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

Part 5:

**Token ring access method and physical layer
specifications**

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

*Partie 5: Méthode d'accès par anneau à jeton et spécifications pour la
couche physique*



Reference number
ISO/IEC 8802-5:1998(E)
ANSI/IEEE
Std 802.5, 1998 Edition



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Abstract: This Local and Metropolitan Area Network standard, ISO/IEC 8802-5 : 1998, is part of a family of local area network (LAN) standards dealing with the physical and data link layers as defined by the ISO/IEC Open Systems Interconnection Basic Reference Model. Its purpose is to provide compatible interconnection of data processing equipment by means of a LAN using the token-passing ring access method. The frame format, including delimiters, addressing, and priority stacks, is defined. The medium access control (MAC) protocol is defined. The finite state machine and state tables are supplemented with a prose description of the algorithms. The physical layer (PHY) functions of symbol encoding and decoding, symbol time, and latency buffering are defined. The services provided by the MAC to the station management (SMT) and the services provided by the PHY to SMT and the MAC are described. These services are defined in terms of service primitives and associated parameters. The 4 and 16 Mbit/s, shielded twisted pair attachment of the station to the medium, including the medium interface connector (MIC), is also defined. The applications environment for the LAN 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 the standard. A Protocol Implementation Conformance Statement (PICS) proforma is provided as an annex to the standard.

Keywords: data processing interconnection, local area network (LAN), medium access control (MAC), token ring

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**Information technology—
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physical layer specifications**

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International Standard ISO/IEC 8802-5:1998(E)

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International Standard ISO/IEC 8802-5 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

This third edition cancels and replaces the second edition (ISO/IEC 8802-5:1995), which has been technically revised.

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*

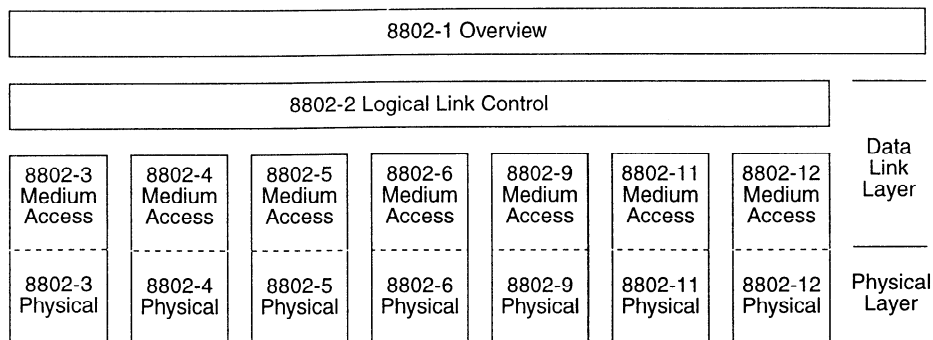
Annexes A and B form an integral part of this part of ISO/IEC 8802. Annexes C to J and P are for information only.



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Foreword to International Standard ISO/IEC 8802-5 : 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 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:

- ISO/IEC 8802-3, utilizing carrier sense multiple access with collision detection (CSMA/CD) as the access method.
- ISO/IEC 8802-4, utilizing token passing bus as the access method.
- ISO/IEC 8802-5, utilizing token passing ring as the access method.
- ISO/IEC 8802-6, utilizing distributed queuing dual bus as the access method.
- ISO/IEC 8802-9, a unified access method offering integrated services for backbone networks.
- ISO/IEC DIS 8802-11, a wireless LAN utilizing carrier sense multiple access with collision avoidance (CSMA/CA) as the access method.
- ISO/IEC DIS 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 10038, *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 (to be renumbered 15802-3).

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.

ANSI/IEEE Std 802.5, 1998 Edition

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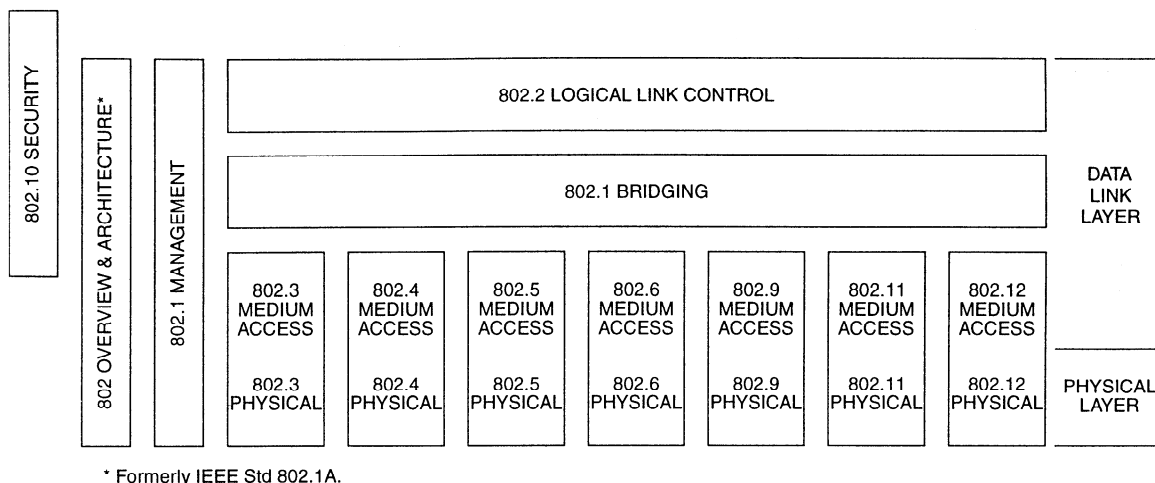
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Introduction to ANSI/IEEE Std 802.5, 1998 Edition

(This introduction is not a part of ANSI/IEEE Std 802.5, 1998 Edition or of ISO/IEC 8802-5 : 1998.)

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.)



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 10038] *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 802.1G [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*
- 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 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*
- IEEE Std 802.11 [ISO/IEC DIS 8802-11] *Wireless LAN Medium Access Control (MAC) and Physical Layer Specifications*
- ANSI/IEEE Std 802.12 [ISO/IEC DIS 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 802.5 [ISO/IEC 8802-5 : 1998]

This standard specifies that each octet of the information field shall be transmitted most significant bit (MSB) first. This convention is reversed from that used in the CSMA/CD and Token Bus standards, which are least significant bit (LSB) first transmission. While the transmission of MSB first is used for token ring, this does not imply that MSB transmission is preferable.

The IEEE 802.5 Working Group maintains a web site including notices to implementors and up-to-date information, at <http://stdsbbs.ieee.org/groups/802/5/>.

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ISO/IEC 8802-5 : 1998 [ANSI/IEEE Std 802.5, 1998 Edition] was approved by the American National Standards Institute (ANSI) on 15 April 1998.

Contents

1.	Overview.....	1
1.1	Scope.....	1
1.2	Normative references.....	3
1.3	Definitions.....	4
1.4	Conventions.....	9
1.5	Abbreviations and acronyms.....	9
1.6	Conformance requirements—station.....	12
1.7	Conformance requirements—concentrator.....	13
1.8	Local regulations.....	13
2.	General description.....	14
2.1	Architectural view.....	14
2.2	Station functional organization and data flow.....	14
2.3	Physical structure of a token ring network.....	17
2.4	Data stations, servers, and system management.....	18
3.	Formats and facilities.....	20
3.1	Formats.....	20
3.2	Field descriptions.....	21
3.3	Medium Access Control (MAC) frames.....	29
3.4	System timing parameters.....	41
3.5	Station policy flags.....	44
3.6	Error counters.....	46
4.	Token ring protocols.....	48
4.1	Overview.....	48
4.2	Specification definitions.....	62
4.3	Token ring MAC protocol specification.....	79
5.	Station specific components.....	105
5.1	General.....	105
5.2	Data signaling rate.....	110
5.3	Symbol coding (differential Manchester 1, 0, J, K).....	111
5.4	Repeat path.....	112
5.5	Symbol encoder.....	112
5.6	Symbol decoder.....	113
5.7	Symbol acquisition/loss and timing synchronization.....	113
5.8	Latency.....	114
5.9	Ring access control.....	116
6.	Token ring management.....	117
6.1	Station management primitives.....	117
6.2	Token ring station managed objects.....	123

7.	Station attachment specifications.....	144
7.1	Media-independent PHY specifications	144
7.2	Media-dependent PMC specifications	146
8.	Concentrator specifications.....	173
8.1	Concentrator lobe port	173
8.2	Concentrator trunk ports	175
8.3	Ring access control function.....	176
8.4	Passive concentrator.....	178
8.5	Active retiming concentrator	182

ANNEXES

Annex A	(normative) Protocol Implementation Conformance Statement (PICS) proforma	184
Annex B	(normative) Channel design considerations.....	198
Annex C	(informative) Jitter considerations	210
Annex D	(informative) Transmitter example	220
Annex E	(informative) Safety and environmental considerations	222
Annex F	(informative) Low-level finite state machines (FSMs).....	224
Annex G	(informative) Differences from 1992 version	229
Annex H	(informative) Example of a MAC frame parsing algorithm	233
Annex I	(informative) Recommended use of priorities for token ring	235
Annex J	(informative) Bibliography	241
Annex P	(normative) Bit error rate (BER) criteria for lobe media testing	242

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

1. Overview

1.1 Scope

For the purpose of compatible interconnection of data processing equipment via a local area network (LAN) using the token ring access method, this part of ISO/IEC 8802

- a) Provides a general description of the token ring local area network (LAN) architecture (clause 2);
- b) Defines the frame format, including the delimiters, address fields, information field, and frame-check sequence (FCS). Defines the Medium Access Control (MAC) frames, timers, and error counters (clause 3);
- c) Defines the MAC protocols including finite state machines and state tables (clause 4);
- d) Defines the system level Physical layer (PHY) signaling specifications that are specific to a ring station (clause 5);
- e) Defines the managed objects necessary to manage the service and protocol elements that are involved in the management of a token ring station (clause 6);
- f) Defines the PHY station attachment specification for 4 and 16 Mbit/s operation. This includes the transmitter, receiver, medium interface connector, and transmission channel for both shielded twisted pair (STP) and unshielded twisted pair (UTP) media (clause 7);
- g) Defines the concentrator, incorporating multiple trunk coupling units (TCUs), for the attachment of a group of stations to the ring (clause 8);

- h) Includes the 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 : 1994¹ (annex A);
- i) Includes channel design examples and formulas for calculating cabling and concentrator system configurations (annex B);
- j) Describes jitter components and provides an example of jitter buildup using a phase lock loop recovery circuit (annex C);
- k) Provides informative transmitter filter design example (annex D);
- l) Provides recommended guidelines for safety and operating environments (annex E);
- m) Illustrates the MAC finite state machines in a notation similar to that used in ISO/IEC 8802-5 : 1992 (annex F);
- n) Describes major improvements made after the first edition of the standard (annex G);
- o) Provides a sample algorithm for the parsing of MAC frames (annex H);
- p) Provides recommendations for the use of token ring access priorities to support multimedia traffic (annex I);
- q) Provides bit error rate (BER) criteria for lobe media testing (annex P).

A particular emphasis of this standard is to specify the externally 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 LAN 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.

This standard, the Third Edition of this part of ISO/IEC 8802, provides enhancements and corrections to the Second Edition. The Second Edition provided greater specificity and improved clarity to the First Edition (1992-06-12) to ensure interoperability of the various components in the token ring network. The intent of this edition is to maintain interoperability with stations designed to this specification and stations designed to prior editions of the standard. However, interoperability with prior implementations (particularly in regard to clause 7) cannot be guaranteed due to nonspecificity within the 1992 edition. Annex G lists the specific differences between the second edition and the first edition.

