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Information processing systems — Fibre Distributed Data Interface (FDDI) —

Part 2 : Token Ring Media Access Control (MAC)

*Systèmes de traitement de l'information — Interface de données distribuées sur
fibre (FDDI) —*

Partie 2 : Mécanisme d'accès au support de l'anneau à jeton (MAC)



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 9314-2 was prepared by Technical Committee ISO/TC 97, *Information processing systems*.

ISO 9314 consists of the following parts, under the general title *Information processing systems — Fibre Distributed Data Interface (FDDI)* —

- *Part 1: Token Ring Physical Layer Protocol (PHY)*
- *Part 2: Token Ring Media Access Control (MAC)*
- *Part 3: Token Ring Physical Layer, Medium Dependent (PMD)*

Introduction

This part of ISO 9314 on the FDDI media access control is intended for use in a high-performance multistation network. This protocol is designed to be effective at 100 Mbit/s using a Token ring architecture and fibre optics as the transmission medium over distances of several kilometres in extent.

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Information processing systems - Fibre Distributed Data Interface (FDDI) -

Part 2: Token Ring Media Access Control (MAC)

1 Scope

This part of ISO 9314 specifies the Media Access Control (MAC), the lower sublayer of the Data Link Layer (DLL), for Fibre Distributed Data Interface (FDDI).

FDDI provides a high-bandwidth (100 Mbit/s), general-purpose interconnection among computers and peripheral equipment using fibre optics as the transmission medium in a ring configuration. FDDI can be configured to support a sustained transfer rate of approximately 80 Mbit/s (10 Mbyte/s). It may not meet the response time requirements of all unbuffered high speed devices. FDDI establishes the connection among many stations distributed over distances of several kilometres in extent. Default values for the FDDI were calculated to accommodate rings of up to 1 000 physical links and a total fibre path length of 200 km (typically corresponding to 500 stations and 100 km of dual fibre cable).

FDDI consists of

- (a) A Physical Layer (PL), which provides the medium, connectors, optical bypassing, and driver/receiver requirements. PL also defines encode/decode and clock requirements as required for framing the data for transmission on the medium or to the higher layers of the FDDI. For purposes of this part of 9314, references to the PL are made in terms of the Physical Layer entity designated PHY.
- (b) A Data Link Layer (DLL), which is divided into two sublayers:
 - (1) A Media Access Control (MAC) which provides fair and deterministic access to the medium, address recognition, and generation and verification of frame check sequences. Its primary function is the delivery of frames, including frame insertion, repetition, and removal. The definition of MAC is contained in this part of ISO 9314.
 - (2) A Logical Link Control (LLC) which provides a common protocol to provide the required data assurance services between MAC and the Network Layer.
- (c) A Station Management (SMT)¹⁾ which provides the control necessary at the station level to manage the processes under way in the various FDDI layers such that a station may work co-operatively on a ring. SMT provides services such as control of station initialization, configuration management, fault isolation and recovery, and scheduling procedures.

¹⁾ SMT will form the subject of a future part of ISO 9314.

The MAC definition contained herein is designed to be as independent as possible from both the physical medium and the speed of operation. Concepts employed in ISO 8802-5, dealing with Token Ring MAC operation have been modified to accommodate the higher FDDI speed while retaining a similar set of services and facilities.

ISO 9314 specifies the interfaces, functions, and operations necessary to ensure interoperability between conforming FDDI implementations. This part of ISO 9314 provides a functional description. Conforming implementations may employ any design technique that does not violate interoperability.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9314. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9314 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 8802-2: ----¹⁾, *Information processing systems - Local Area Networks - Part 2: Logical Link Control (LLC)*.

ISO 8802-5: ----¹⁾, *Information processing systems - Local Area Networks - Part 5: Token Ring Access Method and Physical Layer specification*.

ISO 9314-1: 1989, *Information processing systems - Fibre Distributed Data Interface (FDDI) Part 1: Token Ring Physical Layer Protocol (PHY)*.

ISO 9314-3: ----¹⁾, *Information processing systems - Fibre Distributed Data Interface (FDDI) Part 3: Token Ring Physical Layer, Medium Dependent (PMD)*.

3 Definitions

For the purposes of this part of ISO 9314, the following definitions apply:

3.1 asynchronous: A class of data transmission service whereby all requests for service contend for a pool of dynamically allocated ring bandwidth and response time.

3.2 capture: The act of removing a Token from the ring for the purpose of Frame transmission.

3.3 claim token: A process whereby one or more stations bid for the right to initialize the ring.

3.4 entity: An active functional agent within an Open System Interconnection (OSI) layer sublayer, including both operational and management functions.

