore grows in a *systematic* way along the ring. Correlated jitter is also called *pattern jitter* or *systematic jitter*.

differential Manchester encoding. A signalling method used to encode clock and data bit information into bit symbols. Each bit symbol is split into two halves, where the second half is the inverse symbol of the first half. A 0 bit is represented by a polarity change at the start of the bit time. A 1 bit is represented by no polarity change at the start of the bit time. Differential Manchester encoding is polarity-independent.

fill. A bit sequence that may be either 0 bits, 1 bits, or any combination thereof.

frame. A transmission unit that carries a protocol data unit (PDU) on the ring.

jitter. The time-varying difference between the phase of the recovered clock and the phase of the source clock. Jitter is measured in fractions of a clock cycle, or unit interval (UI).

logical link control sublayer (LLC). That part of the data link layer that supports media-independent data link functions, and uses the services of the MAC to provide services to the network layer.

medium. The material on which the data may be represented. Twisted pairs, coaxial cables, and optical fibers are examples of media.

medium access control sublayer (MAC). The portion of the IEEE 802 data station that controls and mediates the access to the ring.

medium interface connector (MIC). The connector between the station and TCU at which all transmitted and received signals are specified.

monitor. The monitor is that function that recovers from various error situations. It is contained in each ring station; however, only the monitor in one of the stations on a ring is the *active monitor* at any point in time. The monitor function in all other stations on the ring is in standby mode.

multiple frame transmission. A transmission where more than one frame is transmitted when a token is captured.

physical layer (PHY). The layer responsible for interfacing with the medium, detecting and generating signals on the medium, and converting and processing signals received from the medium and the MAC.

protocol data unit (PDU). Information delivered as a unit between peer entities that contain control information and, optionally, data.

repeat. The action of a station in receiving a bit stream (for example, frame, token, or fill) from the previous station and placing it on the medium to the next station. The station repeating the bit stream may copy it into a buffer or modify control bits as appropriate.

repeater. A device used to extend the length, topology, or interconnectivity of the transmission medium beyond that imposed by a single transmission segment.

ring error monitor (REM). A function that collects ring error data from ring stations. The REM may log the received errors, or analyze this data and record statistics on the errors.

ring latency. In a token ring MAC system, the time (measured in bit times at the data transmission rate) required for a signal to propagate once around the ring. The ring latency time includes the signal propagation delay through the ring medium plus the sum of the propagation delays through each station connected to the token ring.

ring parameter server (RPS). That function that is responsible for initializing a set of operational parameters in ring stations on a particular ring.

service data unit (SDU). Information delivered as a unit between adjacent entities that may also contain a PDU of the upper layer.

station (or data station). A physical device that may be attached to a shared medium local area network for the purpose of transmitting and receiving information on that shared medium. A data station is identified by a destination address (DA).

static phase offset. The constant difference between the phase of the recovered clock and the optimal sampling position of the received data.

station management (SMT). The conceptual control element of a station that interfaces with all of the layers of the station and is responsible for the setting and resetting of control parameters, obtaining reports of error conditions, and determining if the station should be connected to or disconnected from the medium.

token. The symbol of authority that is passed between stations using a token access method to indicate which station is currently in control of the medium.

transferred jitter. The amount of jitter in the recovered clock of the upstream adapter. Transferred jitter is important because each adapter must both limit the amount of jitter it generates, and track the jitter delivered by the upstream adapter.

transmit. The action of a station generating a frame, token, abort sequence, or fill and placing it on the medium to the next station. In use, this term contrasts with *repeat*.

trunk cable. The transmission cable that interconnects two TCUs.

trunk coupling unit (TCU). A physical device that enables a station to connect to a trunk cable. The TCU contains the means for inserting the station into the ring or, conversely, bypassing the station.

uncorrelated jitter. The portion of the total jitter that is independent of the data pattern. This jitter is generally caused by *noise* that is *uncorrelated* among adapters and therefore grows in a *nonsystematic* way along the ring. Uncorrelated jitter is also called noise jitter or nonsystematic jitter.

unit interval (UI). One half of a bit time. 125 ns for 4 Mbit/s transmission and 31.25 ns for 16 Mbit/s transmission. UI is used in the specification of jitter.

upstream neighbor's address (UNA). The address of the station functioning upstream from a specific station.

1.3 Abbreviations

A = address-recognized bit
AC = access control (field)

AMP	=	active monitor present
BCN	=	beacon
C	=	frame-copied bit
CL	=	claim
CRS	=	configuration report server
DA	=	destination address
DAT	=	duplicate address test
DC	=	destination class
E	=	error-detected bit
ED	=	ending delimiter
EFS	=	end-of-frame sequence
ETR	=	early token release
FA	=	functional address
FAI	=	functional address indicator
FC	=	frame control (field)
FCS	=	frame-check sequence
FR	=	frame
FS	=	frame status (field)
I	=	intermediate frame bit
LAN	=	local area networks
LLC	=	logical link control (sublayer)
M	=	monitor bit
MA	=	my (station's) address
MAC	=	medium access control (sublayer)
MIC	=	medium interface connector
P	=	priority (of the AC)
PDU	=	protocol data unit
PHY	=	physical (layer)
Pm	=	priority of queued PDU
Pr	=	last priority value received
PRG	=	purge
Px	=	the greater value of Pm or Rr
R	=	reservation (of the AC)
REM	=	ring error monitor
RPS	=	ring parameter server
Rr	=	last reservation value received
RUA	=	received upstream neighbor's address
SA	=	source address
SD	=	starting delimiter
SDU	=	service data unit
SFS	=	start-of-frame sequence
SMP	=	standby monitor present
SMT	=	station management
Sr	=	highest stacked received priority
SUA	=	stored upstream neighbor's address
Sx	=	highest stacked transmitted priority

