
Draft for Development

Token ring local area networks

Part 1. Technical specification (ISO/DP 8802/5)

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This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because the application of standardization to LAN technology is rapidly advancing and not yet sufficiently stable, pending the outcome of deliberations in the International Standards Committee (ISO/TC 97/SC 6 Data Transmission).

It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

A review of this Draft for Development will be carried out not later than two years after its publication. Notification of the start of the review period, with a request for the submission of comments from users of this Draft for Development, will be made in an announcement in the appropriate issue of *BS/News*. Observations which it is felt should receive attention before the official call for comments will be welcomed.

According to the replies received, the responsible BSI Committee will judge whether the Draft for Development can be converted into a British Standard or what other action should be taken.

National foreword

This Draft for Development has been prepared under the direction of the Office and Information Standards Committee.

The primary objective of this Draft for Development is to give advance guidance to product and system designers working in the field of local area networks.

The text of the Draft for Development is identical with Draft E (August 1985) of the standard prepared by the Institute of Electrical and Electronics Engineers, Inc., IEEE 802.5 'Tokening access method and physical layer specifications' and with International Standard 8802.5 which is currently at the draft proposal stage (reference ISO TC 97 SC 6N3244).

For ease of reproduction the IEEE text has been reproduced unchanged.

The Department of Trade and Industry has prepared a Technical Guide (TG 101/4) that contains guidance on implementation and is complementary to this Draft for Development. This Technical Guide is published as DD 136 : Part 2.

Other Drafts for Development on local area networks include:

- DD 98 CSMA/CD Local area networks
Part 1 Technical specification
Part 2 Guidance for implementors
- DD 99 Logical link control for local area networks
Part 1 Technical specification
Part 2 Guidance for implementors
- DD 100 Token bus local area networks
Part 1 Technical specification

IEEE 802.1, although currently at an early stage of development, provides an overview of local area network standardization. The necessary background information for each of the IEEE standards for networks is given in the foreword to each of these standards.

Relevant British Standard publications include:

- BS 6531 10 Mbps slotted ring local area network
- BS 6532 Data terminal equipment for attachment to 10 Mbps slotted ring local area network.

A brochure giving details of existing and projected British Standard publications for Open Systems Interconnection (OSI) may be obtained from the Sales Department, BSI, Linford Wood, Milton Keynes MK14 6LE, at no charge.

Terminology and conventions. The text of IEEE 802.5 has been approved as suitable for publication as a Draft for Development without deviation. Some terminology and certain conventions are not identical with those used in Drafts for Development; attention is drawn especially to the following.

Wherever the words 'IEEE Standard 802.5' appear they should be read as 'DD 136 : Part 1'.

1.0 GENERAL

1.1 SCOPE

For the purpose of compatible interconnection of Data Processing equipment via a local area network using the token-passing ring access method, this IEEE standard:

- defines the frame format, including delimiters, addressing, and frame check sequence, and introduces timers, frame count, and priority stacks (see Section 3);
- defines the medium access control protocol. The finite-state machine and state tables are supplemented with a prose description of the algorithms (see Section 4);
- describes the services provided by the medium access control sublayer to the network management and the LLC sublayer and the services provided by the physical layer to network management and the medium access control sublayer. These services are defined in terms of service primitives and associated parameters (See Section 5);
- defines the physical layer functions of symbol encoding and decoding, symbol timing and latency buffering (See Section 6);
- defines the 1 and 4 megabit per second, shielded twisted pair attachment of the station to the medium including the definition of the medium interface connector (See Section 7).

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

A particular emphasis of this standard is to specify the homogeneous 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.

1.2 DEFINITIONS

Abort Sequence: A sequence which terminates the transmission of a frame prematurely.

Broadcast Transmission: A transmission addressed to all stations.

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

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

Frame: A transmission unit which carries a Protocol Data Unit (PDU) on the ring.

Logical Link Control (LLC): That part of the data link layer which supports media independent data link functions, and uses the services of the medium access control sublayer to provide services to the network layer.

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

Medium Access Control (MAC): The portion of the IEEE 802 data station which controls and mediates the access to the ring.

Medium Interface Connector (MIC): The connector between the station and Trunk Coupling Unit (TCU) at which all transmitted and received signals are specified.