3.5 fibre optics: The technology whereby optical signals from light-generating transmitters are propagated through optical fibre waveguides to light-detecting receivers.

¹⁾ To be published.

3.6 frame: A PDU transmitted between co-operating MAC entities on a ring, consisting of a variable number of octets and control symbols.

3.7 Media Access Control (MAC): The Data Link Layer responsible for scheduling and routing data transmissions on a shared medium Local Area Network (e.g., an FDDI ring).

3.8 nonrestricted token: A Token denoting the normal mode of asynchronous bandwidth allocation, wherein the available bandwidth is time-sliced among all requesters.

3.9 octet: A data unit composed of eight ordered bits (a pair of data symbols).

3.10 Physical (PHY): The Physical Layer responsible for delivering a symbol stream produced by an upstream MAC Transmitter to the logically adjacent downstream MAC Receiver in an FDDI ring.

3.11 physical connection: The full-duplex physical layer association between adjacent physical layer entities (in concentrators, repeaters, or stations) in an FDDI ring.

3.12 primitive: An element of the service interface presented by an entity.

3.13 Protocol Data Unit (PDU): The unit of data transfer between communicating peer layer entities. It may contain control information, address information, data (e.g., an SDU from a higher layer entity), or any combination of the three. The FDDI MAC PDUs are Tokens and Frames.

3.14 receive: The action of a station in accepting a Token, Frame, or other symbol sequence from the incoming medium.

3.15 repeat: The action of a station in receiving a Token or Frame from the adjacent upstream station and simultaneously sending it to the adjacent downstream station. The FDDI MAC may repeat received PDUs (Tokens and Frames), but does not repeat the received symbol stream between PDUs. While repeating a Frame, MAC may copy the data contents and modify the control indicators as appropriate.

3.16 restricted token: A Token denoting a special mode of asynchronous bandwidth allocation, wherein the bandwidth available for the asynchronous class of service is dedicated to a single extended dialogue between specific requesters.

3.17 ring: Two or more stations connected by a physical medium wherein information is passed sequentially between active stations, each station in turn examining or copying and repeating the information, finally returning it to the originating station.

3.18 Service Data Unit (SDU): The unit of data transfer between a service user and a service provider.

3.19 services: A set of functions provided by one OSI layer sublayer entity, for use by a higher layer or sublayer entity or by management entities.

3.20 station: An addressable logical and physical attachment in a ring, capable of transmitting, receiving, and repeating information. An FDDI station has one or more PHY entities, one or more MAC entities, and one SMT entity.

3.21 Station Management (SMT): The supervisory entity within an FDDI station that monitors and controls the various FDDI entities including PMD, MAC, and PHY.

3.22 symbol: The smallest signalling element used by MAC, i.e., the PHY SDU. The symbol set consists of 16 data symbols and 8 control symbols. Each symbol maps to a specific sequence of five code bits as transmitted by the Physical Layer.

3.23 synchronous: A class of data transmission service whereby each requester preallocated a maximum bandwidth and guaranteed a response time not to exceed a specified delay.

3.24 token: An explicit indication of the right to transmit on a shared medium. On a Token Ring, the Token circulates sequentially through the stations in the ring. At any time, it may be held by zero or one station. FDDI uses two classes of Tokens: restricted and nonrestricted.

3.25 transmit: The action of a station in generating a Token, Frame, or other symbol sequence and placing it on the outgoing medium.

4 Conventions and abbreviations

4.1 Conventions

The terms SMT, MAC, LLC, and PHY, when used without modifiers, refer specifically to the local entities. The term LLC unless otherwise qualified refers to any local user of MAC data services, other than SMT, including ISO 8802-2.

Low lines (e.g., `requested_service_class`) are used as a convenience to mark the name of signals, functions, etc., that might otherwise be misinterpreted as independent individual words if they were to appear in text.

The use of a period (e.g., `MA_UNITDATA.request`) is equivalent to the use of low lines except that a period is used as an aid to distinguish modifier words appended to an antecedent expression.

4.1.1 Addressing

my short address (MSA): 16-bit Individual Address of this station (0 = Null).

my long address (MLA): 48-bit Individual Address of this station (0 = Null). If a station does not implement 48-bit addressing then MLA=0.

short addresses: Set of 16-bit station Addresses including MSA if not Null, the 16-bit Broadcast Address (all ones), and any other 16-bit Group Addresses recognized by this station.

long addresses: Set of 48-bit Station Addresses including MLA if not Null, the 48-bit Broadcast Address (all ones), and any other 48-bit Group Addresses recognized by this station.

If a station does not implement 48-bit addressing, then MLA = 0.