TAM = timer, active monitor
TCU = trunk coupling unit
THT = timer, holding token
TK = token
TNT = timer, no token
TQP = timer, queue PDU
TRR = timer, return to repeat
TSM = timer, standby monitor
TVX = timer, valid transmission
TX = transmit
UI = unit interval
UNA = upstream neighbor's address

1.4 References. This standard shall be used in conjunction with the following publications or their approved revisions:

- [1] CISPR Publication 22 (1985), Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.¹
- [2] IEC Publication 380 (1985) (2nd Edition), Safety of Electronically Energized Office Machines.
- [3] IEC Publication 435 (1983) (3rd Edition), Safety of Data Processing Equipment.
- [4] IEC Publication 950 (1986), Safety of Information Technology Equipment.
- [5] ISO Management Architecture, ISO/DIS 7499 Part 4, OSI Management Framework.²

¹ CISPR and IEC publications are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, USA. These publications are also available from International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211, Genève 20, Switzerland/Suisse.

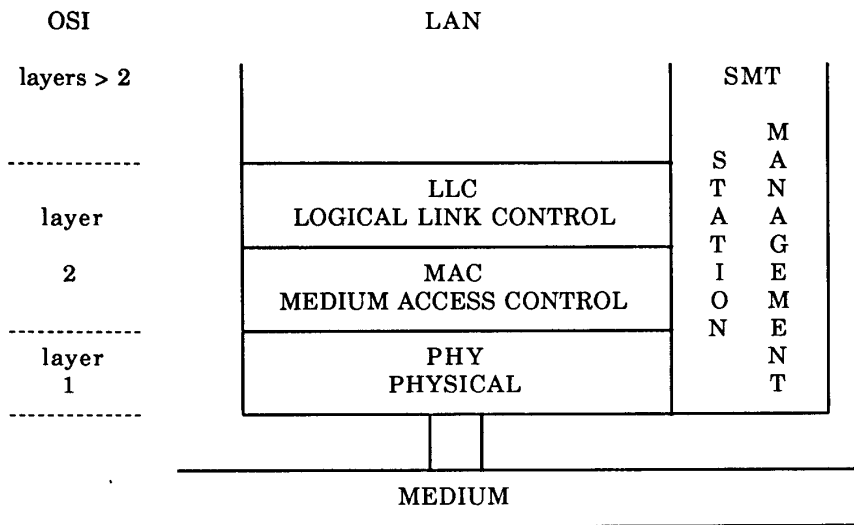
² This draft document is currently in production; when it is published it will become a part of the references of this standard.

2. General Description

There are two important ways to view local area network design: architectural, which emphasizes the logical divisions of the system and how they fit together, and implementational, which emphasizes the actual components, their packaging, and their interconnection.

This standard presents the architectural view, emphasizing the large-scale separation of the system into two parts: the MAC of the data link layer and the PHY. These layers are intended to correspond closely to the lowest layers of the ISO Basic Reference Model of Open Systems Interconnection (see Fig 2-1). The LLC and MAC together encompass the functions intended for the data link layer of the OSI model.

Fig 2-1
Relation of the OSI Reference Model to the LAN Model



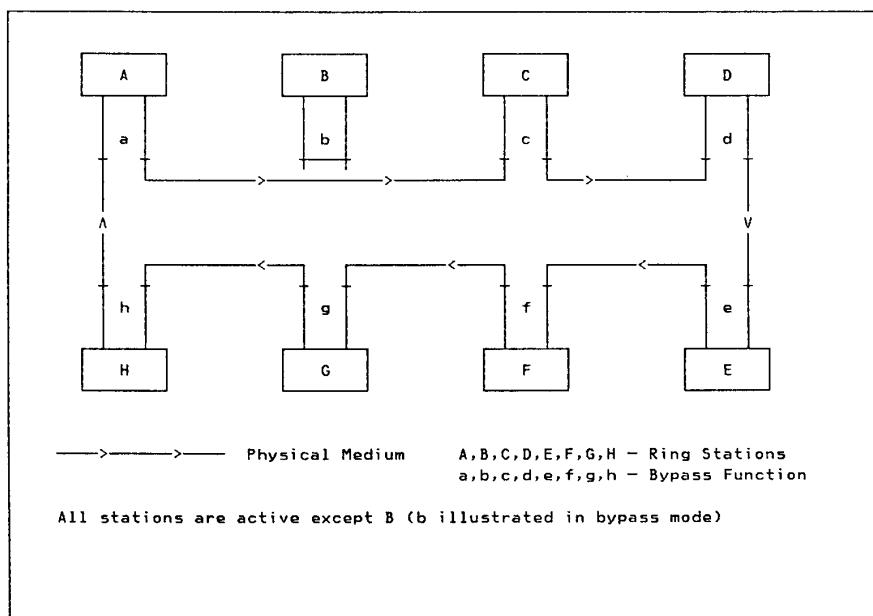
An architectural organization of the standard has the advantages of clarity (a clean overall division of the design along architectural lines makes the standard clearer) and flexibility (segregation of the access-method-dependent aspects of the MAC and PHY allows the LLC to apply to a variety of LAN access methods).