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

Multiple Frame Transmission: A transmission where more than one frame is transmitted when a token is captured.

Network Management (NMT): The conceptual control element of a station which 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.

Physical Layer (PHY): The layer responsible for interfacing with the medium, detecting and generating signals on the medium, and converting and processing signals received from the medium and the medium access control layer.

Protocol-Data-Unit (PDU): Information delivered as a unit between peer entities which contains control information and optionally data.

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

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

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

Service-Data-Unit (SDU): Information delivered as a unit between adjacent entities which may also contain a PDU of the upper layer.

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

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

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

Trunk Cable: The transmission cable which interconnects two trunk coupling units.

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

2.0 GENERAL DESCRIPTION

This standard specifies the formats and protocols used by the token-passing ring medium access control (MAC) sublayer, the physical (PHY) layer, and the means of attachment to the token-passing ring physical medium. The Local Area Network Model and its relationship to the Open System Interconnection (OSI) Reference Model of the International Organization for Standardization (ISO) is illustrated in Figure 1.

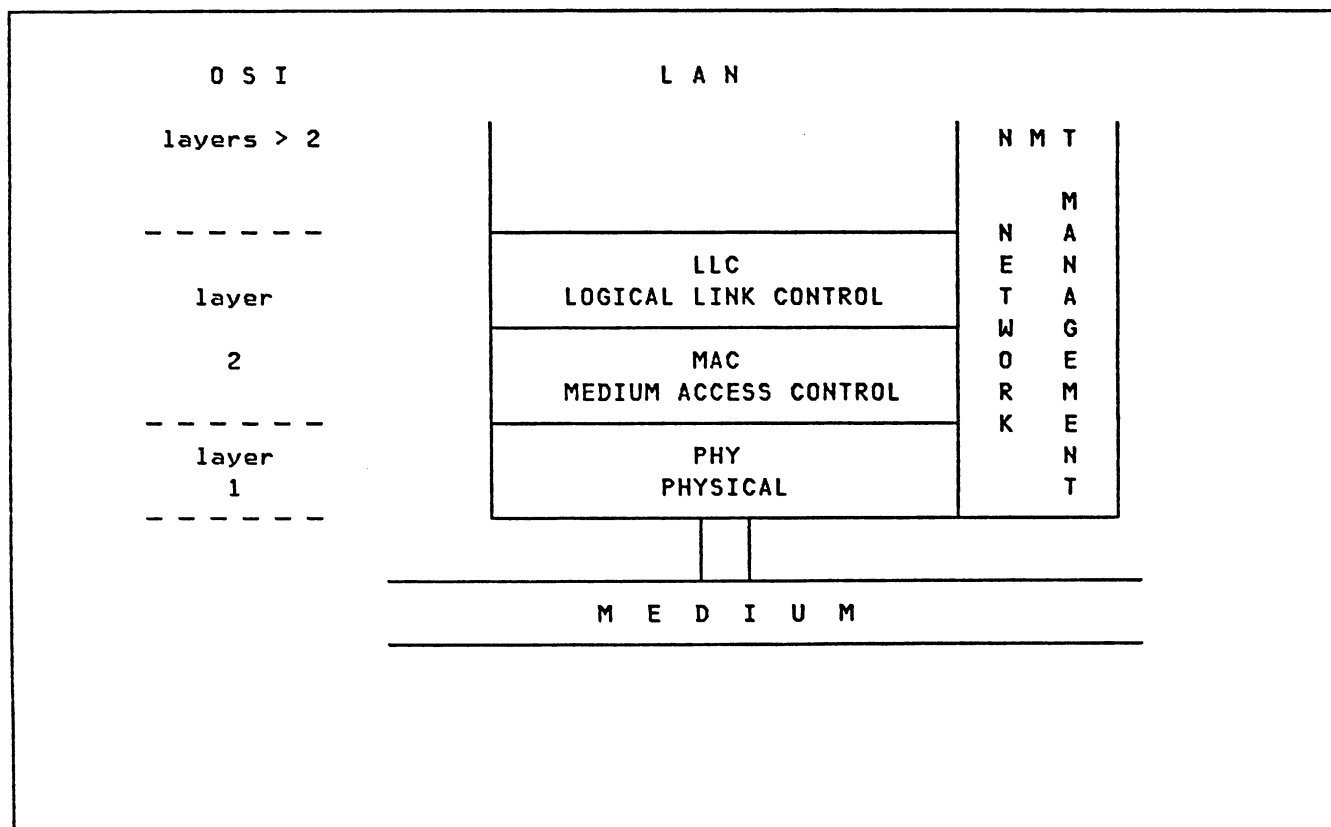


Figure 1. Relation of OSI Reference Model to LAN Model

A token ring consists of a set of stations serially connected by a transmission medium. (see Fig. 2). Information is transferred sequentially, bit by bit, from one active station to the next. Each station generally regenerates and repeats each bit and serves as the means for attaching one or more devices (terminals, work-stations) to the ring for the purpose of communicating with other devices on the network. A given station (the one that has access to the medium) transfers information onto the ring, where the information circulates from one station to the next. The addressed destination station(s) "copies" the information as it passes. Finally, the station which transmitted the information effectively removes 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 signalling sequence that circulates on the medium following each information transfer. Any station, upon detection of an appropriate token, may capture the token by modifying it to a start of frame sequence and appending appropriate control and status fields, address fields, information field, frame check sequence and the end of 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.