When claiming the Token (i.e., the transmitter is in Claim Token state), if the station transmits with 16-bit addressing, then MLA = 0; conversely, if the station transmits with 48-bit addressing, then MSA = 0.

4.1.2 Timing values and timers:

All timing values are expressed as the unsigned twos complements of the target, or remaining, time in octets, i.e., the numerically greater magnitude represents the shortest time remaining. This definition is for reference purposes only and does not prescribe the implementation, except where these timing values appear in Protocol Data Units on the ring. These timing values are not all used simultaneously in the state machines; consequently, the implementation need not materialize them when they are not needed.

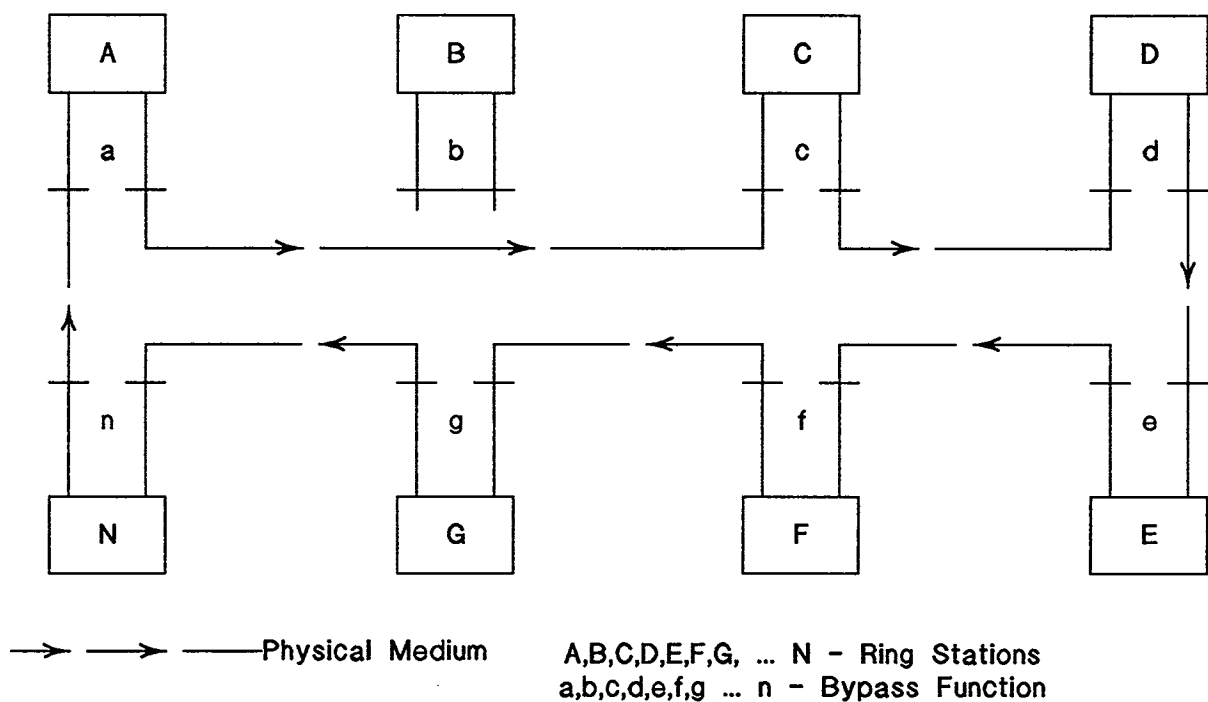
For the purpose of the description contained in this part of ISO 9314, all timers are assumed to be initialized with the unsigned twos complement of the target, or remaining, time in octets. Timers are further assumed to count upward if enabled, expiring when an overflow occurs. All timer comparisons are expressed on the basis of elapsed time. These conventions are only for the convenience of documenting this part of ISO 9314 and do not prescribe implementation.