It should be noted that the exact relationship of the layers described in this standard to the layers defined by the OSI Reference Model is for further study.

A token ring consists of a set of stations serially connected by a transmission medium. (See Fig 2-2.) Information is transferred sequentially, bit by bit, from one active station to the next. Each station generally regenerates and repeats each bit and serves as the means for attaching one or more devices (terminals, work stations) to the ring for the purpose of communicating with other devices on the network. A given station (the one that has access to the medium) transfers information onto the ring, where the information circulates from one station to the next. The addressed destination station(s) *copies* the information as it passes. Finally, the station that transmitted the information effectively removes the information from the ring.

A station gains the right to transmit its information onto the medium when

Fig 2-2
Token Ring Configuration



it detects a token passing on the medium. The token is a control signal comprised of a unique signalling sequence that circulates on the medium following each information transfer. Any station, upon detection of an appropriate token, may capture the token by modifying it to a SFS and appending appropriate control and status fields, address fields, information field, FCS, and the EFS. At the completion of its information transfer and after appropriate checking for proper operation, the station initiates a new token, which provides other stations the opportunity to gain access to the ring.

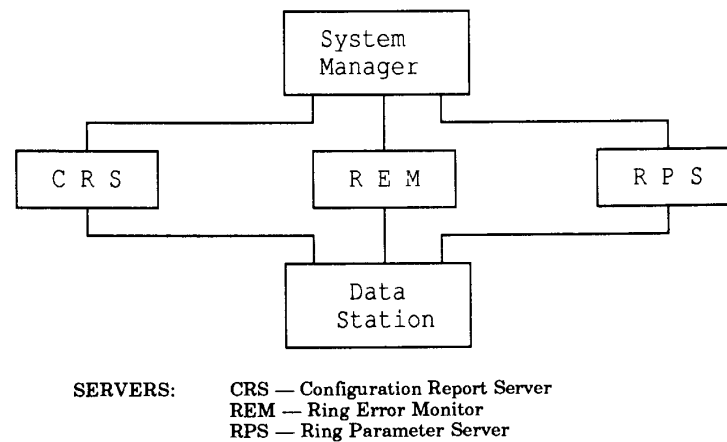
A token holding timer controls the maximum period of time a station shall use (occupy) the medium before passing the token.

Multiple levels of priority are available for independent and dynamic assignment depending upon the relative class of service required for any given message, for example, synchronous (real-time voice), asynchronous (interactive), immediate (network recovery). The allocation of priorities shall be by mutual agreement among users of the network.

Error detection and recovery mechanisms are provided to restore network operation in the event that transmission errors or medium transients (for example, those resulting from station insertion or removal) cause the access method to deviate from normal operation. Detection and recovery for these cases utilizes a network monitoring function that is performed in a specific station with back-up capability in all other stations that are attached to the ring.

Each ring in a token ring network has a set of server stations (*servers*) that are the means through which the systems manager manages the stations in a token ring system. Such arrangement is depicted in Fig 2-3.

Fig 2-3
Relationship of Data Stations, Servers, and System Manager



Servers are data collection and distribution points on each ring where reports from the data stations are gathered. Servers then communicate the necessary information to the systems manager for the purpose of managing a token ring system.

Data stations communicate with the servers by reporting errors that are detected such as lost token, FCS error, or lost frames, and requesting operating parameters when inserting into the ring, reporting changes in configuration due to insertion or removal of stations (UNA changes), responding to requests for various status information, and removal from the ring when requested.

The station to server message format and content is specified in Section 3; and the protocol for message exchange specified in Section 4.

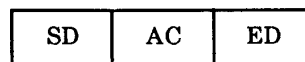
The specification of the format and protocol for the information interchange between the servers and the systems manager is not covered by this standard. However, the abstract entities (parameters, events, and actions) specified in 6.3 and 6.4 are the elements of such communication.

3. Formats and Facilities

3.1 Formats. There are two basic formats used in token rings: tokens and frames. In the following discussion, the figures depict the formats of the fields *in the sequence they are transmitted on the medium*, with the left-most bit or symbol transmitted first.

Processes that require comparison of fields or bits perform that comparison upon those fields or bits *as depicted*, with the left-most bit or symbol compared first and, for the purpose of comparison, considered most significant.

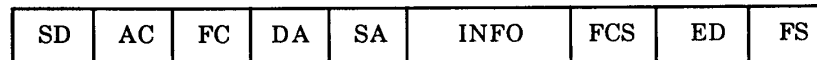
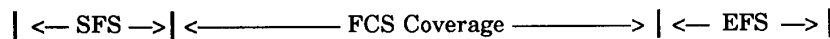
3.1.1 Token Format



SD = Starting Delimiter (1 octet)
AC = Access Control (1 octet)
ED = Ending Delimiter (1 octet)

The token shall be the means by which the right to transmit (as opposed to the normal process of repeating) is passed from one station to another.

3.1.2 Frame Format



SFS = Start-of-Frame Sequence
SD = Starting Delimiter (1 octet)
AC = Access Control (1 octet)
FC = Frame Control (1 octet)
DA = Destination Address (2 or 6 octets)
SA = Source Address (2 or 6 octets)

INFO = Information (0 or more octets) *
FCS = Frame-Check Sequence (4 octets)
EFS = End-of-Frame Sequence
ED = Ending Delimiter (1 octet)
FS = Frame Status (1 octet)

* See 3.2.5 for limitation of information field length.