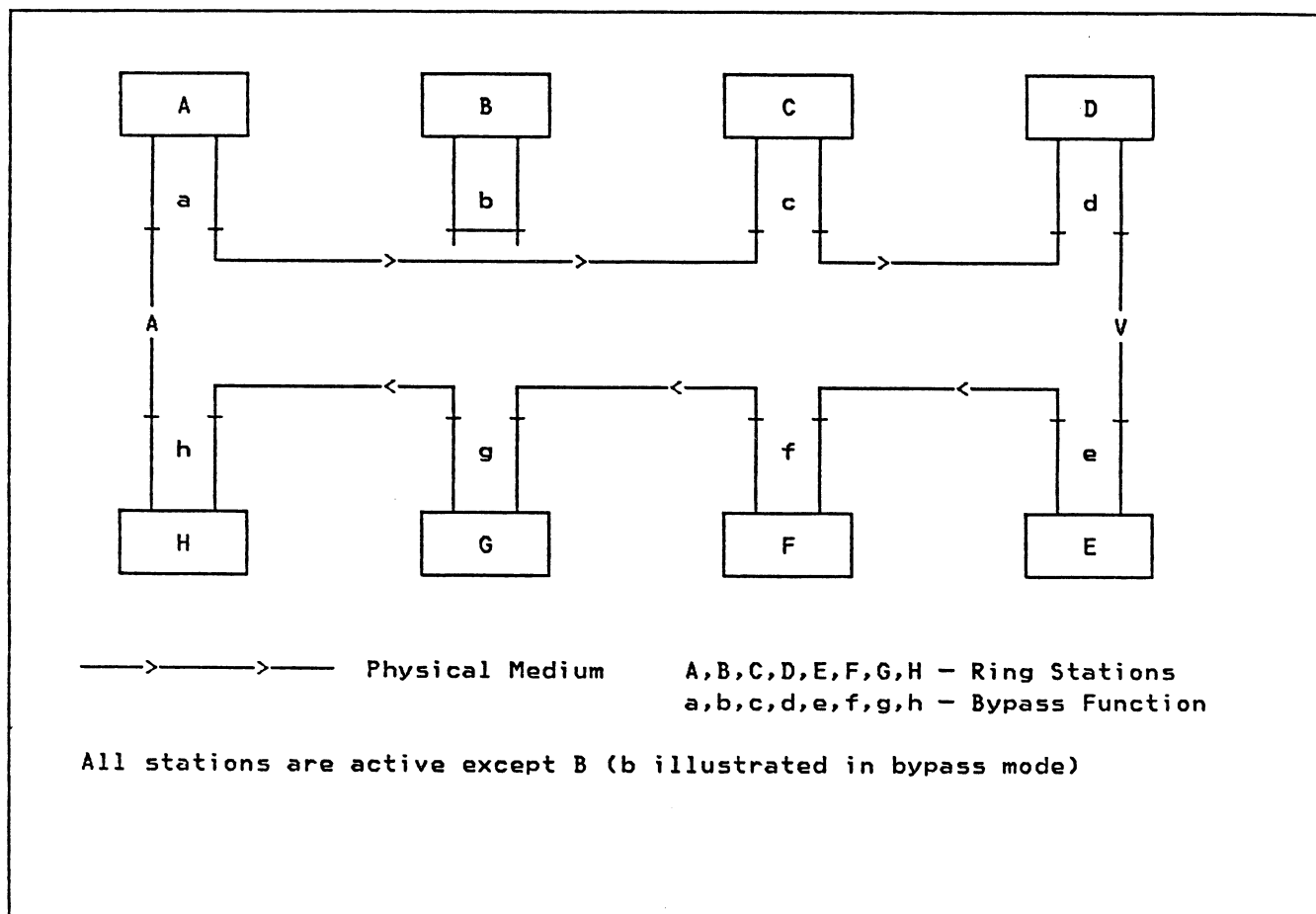


Figure 2. Token Ring Configuration

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

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

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

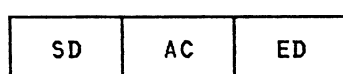
3.0 FORMATS AND FACILITIES

3.1 FORMATS

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

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

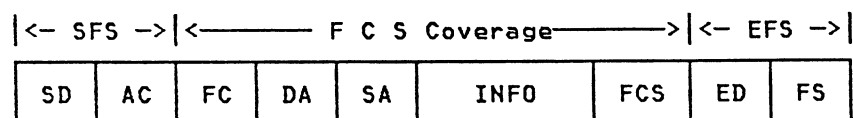
3.1.1 TOKEN FORMAT



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

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

3.1.2 FRAME FORMAT

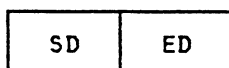


SFS = Start of Frame Sequence	INFO = Information (0 or more octets) *
SD = Starting Delimiter (1 octet)	FCS = Frame Check Sequence (4 Octets)
AC = Access Control (1 octet)	EFS = End of Frame Sequence
FC = Frame Control (1 octet)	ED = Ending Delimiter (1 octet)
DA = Destination Address (2 or 6 octets)	
SA = Source Address (2 or 6 octets)	FS = Frame Status (1 octet)

* - See 3.2.5, "Information (INFO) Field" on page 10 for limitation of information field length.

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

3.1.2.1 Abort Sequence



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

3.1.3 FILL

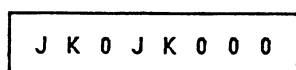
When a station is transmitting (as opposed to repeating), it shall transmit fill preceding or following frames, tokens or abort sequences to avoid what would otherwise be an inactive or indeterminate transmitter state.