4.2 Abbreviations

Error_Ct	Count of reportable frame errors
Frame_Ct	Count of all frames received
Late_Ct	Count of TRT expirations (Token Lateness)
Lost_Ct	Count of PDUs detected as lost
A_Flag	Indicates Destination Address match in last received frame
C_Flag	Indicates successful copying of last received frame
E_Flag	Indicates error detected in last received frame
H_Flag	Indicates Higher Source Address received
L_Flag	Indicates Lower Source Address received
M_Flag	Indicates My Source Address received
N_Flag	Indicates next station addressing
R_Flag	Indicates the Token_class of the last valid Token received was restricted
A_Max	Maximum signal acquisition time
D_Max	Maximum ring latency time
F_Max	Maximum frame time
I_Max	Maximum station physical insertion time
L_Max	Maximum Transmitter Frame set-up time
M_Max	Maximum number of MAC entities allowed on the ring
S_Min	Minimum safety timing allowance
T_Bid_Rc	Bidding TTRT received by this station in Claim Frames
T_Bid_Tx	Bidding TTRT transmitted in this station's Claim Frames
T_Init	Ring initialization time
T_Max	Maximum TTRT to be supported by this station
T_Min	Minimum TTRT to be supported by this station
T_Neg	Negotiated TTRT during Claim process (in receiver)
T_Opr	Operative TTRT for this station (in transmitter)
T_Pri	Set of n priority Token rotation time thresholds
T_Pri(n)	Element n of the set T_Pri
T_React	Worst Case time to react to a station insertion or removal
T_Req	Requested TTRT for this station's synchronous traffic
T_Resp	Worst case time to recover a Token
THT	Token-Holding Timer
TRT	Token-Rotation Timer
TTRT	Target Token Rotation Time
TVX	Valid-Transmission Timer

5 General description

A Token ring consists of a set of stations serially connected by a transmission medium form a closed loop (see figure 1). Information is transmitted sequentially, as a stream of symbols, from one active station to the next. Each station generally regenerates and repeats each symbol and serves as the means for attaching one or more devices to the ring for the purpose of communicating with other devices on the ring. A given station (the one that has access to the medium) transmits information on to the ring, where the information circulates from one station to the next. The addressed destination station(s) copies the information as it passes. Finally, the station that transmitted the information effectively removes it from the ring.



All stations are active except B (b illustrated in bypass mode)

Figure 1 - Token ring configuration example

A station gains the right to transmit its information on to the medium when it detects a Token passing on the medium. The Token is a control signal comprised of a unique symbol sequence that circulates on the medium following each information transmission. Any station, upon detection of a Token, may capture the Token by removing it from the ring. The station then transmits one or more frames of information. At the completion of its information transmission, the station issues a new Token, which provides other stations the opportunity to gain access to the ring.

A Token-holding timer, or equivalent means, limits the length of time a station may (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. The classes of service may be synchronous (typically used for applications such as real-time voice), asynchronous (typically used for interactive applications), or immediate (used for extraordinary applications such as ring recovery). The allocation of ring bandwidth occurs by mutual agreement among users of the ring.

Error detection and recovery mechanisms are provided to restore ring 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 recovery function that is distributed among the stations attached to the ring.

The media access method as specified herein is not intended to place constraints on the logical link control or higher level protocols employed to effect data transfer.

6 Services

This clause specifies the services provided by MAC and the services required by MAC. The intent is to allow higher-level protocol(s) (e.g., ISO 8802-2) to operate correctly with this MAC. How many of the services described in this clause are chosen for a given implementation is up to that implementer; however, a set of MAC services shall be supplied sufficient to satisfy the higher level protocol(s) being used. The services as defined herein do not imply any particular implementation, or any interface. Services described are

- (a) MAC services provided to the local LLC entity, or other MAC users (indicated by MA__ prefix).
- (b) Services required from the local PHY entity by MAC (indicated by PH__ prefix).
- (c) MAC services provided to the local SMT entity (indicated by SM__MA__ prefix).

6.1 MAC-to-LLC services

This subclause specifies the services provided by the Medium Access Control (MAC) to allow the local LLC entity to exchange LLC service data units with peer LLC entities. These services are also used for implementer frames. The following primitives are defined:

```
MA__UNITDATA.request
MA__UNITDATA.indication
MA__UNITDATA__STATUS.indication
MA__TOKEN.request
```

The description of each primitive includes a description of the information that is passed between the LLC and MAC entities.

6.1.1 MA__UNITDATA.request

This primitive defines the transfer of one or more Service Data Units (SDUs) from a local LLC entity to a single peer LLC entity, or to multiple peer LLC entities in the case of group addresses.

6.1.1.1 Semantics of the primitive

```

MA_UNITDATA.request
(
    FC_value (1),
    destination_address (1),
    M_SDU (1),
    requested_service_class (1),
    stream (1),
    FC_value (2),
    destination_address (2),
    M_SDU (2),
    requested_service_class (2),
    stream (2),
    .
    .
    .
    FC_value (n),
    destination_address (n),
    M_SDU (n),
    requested_service_class (n),
    stream (n),
    Token_class
)

```

Each set of FC_value, destination_address, M_SDU, requested_service_class and stream parameters specifies one frame for transmission and is referred to as a subrequest.

The FC_value parameter supplies the Frame Control (FC) field to be transmitted as part of the frame.