The frame format shall be used for transmitting both MAC and LLC messages to the destination station(s). It may or may not have an information field.

3.1.2.1 Abort Sequence



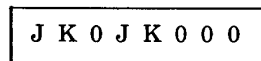
This sequence shall be used for the purpose of terminating the transmission of a frame prematurely. The abort sequence may occur anywhere in the bit stream; that is, receiving stations shall be able to detect an abort sequence even if it does not occur on octet boundaries.

3.1.3 Fill. When a station is transmitting (as opposed to repeating), it shall transmit fill preceding or following frames, tokens, or abort sequences to avoid what would otherwise be an inactive or indeterminate transmitter state.

Fill may be either 0 or 1 bits or any combination thereof and may be *any number* of bits in length, within the constraints of the THT.

3.2 Field Descriptions. The following is a detailed description of the individual fields in the tokens and frames.

3.2.1 Starting Delimiter (SD)

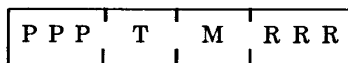


J = non-data-J
K = non-data-K
0 = zero bit

(For a discussion of non-data symbols, see 5.1)

A frame or token shall be started with these eight symbols. If otherwise, it shall not be considered valid.

3.2.2 Access Control (AC)



PPP = priority bits
T = token bit
M = monitor bit
RRR = reservation bits

3.2.2.1 Priority Bits. The priority bits shall indicate the priority of a token and, therefore, which stations are allowed to use the token. In a multiple-priority system, stations use different priorities depending on the priority of the PDU to be transmitted.

The eight levels of priority increase from the lowest (000) to the highest (111) priority. For purposes of comparing priority values, the priority shall be transmitted most significant bit first; for example, 110 has higher priority than 011 (left-most bit transmitted first).

3.2.2.2 Token Bit. The token bit is a 0 in a token and a 1 in a frame. When a station with a PDU to transmit detects a token that has a priority equal to or less than the PDU to be transmitted, it may change the token to a SFS and transmit the PDU.

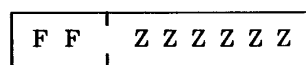
3.2.2.3 Monitor (M) Bit. The M bit is used to prevent a token that has a priority greater than 0 or any frame from continuously circulating on the ring. If an active monitor detects a frame or a high priority token with the M bit equal to 1, the frame or token is aborted.

This bit shall be transmitted as 0 in all frames and tokens. The active monitor inspects and modifies this bit. All other stations shall repeat this bit as received.

3.2.2.4 Reservation Bits. The reservation bits allow stations with high priority PDUs to request (in frames or tokens as they are repeated) that the next token be issued at the requested priority. The precise protocol for setting these bits is described in 4.2.2.

The eight levels of reservation increase from 000 to 111. For purposes of comparing reservation values, the reservation shall be transmitted most significant bit first; for example, 110 has higher priority than 011 (left-most bit transmitted first).

3.2.3 Frame Control (FC)



FF = frame-type bits
ZZZZZZ = control bits

The FC field defines the type of the frame and certain MAC and information frame functions.

3.2.3.1 Frame-type Bits. The frame-type bits shall indicate the type of the frame as follows:

- 00 = MAC frame (contains a MAC PDU)
- 01 = LLC frame (contains an LLC PDU)
- 1x = undefined format (reserved for future use)

MAC Frames. If the frame-type bits indicate a MAC frame, all stations on the ring shall interpret and, based on the finite state of the station, act on the ZZZZZZ control bits.

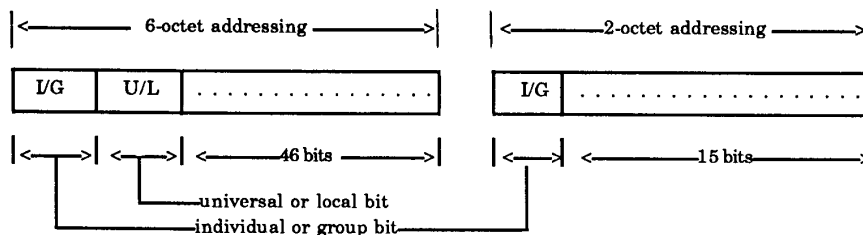
LLC Frames. If the frame-type bits indicate an LLC frame, the ZZZZZZ bits are designated as rrrYYY. The rrr bits are reserved and shall be transmitted as 0's in all transmitted frames and ignored upon reception. The YYY bits may be used to carry the priority (Pm) of the PDU from the source LLC entity to the target LLC entity or entities. Note that P (the priority in the AC field of a frame) is less than or equal to Pm when the frame is transmitted onto the ring.

Undefined Format. The value "1x" is reserved for frame types that may be

defined in the future. However, although currently undefined, any future frame formats shall adhere to the following conditions:

- (1) The format shall be delimited by the 2-octet SFS field and the 2-octet EFS field, as defined in this standard. Additional fields may follow the EFS field.
- (2) The position of the FC field shall be unchanged.
- (3) The SFS and EFS of the format shall be separated by an integral number of octets. This number shall be at least 1 (that is, the FC field) and the maximum length is subject to the constraints of the THT.
- (4) All symbols between the SFS and EFS shall be 0 and 1 bits.
- (5) All stations on the ring check for data symbols and an integral number of octets between the SFS and EFS fields. The error-detected (E) bit of formats that are repeated shall be set to 1 when a non-data symbol or a non-integral number of octets is detected between the SFS and EFS fields.
- (6) All bit errors that occur in the FC field that have a hamming distance of less than four must be detectable by stations using this format and shall not be accepted by any other station conforming to this standard.