The following items are subjects for future study:

- a) Controlled bit altering by any device except a station.
- b) Methodology to assure handling of joining of multiple rings as may be used by managed concentrators to assure normal insertion process protection mechanisms (such as duplicate address test or ring parameter server notification).
- c) Ring data rate determination to allow managed data rate adaptation between stations.
- d) Alternative active concentrators or repeaters that provide increased cabling distances and/or enhanced operation of rings containing devices built to the first edition of this standard, ISO/IEC 8802-5 : 1992.
- e) Converters that allow the interconnection of stations on different media types.
- f) Methodologies to provide enhanced transmission reliability over the trunk cable.

¹Information on references can be found in 1.2.

- g) Definition of concentrator managed objects.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO/IEC 8802. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on ISO/IEC 8802-5 : 1998 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

CISPR Publication 22 : 1985, Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.²

IEC 6073 : 1996, Basic and safety principles for man-machine interface, marking and identification—Coding principles for indicating devices and actuators.³

IEC 60603-7 : 1996, Connectors for frequencies below 3 MHz for use with printed boards—Part 7: Detail specification for connectors, 8-way, including fixed and free connectors with common mating features, with assessed quality.

IEC 60950 : 1991, Safety of information technology equipment.

ISO/IEC 7498-1 : 1994, Information technology—Open Systems Interconnection—Basic Reference Model: The Basic Model.⁴

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

ISO/IEC 8802-2 : 1994 [ANSI/IEEE Std 802.2, 1994 Edition], Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical link control.⁵

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

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 10038 : 1993 [ANSI/IEEE Std 802.1D, 1993 Edition], Information technology—Telecommunication and information exchange between systems—Local area networks—Media access control (MAC) bridges.

²CISPR and IEC publications are available from the International Electrotechnical Commission, 3, rue de Varembe, Case Postale 131, CH-1211, Genève 20, Switzerland/Suisse. These 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.

³See footnote 2.

⁴ISO/IEC publications are available from ISO, Case Postale 56, 1, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse. These 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.

⁵ISO/IEC [ANSI/IEEE] are available from ISO. They are also available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

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

ISO/IEC 10742 : 1994, Information technology—Telecommunications and information exchange between systems—Elements of management information related to OSI Data Link Layer standards.

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

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.

ISO/IEC TR 11802-4 : 1994, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Technical reports and guidelines—Part 4: Token ring access method and physical layer specifications—Fibre optic station attachment.

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, service, protocol.

1.3 Definitions

1.3.1 abort sequence: A sequence transmitted by an originating ring station that terminates the transmission of a frame prematurely. It also causes the ring station receiving this frame to terminate the frame's reception.

1.3.2 accumulated jitter: The jitter at a PHY entity in the ring measured against the transmit clock of the active monitor. It is the total jitter accumulated by all the stations from the active monitor to the measurement point. It is typically used to determine the required size of the elastic buffer.

1.3.3 active monitor: A station on the ring that is performing certain functions to ensure proper operation of the ring. These functions include 1) establishing clock reference for the ring; 2) assuring that a usable token is available; 3) initiating the neighbor notification cycle; 4) preventing circulating frames and priority tokens. In normal operation only one station on a ring may be the active monitor at any instance in time.

1.3.4 active retimed concentrator: A type of token ring concentrator that performs an embedded repeater function in the lobe port's data path, thereby providing ring segment boundaries at the concentrator lobe port connector (CMIC).

1.3.5 adjusted NEXT loss: The NEXT loss in decibels of a channel plus $15\log F/F_{\text{ref}}$, where F is the measured frequency and F_{ref} is a reference frequency (4 MHz at 4 Mbit/s and 16 Mbit/s). It is used to determine the NEXT to interference (NIR) ratio of a channel.

1.3.6 alignment error: Alignment error is the deviation of the recovered clock from the ideal recovered clock embedded by the transmitter. The deviation from the ideal sampling point may be caused by static timing errors in the timing recovery circuit, internal jitter generated in the timing recovery circuit, and the inability to track exactly the jitter on the received data signal.

1.3.7 backup path: Secondary transmission path in trunk cabling and concentrator, normally used for token ring signal transmission only when there is a failure on the main ring path.

1.3.8 beaconing: A ring state that occurs when a station on the ring has detected a ring failure. The frame transmitted by the station to alert the other stations on the ring of the failure is called a beacon frame.

1.3.9 bit error rate (BER): A measurement of error rate stated as a ratio of the number of bits with an error to the total number of bits passing a given point on the ring. A BER of 10^{-6} indicates that an average of one bit per million bits is in error.

1.3.10 broadcast: The act of sending a frame addressed to all stations.

1.3.11 burst4: Exactly four consecutive signal elements of the same polarity.

1.3.12 burst5: Five or more consecutive signal elements of the same polarity.

1.3.13 burst6: Six or more consecutive signal elements of the same polarity.

1.3.14 channel: The data path from any transmitting MIC to the next downstream receiving MIC.

1.3.15 claiming: A ring state that occurs when a station detects that the active monitor functions are not being performed and at least one station is contending to become active monitor.

1.3.16 concentrator: A device that contains multiple interconnected trunk coupling units (TCUs). The concentrator contains two ports, referred to as *ring in* and *ring out*, to interface trunk cable.

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

1.3.18 converter: A type of repeater that converts the data signal from one media to another.

1.3.19 correlated jitter: The portion of the total jitter that is related to the data pattern. Since every PHY receives the same pattern, this jitter is correlated among all similarly configured PHYs receiving the same data pattern and therefore may grow in a systematic way along the ring. Also referred to as *pattern jitter* or *systematic jitter*.

1.3.20 crosstalk: Crosstalk is undesired energy appearing in one signal path as a result of coupling from other signal paths.

1.3.21 cumulative latency: The time it takes for a signal element to travel from the active monitor's transmitter output to its receiver input.

1.3.22 differential Manchester encoding: A signaling method used to encode clock and data bit information into bit symbols. Each bit symbol is split into two halves, or signal elements, where the second half is the inverse 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.

1.3.23 elastic buffer: A variable delay element inserted in the ring by the active monitor to ensure that ring latency remains constant when the cumulative latency changes.

1.3.24 fill: A sequence of data symbols of any combination of 0 and 1 data bits (as opposed to non-data-J and non-data-K bits) whose primary purpose is to maintain timing and spacing between frames and tokens.

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

1.3.26 insertion loss: The signal loss that results when a channel is inserted between a transmitter and a receiver, which is the ratio of the signal level delivered to a receiver before a channel is inserted, to the signal level after the channel is inserted.

1.3.27 jitter: The time varying phase of a pulse train relative to the phase of a reference pulse train. For the specifications in this document, jitter is usually measured as the difference in edge times of the receiver's recovered clock or transmitter data output to a reference clock or data signal, typically the preceding station's transmitter clock or data output. The specifications are measured in nanoseconds.

1.3.28 latency: The time, expressed in number of symbols, it takes for a signal to pass through a ring component. See **ring latency**; **cumulative latency**.

1.3.29 LLC frame: A token ring frame containing an LLC PDU exchanged between peer entities using the MAC services.

1.3.30 lobe cabling: The cabling used to interconnect the station MICs to the TCUs. This cabling includes all work area cabling, horizontal cabling, and patch cables. The lobe cable only carries ring signals when the station is actively connected on the ring (inserted). When the station is not inserted in the ring, the lobe cable may contain local test signals.

1.3.31 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.

1.3.32 MAC frame: A token ring frame containing a MAC PDU exchanged between MAC entities used to convey information that is used by the MAC protocol or management of the MAC sublayer.

1.3.33 main ring path: Principal transmission path in the trunk cabling. The main ring path carries the data in the primary direction. (*Contrast with: backup path.*)

1.3.34 medium: The material on which the data may be transmitted. STP, UTP, and optical fibers are examples of media.

1.3.35 Medium Access Control (sublayer) (MAC): The portion of the data station that controls and mediates the access to the ring.

1.3.36 medium interface connector (MIC): A connector interface at which signal transmit and receive characteristics are specified for attaching stations and concentrators. One class of MICs is the connection between the attaching stations and the lobe cabling. A second set is the attachment interface between the concentrator and its lobes. A third set is the interface between the concentrator and the trunk cabling. Two types of connectors are specified: one for connecting to STP media and one for connecting to UTP media.

1.3.37 monitor functions: The functions that recover from various error situations and are contained in each ring station. In normal operation only one of the stations on a ring is the active monitor at any point in time. The monitor functions in all other stations on the ring ensures that the active monitor function is being performed.

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

1.3.39 near end crosstalk (NEXT): Near end crosstalk is crosstalk that is propagated in a distributed channel in the direction opposite to the direction of the propagation of the signal in the disturbing channel and is measured at or near the source of the disturbing signal.

1.3.40 passive concentrator: A type of token ring concentrator that contains no active elements in the signal path of any lobe port. Embedded repeater functions may be provided by the ring in and ring out port.

1.3.41 phantom signaling: A technique where a dc power source is superimposed on the transmit and receive signal pairs in a transparent or “phantom” fashion (7.2.1) such that its application does not affect the data bearing signals on either pair. This dc power source is normally applied to request a concentrator to insert a lobe into the ring.

1.3.42 Physical (layer) (PHY): The layer responsible for interfacing with the transmission medium. This includes conditioning signals received from the MAC for transmitting to the medium and processing signals received from the medium for sending to the MAC.

1.3.43 physical media components (PMC): The sublayer of the PHY responsible for interfacing with the transmission medium. The functions of the PMC include receive, transmit, clock recovery, and ring access control.

1.3.44 physical signaling components (PSC): The sublayer of the PHY responsible for processing the signal elements received from the ring by the PMC for sending symbols to the MAC and for conditioning the symbols received from the MAC for inclusion as signal elements in the repeated data stream to the PMC.

1.3.45 port: A signal interface provided by token ring stations, passive concentrator lobes, active concentrator lobes, or concentrator trunks that is generally terminated at a media interface connector (MIC). Ports may or may not provide physical containment of channels.

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

1.3.47 protocol implementation conformance statement (PICS): A statement of which capabilities and options have been implemented for a given Open Systems Interconnection (OSI) protocol. (See annex A.)

1.3.48 purging: A ring state that occurs when the active monitor has detected a ring error and is returning the ring to an operational state by transmitting purge frames.

1.3.49 recovery: The process of restoring the ring to normal operation. When the ring is beaconing, claiming, or purging, the ring is in a state of recovery.

1.3.50 repeat: The action of receiving a bit stream (for example, frame, token, or fill) and placing it on the medium. Stations repeating the bit stream may copy it into a buffer or modify control bits as appropriate. Contrast with **transmit**.

1.3.51 repeater: Physical layer coupler of ring segments. Provides for physical containment of channels, dividing the ring into segments. A repeater can receive any valid token ring signal and retransmit it with the same characteristics and levels as a transmitting station.

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

1.3.53 ring in: A port that receives signals from the main ring path on the trunk cable and transmits signals to the backup path on the trunk cable, and provides connectivity to the immediate upstream ring out port.

1.3.54 ring latency: In a token ring, the time (measured in bit times) it takes 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 or other element in the data path connected to the token ring.

1.3.55 ring out: A port that transmits the output signals to the main ring path on the trunk cable and receives from the backup ring path on the trunk cable, and provides connectivity to the immediate downstream ring in port.

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

1.3.57 ring segment: Section of transmission path bounded by repeaters or converters. Ring segment boundaries are critical for determining the transmission limits that apply to the devices within the segment.

1.3.58 routing information: A field, carried in a frame, used by source routing transparent bridges that provides source routing operation in a bridged LAN.

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

1.3.60 shielded twisted pair (STP): Normally refers to those shielded cables with individual pairs of conductors twisted, or with a group of four conductors in a quad configuration, with any characteristic impedance. When used in this document, the term specifically refers to those shielded cables whose pairs have a high-frequency characteristic impedance of 150 Ω and with two pair of conductors shielded from any other individual pairs.