The destination_address parameter may specify either an individual or a group MAC address. It shall contain sufficient information to create the DA (Destination Address) field that is included in the frame by MAC. Address length is determined by the L bit of the associated FC_value parameter (see 7.3.3).

Each M_SDU parameter specifies an LLC service data unit as received at the MAC interface to be transmitted by MAC. There is sufficient information associated with the M_SDU for MAC to determine the length of the service data unit. Associated with each M_SDU is a requested_service_class parameter.

Requested_service_class may be either Synchronous or Asynchronous. If asynchronous, then requested_Token_class and the priority level may optionally be specified.

Stream is a parameter that, if set, shall cause multiple M_SDUs to be transmitted as a result of the MA_UNITDATA.request. Stream, when reset, indicates that this M_SDU is the last one associated with this MA_UNITDATA.request. The frames shall be transmitted in the order presented by this primitive regardless of the associated requested_service_class. If TFR (Token-Rotation Timer) has expired (Late_Ct not= 0) or if a frame is encountered that cannot be transmitted because of its associated requested_service_class and the current value of THT (Token-Holding Timer), then transmission is terminated and a Token is issued as defined by the Token_class parameter. A MA_UNITDATA_STATUS.indication is subsequently returned to LLC. If the transmission_status is successful, MAC may initiate transmission of the remaining frames on the next permitted access opportunity or, alternatively, MAC may require reissuance of a new MA_UNITDATA.request.

Token_class specifies the class of Token that MAC shall issue following transmission of the associated SDUs (i.e., at the end of the request), if no other request is pending that can be honoured. With requests for synchronous service the Token_class shall be the Token_class that was captured; with requests for asynchronous service it may be either restricted or nonrestricted. If no SDUs were specified by the MA_UNITDATA.request, then MAC shall immediately issue the requested class of Token.

6.1.1.2 When generated

This primitive is generated by the local LLC entity whenever data is to be transferred to a peer LLC entity or entities or a Token is to be generated. This may be in response to a request from higher layers of protocol or from data generated internally to LLC.

6.1.1.3 Effect of receipt

The receipt of this primitive shall cause MAC to append all MAC-specific fields, including DA, SA (Source Address), and any fields that are unique to the medium access method, and pass the properly formed frames to the lower layers of protocol for transfer to peer MAC entity or entities.

NOTE - This primitive is the normal means of requesting the transfer of data. The capture of a Token is implicit in this primitive and therefore it is not necessary to issue an MA_TOKEN.request primitive in conjunction with it.

6.1.2 MA_UNITDATA.Indication

This primitive defines the transfer of data from MAC to the local LLC entity.

6.1.2.1 Semantics of the primitive

```
MA_UNITDATA.indication
(
    FC_value,
    destination_address,
    source_address,
    M_SDU,
    reception_status
)
```

The FC_value parameter specifies the value of the frame's FC (Frame Control) field. The destination_address parameter may be either an individual or a group address as specified by the DA field of the incoming frame. The source_address parameter is an individual address as specified by the SA field of the incoming frame. The M_SDU parameter shall specify the MAC service data unit as received by the local MAC entity.

The reception_status parameter indicates the success or failure of the incoming frame. It consists of the following elements:

(a) Frame validity: FR_GOOD, FR_BAD

If a FR_BAD is reported, the reason for the error shall also be reported. The reason shall be one of the following:

(1) Invalid FCS: Calculated FCS (Frame Check Sequence) does not match the received FCS

(2) **Length Error:** The frame did not have a valid data length

(3) **Internal Error:** An internal error has occurred that prevents MAC from transferring to LLC a frame that has been acknowledged by the setting of the (address recognized) and C (frame copied) indicators.

(b) **Frame Status:**

The received E (error detected), A, C, and, optionally, any other Indicator values.

6.1.2.2 When generated

The MA_UNITDATA.indication primitive shall be generated by MAC to indicate to the local LL entity the arrival of an LLC frame addressed to this station.

6.1.2.3 Effect of receipt

The effect of receipt of this primitive by the LLC entity is not specified.

6.1.3 MA_UNITDATA_STATUS.indication

This primitive shall provide an appropriate response to MA_UNITDATA.request primitive signifying the success or failure of the request.

6.1.3.1 Semantics of the primitive

```
MA_UNITDATA_STATUS.indication    (
                                   number_of_SDUs,
                                   transmission_status,
                                   provided_service_class
                                   )
```

The number_of_SDUs parameter reports the number of M_SDUs transmitted on a given access opportunity as a result of this request.