3.2.4 Destination and Source Address (DA and SA) Fields. Each frame shall contain two address fields: the destination (station) address and the source (station) address, in that order. Addresses may be either 2 or 6 octets in length; however, all stations of a specific LAN shall have addresses of equal length.



3.2.4.1 Destination Address (DA). The DA identifies the station(s) for which the information field of the frame is intended. Included in the DA is a bit to indicate whether the DA is an individual or group address and, for 6-octet addresses only, the second bit indicates whether it is a universally or locally administered address.

Individual and Group Addresses. The first bit transmitted of the DA distinguishes individual from group addresses:

0 = individual address

1 = group address

Individual addresses identify a particular station on the LAN and shall be distinct from all other individual station addresses on the same LAN (in the

case of local administration), or from the individual addresses of other LAN stations on a global basis (in the case of universal administration).

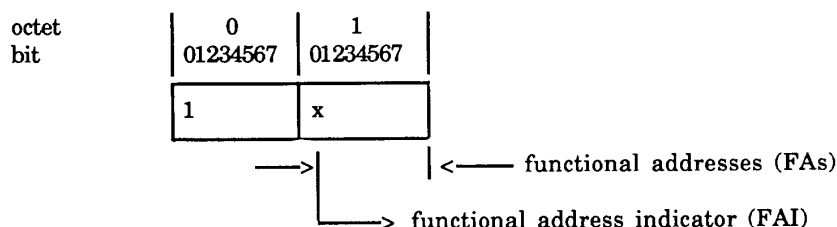
A group address shall be used to address a frame to multiple destination stations. Group addresses may be associated with zero or more stations on a given LAN. In general, a group address is an address associated by convention with a group of logically related stations.

Broadcast Address. The group address consisting of 16 or 48 1's (for 2- or 6-octet addressing, respectively) shall constitute a broadcast address, denoting the set of all stations on a given LAN. Stations using 48-bit addressing must also recognize X'C000FFFFFFFF' as a broadcast address in MAC frames.

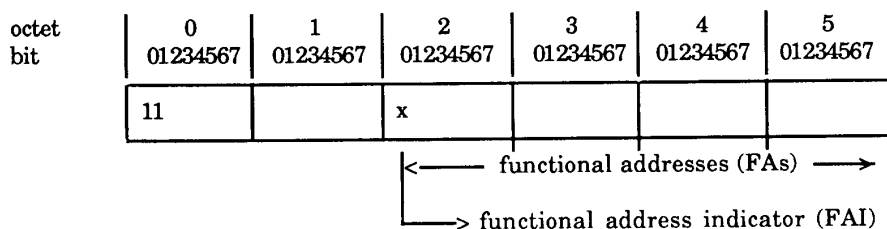
Null Address. An address of 16 or 48 0's (for 2- or 6-octet addressing, respectively) shall be considered a null address. It will mean the frame is not addressed to any particular station.

Functional Addresses (FAs). FAs are a subset of locally administered group addresses. They are bit-significant addresses used to identify well-known functional entities. The Functional Address Indicator (FAI) identifies a FA versus a conventional group MAC address. This indicator is set to a B'1' for conventional group addresses and B'0' for FAs.

2-Octet Addressing



6-Octet Addressing



The following functional addresses are defined:

Function Name	Functional Address (FA)	
	2-Octet	6-Octet
Active monitor	X'01'	X'00000001'
Ring parameter server (RPS)	X'02'	X'00000002'
Ring error monitor (REM)	X'08'	X'00000008'
Configuration report server (CRS)	X'10'	X'00000010'

Address Administration. There are two methods of administering the set of 6-octet station addresses: locally or through a universal authority. The second bit transmitted of the DA indicates whether the address has been assigned by a universal or local administrator:

0 = universally administered

1 = locally administered

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

Information concerning the registration authority and its procedures may be obtained on request to the Secretary General, ISO Central Secretariat, Case Postal 56, CH-1211 Genève, Switzerland.

For information on global address administration contact the Registration Authority for ISO 8802-5, c/o The Institute of Electrical and Electronics Engineers, Inc, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331, USA.

Local Administration. Individual station addresses are administered by a local (to the LAN) authority. (This is the only method allowed for 2-octet addresses.)

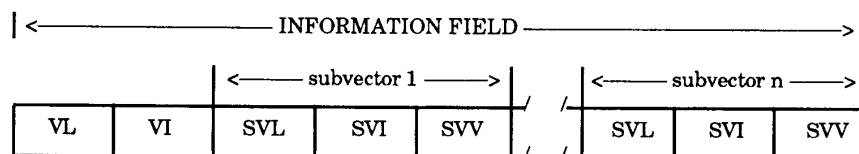
3.2.4.2 Source Address (SA) Field. The SA shall identify the station originating the frame and shall have the same format and length as the DA in a given frame. The individual/group bit shall be 0.

3.2.5 Information (INFO) Field. The information field contains zero, one, or more octets that are intended for MAC, SMT, or LLC. Although there is no maximum length specified for the information field, the time required to transmit a frame may be no greater than the token holding period that has been established for the station.

The format of the information field is indicated in the frame-type bits of the FC field. The frame types defined are MAC frame and LLC frame.