1.3.61 signal element: The logical signal during one half of a bit time which may take on the values of Logic_1 or Logic_0.

1.3.62 source routing: A mechanism to route frames through a bridged LAN. Within the source routed frame, the station specifies the route that the frame will traverse.

1.3.63 standby monitor: A station on the ring that is not in active monitor mode. The function of the standby monitor in normal ring operation is to assure that an active monitor is operating.

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

1.3.65 static timing error: The constant part of the difference in time between the ideal sampling point for the received data and the actual sampling point.

1.3.66 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.

1.3.67 stripping: The action of a station removing the frames it has transmitted from the ring.

1.3.68 symbol: In this standard a symbol consists of two signal elements. Four symbols are defined: data_zero, data_one, non-data_J, and non-data_K.

1.3.69 token: A signal sequence passed from station to station that is used to control access to the medium.

1.3.70 tracking error: The portion of alignment error due to failure to track receiver jitter.

1.3.71 transferred jitter: The amount of jitter in the recovered clock of the upstream PHY which is subsequently transferred to the downstream PHY which in turn is transferred to the next downstream PHY. Transferred jitter is important because each PHY must both limit the amount of jitter it generates and track the jitter delivered by the upstream PHY.

1.3.72 transmit: The action of a station generating a frame, token, abort sequence, or fill and placing it on the medium. *Contrast with: repeat.*

1.3.73 transparent bridging: A bridging mechanism in a bridged LAN that is transparent to the end stations.

1.3.74 trunk cable: The transmission medium for interconnection of concentrators providing a main signal path and a back-up signal path, exclusive of the lobe cabling.

1.3.75 trunk coupling unit (TCU): A device that couples a station to the main ring path. A TCU provides the mechanism for insertion of a station into the ring and removal of it from the ring.

1.3.76 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 stations and therefore grows in a non-systematic way along the ring. Uncorrelated jitter is also called *noise jitter* or *non-systematic jitter*.

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

1.3.78 unshielded twisted pair (UTP): Normally refers to those cables with individual pairs of conductors twisted, or with a group of four conductors in a star quad configuration, with any characteristic impedance. When used in this document, the term specifically refers to those cables whose pairs have a high-frequency characteristic impedance of 100 Ω . Shielded cables with the same high-frequency characteristic impedance are included within this definition.

1.3.79 verified frame: A valid frame as defined in 4.3.2, addressed to the station, for which the information field has met the validity requirements as specified in 3.3.5.2.

1.4 Conventions

When used in this standard, the term *reserved* shall be understood to mean *reserved for future standardization*. Use of reserved values to implement functions not covered by the standard may lead to interoperability problems and therefore is not recommended.

1.5 Abbreviations and acronyms

NOTE—All acronyms and notations used in state machine descriptions are summarized in 4.2.3 and 4.3.5.

A bit	=	address-recognized bit
AC	=	access control (field)
ACR	=	attenuation to crosstalk ratio
AD	=	abort delimiter
AJ	=	accumulated jitter
AUJA	=	accumulated uncorrelated jitter alignment
AMP	=	active monitor present
APS	=	accumulated phase slope
ARC	=	active retiming concentrator
BER	=	bit error rate
BN	=	beacon
C bit	=	frame-copied bit
CATT	=	concentrator maximum flat attenuation
CMIC	=	concentrator medium interface connector
CRS	=	configuration report server
CSQA	=	concentrator square-root-frequency attenuation
CT	=	claim token
DA	=	destination address
DAT	=	duplicate address test

DC	=	destination class
DFAPS	=	delta filtered accumulated phase slope
E bit	=	error-detected bit
ED	=	ending delimiter
EFS	=	end-of-frame sequence
ETR	=	early token release
FA	=	functional address
FAJ	=	filtered accumulated jitter
FAI	=	functional address indicator
FAPS	=	filtered accumulated phase slope
FC	=	frame control (field)
FCS	=	frame-check sequence
FR	=	frame
FS	=	frame status (field)
FSM	=	finite state machine
HFEJ	=	high-frequency edge jitter
I bit	=	intermediate frame bit
IFG	=	interframe gap
INIT	=	initialization
ISI	=	inter-symbol interference
JTOL	=	jitter tolerance
JTOLX	=	jitter tolerance in the presence of crosstalk
LAN	=	local area network
LLC	=	logical link control (sublayer)
LTH bit	=	length bit
M bit	=	monitor bit
MA	=	my (station's) address
MAC	=	Medium Access Control (sublayer)
MGT	=	management
MIC	=	medium interface connector
MIC_S	=	shielded twisted pair MIC
MIC_U	=	unshielded twisted pair MIC
nFAPS	=	normalized filtered accumulated phase slope
NDT	=	net delay time
NEXT	=	near end crosstalk
NIR	=	NEXT loss to insertion loss ratio
NN	=	neighbor notification
OSI	=	Open Systems Interconnection
PDU	=	protocol data unit
PHY	=	Physical (Layer)
PICS	=	protocol implementation conformance statement
PLL	=	phase locked loop
Pm	=	priority of queued PDU
Pr	=	last priority value received
PMC	=	physical media components
P	=	priority bits (of the access control field)
PSC	=	physical signaling components
Px	=	the greater value of Pm or Rr
R	=	reservation bits (of the access control field)
RAC	=	ring access control
REM	=	ring error monitor
RI	=	routing information (a field in the frame format)
RI	=	ring in (trunk in port on a concentrator)
RIMIC	=	ring in MIC

TOKEN RING

RII	=	routing information indicator
RO	=	ring out (trunk out port on a concentrator)
ROMIC	=	ring out MIC
RP	=	ring purge
RPS	=	ring parameter server
RPT	=	repeat
RQ	=	request
Rr	=	last reservation value received
RRL	=	receiver return loss
RS	=	ring station
RUA	=	reporting station's upstream neighbor's address
RX	=	receive
SA	=	source address
SC	=	source class
SCNR	=	signal to crosstalk noise ratio
SD	=	starting delimiter
SDU	=	service data unit
SFS	=	start-of-frame sequence
SIR	=	signal to interference ratio
SMP	=	standby monitor present
Sr	=	highest stacked received priority
SRT	=	source routing transparent
STP	=	shielded twisted pair
SUA	=	stored upstream neighbor's address
SV	=	subvector
SVI	=	subvector identifier
SVL	=	subvector length
SVV	=	subvector value
Sx	=	highest stacked transmitted priority
TAM	=	timer, active monitor
TBR	=	timer, BN receive
TBT	=	timer, BN transmit
TCATT	=	total channel attenuation
TCT	=	timer, claim token
TCU	=	trunk coupling unit
TDCD	=	transmitter duty cycle distortion
TDOV	=	transmitter differential output voltage
TER	=	timer, error report
TID	=	timer, insert delay
TJR	=	timer, join ring
TK	=	token
TNT	=	timer, no token
TOP	=	timer, queue PDU
TRI	=	timer, ring initialization
TRH	=	timer, remove hold
TRP	=	timer, transmit ring purge
TRR	=	timer, return to repeat
TRW	=	timer, remove wait
TSL	=	timer, signal loss
TSM	=	timer, standby monitor
TVX	=	timer, valid transmission
TWF	=	timer, wire fault
TWFD	=	timer, wire fault delay
TX	=	transmit

TXRL	=	transmit return loss
UNA	=	upstream neighbor's address
UTP	=	unshielded twisted pair
VC	=	vector class
VI	=	vector identifier
VL	=	vector length

1.6 Conformance requirements—station

The supplier of a protocol implementation that is claimed to conform to this standard shall complete a copy of the PICS proforma in annex A and shall provide the information necessary to identify both the supplier and the implementation.

1.6.1 Static conformance requirements

1.6.1.1 MAC sublayer

An implementation claiming conformance to this standard shall

- Implement the token format, the frame format, associated address formats and fields, and MAC frame vectors and subvectors as defined in 3.1, 3.2, and 3.3.
- Support 48-bit addressing and use either a universally administered individual address or a locally administered individual address.
- Exhibit external behavior corresponding to the timer system timing parameters as specified in 3.4.
- Exhibit external behavior corresponding to the station policy flags as specified in 3.5.
- Implement capabilities corresponding to the counters as defined in 3.6.
- Recognize the first bit of the source address as the indication of the presence of the routing information field in the frame format. Note that the ability to generate or respond to frames with source routing information is optional.

1.6.1.2 PHY layer

An implementation claiming conformance to this standard shall

- Use a data signaling rate at 4 Mbit/s or 16 Mbit/s as defined in 5.2. Implementations may support either or both data rates.
- Encode and decode symbols as defined in 5.4 and 5.6.
- Achieve signal timing synchronization as defined in 5.7.
- Add latency as defined in 5.8.
- Meet multiple station accumulated jitter requirements defined in 7.1.
- Support either STP or UTP cabling at the MIC as defined in 7.2. Implementations may support either or both media types using the appropriate MIC connector (MIC_S for STP and MIC_U for UTP).
- Provide phantom signaling and wire fault detection as defined in 7.2.1.
- Meet transmit specifications as defined in 7.2.2.
- Meet receiver jitter tolerance specifications as defined in 7.2.3.
- Operate with the channels specified in 7.2.4.

1.6.2 Dynamic conformance requirements

An implementation claiming conformance to this standard shall perform the following actions:

- a) Receive MAC and LLC frames and perform the actions defined in 4.3.
- b) Receive and utilize tokens for the transmission of queued PDUs as defined in 4.3.
- c) Transmit queued PDUs as frames as defined in 4.3.
- d) Strip frames transmitted by the station as defined in 4.3.
- e) Transmit tokens in accordance with 4.3 after a frame(s) has been transmitted.
- f) Perform priority operation as defined in 4.3.
- g) Queue DAT_PDU, AMP_PDU, SMP_PDU, and RQ_INIT_PDU as defined in 4.3.
- h) Autonomously transmit fill and the Ring Purge, Claim Token, and Beacon frames as defined in 4.3.
- i) Enter BYPASS as defined in 4.3.
- j) Assume ACTIVE MONITOR STATE as defined in 4.3.
- k) Assume STANDBY MONITOR STATE as defined in 4.3.

1.7 Conformance requirements—concentrator

The supplier of a protocol implementation which is claimed to conform to this standard shall complete a copy of the PICS proforma in annex A and shall provide the information necessary to identify both the supplier and the implementation.

1.7.1 Static conformance requirements

- a) Support a data signaling rate at 4 Mbit/s or 16 Mbit/s as defined in 5.2. Implementations may support either or both data rates.
- b) Support either STP or UTP cabling at the MIC as defined in 8.1.1 for the lobe connector. Implementations may support either or both medium types using the appropriate MIC connector (MIC_S for STP and MIC_U for UTP).
- c) Support either STP or UTP cabling at the MIC as defined in 8.1.1 for the trunk connector. Implementations may support either or both media types using the appropriate MIC connector (MIC_S for STP and MIC_U for UTP).
- d) Provide the RAC function specified in 8.3 for the lobe connectors. This RAC function is complementary to the station phantom signaling and wire fault detection as defined in 7.2.1.
- e) Support either a passive concentrator function or an active retimed concentrator function. For a passive concentrator function, the signal attenuation and crosstalk parameters are specified in 8.4. For an active retimed concentrator function, the parameters are specified in 8.5. The active retimed concentrator function parameters are closely related to the station PHY function parameters defined in 7.2.1 through 7.2.4.

1.8 Local regulations

The supplier of a protocol implementation that is claimed to conform to this standard should meet local safety and environmental regulations. Annex E provides some limited guidance in this area.

2. General description

2.1 Architectural view

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 (ISO/IEC 7498-1 : 1994). As shown in figure 1, the LLC and MAC together encompass the functions intended for the data link layer of the OSI model. The MAC to LLC service definition is specified in ISO/IEC 15802-1 : 1995.