Fill may be either 0 or 1 bits or any combination thereof and may be any number of bits in length, within the constraints of the Token Holding timer (THT).

3.2 FIELD DESCRIPTIONS

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

3.2.1 STARTING DELIMITER (SD)

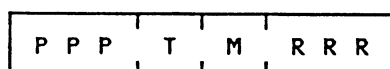


J = Non-data-J
K = Non-data-K
0 = Zero Bit

(For a discussion of non-data symbols, see 6.1, "Symbol Encoding" on page 49)

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

3.2.2 ACCESS CONTROL (AC)



PPP = Priority Bits
T = Token Bit, M = Monitor Bit
RRR = Reservation Bits

3.2.2.1 Priority Bits

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

The eight levels of priority increase from the lowest (000) to the highest (111) priority. For purposes of comparing priority values, the priority shall be trans-

mitted most significant bit first, e.g., 110 has higher priority than 011 (left-most bit transmitted first).

3.2.2.2 Token Bit

The token bit is a 0 in a token and a 1 in a frame. When a station with a PDU to transmit detects a token which has a priority equal to or less than the PDU to be transmitted it may change the token to a start of frame sequence and transmit the PDU.

3.2.2.3 Monitor Bit

The monitor bit is used to prevent a token whose priority is greater than 0 or any frame from continuously circulating on the ring. If an active monitor detects a frame or a "high priority" token with the monitor bit equal to one, the frame or token is aborted.