The transmission_status parameter shall be used to pass information back to the local requesting LLC entity. It shall be used to indicate the success or failure of the previous associated MA_UNITDATA.request. If the MA_UNITDATA.request primitive specified more than one M_SDU, then the transmission_status parameter may apply to all of the SDUs transmitted indicating if all were acknowledged, via the A and C indicators, by a peer MAC entity. In this case, the resolution of the transmission_status is implementer defined.

The provided_service_class parameter specifies the service class that was provided for the transfer.

6.1.3.2 When generated

This primitive shall be generated by MAC in response to an MA_UNITDATA.request primitive from the local LLC entity.

6.1.3.3 Effect of receipt

The effect of receipt of this primitive by LLC is unspecified.

NOTE - In the event of multiple outstanding requests, additional information may be needed in order for LLC to associate the response with the appropriate request. The association may be implied by the requests being serviced in a first-in-first-out (FIFO) manner. Alternatively, MAC may maintain multiple queues of requests, at least one for each class_of_service implemented, servicing each of these queues in a FIFO manner. It is assumed that if the addressed peer MAC entity, or entities, acknowledge receipt of the frame(s) (by setting the A and C indicators), then either the frame(s) will be delivered, or an internal error will be reported, to the corresponding LLC entity, or entities, via an MA__UNITDATA.indication.

6.1.4 MA__TOKEN.request

This primitive is used by LLC to request the capture of the next Token.

6.1.4.1 Semantics of the primitive

```
MA__TOKEN.request      (
                        requested__Token__class
                        )
```

Requested__Token__class may be either restricted or nonrestricted. The priority level may also be specified if multiple levels of priorities are implemented.

6.1.4.2 When generated

This primitive may be generated by the local LLC entity when data of a time critical nature is to be transferred.

6.1.4.3 Effect of receipt

The receipt of this primitive shall cause MAC to capture the next usable Token based on the requested__Token__class parameter. MAC then enters State T2 (Transmit Data) and transmits Idle symbols until an MA__UNITDATA.request primitive is received from LLC unless TRT expires first, in which case MAC shall issue another Token of the same Token__class as was captured.

NOTE - This primitive may be used for time critical operations to minimize the effects of ring latency. This mode of operation may cause longer than usual preambles preceding a frame, thus wasting ring bandwidth; therefore it should not be used for transfers of data on the FDDI ring that are not time critical.

6.2 PHY-to-MAC services

This subclause specifies the services provided at the interface between the MAC and PHY entities to allow MAC to exchange MAC protocol data units with peer MAC entities. Additional detail is provided in the FDDI Physical Layer Protocol standard (ISO 9314-1) concerning conditions that generate these primitives and PHY actions upon receipt of MAC generated primitives.

The following primitives are defined:

```
PH__UNITDATA.request
PH__UNITDATA.indication
PH__UNITDATA__STATUS.indication1)
PH__INVALID.indication
```

¹⁾ This PHY-to-MAC primitive is not used in this part of ISO 9314 on FDDI MAC.

The description of each primitive includes a description of the information that is passed between the MAC and PHY entities. All PHY service data units have the duration of one symbol period.

These services shall be "synchronous", e.g., each PH_UNITDATA.indication causes exactly one PH_UNITDATA.request. Depending upon the current internal configuration of the station, the PH_UNITDATA.request may be returned to the same PHY, or to a different PHY.

6.2.1 PH_UNITDATA.request

This primitive defines the transfer of data from MAC to the local PHY entity.

6.2.1.1 Semantics of the primitive

```
PH_UNITDATA.request          (
                                PH_Request(symbol)
                              )
```

The symbol specified by PH_Request(symbol) shall be one of the following: J, K, T, R, S, I, or n, where n is any of the 16 data symbols specified in the FDDI Physical Layer Protocol standard (ISO 9314-1).

6.2.1.2 When generated

MAC shall send PHY one PH_UNITDATA.request for each PH_UNITDATA.indication received from PHY.

6.2.1.3 Effect of receipt

The effect of receipt of this primitive by PHY is not specified.

6.2.2 PH_UNITDATA.indication

This primitive defines the transfer of data from the PHY entity to MAC.

6.2.2.1 Semantics of the primitive

```
PH_UNITDATA.indication      (
                                PH_Indication(symbol)
                              )
```

The symbol specified by PH_Indication(symbol) shall be one of the following: J, K, T, R, S, n, Q, H, or V.

6.2.2.2 When generated

The PHY entity sends MAC a PH_UNITDATA.indication every time PHY decodes a symbol. This indication is sent once every symbol period.

6.2.2.3 Effect of receipt

Upon receipt of this primitive, MAC shall accept a symbol from PHY, process it, and generate a corresponding PH_UNITDATA.request to PHY.

6.2.3 PH_UNITDATA_STATUS.indication

This primitive has local significance and shall provide an appropriate response to the PH_UNITDATA.request primitive signifying acceptance of the symbol specified by the PH_UNITDATA.request and willingness to accept another symbol.

6.2.3.1 Semantics of the primitive

```
PH_UNITDATA_STATUS.indication      (
                                     transmission_status
                                   )
```

The transmission_status parameter shall be used to signify the transmission completion status.

6.2.3.2 When generated

PHY sends PH_UNITDATA_STATUS.indication to MAC in response to every PH_UNITDATA.request received. The purpose of the PH_UNITDATA_STATUS.indication is to synchronize the MAC data output with the data rate of PHY.

6.2.3.3 Effect of receipt

The receipt of this primitive shall enable MAC to send another PH_UNITDATA.request to PHY.

6.2.4 PH_INVALID.indication

This primitive is generated by the Physical Layer and asserted to MAC to indicate that PHY is unable to present a valid symbol stream to MAC.

6.2.4.1 Semantics of the primitive

```
PH_INVALID.indication              (
                                     PH_Invalid
                                   )
```

The PH_Invalid parameter shall indicate that PHY is unable to present a valid symbol stream to MAC.

6.2.4.2 When generated

The Physical Layer generates this primitive whenever it detects that the symbol stream is invalid.

6.2.4.3 Effect of receipt

Receipt of this primitive by MAC shall cause the MAC receiver to signal FO_Error, or if the ending delimiter has already been received, FR_Received, to the MAC transmitter and enter State R0. Depending upon the state exited on the transition to R0, actions relative to incrementing Frame_Ct, Error_Ct and Lost_Ct are taken as appropriate. FO_Error or FR_Received causes the MAC transmitter to enter State T0.

6.3 MAC-to-SMT services

This subclause specifies the services provided at the interface between the station management (SMT) entity and MAC. This interface is used by the local SMT entity to monitor

and control the operation of MAC. Additional detail is provided in SMT concerning conditions that generate these primitives and SMT actions upon receipt of MAC-generated primitives.

The following primitives are defined:

```
SM_MA_INITIALIZE_PROTOCOL.request
SM_MA_INITIALIZE_PROTOCOL.confirm
SM_MA_CONTROL.request
SM_MA_STATUS.indication
SM_MA_UNITDATA.request
SM_MA_UNITDATA.indication
SM_MA_UNITDATA_STATUS.indication
SM_MA_TOKEN.request
```

The description of each primitive includes a description of the information that is passed between the MAC and the SMT entities.

6.3.1 SM_MA_INITIALIZE_PROTOCOL.request

This primitive has local significance and is used by SMT to change operational parameters of MAC; however, it is not necessary to change these parameters while MAC is operational in the ring.

6.3.1.1 Semantics of the primitive

```
SM_MA_INITIALIZE_PROTOCOL.request (
    individual_MAC_address (16 bit),
    individual_MAC_address (48 bit),
    group_MAC_addresses,
    T_Min_value,
    T_Max_value,
    TVX_value,
    T_Req_value,
    T_Neg_value,
    T_Pri_value,
    indicate_for_own_frame,
    indicate_for_rcv_only_good_frame
)
```

The individual_MAC_address is the octet string that MAC shall use as its individual address. Both a 16-bit and a 48-bit address may be supplied.

Each group_MAC_address is an octet string that MAC shall use as a group address.

T_Max_value specifies the maximum target Token rotation time (TTRT).

TVX_value specifies the value of TVX (Valid_Transmission Timer) to be used.

T_Min_value specifies the minimum target Token rotation time (TTRT) to be supported.

T_Req_value specifies the requested TTRT for asynchronous traffic.

T_Neg_value specifies the negotiated TTRT for asynchronous traffic.

T_Pri_value specifies a set of priority Token rotation time thresholds.

The indicate_for_own_frame parameter specifies that MAC shall also receive and indicate to SMT frames that it has transmitted.

The indicate_for_rcv_only_good_frames parameter is the value MAC shall use to decide whether to generate MA_UNITDATA.indication and SM_MA_UNITDATA.indication primitives only on frames that are good, or alternatively on all frames.

All parameters of this primitive are optional. If a parameter is omitted, MAC shall use the most recently provided value for this parameter or, if no value has been previously provided, the default value for the parameter.

6.3.1.2 When generated

This primitive is generated by SMT whenever it requires MAC to reconfigure.

6.3.1.3 Effect of receipt

Receipt of this primitive shall cause MAC to establish the values of its addresses, timers, and other initialization parameters. Upon completion of this primitive, MAC shall generate a SM_MA_INITIALIZE_PROTOCOL.confirm.