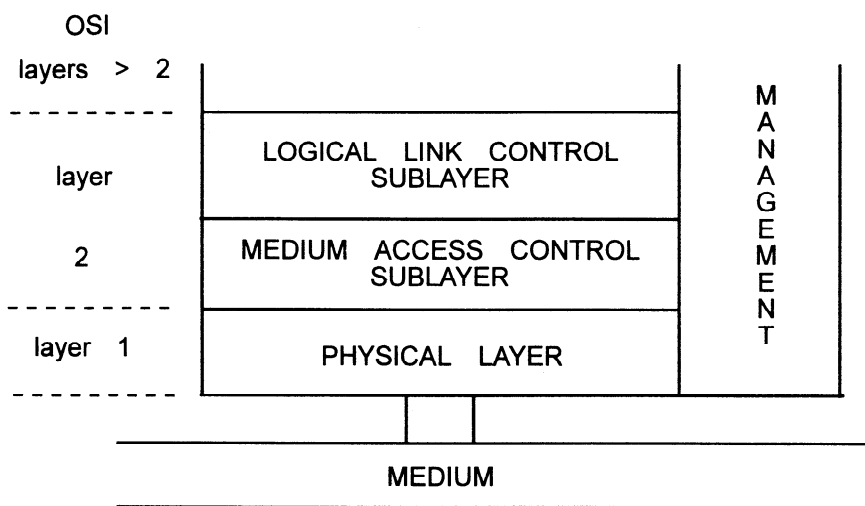


Figure 1—Relation of OSI Reference Model to the LAN Model

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).

The exact relationship of the layers described in this standard to the layers defined by the OSI Reference Model is a subject for further study.

2.2 Station functional organization and data flow

Figure 2 is an illustration of a station's data flow indicating which clauses of this standard address the various functions of a token ring station. The operation of a station is specified in clauses 3 through 7, and operation of the concentrator is specified in clause 8. Internal service interfaces have been defined solely for the purpose of specifying operation between the clauses and are not requirements for a physical interface.

- a) The PMC/PSC internal service interface (PM_UNITDATA.request; PM_UNITDATA.indication) defines the information exchange between the physical media components (PHY) specified in clause 7 and the physical signaling components (PSC) specified in clause 5. This service interface is defined in clause 5.
- b) The PSC/MAC internal service interface (PS_CONTROL.request, PS_STATUS.indication, PS_UNITDATA.indication, PS_UNITDATA.request, PS_EVENT.response) defines the control mechanism of, the mechanism for indicating the status of, and the information exchange between, the physical signaling components (PSC) specified in clause 5 and the MAC sublayer specified in clauses 3 and 4. Clause 3 defines frame formats and station facilities. Clause 4 specifies the MAC protocol that uses the formats and facilities defined in clause 3 to receive and transmit information. This service interface is defined in clause 5.
- c) The MAC/PHY internal service interface (PM_CONTROL.request and PM_STATUS.indication) provides the control mechanism of the PHY functions by the MAC protocol, and the mechanism for indicating the status of the PHY functions to the MAC protocol. This service interface is defined in clause 5.
- d) The MAC/LLC service interface (MA_UNITDATA.indication, MA_UNITDATA.request) is specified in ISO/IEC 15802-1 and defines the information exchange between the MAC sublayer and the LLC sublayer.
- e) The MAC/Bridge service interface (M_UNITDATA.indication, M_UNITDATA.request, M_UNITDATA.response) is specified in ISO/IEC 10038 : 1993 and defines the information exchange between the MAC and the internal bridging sublayer.
- f) The MAC/MGT service interface (MGT_UNITDATA.indication, MGT_UNITDATA.request, MGT_CONTROL.request, MGT_STATUS.indication) defines the control mechanism of, the mechanism for indicating the status of, and the information exchange between, the MAC protocol specified in clause 4 and management (MGT). The managed objects are specified in clause 6. The MGT_UNITDATA.indication and MGT_UNITDATA.request primitives are specified in clause 4 and are used to convey MAC management frames between the MAC and the appropriate management function (e.g., RPS, CRS, REM).

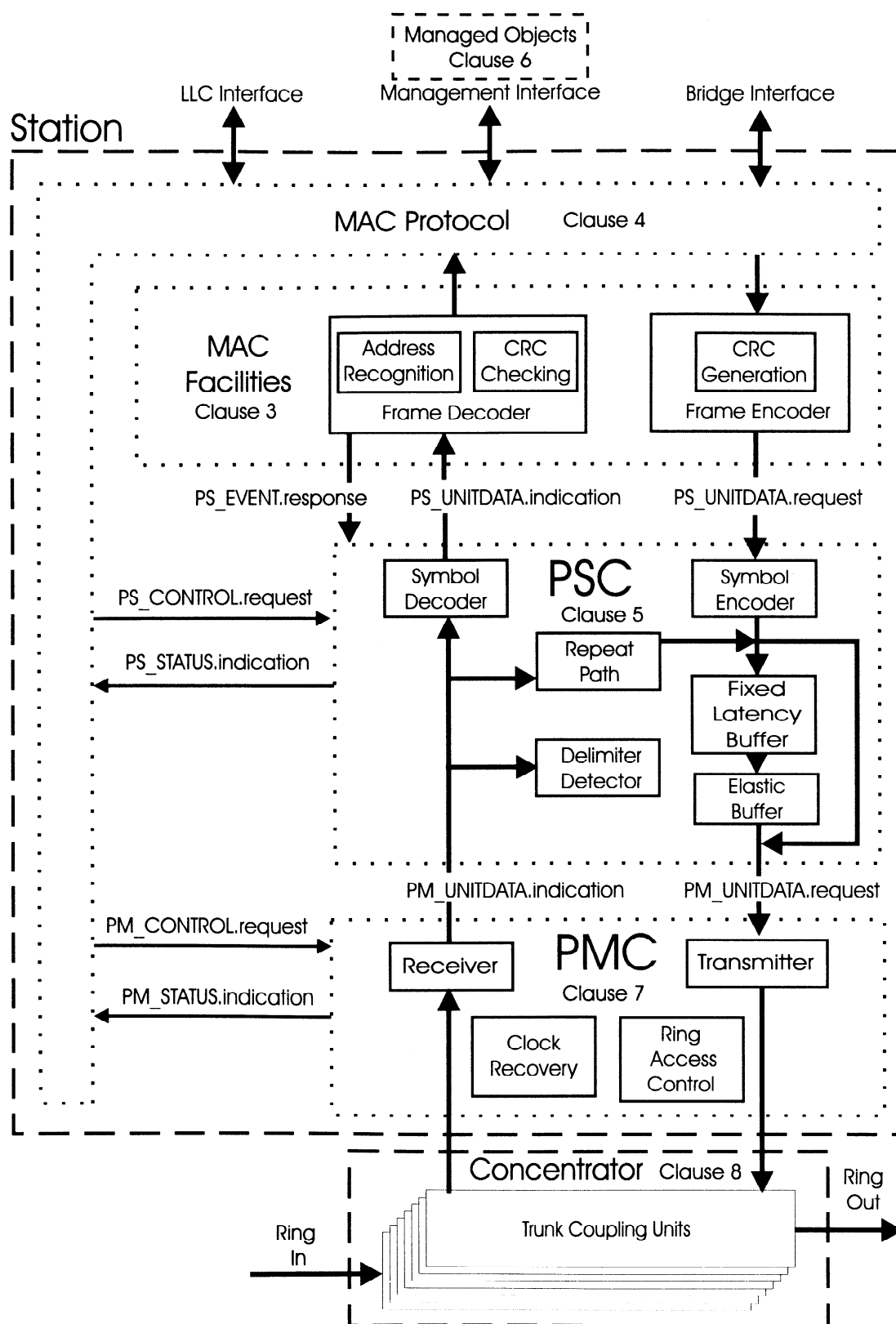


Figure 2—Station functional organization and data flow

2.3 Physical structure of a token ring network

A token ring consists of a star wired system of stations with each station connected by a lobe cable to a concentrator TCU, as shown in figure 2. A concentrator contains multiple TCUs. Concentrators are serially interconnected using the concentrator ring in and ring out ports, forming the main ring path and the back-up ring path. Interconnection on the main ring and back-up ring paths may include the use of repeaters and converters that divide the total signal path into separate segments to bound the total channel path length for each station.

Networks may include repeaters and/or converters at each trunk interface where the transmission medium is changed, i.e., between STP and fiber, between STP and UTP, between UTP and fiber. Thus, each of these interfaces becomes a ring segment boundary. Evaluation and control of jitter buildup across these segments is a subject for future study.

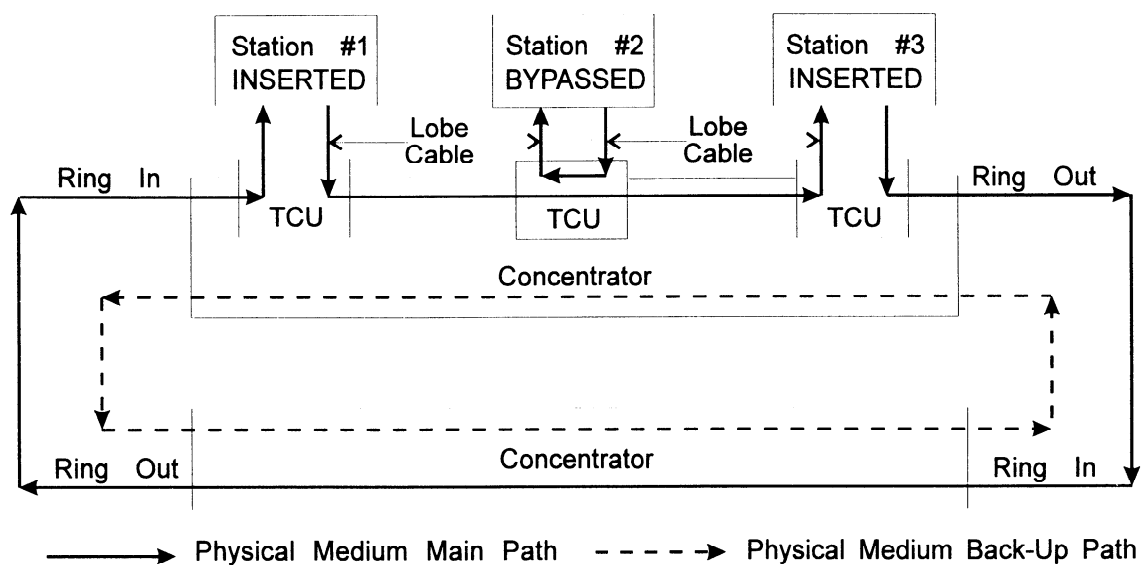


Figure 3—Typical token ring wiring example

Each TCU provides attachment (“insertion” or “bypass”) of the station into or from the trunk ring. This insertion/bypass mechanism is usually controlled by the attaching station’s ring access control (RAC) function. A station performs self-tests of the attached cable lobe and the station’s MAC and PHY layer circuitry by operating a one-node network while the TCU function is in the bypass mode (e.g., Station #2 in figure 3.) When the TCU receives a dc signal from the station via the lobe cable, the TCU switches from bypass mode to inserted mode, allowing the inserting station’s MAC to receive a symbol stream from its upstream neighbor, and provide an output symbol stream to its downstream neighbor.

The maximum station count on a single token ring is limited by both MAC and PHY considerations. If the recommended system timing parameters (see 3.4) are used, operation of up to 250 stations on the ring is possible. Modifications of this station count may occur based on media type, data rate, use of repeaters or converters, and concentrator type.

Information on the token ring is transferred sequentially, bit by bit, from one inserted station to the next. In figure 3, Station #1 would transmit to Station #3 and Station #3 would transmit to Station #1. 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 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 strips the information from the ring.