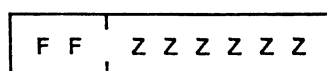
This bit shall be transmitted as 0 in all frames and tokens. The active monitor inspects and modifies this bit. All other stations shall repeat this bit as received.

3.2.2.4 Reservation Bits

The reservation bits allow stations with high priority PDUs to request (in frames or tokens as they are repeated) that the next token be issued at the requested priority. The precise protocol for setting these bits is described in 4.2.2, "Operational Finite-State Machine" on page 26.

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

3.2.3 FRAME CONTROL (FC)



FF = Frame Type Bits
ZZZZZZ = Control Bits

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

3.2.3.1 Frame Type Bits

The Frame Type Bits shall indicate the type of the frame as follows:

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

Medium Access Control Frames: If the Frame Type Bits indicate a MAC frame, all stations on the ring shall interpret and, based on the finite state of the station, act on the ZZZZZZ control bits.

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

Undefined Format: The value "1x" is reserved for frame types that may be defined in the future. However, although currently undefined, any future frame formats shall adhere to the following conditions:

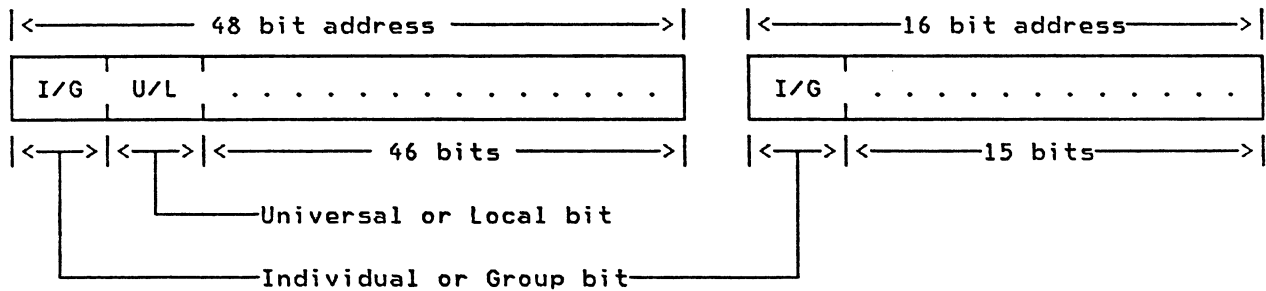
1. The format shall be delimited by the 1-octet starting delimiter (SD) field and the 1-octet ending delimiter (ED) field, as defined in this standard. Additional fields may follow the ending delimiter field.
2. The position of the Access Control (AC) and Frame Control (FC) fields shall be unchanged.
3. The starting delimiter and ending delimiter of the format shall be separated by an integral number of octets. This number shall be at least 2 (i.e., the AC and FC fields) and the maximum length is subject to the constraints of the Token Holding timer.
4. All symbols between the SD and ED shall be 0 and 1 bits.
5. All stations on the ring check for data symbols and an integral number of octets between the SD and ED fields. The Error Detected Bit of formats which are repeated shall be set to 1 when a non-data symbol or a non-integral number of octets is detected between the SD and ED fields.
6. All bit errors that occur in the FC field which have a hamming distance of less than four must be detectable by stations using this format and shall not be accepted by any other station conforming to this standard.

3.2.4 DESTINATION AND SOURCE ADDRESS FIELDS

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

3.2.4.1 Destination Address

The Destination Address identifies the station(s) for which the information field of the frame is intended. Included in the destination address is a bit to indicate whether the destination address is an individual or group address and, for 48 bit addresses only, the second bit indicates whether it is a universally or locally administered address.



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

0 = individual address,

1 = group address

Individual addresses identify a particular station on the LAN and shall be distinct from all other individual station addresses on the same LAN (in the case of local Administration), or from the individual addresses of other LAN stations on a global basis (in the case of Universal Administration).

A group address shall be used to address a frame to multiple destination stations. Group addresses may be associated with zero or more stations on a given LAN.

Note: A group address is an address associated by convention with a group of logically related stations.

Broadcast Address: The group address consisting of 16 or 48 1's (for two- or six-octet addressing, respectively) shall constitute a broadcast address, denoting the set of all stations on a given LAN.

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

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

0 = universally administered

1 = locally administered

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

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

Note: Appendix A contains a suggested method for hierarchical structuring of locally administered addresses.