3.2.5.1 MAC Frame Format. Figure 3-1 defines the format of the information field, when present, for MAC frames.

Vector. The fundamental unit of MAC and SMT information. A vector contains its length, an identifier of its function, and zero or more subvectors. Only one vector is permitted per MAC frame.



VL (2 octets) = vector length
 VI (2 octets) = vector identifier
 SVL (1 octet) = subvector length
 SVI (1 octet) = subvector identifier
 SVV (n octets) = subvector value

Fig 3-1
MAC Frame Information Field Structure

VL (vector length). A 16-bit binary number that gives the length, in octets, of the vector. The length includes the VL field and can have values such that $X'0004' \leq VL \leq X'FFFF'$ (subject to the constraints of the THT (token holding timer)).

VI (vector identifier). A 2-octet code point that identifies the vector.

DESTINATION CLASS (DC) (4 bits)	SOURCE CLASS (4 bits)	VECTOR CODE (8 bits)
------------------------------------	--------------------------	-------------------------

The first octet of the vector identifier of a MAC frame is divided into two 4-bit function class fields. The DC provides a means to route the frame to the appropriate management function within a ring station. The source class provides the ring station the ability to ensure that the source of the vector is valid. The function classes are as follows:

Function Class	Class Value
Ring Station (RS)	X'0'
Configuration report server (CRS)	X'4'
Ring parameter server (RPS)	X'5'
Ring error monitor (REM)	X'6'

The second octet of the vector identifier is the code that uniquely identifies the vector.

Code points from X'C0' through X'FE' are unreserved and are set aside to permit the implementer to define special system-dependent functions that do not have general applicability. Such special system-dependent functions are beyond the scope of this standard.

SV (subvector). Vectors require all data or modifiers to be contained within subvectors. One subvector is required to contain each piece of data or modifier that is being transported. A subvector is not position-dependent within a vector, but rather, each subvector must be identified by its subvector identifier.

SVL (subvector length). An 8-bit binary number that gives the length, in octets, of the subvector. The length includes the length of the SVL field. A subvector length of X'FF' means that the subvector is longer than 254 octets and the actual length is included in the next two octets.

SVI (subvector identifier). A 1-octet code point that identifies the subvector. The code point of X'FF' indicates that an expanded identifier is being used and is contained in the next two octets.

The subvectors are of two types. The subvectors with code points from X'00' through X'7F' are used so that certain specific strings that are common to many vectors can be formatted and labeled in a standard manner. This standardization is intended to facilitate sharing of data between MAC and SMT applications and make the data as application-independent as possible.

The subvectors with code points from X'80' through X'FE' are for specific definition within a particular vector by vector identifier. For example, the subvector X'90' can have an entirely different definition in every different vector. The subvector X'40' has only one definition across all vectors and applications.

Subvectors themselves may contain other subvectors and other types of vectors and optional fields that are unique only to the particular subvector to which they belong.

3.2.5.2 LLC Frame Format. The format of the information field for LLC frames is not specified in this standard. However, in order to promote interworking among stations, all stations shall be capable of receiving frames whose information field is up to and including 133 octets in length.

3.2.5.3 Order of Bit Transmission. Each octet of the information field shall be transmitted most significant bit first.

3.2.6 Frame Check Sequence (FCS). The FCS shall be a 32-bit sequence based on the following standard generator polynomial of degree 32.

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

The FCS shall be the 1's complement of the sum (modulo 2) of the following:

- (1) The remainder of $X^k \times (X^{31} + X^{30} + X^{29} + \dots + X^2 + X + 1)$ divided (modulo 2) by $G(X)$, where k is the number of bits in the FC, DA, SA, and INFO fields, and
- (2) The remainder after multiplication by X^{32} and then division (modulo 2) by $G(X)$ of the content (treated as a polynomial) of the FC, DA, SA, and INFO fields.

The FCS shall be transmitted commencing with the coefficient of the highest term.

As a typical implementation, at the transmitter, the initial remainder of the division is preset to all 1's and is then modified by division of the FC, DA, SA,

and INFO fields by the generator polynomial, $G(X)$. The 1's complement of this remainder is transmitted, most significant bit first, as the FCS.

At the receiver, the initial remainder is preset to all 1's and the serial incoming bits of FC, DA, SA, INFO, and FCS, when divided by $G(X)$, results, in the absence of transmission errors, in a unique non-zero remainder value. The unique remainder value is the polynomial:

$$X^{31} + X^{30} + X^{26} + X^{25} + X^{24} + X^{18} + X^{15} + X^{14} + X^{12} + X^{11} + X^{10} + X^8 + X^6 + X^5 + X^4 + X^3 + X + 1$$

3.2.7 Ending Delimiter (ED)



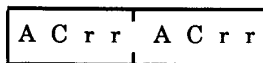
J = non-data-J
 K = non-data-K
 1 = binary one
 I = intermediate frame bit
 E = error-detected bit

The transmitting station shall transmit the delimiter as shown. Receiving stations shall consider the ED valid if the first six symbols J K 1 J K 1 are received correctly.

3.2.7.1 Intermediate Frame Bit (I Bit). If the I flag is utilized to determine the end of a station's transmission, the I bit shall be transmitted as 1 in intermediate (or first) frames of a multiple frame transmission. The I bit in the last or only frame of the transmission shall be transmitted as 0.