A station gains the right to transmit its information onto the medium when it detects a token passing on the medium. The token is a control signal comprised of a unique signaling 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 start of frame sequence and appending appropriate control and status fields, address fields, routing information field, information field, check sum, and the ending frame sequence. 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.

The maximum period of time a station may transmit on the medium before releasing the token is controlled by counter CTO (used as a timer).

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, real-time voice, interactive, immediate (network recovery). The allocation of priorities is 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 utilize a network monitoring function that is performed in a specific station (the active monitor), with back-up capability in all other stations that are attached to the ring (standby monitors).

2.4 Data stations, servers, and system management

Each ring in a token ring network may have a set of server stations (servers) that provide a means through which a system manager manages the stations in a token ring system. Such arrangement is depicted in figure 4.

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

Data stations communicate with the servers by

- a) Reporting errors that are detected, such as lost token, FCS error, or lost frames;
- b) Requesting operating parameters when inserting into the ring;
- c) Reporting changes in configuration due to insertion or removal of stations (UNA changes);
- d) Responding to requests for various status information; and
- e) Removing from the ring when requested.

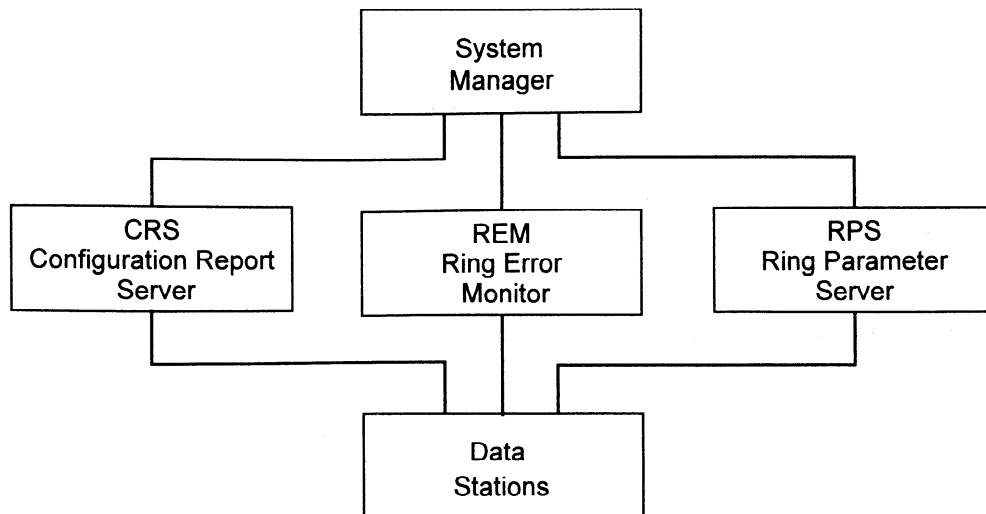


Figure 4—Relationship of data stations, servers, and system manager

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

The RPS sets MAC entity parameters and can limit access to the ring. It does this by responding to the Request Initialization MAC frame with an Initialize Station MAC frame.

The CRS receives management information about the current status and configuration of the ring, and may issue MAC frames to stations on the ring in response to a request from a management entity.

The REM receives from MAC entities, and reports to the requester, error statistics regarding ring and station operation.

Specification of the operation of the RPS, CRS, and REM is beyond the scope of this standard.

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 objects (parameters, events, and actions) specified in clause 6 are the elements of such communication.

A source routing station may send and receive frames that include a routing information field as specified in ISO/IEC 10038 : 1993. The routing information field may be determined through the use of protocols specified in ISO/IEC 8802-2 : 1994. A station that does not support the source routing information field is prohibited from setting the RII bit (first bit in the source address field).

A source routing transparent bridge copies frames based on the routing information field as well as the destination address as specified in ISO/IEC 10038 : 1993. A source routing transparent bridge may set the address-recognized bits in a frame that it copies with intent to forward. Otherwise, stations are prohibited from setting the address-recognized bits unless the frame is addressed to the station's individual address or to a group address for which the station is enabled.

3. Formats and facilities

This clause defines token ring formats (3.1), token and frame field descriptions (3.2), MAC frames (3.3), system timing parameters (3.4), station policies (3.5), and error counters (3.6).

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.

Binary values are represented by the binary digits 0, 1 , or x, which are enclosed by B' and '. The lower-case x represents a digit that may be 0 or 1. An example of a binary notation is B'001x'.

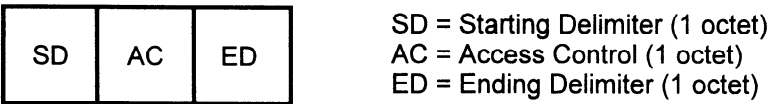
Hexadecimal values are represented by hexadecimal digits 0–9, A–F, or x, which are enclosed by X' and '. The lowercase x represents a digit that may be any hexadecimal value. An example of a hexadccimal notation is X'01 6F'.

All values are stated most significant digit first. Spaces within a value are for clarity and may be ignored.

3.1 Formats

The symbol sequences used in token ring are the token, frame, abort sequence, and fill.

3.1.1 Token format



Error (E-bit) coverage is the AC field

Figure 5—Token format

The token is the means by which the right to transmit (as opposed to the normal process of repeating) is passed from one station to another. The token may occur anywhere in the data stream; that is, receiving stations shall be able to detect a token on any signal element boundary.

Error checking of token formats is defined in 3.2.8.2, and validity requirements are specified in 4.3.1.

3.1.2 Frame format

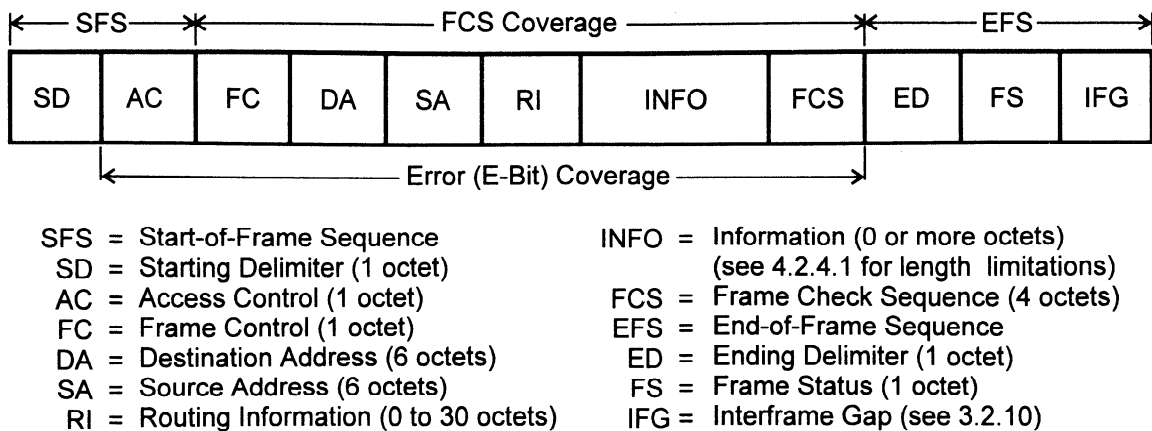


Figure 6—Frame format

The frame format shall be used for transmitting both MAC and LLC messages to the destination station(s). It may or may not contain an information (INFO) field. It may or may not contain a routing information (RI) field (see 3.3.5.1 regarding restrictions in certain MAC frames). The frame format may occur anywhere in the data stream; that is, receiving stations shall be able to detect a frame on any signal element boundary.

Error checking of frame formats is defined in 3.2.8.2 and validity requirements are specified in 4.3.2.

3.1.3 Abort sequence

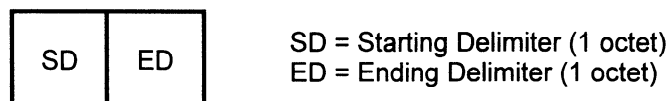


Figure 7—Abort sequence

The abort sequence is transmitted by a station when an error condition causes the station to prematurely terminate the transmission of a frame. The abort sequence causes stations receiving the frame to recognize that it is not a valid frame. The abort sequence may occur anywhere in the data stream; that is, receiving stations shall be able to detect an abort sequence on any signal element boundary.

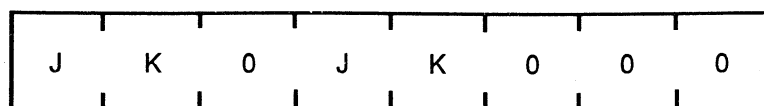
3.1.4 Fill

A station shall transmit fill as any combination of Data_zero and Data_one symbols in accordance with the protocol described in clause 4.

3.2 Field descriptions

The following is a detailed description of the individual fields used for the abort sequence, token, and frame formats.

3.2.1 Starting delimiter (SD) field



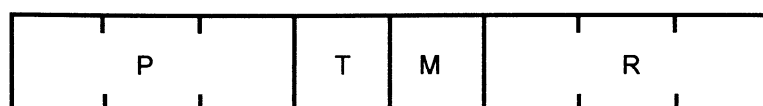
J = Non-data_J symbol
K = Non-data_K symbol
0 = Data_zero symbol

(For a discussion of non-data symbols, see 5.3.)

Figure 8—Starting delimiter field

A frame, token, or abort sequence always starts with a starting delimiter. Receiving stations shall consider the SD valid only if all eight symbols of the SD (J K 0 J K 0 0 0) are received correctly.

3.2.2 Access control (AC) field



P = priority bits
T = token bit
M = monitor bit
R = reservation bits

Figure 9—Access control field

3.2.2.1 Priority bits

The priority bits indicate the priority of a token and, therefore, when stations are allowed to use the token. Frames carry the same access priority as the token used to gain access. In a multiple-priority system, the priorities of tokens that a station uses depend on the priority of the PDU to be transmitted. The eight levels of priority increase from the lowest (B'000') to the highest (B'111') priority.

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 B'000' or any frame from continuously circulating on the ring. All frames and tokens shall be transmitted with the M bit set to 0. As a token with priority greater than zero or any frame is being repeated by the active monitor, the M bit is set to 1. All other stations repeat this bit as received. If an active monitor detects a token or a frame with the M bit equal to 1, it initiates the ring purge process. During beaconing, the station downstream from the beaconing station will optionally assume this role of setting and inspecting the M bit.

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 clause 4. The eight levels of reservation increase from B'000' to B'111'.

3.2.3 Frame control (FC) field

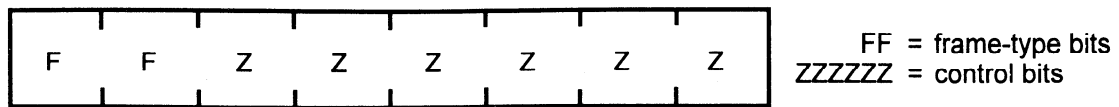


Figure 10—Frame control field

The FC field identifies the frame type and indicates MAC frame handling or LLC frame priority.

3.2.3.1 Frame-type bits

The frame-type bits indicate the type of the frame as follows:

- a) B'00' = MAC frame (contains a MAC PDU)
- b) B'01' = LLC frame (contains an LLC PDU)
- c) B'1x' = undefined format (reserved for future standardization)

In this standard, the term MAC frame is defined as the type of frame used to convey information used by the MAC protocol or management of the MAC sublayer.

3.2.3.1.1 Undefined frame format

The value B'1x' is reserved for frame types that may be defined in the future. However, although currently undefined, any future frame formats are required to adhere to the following conditions to ensure compatibility:

- a) The frame format shall be delimited by the SFS fields and the EFS fields. No additional fields may be included in or follow the EFS field.
- b) The position of the AC and FC field shall be unchanged.
- c) 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 token holding time.
- d) All symbols between the SD and ED shall be Data_zero and Data_one symbols.

3.2.3.2 ZZZZZZ bits

3.2.3.2.1 MAC frames

If the frame-type bits indicate a MAC frame, the ZZZZZZ control bits specify MAC frame handling (see 3.3.1 and 3.3.5).

3.2.3.2.2 LLC frames

If the frame-type bits indicate an LLC frame, the ZZZZZZ bits are designated as “rrrYYY”. The “rrr” bits are reserved for future standardization and shall be transmitted as B'000' in all transmitted frames and may be ignored upon reception. The “YYY” bits may be used to carry the user priority 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) does not convey user priority.

3.2.3.2.3 Undefined frame format

The *ZZZZZZ* bits are undefined and reserved for future standardization.

3.2.4 Destination address (DA) and source address (SA) fields

Each frame contains two address fields: the destination (station) address and the source (station) address, in that order. Representation of addresses used in this standard are different than the representation utilized in ISO/IEC 15802-1 : 1995.

3.2.4.1 Destination address (DA) field

The frame's DA identifies the station or stations for which the information field of the frame is intended. Included in the frame's DA are two bits that 1) indicate whether the DA is a group or individual address and 2) indicate whether the DA is a locally or universally administered address.

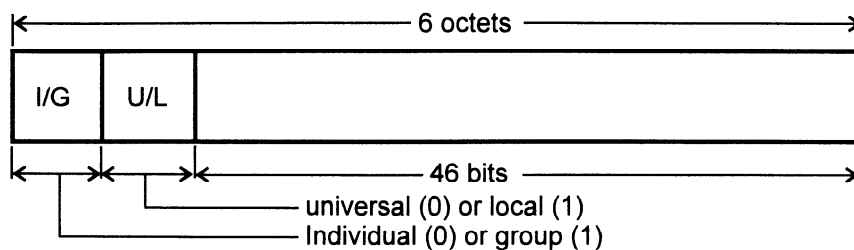


Figure 11—Destination address field

3.2.4.1.1 Individual address

When the first bit of the frame's DA field is equal to a zero (0), the address is an individual address. An individual address identifies a particular station and must 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).

3.2.4.1.2 Group address

When the first bit of the frame's DA field is equal to a one (1), the address is a group address. A group address is 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. It has been observed that several protocols in general usage today require support for one or more general group addresses, and that failure to provide station support for multiple group address recognition can be a serious impediment to use of that station in multi-protocol environments. It is recommended that stations support recognition of multiple general group addresses.

3.2.4.1.3 Broadcast address

The group address X'FF FF FF FF FF FF' is defined as a broadcast address and denotes the set of all stations on a given LAN. X'C0 00 FF FF FF FF' is also a broadcast address for MAC frames. Note that this requirement generally places the address X'C0 00 FF FF FF FF' in the set of addresses recognized by the token ring station and therefore the use of X'C0 00 FF FF FF FF' for non-MAC frames should be avoided.

3.2.4.1.4 Null address

The individual address X'00 00 00 00 00 00' is defined as the null address. It indicates the frame is not addressed to any station. No station shall be assigned the null address and therefore frames addressed to the null address are not expected to be copied by the station.

3.2.4.1.5 Functional addresses (FAs)

FAs are contained within a subset of locally administered group addresses. They are bit-significant addresses used to identify well-known functional entities. There are 31 functional addresses that are indicated by the least significant 31 bits of the destination address when the most significant 17 bits indicate functional addressing. The functional address indicator (FAI) identifies an FA (versus a general group address) when the first 2 octets of the DA are X'C000' and the first bit of the third octet is B'0' (i.e., B'1100 0000 0000 0000 0'). The remaining 31 bits of the address field each represent a functional address.

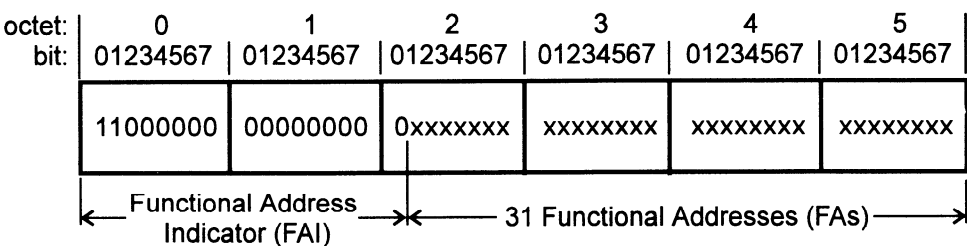


Figure 12—Functional address format

The following functional addresses are defined for use in MAC frames:

Table 1—MAC functional address

Functional address (FA)	Function name	6 octet address
B'xxx xxxx xxxx xxxx xxxx xxxx xxx1'	Active monitor	X'C0 00 00 00 00 01'
B'xxx xxxx xxxx xxxx xxxx xxxx xxx1x'	Ring parameter server (RPS)	X'C0 00 00 00 00 02'
B'xxx xxxx xxxx xxxx xxxx xxxx xxx1xxx'	Ring error monitor (REM)	X'C0 00 00 00 00 08'
B'xxx xxxx xxxx xxxx xxxx xxxx xxx1 xxxx'	Configuration report server (CRS)	X'C0 00 00 00 00 10'

The 6 octet address in the table indicates the address for that single function. Multiple functions are addressed by combining the functional addresses. An example is X'C0 00 00 00 00 12' which is addressed to both the RPS and the CRS functions.

When a station “sets” a functional address, it will recognize all frames sent to that function by setting the A bits and attempting to copy all frames whose DA contains the FAI and has the corresponding FA bit set to B'1'. The active monitor functional address shall only be set as specified in 4.3.4. All other functional addresses are set by management.

Use of functional addresses, octet 5 bit 1 through octet 5 bit 7, that are not defined above are reserved. Functional addresses, octet 2 bit 1 through octet 5 bit 0, are available for general use.

Refer to ISO/IEC TR 11802-2: 1995 for locally administered MAC group (functional) addresses used by this part of ISO/IEC 8802. Also note that functional address X'C0 00 00 00 00 80' is widely used by higher layer protocols and that functional address X'C0 00 00 00 01 00' is widely used for bridging. Because a functional address may be used simultaneously by multiple protocols, a user cannot assume that it designates a single function. Other frame fields should be used to identify the destination function.

The MAC protocol depends on receiving a proper INITIALIZE STATION MAC frame when the RPS functional address is recognized by any station on the ring. The join ring process may not complete properly (e.g., fail joining the ring) if the RPS function does not function as expected (see 4.3.4, JS=RQI). Therefore, if a station does not perform the RPS function, it shall not recognize the RPS functional address and shall not set A or C bits in a frame addressed exclusively to the RPS functional address.

3.2.4.1.6 Address administration

There are two methods of administering 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

3.2.4.1.7 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 from the Secretary General, ISO Central Secretariat, Case Postale 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, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

3.2.4.1.8 Local administration

Individual station addresses are administered by a local (to the LAN) authority. Network administrators should be careful when assigning locally administered addresses due to the structure of hierarchical addressing (defined in previous versions of this standard). The least significant 14 bits of the first two octets of the address have a special meaning (ring ID). Two values of ring ID are assigned for use with all stations (null ring—all zeros, and any ring—all ones). Because of this, the following sets of addresses should be used with care: X'40 00 xx xx xx xx', X'7F FF xx xx xx xx', X'C0 00 xx xx xx xx', X'FF FF xx xx xx xx' (where x is any hexadecimal value). When using locally administered addresses in these ranges, it is possible for the duplicate address test (DAT) to fail when another station is using an address that only differs by the first two octets. In addition, locally administered group addresses with the last 4 octets X'FF FF FF FF' may also be recognized by hierarchical addressing as a broadcast address. Note that the hierarchical addressing "ring ID" is not associated with the "local ring number" subvector.

Hierarchical addressing for locally administered addresses is not required nor specified by this standard. Future implementations are discouraged from implementing hierarchical addressing.

3.2.4.2 Source address (SA) field

The frame's SA identifies the station originating the frame. In contrast to the DA field, no individual/group (I/G) bit is encoded in the SA since the SA is constrained to be an individual address. The implied value for the I/G is always 0. In its place is the routing information indicator (RII) bit used to indicate the presence or absence of a routing information (RI) field in the frame. If the RII bit is 0, then no RI field is

present, and if the RII bit is 1, then a RI field is present. The universal/local (U/L) bit still indicates whether the address is universally or locally administered, as in the DA.

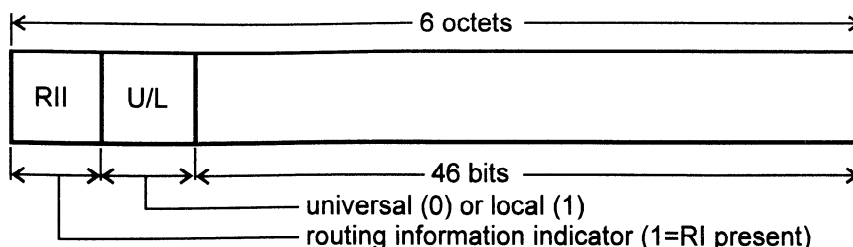


Figure 13—Source address field

3.2.5 Routing information (RI) field

When a frame's routing information indicator bit in the source address field is equal to 1 (RII=1), the RI field shall be included in the frame. The following provides sufficient information for the MAC entity to determine the size of the RI field and parse the frame properly. The detailed structure and contents for the RI field is described in ISO/IEC 10038 : 1993 and ISO/IEC 8802-2 : 1994.

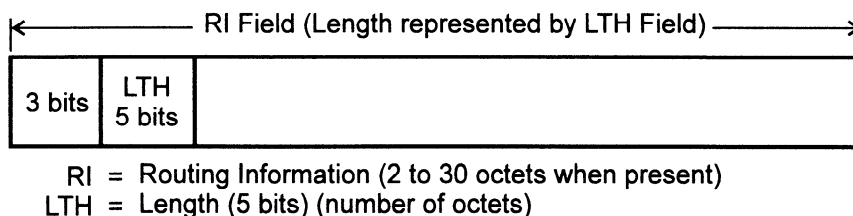


Figure 14—Routing information field

3.2.5.1 Length bits (LTH)

These five bits indicate the length (in octets) of the RI field. Length field values shall be even values between 2 and 30, inclusive.

3.2.6 Information (INFO) field

The information field contains zero, one, or more octets that are intended for MAC, MGT, or LLC. The maximum length of the information field is limited by the maximum frame length as specified in 4.2.4.1, Counter, transmitted octets. 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.

3.2.6.1 Order of bit transmission

Each octet of the information field shall be transmitted most significant bit first.

3.2.6.2 MAC frame format

The format of the information field for MAC frames is specified in 3.3.2. All stations shall be capable of receiving MAC frames whose total length is the size of the largest frame specified in table 5. However, it is

recommended that all stations be capable of receiving MAC frames whose total length is up to and including 96 octets.

3.2.6.3 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 LLC frames whose information field is up to and including 133 octets in length.

3.2.7 Frame-check sequence (FCS) field

The FCS is a 32-bit sequence based on the following standard generator polynomial of degree 32.

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

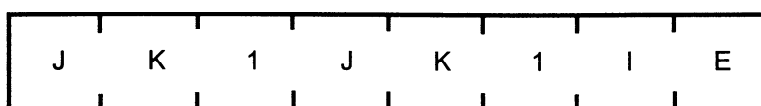
A valid FCS is the ones complement of the sum (modulo 2) of the following:

- The remainder of $X^k (X^{31} + X^{30} + X^{29} + \dots + X^2 + X + 1)$ divided (modulo 2) by $G(X)$, where k is the number of bits in the FC, DA, SA, RI, and INFO fields, and
- 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, RI, 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, RI, and INFO fields by the generator polynomial, $G(X)$. The ones 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, RI, and FCS, when divided by $G(X)$, results, in the absence of transmission errors, in a unique nonzero remainder value. The unique remainder value is the polynomial:

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

3.2.8 Ending delimiter (ED) field



J = Non-data_J symbol
K = Non-data_K symbol
1 = Data_one symbol
I = intermediate frame bit
E = error-detected bit

Figure 15—Ending delimiter field

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.

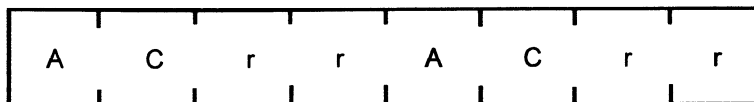
3.2.8.1 Intermediate frame bit (I bit)

The I bit is optionally 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.

3.2.8.2 Error-detected bit (E bit)

The E bit shall be transmitted as 0 by the station when it originates the token, abort sequence, or frame. All stations on the ring check tokens and all frame formats for errors (for example, FCS error in a MAC or LLC frame or non-data symbols within a frame or token). The E bit of a frame being repeated is set to 1 when a frame with an error (4.3.2) is detected and, optionally, the E bit of a token being repeated is set to 1 when a token with an error (4.3.1) is detected; otherwise, the E bit is repeated as received.

3.2.9 Frame status (FS) field



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

Figure 16—Frame status field

The reserved (r) bits are reserved for future standardization. They shall be transmitted as 0's and repeated as received.

3.2.9.1 Address-recognized (A) bits and frame-copied (C) bits

The A and C bits shall be transmitted as 0 by the station when it originates the frame. If another station recognizes the DA as its own address or relevant group address, or if indicated by the bridge interface, it sets both of the A bits to 1. If it copies the frame, it also sets both of the C bits to 1. The A and C bits are set without regard to the value of the received E bit and only if the frame is valid as defined in 4.3.2.

3.2.10 Interframe gap (IFG) field

The interframe gap is composed of fill (3.1.4) and shall be a minimum of 1 octet in length (a length of 2 octets is recommended) for 4 Mbit/s transmission and shall be a minimum of 5 octets in length for 16 Mbit/s transmission. Note that the size and content of the IFG may be altered (see 5.8.3.3). Receiving stations can not be assured of receiving the full IFG (5.8.3.3). Note that additional fill may follow the interframe gap.

3.3 Medium Access Control (MAC) frames

The following subclauses give descriptions of various MAC frames that are used in the management of the token ring. Definitions and requirements for PDU priority (Pm), FC, DA, INFO field content (Vector Class—VC, Vector Identifier—VI, Subvector Identifier—SVI, and Subvector Value—SVV) are also given.

3.3.1 MAC frame control

Frames with the following FC values are handled as follows:

- a) 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.
- b) If the frame has an FC field value X'01' through X'3F', it is addressed to the station, and it has a Destination Class B'0000' (station), then every effort should be made to copy the frame. The MAC protocol (4.3.4) has been designed to handle the case when a MAC frame is not copied. FC values of X'01' through X'06' shall only be used for the corresponding MAC frames as defined in table 4.

3.3.2 MAC frame information field format

Figure 17 shows the format of the information field for MAC frames.

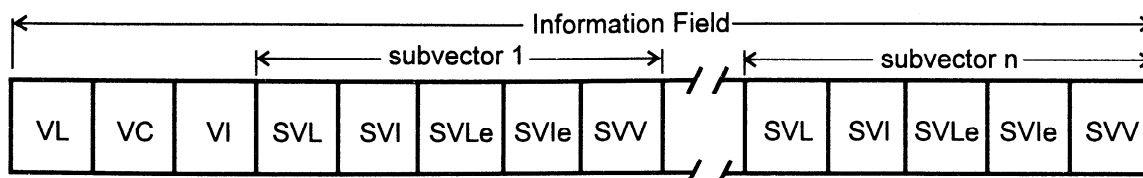


Figure 17—MAC frame information field structure

Vector. The fundamental unit of MAC and MGT 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 (vector length). A 16-bit binary number that gives the length, in octets, of the vector. The length includes the length of the VL field and can have values such that $X'0004' \leq VL \leq X'FFFF'$, subject to the other constraints in clause 4 on the length of the INFO field.

VC (vector class). A one-octet code point that identifies the function class of both the source and destination entities. The function classes are defined as follows:

Table 2—Vector class values

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'
Network management (NM)	X'8'

The organization of the vector class field is shown in figure 18.

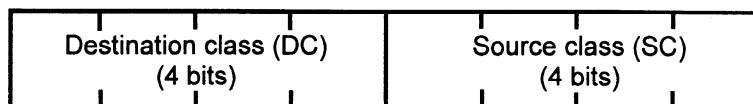


Figure 18—Vector class field

The VC field is divided into two 4-bit fields specifying the destination class (DC) and the source class (SC).

The DC field provides a means to route the frame to the appropriate management function within the station. Table 5 defines the MAC frames sent to destination class 0 that are processed by the ring station as specified in 4.3.4. All other MAC frames sent to destination class 0 may be ignored.

The SC field allows the station's MAC and MGT functions to reject vector identifiers from invalid sources.

VI (vector identifier). A one- or three-octet code point that uniquely identifies the vector. This field is one octet in length if the first octet is not X'FF' and three octets in length if the first octet is X'FF'. A value of X'FF' means the vector code is contained in the next two octets. A vector code of less than X'FF' shall be transmitted using one octet. A vector code of greater than or equal to X'FF' shall be transmitted using three octets. The definition of all undefined vector codes used with a source class or destination class of zero (ring station) is reserved for future standardization.

SV (subvector). Vectors require all data or modifiers to be contained within subvectors. A separate 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 is identified by its subvector identifier.

SVL (subvector length). A one-octet field that uniquely identifies the length of the subvector depending on its value. If the SVL value is less than X'FF' then SVL contains the length, in octets, of the subvector including the length of SVL, SVI, SVIe (if present), and SVV fields. If the value of SVL is X'FF', then the subvector length is specified in the SVLe field.

SVI (subvector identifier). A one-octet field that identifies the subvector depending on its value. A value of X'FF' indicates the subvector code is contained in the SVIe field.

Definitions of the SVIe subvector codes are beyond the scope of this standard and are reserved for future standardization. The subvectors with code points from X'00' through X'7F' are defined to have the same definition for all vectors 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 MGT 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.

SVLe (extended subvector length). A zero- or two-octet field depending on the value of SVL. If the SVL value is less than X'FF' then the length of SVLe is zero. When the SVL value is X'FF', then the length of the SVLe field is 2 octets and its value identifies the length, in octets, of the subvector including the length of the SVL, SVI, SVLe, SVIe (if present), and SVV fields.

SVIe (extended subvector identifier). A zero- or two-octet field depending on the value of SVI whose value identifies the subvector. If the value SVI is less than X'FF' then the length of SVIe is zero. When the SVI value is X'FF', the SVIe field is 2 octets in length and contains the code point identifying the subvector. The definition of the extended subvector identifier is provided for future expansion and definition of the SVIe subvector codes is reserved for future standardization.

SVV (subvector value). This field contains the subvector information as described in 3.3.4.

3.3.3 Vector descriptions

Following is a list of vectors used by the ring station in numerical order of the vector identifier.

X'00'—Response (RSP). The RSP MAC frame is sent by a station as specified by the MAC protocol to acknowledge receipt of, or to report an error in, a received MAC frame. The RSP MAC frame is never sent to Destination Class 0 (ring station). The RSP MAC frame is not required to be sent if the received frame initiating the response was sent to a broadcast address and the address-recognized and frame-copied bits in the FS field were all ones.

X'02'—Beacon (BN). The BN MAC frame is transmitted by a station which detects a continuing interruption to the data flow on the ring.

X'03'—Claim Token (CT). The CT MAC frame is used by stations when restoring the active monitor function to the ring.

X'04'—Ring Purge (RP). The RP MAC frame is transmitted by the active monitor to verify the ring data path before restoring the token.

X'05'—Active Monitor Present (AMP). The AMP MAC frame is transmitted periodically by the active monitor to indicate its presence on the ring and to initiate the Neighbor Notification Process.

X'06'—Standby Monitor Present (SMP). The SMP MAC frame is transmitted by standby monitor stations as part of the Neighbor Notification Process.

X'07'—Duplicate Address Test (DAT). The DAT MAC frame is used during the Join Ring Process to verify that the station's individual address is unique.

X'08'—Lobe Media Test (TEST). The TEST MAC frame is optionally used by a station during the Join Ring Process to test its lobe connection prior to inserting into the ring or at any time the station needs to test the transmission path such as during the Beacon Test state. When the TEST MAC frame is used, it is addressed to the null address which is specifically addressed to no station. The station determines the quality of the transmission path by inspecting the received frame for errors (see 4.3.2).

X'0B'—Remove Ring Station (REMOVE). The REMOVE MAC frame is sent to any of the station's non-broadcast addresses to force its removal from the ring. The REMOVE MAC frame is sent by a configuration report server (CRS) or optionally by network management (NM).

X'0C'—Change Parameters (CHG_PARM). The CHG_PARM MAC frame is sent by the CRS to a ring station to set its ring operating parameters. The ring station normally replies with an RSP MAC frame if the SET_APPR_PARMS action is taken.

X'0D'—Initialize Station (INIT). The INIT MAC frame is sent by the RPS to a ring station to initialize its ring operating parameters. The ring station normally replies with an RSP MAC frame if the SET_APPR_PARMS action is taken.

X'0E'—Request Station Addresses (RQ_ADDR). The RQ_ADDR MAC frame is sent by any non-zero function class (such as CRS) to a station(s) to request the addresses recognized by the station.

X'0F'—Request Station State (RQ_STATE). The RQ_STATE MAC frame is sent by any non-zero function class (such as CRS) to a station(s) to request information on the state of the station.

X'10'—Request Station Attachments (RQ_ATTCH). The RQ_ATTCH MAC frame is sent by any non-zero function class (such as CRS) to a station(s) to request information on the functions active in the station.

X'20'—Request Initialization (RQ_INIT). The RQ_INIT MAC frame is sent by a station to the RPS as part of the join ring process. It informs the RPS that a station has been inserted and will accept modified parameters from either the RPS or CRS.

X'22'—Report Station Addresses (RPRT_ADDR). The RPRT_ADDR MAC frame is sent by a station in response to a Request Station Addresses MAC frame.

X'23'—Report Station State (RPRT_STATE). The RPRT_STATE MAC frame is sent by a station in response to a Request Station State MAC frame.

X'24'—Report Station Attachments (RPRT_ATTCH). The RPRT_ATTCH MAC frame is sent by a station in response to a Request Station Attachments MAC frame.

X'25'—Report New Active Monitor (NEW_MON). The NEW_MON MAC frame is sent by a station to the CRS to report that it has become the active monitor.

X'26'—Report SUA Change (SUA_CHG). The SUA_CHG MAC 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.

X'27'—Report Neighbor Notification Incomplete (NN_INCMP). The NN_INCMP MAC frame is sent by the active monitor to the REM to report an error in the neighbor notification process.

X'28'—Report Active Monitor error (ACT_ERR). The ACT_ERR MAC frame is sent to the REM by an active monitor if it detects more than one station is active monitor on the ring or if another station indicates a problem with the active monitor function by initiating the Claim Token process.

X'29'—Report Error (RPRT_ERR). The RPRT_ERR MAC frame is sent to the REM by a station to report errors detected since the last error report.

The following VIs are reserved:

X'01'- Re-IMPL

X'09'-Transmit forward

X'0A'-Resolve

X'2A'-Report transmit forward

3.3.4 Subvector descriptions

Following is a list of subvectors, in numerical order of their respective subvector identifier values. The lengths specified are only for the SVV field and do not include the length of SVL and SVI fields.

X'01'—Beacon Type. This subvector has a value field 2 octets long and is used to indicate the type of fault detected. It has one of the following values:

X'0001'—Issued by a Dual Ring station during reconfiguration. Refer to IEEE Std 802.5c-1991 [B4].⁶

X'0002'—Signal loss.