3.2.4.2 Source Address Field

The Source Address shall identify the station originating the frame and shall have the same format and length as the destination address in a given frame. The individual/group bit shall be 0.

3.2.5 INFORMATION (INFO) FIELD

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

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

3.2.5.1 MAC Frame Format

The following defines the format of the information field, when present, for MAC frames.

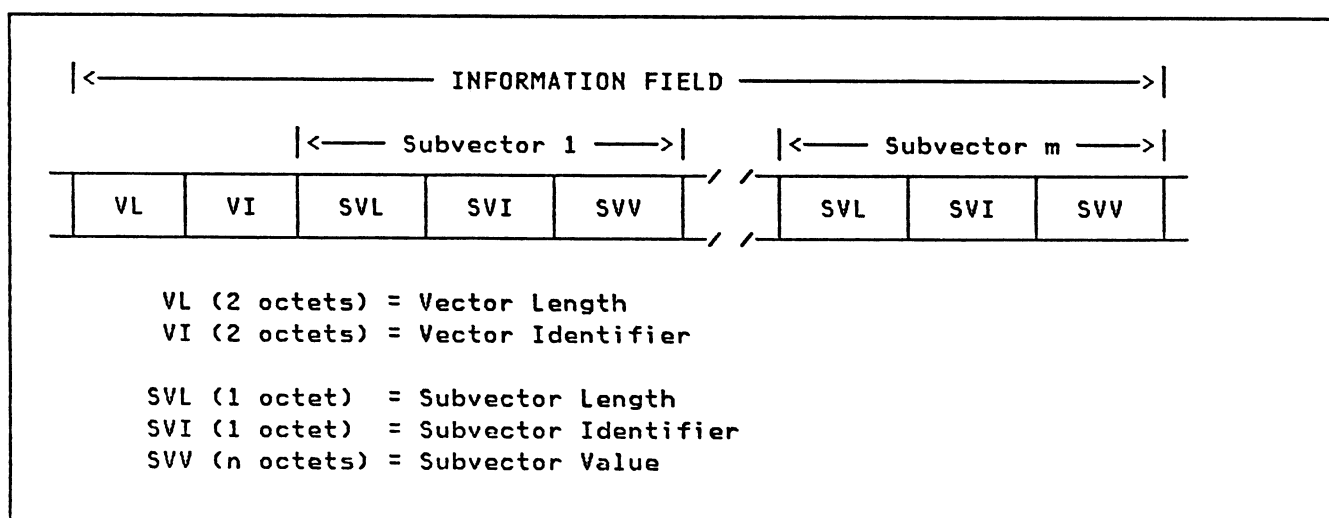


Figure 3. MAC Frame Information Field Structure

Vector: The fundamental unit of MAC and NMT 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 VL field and can have values such that $X'0004' \leq VL \leq X'FFFF'$ (subject to the constraints of the Token Holding timer).

VI (vector identifier): A two octet code point that identifies the vector.

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

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

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

The subvectors are of two types. The subvectors with code points from X'00' through X'7F' are used so that certain specific, common (to many vectors) strings of MAC or NMT data can be formatted and labeled in a standard manner. This standardization is intended to facilitate sharing of data between MAC and NMT 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 which are unique only to the particular subvector to which they belong.

3.2.5.2 LLC Frame Format

The format of the information field for LLC frames is not specified in this standard. However, in order to promote interworking among stations, all stations shall be capable of receiving frames whose information field is up to and including 133 octets in length. (See IEEE Standard 802.2 for additional information)

3.2.5.3 Order of Bit Transmission

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

3.2.6 FRAME CHECK SEQUENCE (FCS)

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

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

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

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

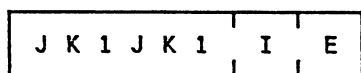
The FCS shall be transmitted commencing with the coefficient of the highest term.

As a typical implementation, at the transmitter, the initial remainder of the division is preset to all ones and is then modified by division of the FC, DA, SA, and INFO fields by the generator polynomial, $G(X)$. The one's complement of this remainder is transmitted, most significant bit first, as the frame check sequence.