6.3.2 SM_MA_INITIALIZE_PROTOCOL.confirm

This primitive is used by the MAC to inform SMT that the SM_MA_INITIALIZE_PROTOCOL.request is complete.

6.3.2.1 Semantics of the primitive

```
SM_MA_INITIALIZE_PROTOCOL.confirm    (
                                     status
                                     )
```

The status parameter indicates the success or failure of the SM_MA_INITIALIZE_PROTOCOL.request.

6.3.2.2 When generated

This primitive shall be generated by MAC upon completion of a SM_MA_INITIALIZE_PROTOCOL.request.

6.3.2.3 Effect of receipt

The effect of receipt of this primitive by SMT is not specified.

6.3.3 SM_MA_CONTROL.request

This primitive has local significance and is used by the local SMT entity to control the operation of MAC.

6.3.3.1 Semantics of the primitive

```
SM_MA_CONTROL.request              (
                                   control_action,
                                   beacon_information,
```

```

requested_status
requested_condition
)

```

The control_action parameter shall include the following: Reset, Beacon, Present_Status, Reset_Counters, Interrupt_Upon_Conditions, or Send_Bad_FCS.

The beacon_information parameter shall contain the DA field and the Information field for use in the Beacon Frame if the control_action parameter specifies Beacon.

The requested_status parameter shall include the following: current values of all counters; current values of all timers, R_Flag (Token class restricted) value, current Receiver state machine state, and current Transmitter state machine state.

The requested_condition parameter shall include one or more of the following: capture of Token, receipt of frame, and passing of the Token.

6.3.3.2 When generated

This primitive is generated by SMT to cause MAC to take the action specified by the control_action parameter.

6.3.3.3 Effect of receipt

Receipt of this primitive by MAC shall cause it to take the following actions:

- (a) If the control_action parameter is Reset or Beacon, then MAC shall
 - (1) Generate the MAC_Reset signal.
 - (2) Enter Receiver State R0 (Listen).
 - (3) Enter Transmitter State T0 (Transmit IDLE).
- (b) If the control_action parameter is Beacon, then, following the above, State T (Transmit Beacon) shall be entered in the Transmitter state machine. The Beacon Frame shall be constructed using the beacon_information parameter.
- (c) If the control_action parameter is Present_Status, then MAC shall present the status to SMT as indicated by the requested_status parameter.
- (d) If the control_action parameter is Reset_Counters, then MAC shall reset all counters.
- (e) If the control_action parameter is Interrupt_Upon_Condition, then MAC shall signal SMT when any of the requested_conditions are detected.
- (f) If the control_action parameter is Send_Bad_FCS, then MAC shall send bad FCS with a specific frame to be transmitted.

6.3.4 SM_MA_STATUS.Indication

This primitive is used by MAC to inform the local SMT entity of errors and significant status changes.

6.3.4.1 Semantics of the primitive

```
SM_MA_STATUS.indication      (
                               Status_report
                              )
```

The status_report parameter shall specify appropriate status including the following:

- (a) Any change of Ring_Operational status
- (b) Receipt of My_Claim, Higher_Claim, or Lower_Claim
- (c) Receipt of My_Beacon or Other_Beacon
- (d) Expiration of TVX
- (e) Expiration of TRT and Late_Ct not= 0
- (f) Receipt of PH_Invalid causing the Receiver to enter State
- (g) Receipt of MAC_Reset causing the Receiver to enter State R0
- (h) Overflow of Frame_Ct, Error_Ct, or Lost_Ct
- (i) Receipt of a frame with the Destination Address equal to this station's individual address and the received A Indicator set
- (j) Recognition that this station's transmitted frame was lost in the course of its circulation around the ring
- (k) Any time the R_Flag goes from Reset to Set
- (l) Any time a station sets Ax but does not set Cx
- (m) Receipt of a Token if the MAC Transmitter is in State T2 (Transmit Data) or T3 (Issue Token)
- (n) Expiration of TRT whilst in MAC Transmitter State T4 (Claim Token) or T5
- (o) Occurrence of any condition specified in a previously received SM_MA_CONTROL.request (interrupt_upon_condition)

6.3.4.2 When generated

This primitive shall be generated by MAC when any of the listed reportable conditions are detected.

6.3.4.3 Effect of receipt

The effect of receipt of this primitive by SMT is not specified.

6.3.5 SM_MA_UNITDATA.request

This primitive defines the transfer of one or more SMT Service Data Units (SDU) from the local SMT entity. Any defined PDU format may be sent.