X'0003'—Timer TCT expired during claiming token; no claim token frames received.

X'0004'—Timer TCT expired during claiming token; claim token frames received.

X'02'—Upstream Neighbor's Address (UNA). This subvector value field is 6 octets long and contains the address of the upstream neighbor of the sending station. When transmitting, this is the value of SUA. When received, the value of this subvector is referred to as Reported Upstream Address (RUA).

X'03'—Local Ring Number. This subvector has a value field 2 octets long. It indicates the local ring number of the sending station. This value is assigned to the station by the Initialize Station MAC frame or the Change Parameters MAC frame and is used in the subvector field of appropriate report frames. This value does not affect the MAC address assigned to the station.

⁶The numbers in brackets preceded by the letter B correspond to those of the bibliography in annex J.

X'04'—Assign Physical Drop Number. This subvector has a value field 4 octets long. It specifies the physical location of the target station. The value of this subvector is not defined by this standard. This value is assigned to the station by the Initialize Station MAC frame or the Change Parameters MAC frame and is used in the subvector field X'0B' of appropriate report frames.

X'05'—Error Report Timer Value. This subvector has a value field 2 octets long. It states the value of TER in increments of 10 ms.

X'06'—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 X'0' to X'F'. Defined function classes are the following:

Table 3—Function class values

Subvector value	Function class	Class value
B'xxxx 1xxx xxxx xxxx'	Configuration report server (CRS)	X'4'
B'xxxx x1xx xxxx xxxx'	Ring parameter server (RPS)	X'5'
B'xxxx xx1x xxxx xxxx'	Ring error monitor (REM)	X'6'
B'xxxx xxxx 1xxx xxxx'	Network Management (NM)	X'8'

Other function classes are reserved for future standardization.

X'07'—Authorized Access Priority. This subvector has a value field 2 octets long. The value is set by the system administrator and it may establish the maximum frame access priority (Pm) at which a station queues non-MAC frames.

X'09'—Correlator. This subvector has a value field 2 octets long and is used to associate responses with requests. The value of the correlator SV for a frame sent in response to a received frame shall be the value of the received correlator SV. If the received frame does not contain a correlator, the MAC may send any value or omit the correlator SV in the transmitted frame.

X'0A'—SA of Last AMP or SMP Frame. This subvector has a value field 6 octets long and is used in the Report Neighbor Notification Incomplete MAC frame. Its value is the same as the value of LMP which is specified in table 7. A value of null indicates that the AMP frame was not received. A value equal to the station's address indicates either that the AMP frame was not received or that no SMP frames were received. Any other value indicates the SA of the last SMP frame received.

X'0B'—Physical Drop Number. This subvector has a value field 4 octets long. It reports the physical location of the sending station (see X'04' Assign Physical Drop Number).

X'20'—Response Code. This subvector has a value field 4 or 6 octets long and is used in the Response MAC frame. It consists of a 2-octet response code followed by the 1-octet vector class (VC) and the 1- or 3-octet vector identifier (VI) from the received MAC frame that caused the station to send the Response MAC frame. The response code values are as follows:

- X'0001'—Positive acknowledgment. The MAC frame was accepted by the station.
- X'8001'—MAC frame information field is incomplete. The MAC frame was too short to contain the vector length, vector class and vector ID.
- X'8002'—Vector length error. Vector length does not agree with the length of the frame or a subvector was found that did not fit within the vector.
- X'8003'—Unrecognized vector ID. The vector ID is not recognized by the station.
- X'8004'—Inappropriate source class. The source class is not valid for the VI.
- X'8005'—Subvector length error. The length of a recognized subvector conflicts with its expected length or is less than 2.
- X'8006'—Reserved.
- X'8007'—Missing subvector. A subvector required to process the MAC frame is not in the MAC frame.
- X'8008'—Subvector unknown. A subvector received in the MAC frame is not known by the adapter.
- X'8009'—MAC frame too long. The received frame was rejected because it exceeded maximum length.
- X'800A'—Function requested was disabled. The received MAC frame was rejected because the function requested was disabled.

X'21'—Individual Address Count. This subvector has a value field 2 octets long. The default value of X'00 00' means more than one individual address is not supported. A non-zero value specifies the number of individual addresses in use by this station.

X'22'—Product Instance ID. This subvector's value is used by a station manufacturer to identify a station's characteristics, such as serial number, machine type, model number, plant of manufacture, etc. The length of this subvector is not defined by this standard. It is recommended that this subvector be the "ResourceTypeID" managed object as specified by ISO/IEC 10742 : 1994.

X'23'—Ring Station Version Number. This subvector is used in the Request Initialization and Report Station State MAC frames. The length and value of this subvector is not defined by this standard.

X'26'—Wrap Data. The length and function of this subvector are product implementation choices. The subvector is used in the Lobe Media Test MAC frame.

X'28'—Station Identifier. This subvector has a value field 6 octets long and is used in the Report Station State MAC frame. It should uniquely identify the station. It is recommended that this value be a universally administered individual address.

X'29'—Ring Station Status. This subvector is used in the Report Station State MAC frame. The length and contents of this subvector are not specified by this standard. However, an application receiving this subvector may be able to determine its format by examination of the Product Instance ID subvector (X'22').

X'2B'—Group Addresses. This subvector has a value field of 4 or 6 octets in length. It contains a group address of the reporting station. When 4 octet values are used, the field will contain the low order 4 octets of the address and no assumptions can be made about the first 2 octets of the address. A value of all zeros is used to denote that a station does not support a group address or that a group address is not assigned. If more than one group address is recognized, then any of those addresses may be reported.

X'2C'—Functional Addresses. This subvector has a value field 4 octets long and specifies the functional addresses that are active in the reporting station (see 3.2.4.1).

X'2D'—Isolating Error Counts. This subvector has a value field 6 octets long and is used in the Report Error MAC frame. It indicates the number of each type of error detected since the last error report. Refer to 3.6 for a description of each of the counters. Isolating errors are errors that are known to occur between the reporting station and its upstream station. If a counter has not been incremented or is marked reserved, its value shall be reported as X'00'.

- Octet 0—line error (CLE)
- Octet 1—internal error (CIE)
- Octet 2—burst error (CBE)
- Octet 3—AC error (CACE)
- Octet 4—abort sequence transmitted (CABE)
- Octet 5—reserved (X'00')

X'2E'—Non-isolating Error Counts. This subvector has a value field 6 octets long and is used in the Report Error MAC frame. It indicates the number of each type of error detected since the last error report. Refer to 3.6 for a description of each of the counters. The origin of Non-isolating errors are unknown. If a counter has not been incremented or is marked reserved, its value shall be reported as X'00'.

- Octet 0—lost frame error (CLFE)
- Octet 1—receive congestion (CRCE)
- Octet 2—frame-copied error (CFCE)
- Octet 3—frequency error (CFE)
- Octet 4—token error (CTE)
- Octet 5—reserved (X'00')

X'30'—Error Code. This subvector has a value field 2 octets long and is used in the Report Active Monitor Error MAC frame. It has one of the following values:

- X'0001' — Active monitor error, used when the active monitor receives a Claim Token MAC frame.
- X'0002' — Duplicate active monitor, used when the active monitor receives a RP or an AMP MAC frame that it did not transmit, indicating the presence of another active monitor.
- X'0003' — Duplicate address, used when a station in claim token receives a Claim Token MAC frame in which the SA equals the station's individual address (SA equal to MA) but the RUA is different from the station's SUA. This indicates that another station on the ring has the same individual address.

The following SVIs are reserved:

X'27'—Frame Forward

X'2A'—Transmit Forward Status Code

X'2F'—Function Request ID

3.3.5 MAC frame tables

Tables 4 and 5 are tabulations of MAC frame requirements for transmitting and receiving stations, respectively.

3.3.5.1 MAC frames transmitted

A station shall support the frames shown in table 4. The Beacon, Claim Token, Ring Purge, Active Monitor Present, and Standby Monitor Present MAC frames shall be transmitted as shown. Other frames may be transmitted with additional subvectors.

MAC frames shall be queued for transmission with the Pm values specified in table 4. It is recommended that all MAC frames transmitted on a token be queued for transmission with a Pm of 7.

Table 4—MAC frame transmit definitions

Vector (VI,Name)	FC Pm	DA	VC	Designator**7	Subvector (SVI,Name)
X'00' Response	X'00' **2	SA of rcvd frame	X'*0'		X'09' Correlator **5 X'20' Response Code
X'02' **4 Beacon	X'02' **3	broadcast	X'00'		X'01' Beacon Type X'02' UNA X'0B' Physical Drop Number
X'03' **4 Claim Token	X'03' **3	broadcast	X'00'		X'02' UNA X'0B' Physical Drop Number
X'04' **4 Ring Purge	X'04' **3	broadcast	X'00'		X'02' UNA X'0B' Physical Drop Number
X'05' **4 Active Monitor Present	X'05' **1	broadcast	X'00'		X'02' UNA X'0B' Physical Drop Number
X'06' **4 Standby Monitor Present	X'06' **1	broadcast	X'00'		X'02' UNA X'0B' Physical Drop Number
X'07' **4 Duplicate Address Test	X'01' **1	DA=MA	X'00'		none
X'08' Lobe Media Test	X'00' **1	Null	X'00'		X'26' Wrap Data
X'20' **4 Request Initialization	X'00' or X'01' **1 **6	FA(RPS)	X'50'	op_txop_tx op_tx	X'02' UNA X'21' Individual Address Count X'22' Product Instance ID X'23' Ring Station Version Number
X'22' Report Station Addresses	X'00' **2	SA of request	X'*0'	op_tx op_tx	X'09' Correlator **5 X'02' UNA X'2B' Group Address X'2C' Functional Address(s) X'21' Individual Address Count X'0B' Physical Drop Number
X'23' Report Station State	X'00' **2	SA of request	X'*0'	op_tx op_tx	X'09' Correlator **5 X'28' Station Identifier X'29' Ring Station Status X'23' Ring Station Version Number
X'24' Report Station Attachments	X'00' **2	SA of request	X'*0'	op_tx op_tx	X'09' Correlator **5 X'06' Authorized Function Classes X'07' Authorized Access Priority X'2C' Functional Address(s) X'21' Individual Address Count X'22' Product Instance ID
X'25' **4 Report New Active Monitor	X'00' **1	FA(CRS)	X'40'	op_tx op_tx	X'02' UNA X'0B' Physical Drop Number X'22' Product Instance ID
X'26' **4 Report SUA Change	X'00' **1	FA(CRS)	X'40'	op_tx	X'02' UNA X'0B' Physical Drop Number
X'27' **4 Report Neighbor Notification Incomplete	X'00' **1	FA(REM)	X'60'		X'0A' SA of Last AMP or SMP Frame
X'28' **4 Report Active Monitor Error	X'00' **1	FA(REM)	X'60'	op_tx	X'30' Error Code X'02' UNA X'0B' Physical Drop Number
X'29' **4 Report Error	X'00' **1	FA(REM)	X'60'	op_tx	X'2D' Isolating Error Count X'2E' Non-isolating Error Count X'02' UNA X'0B' Physical Drop Number

Legend:	VC=X'*0'	Indicates the destination class of the requesting entity.
	**1	Indicates Pm=7 or 3.
	**2	Indicates Pm=7 or 0.
	**4	Shall not be transmitted with an RI field.
	**5	See 3.3.4 for exception to X'09' Correlator SV.
	**6	During the join process, a station may transmit multiple Request Initialization MAC frames (Vector X'20') as part of the assured delivery process. The first Request Initialization frame shall be transmitted with an FC value of X'00'. If the Ring Parameter Server sets the A bits in the frame, but subsequently does not respond to the station, the station may transmit subsequent Request Initialization MAC frames with an FC value of X'01'.
	**7	Subvectors with no preceding designator shall be transmitted.
	op_tx	Indicates SV is optional and may be omitted.