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

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

3.2.7 ENDING DELIMITER (ED)



J = Non-data-J, K = Non-data-K, 1 = A One Bit
 I = Intermediate Frame Bit
 E = Error Detected Bit

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

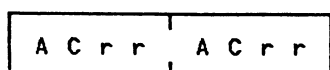
3.2.7.1 Intermediate Frame Bit (I Bit)

To indicate that this is an intermediate (or first) frame of a multiple frame transmission the I-bit shall be transmitted as 1. An I bit of 0 indicates the last or only frame of the transmission.

3.2.7.2 Error Detected Bit (E Bit)

The error detected bit (E) shall be transmitted as 0 by the station that originates the token, abort sequence or frame. All stations on the ring check tokens and frames for errors (e.g., FCS error, non-data symbols - see 4.2.1, "Receive Actions" on page 24). The E bit of tokens and frames which are repeated shall be set to 1 when a frame with error is detected; otherwise the E bit is repeated as received.

3.2.3 FRAME STATUS (FS)



A = Address Recognized Bits
 C = Frame Copied Bits
 r = Reserved Bits

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

3.2.8.1 Address Recognized (A) Bits and Frame Copied (C) Bits

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

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

The A and C bits shall be set without regard to the value of the E bit and only if the frame is good as defined in 4.2.1, "Receive Actions" on page 24. Only the values that are 00rr 00rr, 10rr 10rr and 11rr 11rr shall be considered valid. All other values are invalid and ignored by the receiver.

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

3.3 MEDIUM ACCESS CONTROL FRAMES

The following are descriptions of various MAC frames that are used in the management of the token ring. Values for the Frame Control (FC) bits are defined. Values, other than those defined below, will be ignored by the receiving station(s). All unassigned values are reserved for future specification.

The values for PDU priority (Pm), Destination Address (DA) and Information Field content (Vector Identifier -VI, Subvector Identifier -SVI and Subvector Value -SVV) associated with the particular MAC Supervisory Frame are also indicated. The digits enclosed by X' and ' (e.g., X'07') are the hexadecimal value of the assigned code point. The general format for the information field of MAC frames is described under 3.2.5, "Information (INFO) Field" on page 10.

3.3.1 CLAIM TOKEN MAC FRAME (CL_TK)

When a station which is in standby state determines that there is no active monitor operating on the ring, it shall enter a "claiming token" state. While in this state the station shall send claim token frames and inspect the source address of the claim token MAC frames it receives. If the source address matches its own (MA) address and subvector 1 matches the Stored Upstream Neighbor's Address (SUA), it has claimed the token and shall enter active monitor mode and generate a new token. (For a more detailed description see Figure 8 on page 31.)

The CL_TK values are as follows:

```

Pm: Zero
FC: 00 000011    (Claim Token)
DA: All stations, this ring
VI: X'0003'      (Claim Token)
SVI-1 : X'02'    (RUA - Received Upstream Neighbor's Address)
SVV-1 : ----     (2 or 6 octet address)

```

3.3.2 DUPLICATE ADDRESS TEST MAC FRAME (DAT)

This frame is transmitted with DA = MA as part of the initialization process. If the frame returns with the A bits set to one, it indicates that there is another station on the ring with the same address. If such an event occurs, the station's

network manager is notified and the station returns to bypass state. A station that copies a DAT frame will ignore it.

The DAT values are as follows:

```
Pm: Zero
FC: 00 000000
DA: MA          (This station's address)
VI: X'0007',    (Duplicate Address Test)
```

3.3.3 ACTIVE MONITOR PRESENT MAC FRAME (AMP)

This frame is transmitted by the active monitor. It shall be queued for transmission following the successful purging of the ring or following the expiration of the active monitor timer (TAM). Any station in standby state which receives this frame shall reset its standby monitor timer (TSM).

The AMP values are as follows:

```
Pm: Pr *
FC: 00 000101
DA: All stations, this ring
VI: X'0005'      (Active Monitor Present)
SVI-1 : X'02'    (RUA - Received Upstream Neighbor's Address)
SVV-1 : ----     (2 or 6 octet address)
```

* - An AMP is transmitted at the ring service priority (Pr) which exists at the time a token is received after an AMP PDU is queued. The default value for Pm for this frame is seven; see 5.3.2.1, "MA_INITIALIZE_PROTOCOL.request" on page 41 to change this value.