3.2.7.2 Error-Detected Bit (E Bit). The E bit shall be transmitted as 0 by the station that originates the token, abort sequence, or frame. All stations on the ring check tokens and frames for errors (for example, FCS error, non-data symbols: see 4.2.1). The E bit of tokens and frames that are repeated shall be set to 1 when a frame with error is detected; otherwise the E bit is repeated as received.

3.2.8 Frame Status (FS)



A = address recognized bits
 C = frame copied bits
 r = reserved bits

These reserved bits are reserved for future standardization. They shall be transmitted as 0's; however, their value shall be ignored by the receivers.

3.2.8.1 Address Recognized (A) Bits and Frame Copied (C) Bits. The A and C bits shall be transmitted as 0 by the station originating the frame. If another station recognizes the DA as its own address or relevant group address it shall set the A bits to 1. If it copies the frame (into its receive buffer), it shall also set the C bits to 1. This allows the originating station to differentiate among three conditions:

- (1) Station non-existent/non-active on this ring
- (2) Station exists but frame not copied
- (3) Frame copied

The A and C bits shall be set without regard to the value of the E bit and only if the frame is *good* as defined in 4.2.1. Only the values that are 00rr 00rr, 10rr 10rr, and 11rr 11rr shall be considered valid. All other values are invalid and ignored by the receiver.

If a destination station detects that the A bits have already been set, and the DA is not a group address, it may imply that a duplicate address problem exists. The second condition (station existent but frame not copied) allows the originating station to log the instances when, for example, congestion has prevented a destination station from copying the frame.

3.3 Medium Access Control (MAC) Frames. The following are descriptions of various MAC frames that are used in the management of the token ring. Values for PDU priority (Pm), FC, DA, INFO field content (Vector Identifier—VI, Subvector Identifier—SVI, and Subvector Value—SVV) associated with the particular MAC supervisory frame are indicated in 3.3.3.

Frames with the following FC values are to be handled as follows:

- (1) If the value of the FC of the frame is X'00' and it is addressed to the station, it will be copied only if there is sufficient free buffer available for copying.
- (2) If the value of the FC of the frame is X'01' and it is addressed to the station, every effort will be made to copy the frame including overwriting previously received information.
- (3) If the value of the FC of the frame is greater than X'01', it will be addressed to all stations on the ring. It will be copied only if there is sufficient free buffer available for copying. If the frame is not copied, action will be based on the value of the FC field.

The digits enclosed by X' and ' (for example, X'07') are the hexadecimal value of the assigned code point. Values other than those defined below will be ignored by the receiving station(s). All unassigned values are reserved for future specification. The general format for the information field of MAC frames is described under 3.2.5.

3.3.1 Vector Description

3.3.1.1 Claim Token MAC Frame (CL_TK). When a station that is in standby state determines that there is no active monitor operating on the ring, it shall enter a *claiming token* state. While in this state the station shall send claim token frames and inspect the SA of the claim token MAC frames it receives. If the SA matches its own MA and the RUA subvector matches the SUA, it has claimed the token and shall enter active monitor mode and generate a new token. (For a more detailed description, see Fig 4-5.)

3.3.1.2 Duplicate Address Test MAC Frame (DAT). This frame is transmitted with DA equal to MA as part of the initialization process. If the frame returns with the A bits set to 1, it indicates that there is another station on the

ring with the same address. If such an event occurs, the station's network manager is notified and the station returns to bypass state. A station that copies a DAT frame will ignore it.

3.3.1.3 Active Monitor Present MAC Frame (AMP). This frame is transmitted by the active monitor. It shall be queued for transmission following the successful purging of the ring or following the expiration of the TAM. Any station in standby state that receives this frame shall reset its TSM.

An AMP is transmitted at the ring service priority (Pr) that exists at the time a token is received after an AMP PDU is queued. The default value for Pm for this frame is seven; see 6.3.2.1 to change this value.

3.3.1.4 Standby Monitor Present MAC Frame (SMP). This frame is transmitted by the standby monitor(s). After receipt of an AMP or SMP frame whose A and C bits equal 0, the TQP is reset. When timer TQP expires, an SMP PDU shall be queued for transmission.

The queueing of a SMP PDU is delayed for a period of TQP to assure that the transmission of SMP frames do not use more than 1% of the bandwidth of the ring in any TQP period of time.

Stations that receive an AMP or SMP frame in which the value of the A and C bits are 0 will regard the frame as having originated from their upstream neighbor's station. Therefore, a station that copies such a frame shall record the SA contained in the frame as the SUA for later transmission as a subvector in certain MAC frames as well as performing a comparison with certain MAC frames.

3.3.1.5 Beacon MAC Frame (BCN). This frame shall be sent as a result of serious ring failure (for example, broken cable, jabbering station, etc). It is useful in localizing the fault. The transmission of BCN is covered in Fig 4-5.

The immediate upstream station is part of the failure domain about which the BCN is reporting. Therefore, as noted above, the address of the upstream station that was previously recorded is included in the MAC info field.

3.3.1.6 Purge MAC Frame (PRG). This frame is transmitted by the active monitor. It shall be transmitted following claiming the token or to perform reinitialization of the ring following the detection of an M bit set to 1 or the expiration of timer TVX.

3.3.1.7 Change Parameters MAC Frame (CHG_PARM). This frame is sent by the CRS to set appropriate ring operational values.

3.3.1.8 Initialize Ring Station (INIT). This frame is sent by the RPS in response to the Request Initialization MAC frame sent to the RPS. This frame sets appropriate ring operational values in a station.

3.3.1.9 Lobe Media Test MAC Frame (TEST). This frame can be sent by a station to test the continuity and bit error rate of the wire in a loop-back path, prior to the station's physical insertion in the ring. The DA field of this frame is the null address (16 or 48 zeros). The wrap data is a bit string that can be chosen arbitrarily by the transmitting station.

3.3.1.10 Remove Ring Station MAC Frame (REMOVE). This frame is sent by the CRS to a specific station causing an unconditional removal.

3.3.1.11 Report Error MAC Frame (ERROR). This frame is sent by a sta-

tion to the REM. When a timer expires, the values of the counters are reported, if they have been incremented since the last expiration. If a counter overflows before the threshold timer expires, the counter values are reported at the time of the overflow. A timer value of 0 implies no report will be sent.

3.3.1.12 Report Active Monitor Error MAC Frame (ACTIVE_ERROR). This frame is sent by the active monitor to the REM when it receives a Purge or an AMP MAC frame that it did not transmit, or when it receives a Claim Token MAC frame. In this case this indicates that a duplicate active monitor or another station has detected an error in the active monitor. It is also sent by a station in Claim Token State if it receives a Claim Token MAC frame in which the SA is equal to the MA but $RUA \neq SUA$. In this case, this report indicates a possible duplicate address on the ring.

3.3.1.13 Report Neighbor Notification Incomplete MAC Frame (NN_INCOMP). This frame is sent by the active monitor to the REM when its TAM expires before the completion of the neighbor notification process, detected by not receiving an AMP or SMP with A equal to C equal to 0. It indicates a congested station, a failing station, or a high bit error rate on the ring.

3.3.1.14 Report New Active Monitor MAC Frame (NEW_MON). This frame is sent by a station to the CRS to report that it has become the active monitor.

3.3.1.15 Report Ring Station Addresses MAC Frame (RPT_ADDR). This frame is sent by a station to the sender of Request Ring Station Addresses MAC frame.

3.3.1.16 Report Ring Station Attachments MAC Frame (RPT_ATTCH). This frame is sent by a station to the sender of Request Ring Station Attachments MAC frame.

3.3.1.17 Report Ring Station State MAC Frame (RPT_STATE). This frame is sent by a station to the sender of Request Ring Station State MAC frame.

3.3.1.18 Report SUA Change MAC Frame (SUA_CHG). This frame is sent by a station to the CRS when a change is made in the station's SUA as the result of the neighbor notification process.

3.3.1.19 Request Initialization MAC Frame (RQ_INIT). This frame is sent by a station to its RPS after successfully inserting (transition made to Standby State) in the ring. This is to inform the RPS that a station has been inserted and will accept modified parameters from either the RPS or CRS.

3.3.1.20 Request Ring Station Addresses MAC Frame (RQ_ADDR). This frame is sent by one of the management servers (CRS, REM, or RPS) to a specific station to request the different addresses recognized by the ring station.

3.3.1.21 Request Ring Station Attachments MAC Frame (RQ_ATTCH). This frame is sent by one of the management servers (CRS, REM, or RPS) to a specific station to request information on the functions active in the ring station.

3.3.1.22 Request Ring Station State MAC Frame (RQ_STATE). This frame is sent by one of the management servers (CRS, REM, or RPS) to a specific station to request the state information of the ring station.

3.3.1.23 Response MAC Frame (RSP). This frame is sent by a station to acknowledge receipt of, or to report an error (for example a syntax error) in, a received MAC frame. It reports on whether or not the corresponding received frame was processed correctly by the receiving station.

The MAC frames requiring a response include Change Parameters MAC frame and Initialize Ring Station MAC frame.

3.3.2 Subvector Descriptions. Below is a list of subvectors, listed in alphabetical order, along with their respective subvector values.

3.3.2.1 Assign Physical Drop Number. This subvector has a value field 4 octets long. It specifies the physical location of the target station. It is installation-dependent.

3.3.2.2 Authorized Access Priority. This subvector has a value field 2 octets long. The system administrator assigns maximum priorities to each station.

3.3.2.3 Authorized Function Classes. This subvector has a value field 2 octets long. It indicates the functional classes that are allowed to be active in the station. Valid range is B'0000 0000 0000 0000' to B'1111 1111 1111 1111' where each bit 0 to 15 corresponds to function class B'0000' to B'1111'. Defined function classes are the following:

Function Class	Class Value
Ring Station (RS)	X'0'
Configuration report server (CRS)	X'4'
Ring parameter server (RPS)	X'5'
Ring error monitor (REM)	X'6'

3.3.2.4 BCN Type. This subvector has a value field 2 octets long and is used to indicate the type of error detected. It has one of the following possible values:

X'0001'—Issued by station during reconfiguration (for future study)

X'0002'—Continuous J symbols received

X'0003'—Timer TNT expired during claiming token; no FR_CL_TK received

X'0004'—Timer TNT expired during claiming token; FR_CL_TK (SA<MA) received

3.3.2.5 Correlator. This subvector has a value field 2 octets long and is used by the sending station to relate its transmitted requests with the responses it receives. Any pattern of bits may be used as the correlator.

3.3.2.6 Error Code. This subvector has a value field 2 octets long and is used in the Report Active Monitor Error MAC frame. It has the following code points:

X'0001'—Active monitor error, used when the active monitor receives a Claim Token MAC frame, indicating that another station detected an error in the active monitor.