3.3.4 STANDBY MONITOR PRESENT MAC FRAME (SMP)

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

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

The SMP values are as follows:

```
Pm: Zero
FC: 00 000000
DA: All stations, this ring
VI: X'0006',    (Standby Monitor Present)
SVI-1 : X'02'    (RUA Received Upstream Neighbor's Address)
SVV-1 : ----     (2 or 6 octet address)
```

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

3.3.5 BEACON MAC FRAME (BCN)

This frame shall be sent as a result of serious ring failure (e.g. broken cable, jabbering station etc.). It is useful in localizing the fault. The transmission of Beacon is covered in the Standby Monitor Finite-State Machine. (See Figure 8 on page 31.)

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

The BCN values are as follows:

```
Pm: Zero
FC: 00 000010
DA: All stations, this ring
VI: X'0002',          (Beacon)
SVI-1 : X'02'          (RUA - Received Upstream Neighbor's Address)
SVV-1 : ----          (2 or 6 octet address)
SVI-2: X'01'          (Beacon Type)
SVV-2:
X'0001' - Issued by station during reconfiguration (for future study)
X'0002' - Continuous J symbols received
X'0003' - Timer TNT expired during claiming token; no FR_CL_TK received
X'0004' - Timer TNT expired during claiming token; FR_CL_TK (SA<MA) received
```

3.3.6 PURGE MAC FRAME (PRG)

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

The PRG values are as follows:

```
Pm: Zero
FC: 00 000100
DA: All stations, this ring
VI: X'0004'          (Purge)
SVI-1 : X'02'          (RUA - Received Upstream Neighbor's Address)
SVV-1 : ----          (2 or 6 octet address)
```

3.4 TIMERS

The value of these timers shall be established by mutual agreement among the users of the LAN.

Note: The term Reset, when applied to timers, is to be understood to mean the timer is reset to its initial value and (re)started.

3.4.1 TIMER, RETURN TO REPEAT (TRR)

Each station shall have a timer TRR to ensure that the station shall return to Repeat State. TRR shall have a value greater than the maximum ring latency. The maximum ring latency consists of the signal propagation delay around a maximum-

length ring plus the sum of all station latencies. The operation of TRR is described in the operational finite-state machine. The default time-out value of TRR shall be 2.5 ms.

3.4.2 TIMER, HOLDING TOKEN (THT)

Each station shall have a timer THT to control the maximum period of time the station may transmit frames after capturing a token. A station may initiate transmission of a frame if such transmission can be completed before timer THT expires. The operation of THT is described in the operational finite-state machine. The default time-out value of THT shall be 10 ms.

3.4.3 TIMER, QUEUE PDU (TQP)

Each station shall have a timer TQP for the purpose of timing the enqueueing of a SMP PDU after reception of a AMP or SMP frame in which the A and C bits were equal to 0. The default time-out value of TQP is 10 ms.

3.4.4 TIMER, VALID TRANSMISSION (TVX)

Each station shall have a timer TVX which is used by the active monitor to detect the absence of valid transmissions. The operation of TVX is described in the monitor finite-state machine. The time-out value of TVX shall be the sum of the time-out value of THT plus the time-out value of TRR.

3.4.5 TIMER, NO TOKEN (TNT)

Each station shall have a timer TNT to recover from various token related error situations. TNT shall have a time-out value equal to TRR plus n times THT. (where n is the maximum number of stations on the ring). The operation of TNT is described in the monitor finite-state machines. The default time-out value of TNT shall be 1 second.

3.4.6 TIMER, ACTIVE MONITOR (TAM)

Each station shall have a timer TAM which is used by the active monitor to stimulate the enqueueing of a AMP PDU for transmission. The default time-out value of timer TAM shall be 3 seconds.

3.4.7 TIMER, STANDBY MONITOR (TSM)

Each station shall have a timer TSM which is used by the stand-by monitor(s) to assure that there is an active monitor on the ring and to detect a continuous stream of tokens. The default time-out value of timer TSM shall be 7 seconds.

3.5 FLAGS

Flags are used to "remember" the occurrence of a particular event. They shall be set when the event occurs. The flags used are: