ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-105

DATA LINK LAYER PROTOCOL FOR THE D-CHANNEL OF THE S-INTERFACES BETWEEN DATA PROCESSING EQUIPMENT AND PRIVATE CIRCUIT SWITCHING NETWORKS

September 1985

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BRIEF HISTORY

This Standard ECMA-105 is one of a series of standards for the connection of Data Processing Equipments to Private Circuit Switching Networks.

It is using the ISDN concepts such as developed by CCITT. It is also within the framework of the co-ordination of standards for Open Systems Interconnection as defined by ISO 7498. It is based on the practical experience of ECMA Member Companies and the results of their active and continuous participation in the current work of ISO, CCITT and various national standardization bodies in Europe and in the USA. It represents a pragmatic and widely based consensus.

This Standard ECMA-105 standardizes the Data Link Layer Protocol to be used on the D Channel at the S reference point of DPE to PCSN interfaces (also called S interfaces in this Standard).

Adopted as Standard ECMA-105 by the General Assembly of ECMA on June 13-14, 1985.

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1 GENERAL

1.1 Scope and field of application

This ECMA Standard describes in general terms the Link Access procedure on the D-channel, LAPD. This protocol is based on the Data Link layer protocol such as described in CCITT Recommendations I.440 and I.441.

The purpose of LAPD is to convey information between layer 3 entities across the PCSN user-network interface using the D-channel.

The definition of LAPD uses the principles and terminology of :

- CCITT Recommendation X.200 and X.210 - the reference model for Open Systems Interconnection (OSI); and
- CCITT Recommendation X.25 LAPB - user-network interface for packet mode terminals; and
- ISO 3309 and ISO 4335 - High-level Data Link Control (HDLC) standards for frame structure and elements of procedures.

LAPD is a protocol that operates at the Data Link layer of the OSI architecture. The relationship between the Data Link layer and other protocol layers is defined in CCITT Rec. I.311.

Note 1
A PCSN is a Circuit Switching Network with fully digital transmission capabilities operated over a private domain and bounded by S interfaces.

Note 2
The Physical layer is defined in Standard ECMA-105 (based on CCITT Rec. I.430) and Standard ECMA-106 (based on CCITT Rec. I.431. The layer 3 protocol is defined in Standard ECMA-106 (based on CCITT Rec. I.450 and Rec. I.451).
Reference should be made of these standards for the complete definition of the protocols and procedures across the PCSN user-network interface.

Note 3
The term Data Link layer is used in the main text of this Standard. However, mainly in figures and tables, the terms "layer 2" and "L2" are used as abbreviations. Furthermore, in accordance with CCITT Recommendations Q.930 (I.450) and Q.931 (I.451), the term "layer 3" is used to indicate the layer above the Data Link layer.

LAPD is independent of the transmission bit rate. It requires a full duplex, bit-transparent D-channel.

The characteristics of the D-channel are defined in CCITT Rec. I.412.

Section 1.2 below describes basic concepts used in this Standard and in CCITT Rec. Q.920 (I.440) and Rec. Q.921 (I.441).

Section 1.3 lists the references

Section 1.4 gives an overview description of LAPD functions and procedures.

Section 1.5 summarizes the services that the Data Link layer provides to layer 3 and the services that the Data Link layer requires from the Physical layer.

Section 1.6 provides an overview of the Data Link layer structure.

1.2 Concepts and terminology

The basic structuring technique in the OSI Reference Model is layering. According to this technique, communication among application processes is viewed as being logically positioned into a set of layers represented in a vertical sequence as shown in Figure 1.

Entities exist in each layer. Entities in the same layer but in different systems which must exchange information to achieve a common objective are called "peer entities". Entities in adjacent layers interact through their common boundary. In order to provide its services the Data Link layer entity uses the services provided by the Physical layer.

A Data Link layer Service Access Point (SAP) is the means by which the Data Link layer provides services to layer 3. Associated with each Data Link layer SAP is one or more data link connection endpoint(s) (see Figure 2). A data link connection endpoint is identified by a Connection Endpoint Identifier (CEI) as seen from layer 3 and by a Data Link Connection Identifier (DLCI) as seen from the Data Link layer.

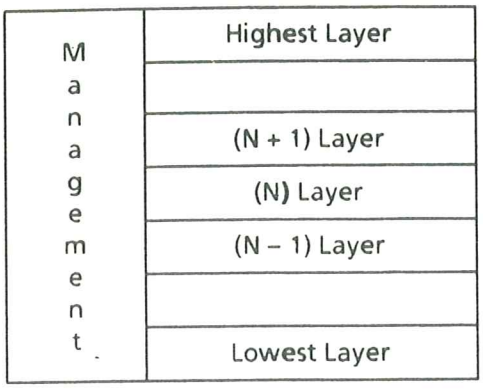


Figure 1: Layering

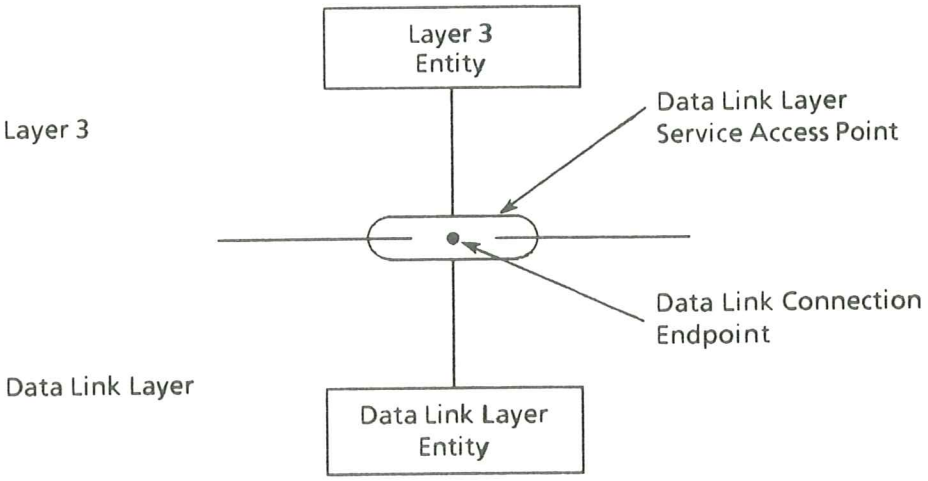


Figure 2: Entities, Service Access Points and Data Link Connection Endpoints

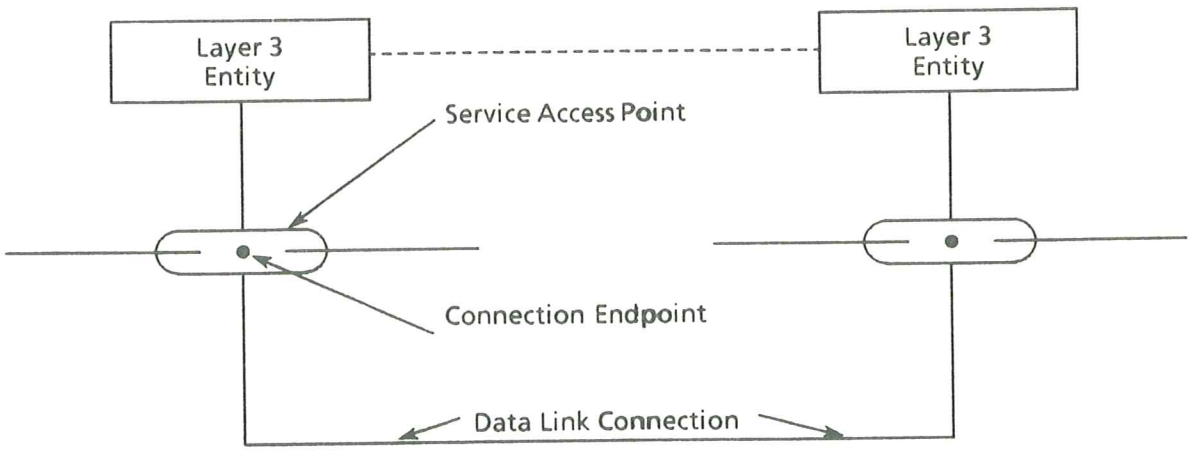


Figure 3: Peer-to-peer Relationship

Cooperation between Data Link layer entities is governed by a peer-to-peer protocol specific to the layer. In order for information to be exchanged between two or more layer 3 entities, an association must be established between the layer 3 entities in the Data Link layer using the Data Link layer protocol. This association is called a data link connection. Data link connections are provided by the Data Link layer between two or more SAPs that have the same SAP indentifier (see figure 3).

Data Link layer message units are conveyed between Data Link layer entities by means of a physical connection.

Layer 3 requests services from the Data Link layer via service primitives. The same applies for the interaction between the Data Link layer and the Physical layer. The primitives represent, in an abstract way, the logical exchange of information and control between the Data Link layer and adjacent layers. They do not specify or constrain the implementation of entities or interfaces.

The primitives that are exchanged between the Data Link layer and adjacent layers are of the following four types (see also Figure 4):

- REQUEST,
- INDICATION,
- RESPONSE, and
- CONFIRM.

The REQUEST primitive type is used when a higher layer is requesting a service from the next lower layer.

The INDICATION primitive type is used by a layer providing a service to notify the next higher layer of the occurence of unsolicited events.

The RESPONSE primitive type is used by a layer to acknowledge receipt, from a lower layer, of the primitive type INDICATION.

The CONFIRM primitive type is used by the layer providing the requested service confirm that the activity has been completed by the peer entity.

Layer-to-layer interactions are specified in section 4.

Information is transferred, in various types of message units, between peer entities and between entities in adjacent layers that are attached to a specific SAP. The message units are of two types:

- Message units of a peer-to-peer protocol, and

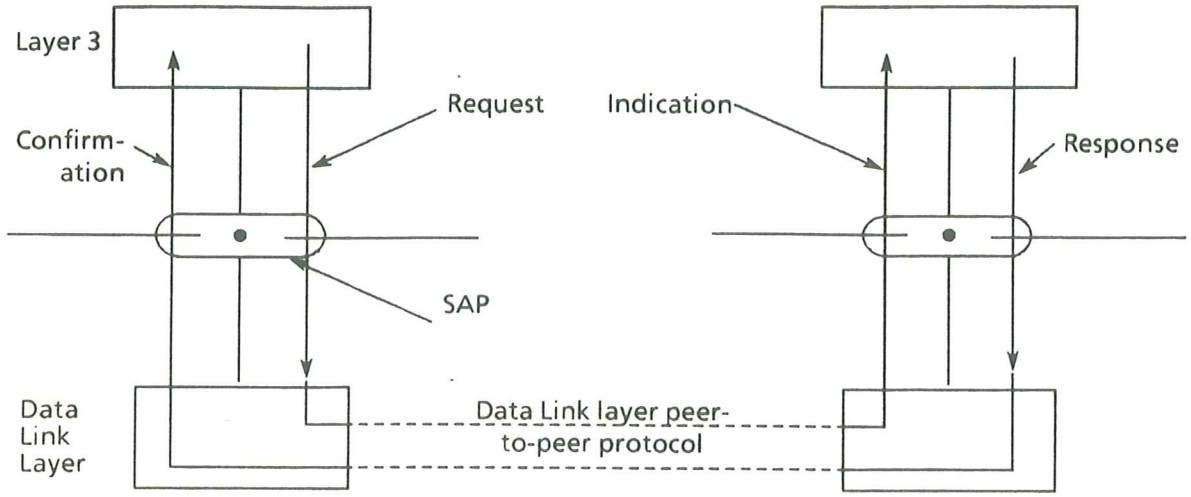
- Message units that contain layer-to-layer information concerning status and specialized service requests.

The message units of the layer 3 peer-to-peer protocol are carried by the data link connection. The message units containing layer-to-layer information concerning status and specialized service requests are never conveyed over a data link or a physical connection.

This Standard specifies (see also Figure 5):

- The peer-to-peer protocol for the transfer of information and control between any pair of Data Link layer service access points; and

- The interactions between the Data Link layer and layer 3, and between the Data Link layer and the Physical layer.



Note: The same Principle applies for Data Link layer - Physical layer interactions

Figure 4: Primitive Action Sequence

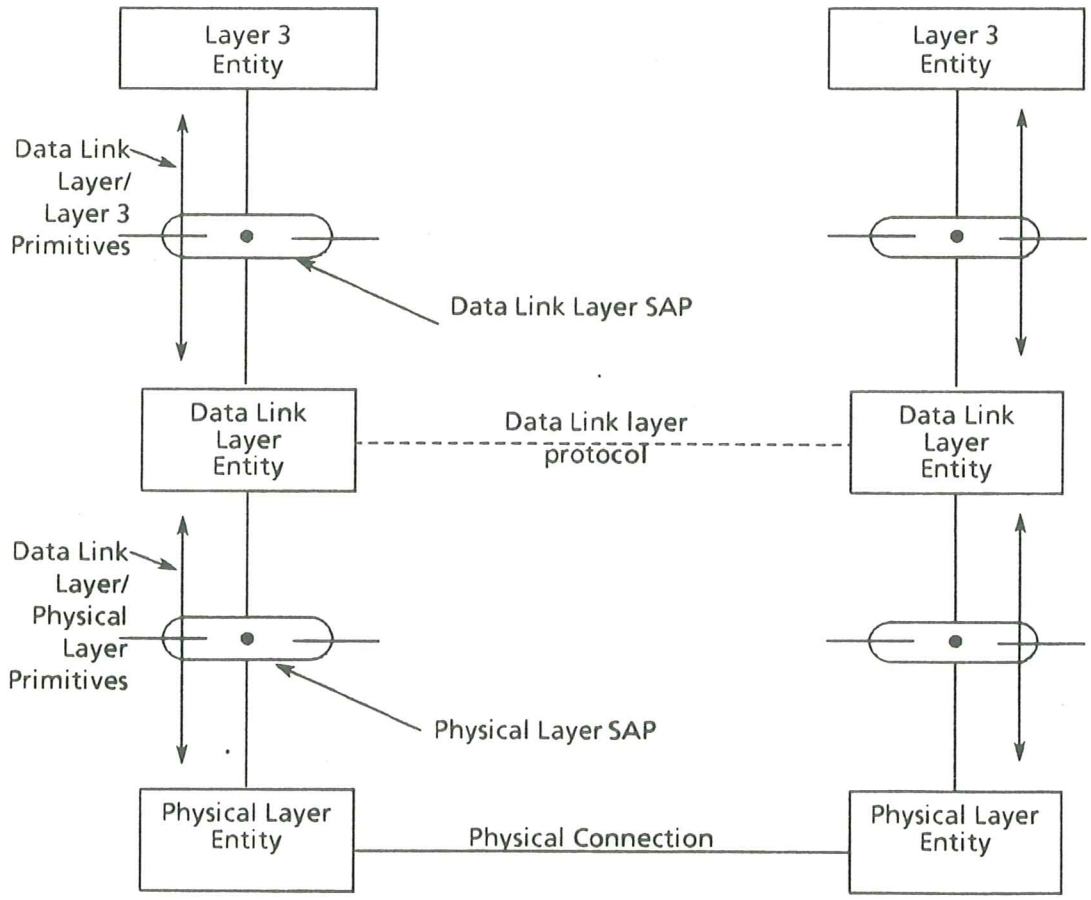


Figure 5: Data Link Layer Reference Model

1.3 References

ECMA-103	: Physical Layer at the Basic Access Interface between Data Processing Equipment and Private Circuit Switching Networks
ECMA-104	: Physical Layer at the Primary Rate Access Interface between Data Processing Equipment and Private Circuit Switching Networks
ECMA-106	: Layer 3 Protocol for Signalling over the D-Channel of the S-Interfaces between Data Processing Equipment and Private Circuit Switching Networks
CCITT Rec. X.25	: Interface between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks
CCITT Rec. X.200	: Reference Model of Open Systems Interconnections for CCITT Applications
CCITT Rec. X.210	: OSI Layer Service Connections
CCITT Rec. I.311	: ISDN Protocol Reference Model
CCITT Rec. I.411	: ISDN User-Network Interfaces - Reference Configuration
CCITT Rec. I.440	: ISDN User-Network Interface - Data Link Layer - General Aspects
CCITT Rec. I.441	: ISDN User-Network Interface - Data Link Layer - Specification
ISO 3309	: Information Processing Systems - Data Communication - High Level Data Link Control Procedures - Frame Structure
ISO 4335	: Data Communication - High Level Data Link Control Procedures - Consolidation of Elements of Procedures
ISO 7809	: Data Communication - High Level Data Link Control Procedures - Consolidation of Classes of Procedures

1.4 Overview description of LAPD functions and procedures

1.4.1 General -

The purpose of LAPD is to convey information between layer 3 entities across the PCSN user-network interface using the D-channel. Specifically, LAPD will support:

- multiple terminal installations at the TE-PCSN interface, and
- multiple layer 3 entities.

All Data Link layer messages are transmitted in frames which are delimited by flags (A flag is a specific bit pattern). The frame structure is defined in section 3.

LAPD includes functions for:

- the provision of one or more data link connections on a D-channel.
- discrimination between the data link connections by means of a data link connection identifier (DLCI) contained in each frame,
- frame delimiting, alignment and transparency, allowing recognition of a sequence of bits transmitted over a D-channel as a frame,
- sequence control, to maintain the sequential order of frames across a data link connection,
- detection of transmission, format and operational errors on a data link,
- recovery from detected transmission, format, and operational errors, notification to the amanegement entity of unrecoverable errors, and
- flow control.

Data Link layer functions provide the means for information transfer between multiple combinations of connection endpoints. The information transfer may be via point-to-point data links or via broadcast data links. In the case of point-to-point information transfer, a frame is directed to a single endpoint while in case of broadcast information transfer a frame is directed towards one or more endpoints.

Figure 6 shows two examples of point-to-point information transfer. Figure 7 shows an example of broadcast information transfer.

Two types of operation of the Data Link layer are defined for layer 3 information transfer : unacknowledged, and acknowledged. They may coexist on a single D-channel.

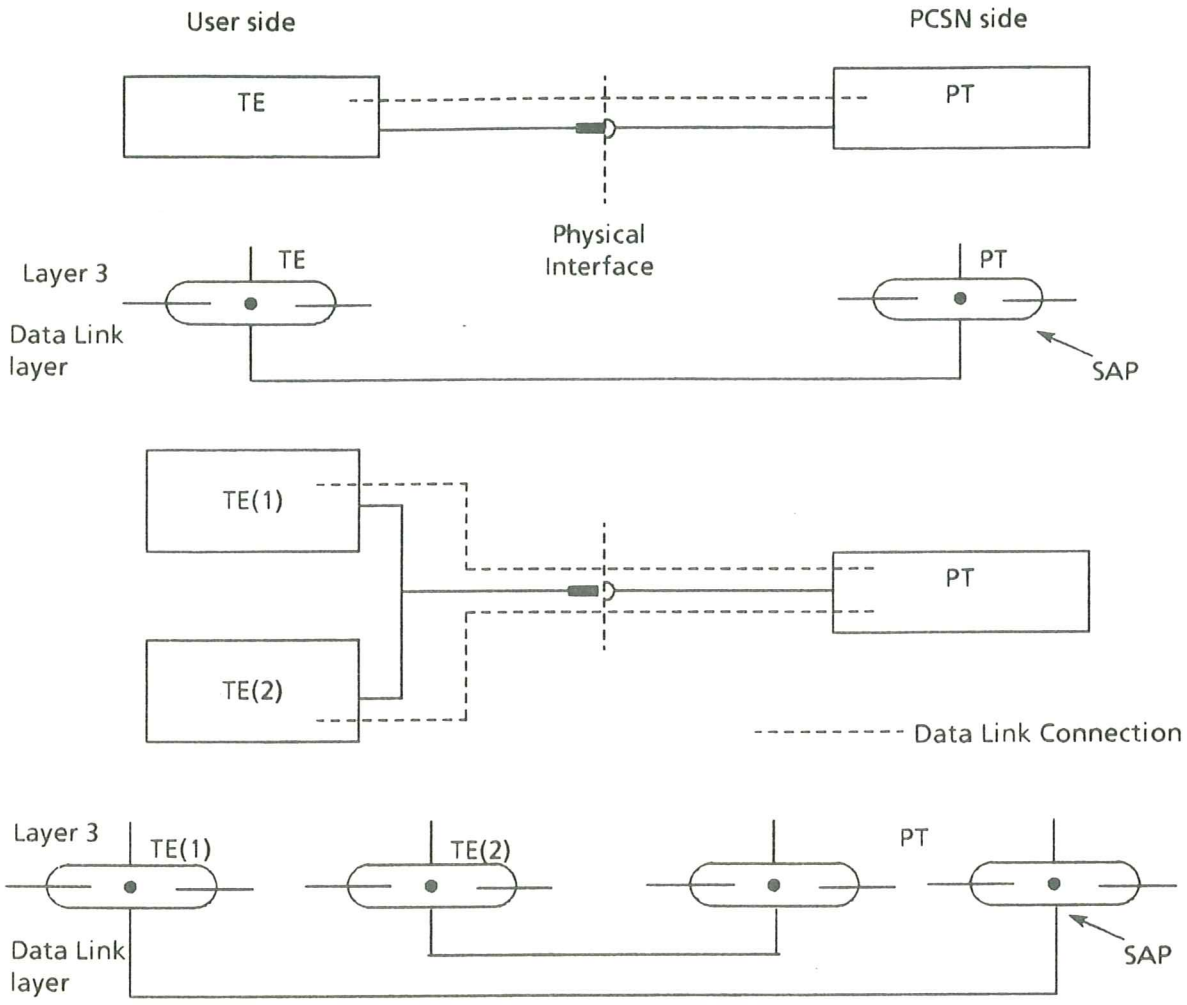


Figure 6: Point-to-Point Links

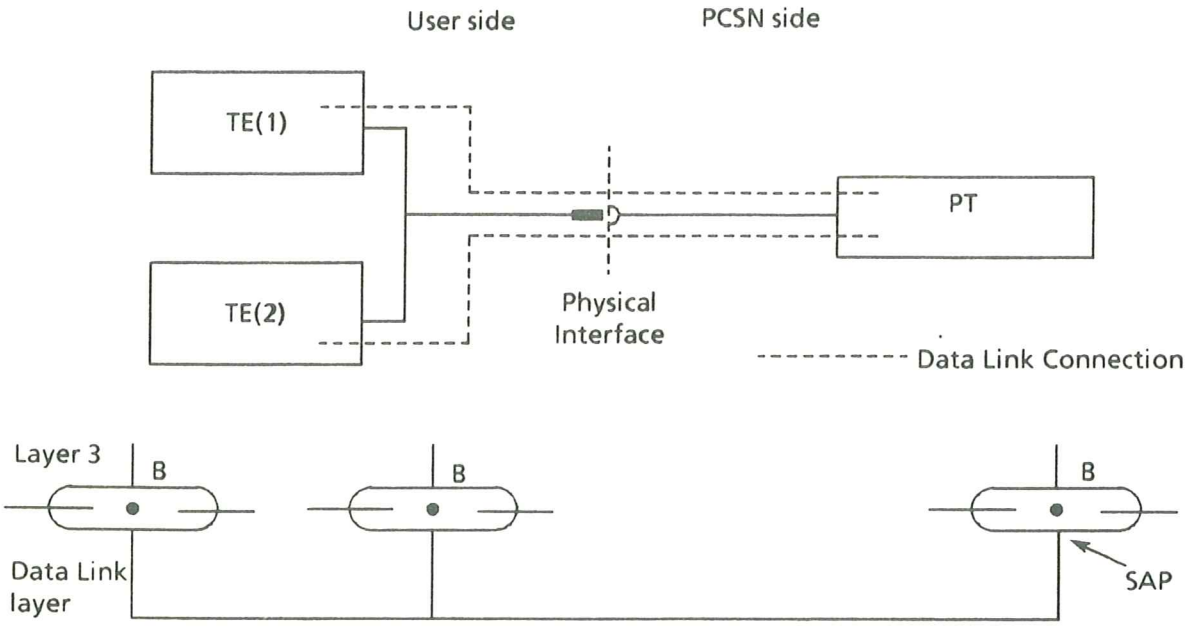


Figure 7: Broadcast Links

1.4.2 Unacknowledged operation -

With this type of operation layer 3 information is transmitted in unnumbered information (UI) frames.

At the Data Link layer the UI frames are not acknowledged. Transmission and format errors may be detected but no error recovery mechanism is defined. Flow control mechanisms are not defined.

Unacknowledged operation is applicable for point-to-point and broadcast information transfer; that is an Unnumbered Information frame may be sent to a specific connection endpoint or broadcast to multiple endpoints associated with a specific Service Access Point Identifier (SAPI).

1.4.3 Acknowledged operation -

With this type of operation, layer 3 information is transmitted in frames that are acknowledged at the Data Link layer.

Error recovery procedures based on retransmission of unacknowledged frames are specified. In the case of errors which cannot be corrected by the Data Link layer, a report to the management entity is made. Flow control procedures are also defined.

Acknowledged operation is applicable for point-to-point information transfer and will be done by a multiple frame operation. Layer 3 information is sent in numbered information (I) frames. A number of I frames may be outstanding at the same time.

Multiple frame operation is initiated by a multiple frame establishment procedure using Set Asynchronous Balanced Mode (SABM) command (See 5.4.1).

1.4.4 Establishment of information transfer modes -

1.4.4.1 Data link connection identification (DLCI) -

A data link connection is identified by a Data Link Connection Identifier carried in the address field of each frame.

The data link connection identifier is associated with a Connection Endpoint Identifier (CEI) at the two ends of the data link (see Figure 9). The connection endpoint identifier is used to identify message units passed between the Data Link layer and layer 3. It consists of the Service Access Point Identifier (SAPI) and the Connection Endpoint Suffix (CES).

The Data Link Connection Identifier (DLCI) consists of two elements: the Service Access Point Identifier (SAPI) and the Terminal Endpoint Identifier (TEI).

The SAPI is used to identify the service access point on the PCSN side or the DPE side of the DPE-PCSN interface.

The TEI is used to identify a specific connection endpoint within a service access point.

The TEI will be assigned automatically by means of a separate TEI assignment procedure (see 5.3.2).
The same SAPI may be found in different TEs connected at the same S reference point. Two TEs connected at the same S reference point shall have two different TEIs.

The DLCI is a pure layer 2 concept. It will be internally used by the Data Link layer entity and not known by the layer 3 nor by the management entity. In these latter entities the concept of Connection Endpoint Identifier (CEI) will be rather used.

The CEI is the parameter of the layer 3 (or management) to layer 2 primitives used to map the multiplexing function of these entities onto the multiplexing function of the layer 2 entity. The CEI is composed of the SAPI information and a reference value named Connection Endpoint Suffix (CES). The CES is an arbitrary value selected by the layer 3 or management entity to refer to the request made to the Data Link layer entity. When the relevant TEI is known by this entity, it will internally associate the DLCI to the CEI until a DL-RELEASE-REQUEST is issued by the higher layer entity or the DL-RELEASE-INDICATION has to be returned. The layer 3 and management entities will use this CEI to address the PCSN until they receive a DL-RELEASE-INDICATION primitive.
Note: Both CEI and DLCI identify a data link connection, but only the DLCI has the same value at both ends of the link.

Figure 8: CEI versus DLCI

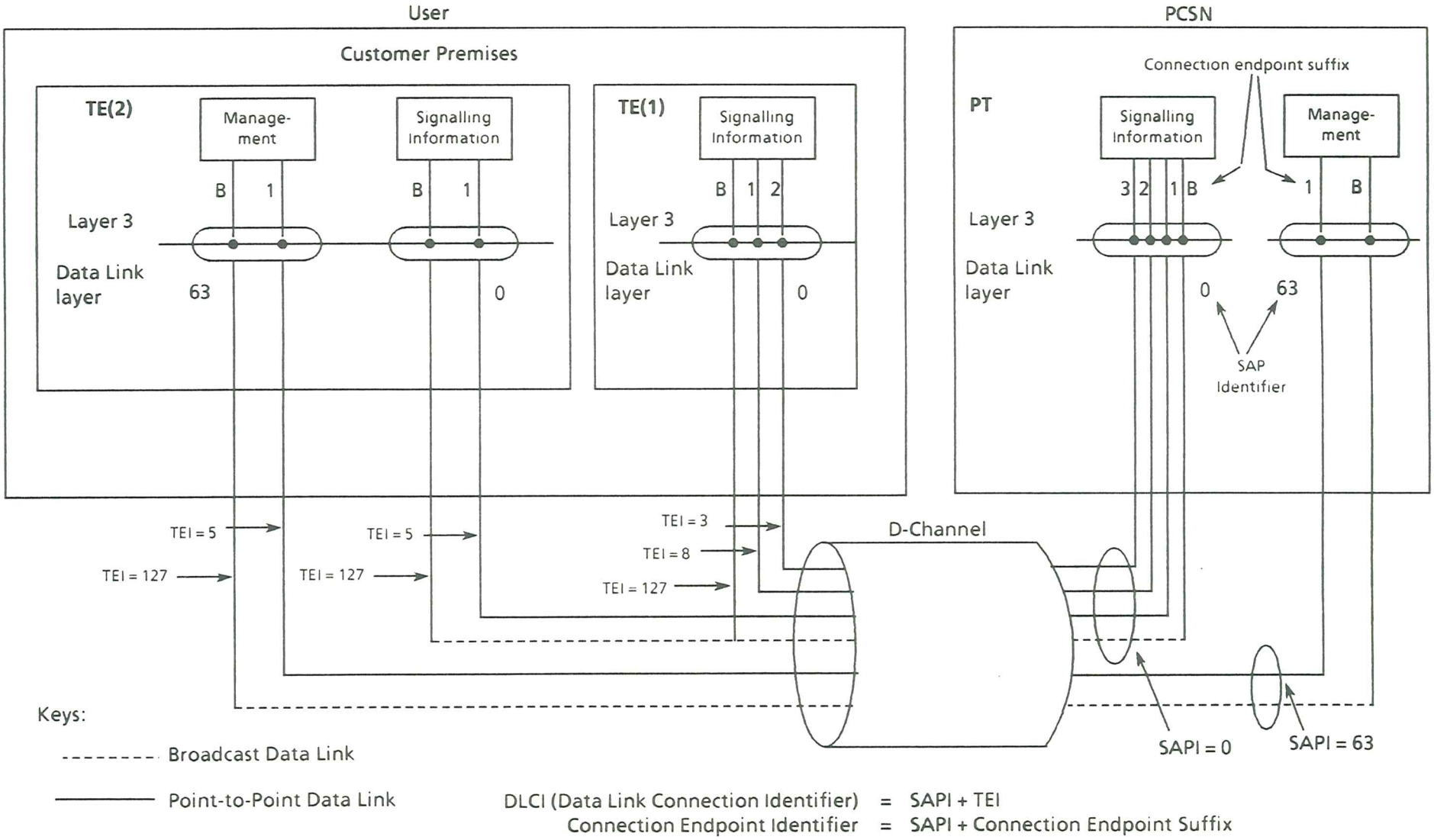


Figure 9: Overview Description of the Relation between SAPI, TEI and Data Link Connection Endpoint Identifier

1.4.4.2 Data Link states with respect to TEI assignenment -

A point-to-point data link may be in one of three basic states, see Figure 10:

i) TEI unassigned state. In this state a TEI has not been assigned or verified. No layer 3 information transfer is possible, or

ii) TEI assigned state. In this state a TEI has been assigned/verified by means of the TEI assignment procedure. Unacknowledged information transfer is possible, or

iii) Multiple-frame-established state. This state is established by means of the multiple frame establishment procedure. Acknowledged multiple frame and unacknowledged information transfer is possible.

A broadcast data link is always in an information transfer state capable of only unacknowledged information transfer (i.e all information is transferred on a broadcast data link by use of UI frames).

These three basic states describe the major steps for establishing a logical point to point link and the operational mode of the LAP. Additional states are required for the function of the LAP, these are described in the state transition tables (see appendix B)

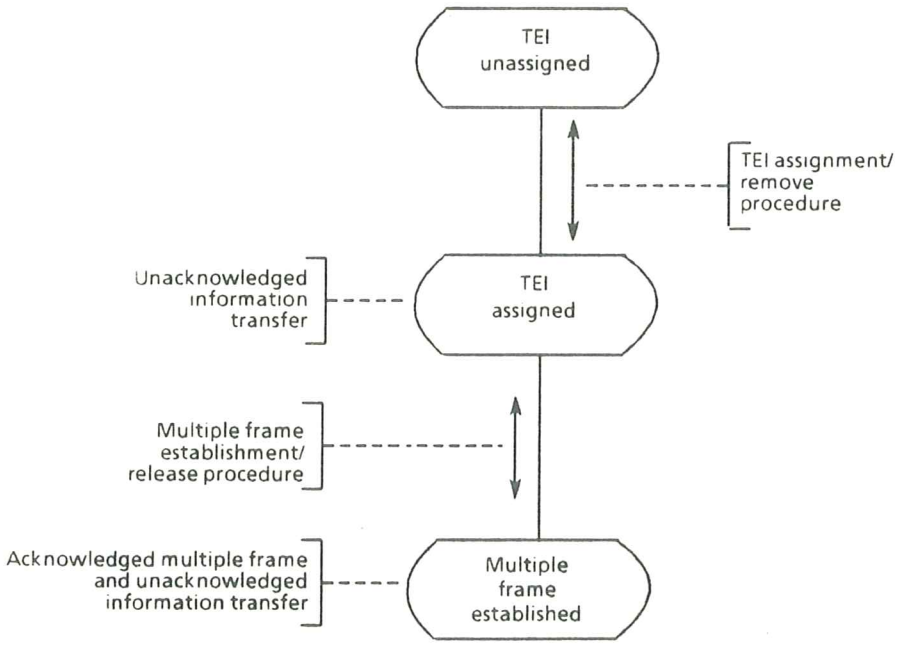


Figure 10: Basic Link States for Point-to-Point Link

1.4.4.3 TEI assignement procedure -

The purpose of this procedure is to allow:

- a TE to request the PCSN to assign a TEI value that the Data Link layer entities within the requesting TE will use in subsequent communications over the data link; and

- a TE to request the PCSN to verify a TEI value, already present in the TE, that the data link entities within the requesting TE will use in subsequent communications over the data link.

An example of the assignment procedures can be found in Appendix D.

The assigned TEI value is typically common to all SAPs (if more than one) in a TE. The procedure is conceptually located in the management entity.

When a TEI has been assigned/verified, the TE establishes an association between the TEI and a connection endpoint suffix in each SAP; that is the data link connection identifier is associated with connection endpoint identifier. In the PCSN, the corresponding association is made upon reception of the first frame containing the assigned/verified TEI.

At that point in time, a point-to-point Data Link layer connection exists.

In the Data Link layer entity, a tuple (TEI,CES) for a given SAPI exists as soon as a TEI has been assigned to a request (the reference of which is CES). The release of the multiple frame mode does not invalidate the association TEI-CES. Removal of the TEI erases the TEI and invalidates the tuple (TEI,CES).
A request from the layer 3 entity to establish a connection with a given CES will reuse the assigned TEI if the tuple CES-TEI is still valid.

The association between the data link connection identifier and connection endpoint identifier will be removed:

- in the PCSN on request from layer 3, or by the Data Link layer itself; and

- in the TE, on request from the management entity; for example, when recognizing that the TEI value is no longer valid, or by the Data Link layer itself.

When in the TEI assigned state or the multiple-frame-established state, the TEI assignment procedure may be used to check the status of a TEI.

Note
In principle the TEI is not systematically memorized outside calls on the PCSN side. Since TEI assignment procedures may be of long duration, for better efficiency the TE should memorize the TEI value it has been allocated as long as possible (see criteria for assignement/removal of TEI values).

A TE in the TEI unassigned state shall use the TEI assignment procedures to enter the TEI assigned state. Conceptually these procedures exist in the management entity. The TEI management function on the PCSN side is referred to as the Assignment Source Point (ASP) in this Standard.

The purpose of this procedure is to allow:

- a TE to request the PCSN to select a TEI value that the Data Link layer entities within the requesting TE will use in their subsequent communications;

- a TE to request the PCSN to verify a TEI value already present in the TE, which the Data Link layer entities within the requesting TE will use in their subsequent communications;

- a PCSN to remove a previously assigned TEI from specific or all TEs.

Additionally, the TE management entity should instruct the TE Data Link layer entity to remove a TEI value for its own internal reasons, for example losing the ability to communicate with the PCSN or a no power condition. Other internal reasons, for example, local monitoring or detection of malfunctions, require further study.

Typically, one TEI value would be used by the TE (for example a Data Link layer entity which has been assigned a TEI value could use that value for all SAPs which it supports). If required, a number of TEI values may be requested by multiple use of the procedures defined in 5.3.2.
It shall be the responsibility of the TE to maintain the association between TEI, SAPI and CES.

The actions taken by a Data Link layer entity to initiate these procedures on receipt of different primitives from layer 3 or from Physical layer are included in 4.2 and 5.3. Alternatively, the management entity may initiate these procedures for its own reasons.

1.4.4.4 Establishment of multiple frame operation -

Before point-to-point multiple frame information transfer may start an exchange of an SABM frame and an Unnumbered Acknowledgement (UA) frames must take place.

The multiple frame establishment procedure is specified in detail in 5.4.1.2.

1.5 Service characteristics

1.5.1 General -

The Data Link layer provides services to layer 3 and utilizes the services provided by the Physical layer.

Note
Communication between different layers in the OSI reference model makes use of primitives which are passed across the layer boundaries. Primitives represent, in an abstract way, the logical exchange of information and control between the Data Link layer and adjacent layers. They do not specify nor constrain implementations.

1.5.2 Services provided to layer 3 -

The specification of the interactions with layer 3 (primitives) provides a description of the service that the Data Link layer plus the Physical layer offer to layer 3, as viewed from layer 3.

Two forms of information transfer services are associated with layer 3. The first is based on unacknowledged information transfer at the Data Link layer while the second service is based on acknowledged information transfer at the Data Link layer.

The Data Link layer aslo provides administrative services to layer 3 in order to implement information transfer services. Layer 3 message units are handled according to their respective layer 3 priority.

1.5.2.1 Unacknowledged information transfer service -

In this case the information transfer is not acknowledged at the Data Link layer.

The information transfer is via broadcast or point-to-point data links.

The characteristics of the unacknowledged information transfer service are summarized as follows:

- provision of a data link connection between layer 3 entities for unacknowledged information transfer of layer 3 message units,
- identification of data link connection endpoints to permit a layer 3 entity to identify another layer 3 entity, and
- no verification of message arrival within the Data Link layer.

The primitives associated with the unacknowledged information transfer service are:

DL-UNIT DATA-REQUEST/INDICATION

The DL-UNIT DATA-REQUEST primitive is used to request that a message unit be sent using the procedures for unacknowledged information transfer service; DL-UNIT DATA-INDICATION indicates the arrival of a message unit received by means of unacknowledged information transfer.

1.5.2.2 Acknowledged information transfer services -

The characteristics of these services are summarized as follows:

- provision of a data link connection between layer 3 entities for acknowledged information transfer of layer 3 message units,

- identification of data link connection endpoints to permit a layer 3 entity to identify another layer 3 entity,

- sequence integrity of Data Link layer message units in the absence of machine malfunctions,

- notification to the peer entity in the case of machine errors, for example loss of sequence,

- notification to the management entity of unrecoverable errors detected by the Data Link layer, and

- flow control.

The primitives associated with the acknowledged information transfer services are:

- Data transfer

  DL-DATA-REQUEST/INDICATION

  The DL-DATA-REQUEST primitive is used to request that a message unit be sent using the procedures for these acknowledged information transfer; DL-DATA-INDICATION indicates the arrival of a message unit received by means of acknowledged information transfer. These primitives are used for multiple frame operation.

- Establishment of multiple frame operation

  DL-ESTABLISH-REQUEST/INDICATION/CONFIRM

  These primitives are used to request, indicate and confirm the establishment of the multiple frame operation between two service access points.

- Termination of multiple frame operation.

  DL-RELEASE-REQUEST/INDICATION

  These primitives are used to request and indicate an attempt to terminate multiple frame operation between two service access points.

1.5.2.3 Administrative services -

The characteristics of the administrative services will allow the following:

- assignment and removal of TEI values to be used on all point-to-point data link connections, and

- data link connection information exchange between the PCSN and the TE.

Some of these services are considered to be conceptually provided by management entities either on the TE side or the PCSN side. The method of describing these administrative functions uses service primitives.

Note
It is recognized that the current OSI reference model does not completely define a management entity and its relations with other layer entities.

The use of the term "service primitives" between the management entity and the Data Link layer entity is provisionally adopted in the standard together with its representation method using "MDL".

The primitives associated with these services are:

- Assignment of TEI value

  MDL-ASSIGN-REQUEST/INDICATION

  These primitives are used to convey a TEI, obtained or verified via the automatic TEI assignment procedure in the management entity, from the management entity to the Data Link layer in order that the TE Data Link layer entities can begin to communicate with the PCSN Data Link layer entities using the assigned TEI value.

- Removal of TEI value

  MDL-REMOVE-REQUEST

  This primitive is used to convey a management function request for removal of a TEI-value that has been previously assigned via the MDL-ASSIGN primitives.

- Notification of an error

  MDL-ERROR-INDICATION/RESPONSE

- Data transfer

  MDL-UNIT-DATA-REQUEST/INDICATION

1.5.3 Services required from the Physical layer -

The services provided by the Physical layer are described in detail in Standard ECMA-103 and ECMA-104 (based on CCITT Rec. I.430 and Rec. I.431). They are summarized as follows:

- Physical layer connection for the transparent transmission of bits in the same order in which they are submitted to the Physical layer,

- indication of the physical status of the D-channel,

- transmission of Data Link layer message units according to their respective Data Link layer priority.

Some of the above services may be implemented in the management entity on the TE side or PCSN side. Since the CCITT has not defined these functions, the method of describing these services is by means of service primitives. The primitives between the Data Link layer and the Physical layer are:

- PH-DATA-REQUEST/INDICATION

  These primitives are used to request that a message unit be sent and to indicate the arrival of a message unit (i.e. Data transfer).

- PH-ACTIVATE-REQUEST/INDICATION

  These primitives are used to request activation of the Physical layer connection and to indicate that the Physical Layer connection has been activated.

- PH-DEACTIVATE-INDICATION

  This primitive is used to indicate that the physical connection has been deactivated.

1.6 Overview of Data Link layer structure

Figure 11 is a tutorial description of the functional block diagram of the Data Link layer supported on a single D-channel that could exist at the PCSN side of the interface.
This figure illustrates two procedural types: the data link procedure and the multiplex procedure.
The TE configuration will be a subset of this figure.

1.6.1 Data Link procedure -

This procedure analyses the control field of the received frame (see 3.4) and provides appropriate peer-to-peer responses and layer-to-layer indications. In addition, it analyses the Data Link layer service primitives and transmits the appropriate peer-to-peer command and responses.

1.6.2 Multiplex procedure -

This procedure analyses the flag, Frame Check Sequence (FCS), and address octets of a received frame. If the frame is correct, it distributes the frame to the appropriate data link procedural block based on the data link connection identifier (see 1.4.4.1).
On frame transmission, this procedure may provide Data Link layer contention resolution between the various data link procedure blocks. The contention resolution is based on the SAPI, giving priority to signalling information by assigning a SAPI value with more leading 0s (see SAPI allocation in 3.3.3).

1.6.3 Structure of the data link procedure -

The functional model of the data link procedure is shown in Figure 12.
The model consists of several functional blocks for point-to-point and broadcast connections. Each of these functional blocks consists of three functional entities, namely a transmission control, a reception control and a data link state control.

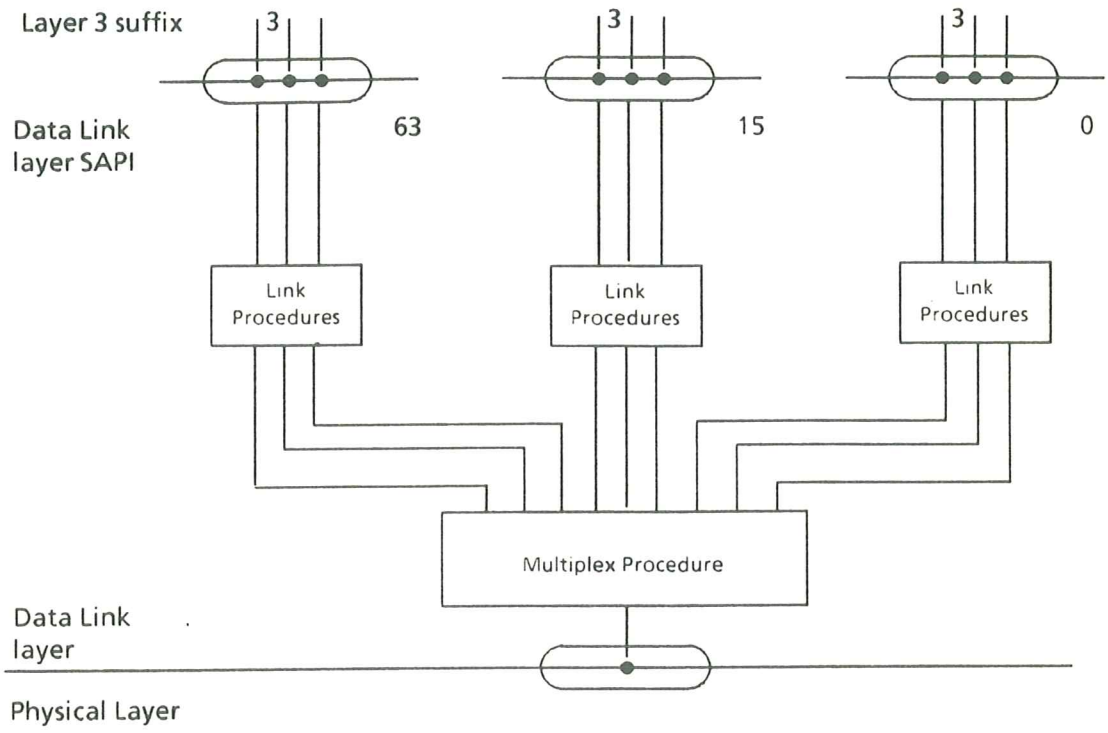


Figure 11: Functional Block Diagram of Data Link Layer

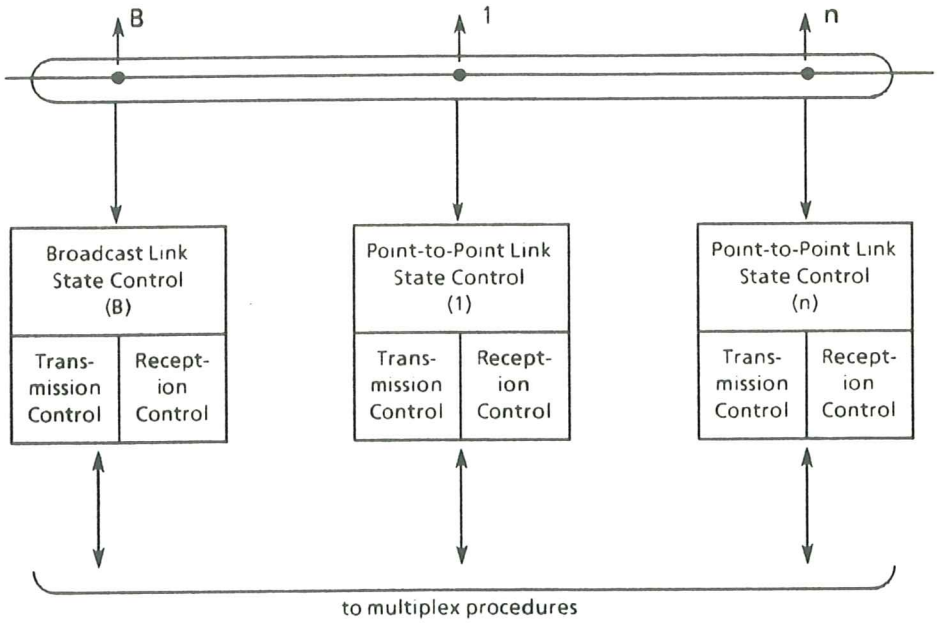


Figure 12: Link Procedure Structure

2 FRAME STRUCTURE FOR PEER-TO-PEER COMMUNICATION

2.1 General

All Data Link layer peer-to-peer exchanges are in frames conforming to the format shown in Figure 13. Two format types are possible: a format where there is no information field, and a format for frames containing an information field.

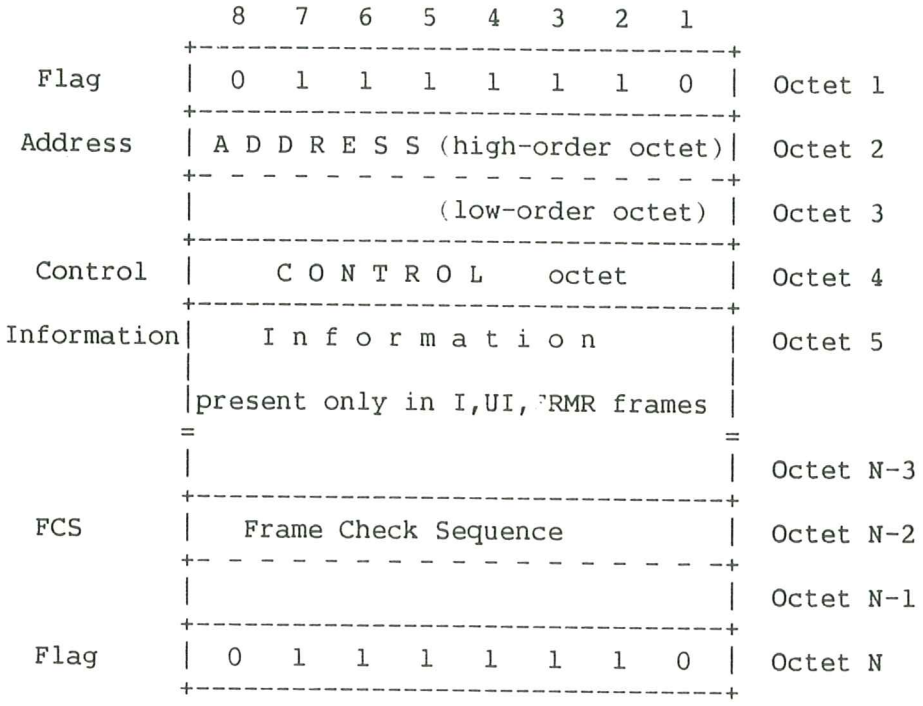


FIGURE 13: FRAME FORMATS

2.2 Flag sequence

All frames shall start and end with the flag sequence consisting of one ZERO followed by six contiguous ONEs and one ZERO. The flag preceding the address field is defined as the opening flag. The flag following the FCS field is defined as the closing flag.

2.3 Address field

The address field shall consist of two octets as illustrated in Figure 13. The address field identifies the intended receiver of a command frame and the transmitter of a response frame. The format of the address fiels is defined in 3.2. Single octet address field is reserved for LAPB operation.

2.4 Control field

The control field shall consist of one octet. Figure 13 illustrates the frame format. The format of the control field is defined in 3.4.

2.5 Information field

The information field of a frame, when present follows the control field (see 2.4 above) and precedes the frame check sequence (see 2.7). The contents of the information field shall consist of an integer number of octets (zero length included). See 3.6.10 for the coding and grouping of bits in the information field as defined in the Standard.

The maximum number of octets in the information field is defined in 5.9.3.

2.6 Transparency

A transmitting Data Link layer entity shall examine the frame content between the opening and closing flag sequences, (address, control, information and FCS fields) and shall insert a ZERO after all sequences of five contiguous ONEs (including the last five bits of the FCS) to ensure that a flag or an abort sequence is not simulated within the frame. A receiving Data Link layer entity shall examine the frame contents between the opening and closing flag sequences and shall discard any ZERO which directly follows five contiguous ONEs.

2.7 Frame checking sequence field (FCS)

The FCS field shall be a 16-bit sequence. It shall be the ones complement of the sum (modulo 2) of:

- The remainder of (x raised to k power) (x15 + x14 + x13 + x12 + x11 + x10 + x9 + x8 + x7 + x6 + x5 + x4 + x3 + x2 + x1 + 1) divided (modulo 2) by the generator polynomial x16 + x12 + x5 + 1, where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency, and,

- The remainder of the division (modulo 2) by the generator polynomial x16 + x12 + x5 + 1, of the product of x16 by the content of the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency.

As a typical implementation at the transmitter, the initial content of the register of the device computing the remainder of

the division is preset to all ONEs and is then modified by division by the generator polynomial (as described above) on the address, control and information fields; the ONE's complement of the resulting remainder is transmitted as the sixteen-bit FCS.

As a typical implementation at the receiver, the initial content of the register of the device computing the remainder is preset to all ONEs. The final remainder after multiplication by x16 and then division (modulo 2) by the generator polynominal x16 + x12 + x5 + 1 of the serial incoming protected bits and the FCS, will be 0001 1101 0000 1111 (x15 through x0, respectively) in the absence of transmission errors.

2.8 Format convention

2.8.1 Numbering convention -

The basic convention used in this Recommendation is illustrated in Figure 14. The bits are grouped into octets. The bits of an octet are shown horizontally and are numbered from 1 to 8. Multiple octets are shown vertically and are numbered from 1 to n.

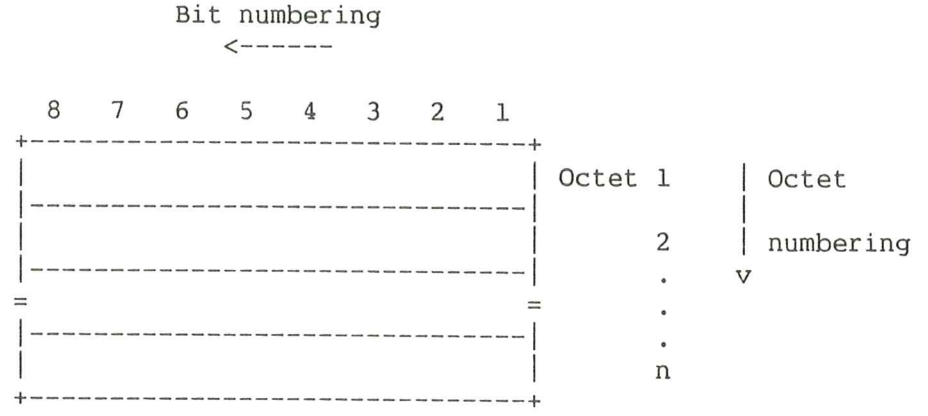


Figure 14: Format convention

2.8.2 Order of bit transmission -

The octets are transmitted in ascending numerical order; inside an octet bit 1 is the first bit to be transmitted.

2.8.3 Field mapping convention -
When a field is contained within a single octet, the lowest bit number of the field represents the lowest order value.

When a field spans more than one octet, the order of bit values progressively decreases as the octet number increases within each octet. The lowest bit number associated with the field represents the lower order value.

For example, a bit number can be identified as a couple (o, b) where o is the octet number and b is the relative bit number within the octet. Figure 15 illustrates a field that spans from bit (1, 3) to bit (2, 7). The high order bit of the field is mapped on bit (1, 3) and the low-order bit is mapped on bit (2, 7).

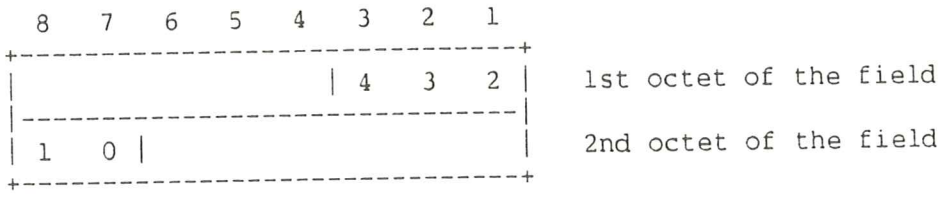


Figure 15: Field mapping convention

Note
The values inside the octets show the power of 2.

An exception to the preceeding field mapping convention is the data link layer Frame Check Sequence (FCS) field, which spans two octets. In this case, bit 1 of the first octet is the high-order bit and bit 8 of the second octet is the low-order bit (Figure 16).

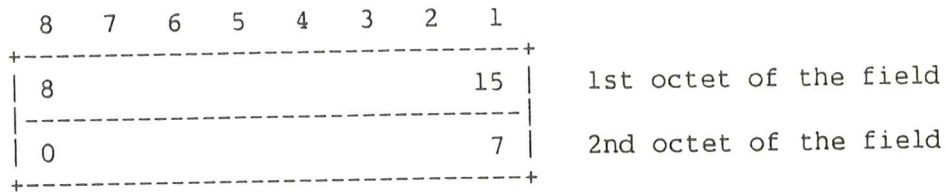


Figure 16: FCS mapping convention

Note
The values inside the octets show the power of 2.

2.9 Invalid frames

An invalid frame is a frame which:

- is not properly bounded by two flags, or
- for unacknowledged operation and multiple frame acknowledge operation has fewer than five octets between flags, or
- does not consist of an integral number of octets, prior to ZERO bit insertion or following ZERO bit extraction, or
- contains a frame check sequence error.

Invalid frames shall be discarded without notification to the sender. No action is taken as the result of that frame.

2.10 Frame abort

Receipt of seven or more contiguous ONEs shall be interpreted as an abort and the Data Link layer entity shall ignore the frame currently being received.

The need for frame abortion is beyond the scope of this Standard.

3 DATA LINK LAYER PEER-TO-PEER COMMUNICATION

ELEMENTS OF PROCEDURES AND FORMATS OF FIELDS

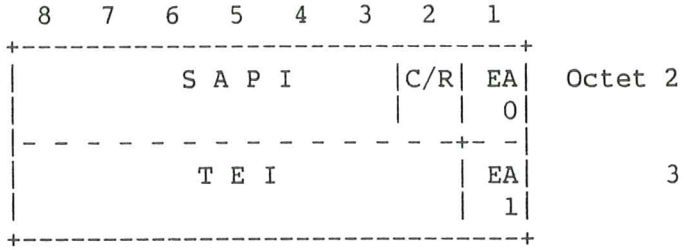
3.1 General

The elements of procedures define the commands and responses that are used on the data link connections carried on the D-channel.

Procedures are derived from these elements of procedures and are described in 5.

3.2 Address field form

The address field format shown in Figure 17 contains the address field extension bits, a command/response indication bit, a Data Link layer service access point identifier (SAPI) subfield, and a terminal endpoint identifier (TEI) subfield.



EA = Address field extension bit
C/R = Command/response field bit
SAPI = Service access point identifier
TEI = Terminal endpoint identifier

Figure 17: Address field format

3.3 Address field variables

3.3.1 Address field Extension bit (EA) -

The address field range is extended by reserving the first transmitted bit of the address field octets to indicate the final octet of the address field. The presence of a ONE in the first bit of an address field octet signals that it is the final octet of the address field. The double octet address field for LAPD operation shall have bit 1 of the first octet set to ZERO and bit 1 of the second octet set to ONE. This field may be used to differentiate LAPB from LAPD frames.

3.3.2 Command/Response field bit (C/R) -

The C/R bit identifies a frame as either a command or a response. The TE side shall send commands with the C/R bit set to ZERO and responses with the C/R bit set to ONE. The network side shall do the opposite; that is, commands are sent with C/R set to ONE, and responses are sent with C/R set to ZERO. The combinations for the network side and TE side are shown in Figure 18.

	PCSN side C/R value	TE side C/R value
Commands from	1	0
Responses to	1	0
Commands to	0	1
Responses from	0	1

Figure 18: C/R field bit usage

In conformance with HDLC rules, commands use the peer Data Link layer entity's address while responses use the own Data Link layer entity's address. According to these rules, both peer entities on a point to point data link connection use the same address composed of SAPI-TEI where SAPI and TEI conform to the definitions contained in 3.3.3 and 3.3.4.

3.3.3 Service access point identifier (SAPI) -

The service access point identifier (SAPI) identifies a service provided by a Data Link layer entity to a layer 3 entity. Consequently, the SAPI specifies a Data Link layer entity that should process a Data Link layer frame and also a layer 3 entity which is to receive information carried by the Data Link layer frame. The SAPI allows to access up to 64 different services. Bit 3 of the address field octet containing the SAPI is the least-significant binary digit and bit 8 is the most significant. The SAPI values are allocated as follows:

SAPI Value	Related entity
0	Call control procedures
63	Management procedures
All others	Reserved for future standardization

3.3.4 Terminal endpoint identifier (TEI) -

The terminal endpoint identifier (TEI) for a point-to-point data link connection is associated with only one terminal (TE). A TE may contain one or more TEIs. The TEI for a broadcast data link is associated with all user side Data Link layer entities containing the same SAPI. The TEI subfield allows 128 values where bit 2 of the address field octet containing the TEI is the least significant binary digit and bit 8 is the most-significant binary digit. The following conventions shall apply in the assignment of these values.

3.3.4.1 TEI for broadcast data link connection -

The TEI subfield bit pattern "111 1111" (= 127) is defined as the group TEI. The group TEI is assigned to the broadcast data link connection associated with the addressed SAP.

3.3.4.2 TEI for point-to-point data link connection -

The remaining TEI values are used for the point-to-point data link connections associated with the addressed SAP.

The TEI values retained for automatic assignement shall be allocated in the range 64-126.

3.4 Control field formats

The control field identifies the type of frame, which will be either a command or response. The control field will contain sequence numbers where applicable.

Three types of control field formats are specified for numbered information transfer (I format), supervisory functions (S format), and unnumbered information transfers and control functions (U format). The control field formats are shown in Figure 19.

3.4.1 Information transfer format - I -

The I format shall be used to perform an information transfer between layer 3 entities. The functions of N(S), N(R) and P (defined in 3.5) are independent; that is, each I frame has an N(S) sequence number and an N(R) sequence number which may or may not acknowledge additional I frames received by the Data Link layer entity and a P bit that may be set to ZERO or ONE. The use of N(S), N(R) and P is defined in 3.5 and 5.

3.4.2 Supervisory format - S -

The S format shall be used to perform data link supervisory control functions, such as to acknowledge I frames, request retransmission of I frames, and request a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent; that is, each supervisory frame has an N(R) sequence number which may or may not acknowledge additional I frames received by the Data Link layer entity, and a P/F bit that may be set to ZERO or ONE.

3.4.3 Unnumbered format - U -

The U format shall be used to provide additional data link control functions and unnumbered information transfers. This format does not contain sequence numbers but does include a P/F bit that may be set to binary ZERO or ONE.

3.5 Control field parameters and associated state variables

The various parameters associated with the control field formats

are described in this section. The coding of the bits within these parameters is such that the lowest numbered bit within the parameter field is the least-significant bit.

Control field	8	7	6	5	4	3	2	1	
I Format	N (R)			P	N (S)			0	Octet 4
S Format	N (R)			P/F	S	S	0	1	Octet 4
U Format	M	M	M	P/F	M	M	1	1	Octet 4

N(S) Transmitter send sequence number
N(R) Transmitter receive sequence number
S Supervisory function bit
M Modifier function bit
P/F Poll bit when issued as a command, final bit when issued as a response.

FIGURE 19: Control field format

3.5.1 Poll/Final bit -

All frames contain P/F, the Poll/Final bit. The Poll/Final (P/F) bit serves a function in both command frames and responses frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit. The P bit set to ONE is used by a Data Link layer entity to solicit (poll) a response frame from the peer Data Link layer entity. The F bit set to ONE is used to indicate the response frame transmitted as a result of a soliciting (poll) command.

The use of the P/F bit is described in 5.1.

3.5.2 Modulus -

Each I frame is sequentially numbered and may have the value 0 through "n" minus 1 (where "n" is the modulus of the sequence numbers). The modulus equals 8 and the sequence numbers cycle through the entire range, 0 to 7.

3.5.3 Multiple frame operation - variables and sequence numbers

3.5.3.1 Send state variable V(S) -

Each point-to-point data link connection endpoint shall have an associated send state variable (V(S)) when using I frame commands. The send state variable denotes the sequence number of the next in-sequence I frame to be transmitted. The send state variable can take on the value 0 to modulus minus 1. The value of the send state variable shall be incremented by 1 with each successive I frame transmission and shall not exceed V(A) by more than the maximum number of outstanding I frames k.
The value of k may be in the range 1 < (or=) k < (or=) 7.

3.5.3.2 Acknowledge state variable V(A) -

Each point-to-point data link connection endpoint shall have an associated acknowledge state variable (V(A)) when using I frame commands and supervisory frame commands/responses. The acknowledge state variable allows to identify the last frame that has been acknowledged by its peer (V(A)-1 equals the N(S) of last acknowledged I frame). The acknowledge state variable can take on the value 0 to modulus minus 1. The value of the acknowledged state variable shall be updated by the valid N(R) values received from its peer (see 3.5.3.5). A valid N(R) value is one that is in the range V(A) <(or =) N(R) <(or =) V(S) unless V(S) < V(A), in which case N(R) is INVALID if it is in the range V(S) < N(R) < V(A).

3.5.3.3 Send sequence number N(S) -

Only I frames contain N(S), the send sequence number of transmitted I frames. At the time that an in-sequence I frame, is designated for transmission the value of N(S) is set equal to the value of the send state variable V(S).

3.5.3.4 Receive state variable V(R) -

Each point-to-point data link connection endpoint shall have an associated receive state variable (V(R)) when using I frame commands and supervisory frame commands/responses. The receive state variable denotes the sequence number of the next in-sequence I frame expected to be received. The receive state variable can take on the value 0 to modulus minus 1. The value of the receive state variable shall be incremented by 1 with the receipt of an error free, in-sequence I frame the send sequence number N(S) of which equals the receive state variable (V(R)).

3.5.3.5 Receive sequence number N(R) -

All I frames and supervisory frames contain N(R), the expected serial sequence number of the next received I frame. At the time that a frame of the above types is designated for transmission, the value of N(R) is set equal to the current value of the receive state variable V(R). N(R) indicates that the Data Link layer entity transmitting the N(R) has correctly received all I frames numbered up to and including N(R) -1.

3.6 Commands and responses

The following commands and responses are used by either the user or the network Data Link layer entities and are represented in Figure 20. Each data link connection supports the appropriate set of commands and responses for the type of operation desired (see section 5).

For purposes of the LAPD procedures, the supervisory function bit enclosing "11" and those encodings of the modifier function bits in Figure 19 not identified in Figure 20 are identified as "invalid or not implemented" command and response control fields.

The commands and reponses are defined as follows:

Format	Commands	Response	8	7	6	5	4	3	2	1
Information	I		N (R)			P	N (S)			0
Supervisory	RR	RR	N (R)			P/F	0	0	0	1
	RNR	RNR	N (R)			P/F	0	1	0	1
	REJ	REJ	N (R)			P/F	1	0	0	1
Unnumbered	SABM		0	0	1	P	1	1	1	1
		DM	0	0	0	F	1	1	1	1
	UI		0	0	0	P	0	0	1	1
	DISC		0	1	0	P	0	0	1	1
		UA	0	1	1	F	0	0	1	1
		FRMR	1	0	0	F	0	1	1	1

FIGURE 20: Commands and responses

3.6.1 Information (I) command -

The function of the information (I) command is to transfer across a data link connection sequentially numbered frames containing information fields provided by layer 3. This command is used in multiple frame operation on point-to-point data link connections.

3.6.2 Set asynchronous balanced mode (SABM) command -

The SABM unnumbered command is used to place the addressed user side or network side into the modulo 8 multiple frame acknowledged operation.

No information field is permitted with the SABM command. A Data Link layer entity confirms acceptance of a SABM command by the transmission at the first opportunity of a UA response.

Upon acceptance of this command, the Data Link layer entity's send state variable V(S), acknowledge state variable V(A), receive state variable V(R) and retransmission counter are set to 0. The transmission of a SABM command indicates the clearence of a busy condition that was reported by the earlier transmission of an RNR frame by that same data link layer entity.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher level (for example, layer 3) or the management entity to recover from the possible loss of the contents of such I frames.

3.6.3 Disconnect (DISC) command -

The DISC unnumbered command shall be transmitted to terminate the multiple frame operation.

No information field is permitted with the DISC command. Prior to actioning the command, the Data Link layer entity receiving the DISC command confirms the acceptance of a DISC command. The Data Link layer entity sending the DISC command terminates the multiple frame operation when it receives the acknowledging UA or DM response.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher level (for example, layer 3) or the management entity to recover from the possible loss of the contents of such I frames.

3.6.4 Unnumbered information (UI) command -

When a layer 3 or management entity requests unacknowledged information transfer, the UI unnumbered command shall be used to send information to its peer without affecting Data Link layer variables. UI command frames, do not carry a sequence number, therefore, the UI frame may be lost without notification to the management entity if a data link exception occurs during transmission of the command.

3.6.5 Receive ready (RR) command/response -

The receive ready (RR) supervisory frame is used by a Data Link layer entity to:

- indicate it is ready to receive an I frame;
- acknowledge previously receive I frames numbered up to and including N(R) - 1 (as defined in section 5);
- clear a busy condition that was indicated by the earlier transmission of an RNR frame by that same Data Link layer entity.

In addition to indicating the status of a Data Link layer entity, the RR command with P bit set to ONE may be used by the Data Link layer entity to ask for the status of its peer Data Link layer entity.

3.6.6 Reject (REJ) command/response -

The reject (REJ) supervisory frame is used by a Data Link layer entity to request retransmission of I frames starting with the frame numbered N(R). The value of N(R) in the REJ frame acknowledges frames numbered up to and including N(R) - 1. New I frames pending initial transmission shall be transmitted following the retransmitted I frame(s).

Only one REJ exception condition for a given direction of information transfer shall be established at a time. The REJ exception condition is cleared (reset) upon the receipt of an I frame with an N(S) equal to the N(R) of the REJ frame.

The transmission of a REJ frame shall also indicate the clearance of any busy condition within the sending Data Link layer entity that was reported by the earlier transmission of an RNR frame by that same data link layer entity.

A TE shall only use REJ response formats on the sender side. It shall however be capable of receiving REJ command frames.

AT the network side, in addition to indicating the status of a data link layer entity, the REJ command with P bit set to ONE may

be used by the Data Link layer entity to ask for the status of its peer Data Link layer entity.

3.6.7 Receive not ready (RNR) command/response -

The Receive Not Ready (RNR) supervisory frame shall be used by a data link layer entity to indicate a busy condition; that is, temporary inability to accept additional incoming I frames. The value of N(R) in the RNR frame acknowledges I frames numbered up to and including N(R) - 1. Acknowledgement of I frame N(R) and subsequent I frames received, if any, will be indicated in subsequent exchanges.

In addition to indicating the status of a Data Link layer entity, the RNR command with P bit set to ONE may be used by the Data Link layer entity to ask for the status of its peer Data Link layer entity.

3.6.8 Unnumbered acknowledgement (UA) response -

The UA unnumbered response is used by a Data Link layer entity to acknowledge the receipt and acceptance of the mode setting commands (SABM or DISC).

Received mode setting commands are not actioned until the UA response is transmitted. No information field is permitted with the UA response. The transmission of the UA response indicates the clearance of any busy condition that was reported by the earlier transmission of an RNR frame by that same Data Link layer entity.

3.6.9 Disconnected mode (DM) response -

The DM unnumbered response is used by a Data Link layer entity to report to its peer that the Data Link layer is in a state such that multiple frame operation cannot be performed. No information field is permitted with the DM response. A Data Link layer entity shall transmit a DM response to any valid command which it cannot action.

3.6.10 Frame reject (FRMR) response -

The FRMR unnumbered response may be used by a Data Link layer entity, to report an error condition not recoverable by retransmission of the identical frame; that is, at least one of the following conditions, which results from the receipt of a valid frame:

- The receipt of a command or response control field that is undefined or not implemented.

- The receipt of a frame with with an information which is not permitted or the receipt of a supervisory or unnumbered frame with incorrect length;

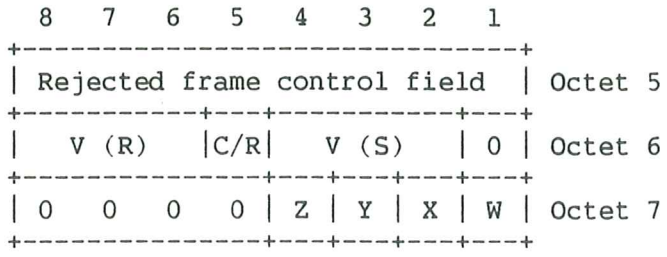
- The receipt of an invalid N(R).

- The receipt of an I frame with an information field which exceeds the maximum established length.

An undefined control field is any of the control field encodings that are not identified in Figure 20.

A valid N(R) value is one that is in the range V(A) < (or =) N(R) < (or =) V(S) unless V(S) < V(A), in which case N(R) is INVALID if it is in the range V(S) < N(R) < V(A)..

An information field which immediately follows the control field and consists of three octets is returned with this response and provides the reason for the FRMR response. This information field format is given in Figure 21.



- The rejected frame control field is the control field of the received frame which caused the frame reject.
- V(S) is the current send state variable value on the user side or network side reporting the rejection condition.
- C/R is set to ONE if the frame rejected was a response, and is set to ZERO if the frame rejected was a command.
- V(R) is the current receive state variable value on the user side or network side reporting the rejection condition.
- W set to ONE indicates that the control field received and returned in octet 5 was undefined or not implemented.
- X set to ONE indicates that the control field received and returned in octet 5 was considered invalid because the frame contained an information field which is not permitted with this frame or is a supervisory or unnumbered frame with incorrect length. Bit W must be set to ONE in conjunction with this bit.
- Y set to ONE indicates that the information field received exceeded the maximum established capacity of the user side or network side reporting the rejection condition.
- Z set to ONE indicates that the control field received and returned in octet 5 contained an invalid N(R).
- Octet 6 bit 1 and octet 7 bits 5 to 8 shall be set to ZERO

FIGURE 21: FRMR information field format

4 ELEMENTS FOR LAYER-TO-LAYER COMMUNICATION

4.1 General

Communications between layers and, for this Standard, between the Data Link layer and the management entity are accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link and adjacent layers. They do not specify or constrain the implementation of entities or interfaces.

Primitives consist of commands and their respective responses associated with the services requested of a lower layer. The general syntax of a primitive is:

XX - Generic name - Type : Parameters

Where XX designates the layer providing the service.

For this Standard XX is DL for the Data Link layer, PH for the Physical layer, or MDL for the management entity to the Data Link layer interface.

4.1.1 Primitives types -

The primitives types defined in this Standard are:

4.1.1.1 REQUEST -

The REQUEST primitive type is used when a higher layer is requesting a service from the next lower layer.

4.1.1.2 INDICATION -

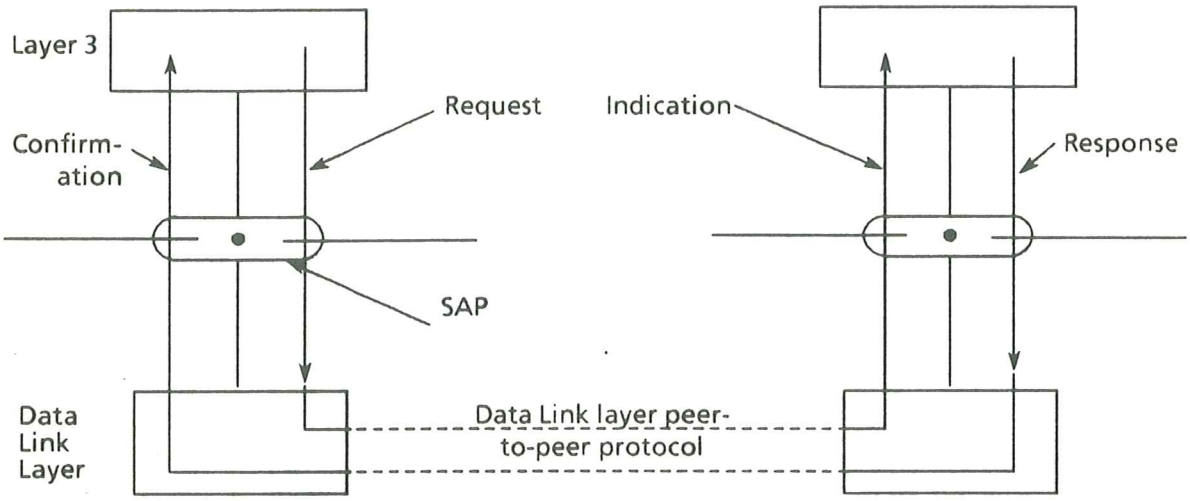
The INDICATION primitive type is used by a layer providing a service to notify the next higher layer of unsolicited events.

4.1.1.3 RESPONSE -

The RESPONSE primitive type is used by a layer to acknowledge receipt, from the next lower layer, of the INDICATION primitive type.

4.1.1.4 CONFIRM -
The CONFIRM primitive type is used by the layer providing the requested service to confirm that the activity has been completed by the peer entity.

Figure 22 illustrates the relationship of the primitive types to the layer 3 and the Data Link layer.



Note: The same Principle applies for Data Link layer - Physical layer interactions

Figure 22: Relationship of the Primitive Types to the Layer 3 and the Data LInk Layer

4.1.2 Generic names. -

The generic name specifies the activity that the addressed layer should perform.

Table 1 summarizes the primitives defined in this Standard. Note that not all primitives have associated parameters.

The primitive generic names that are defined in this Standard are:

4.1.2.1 DL-ESTABLISH -

The DL-ESTABLISH primitives are used to request, indicate and confirm the outcome of the procedures for establishing multiple frame operation. The DL-ESTABLISH-REQUEST will be used by the upper layer to cause a link to be established, the DL-ESTABLISH -CONFIRM will be returned in case of success. In case of unsolicited link establishment the DL-ESTABLISH -INDICATION will be used to inform the layer 3 entity.

4.1.2.2 DL-RELEASE -

The DL-RELEASE primitives are used to request, indicate and confirm the outcome of the procedures for terminating a previously established multiple frame operation. The request will be made by a DL-RELEASE-REQUEST and aknowledged by a DL-RELEASE-CONFIRM. In the case of a Data Link layer malfunction, layer 3 may be notified by a DL-RELEASE-INDICATION.

4.1.2.3 DL-DATA -

The DL-DATA primitives are used to pass to and from the Data Link layer the layer 3 messages which are to be transmitted, or have been received, using acknowledged operation. DL-DATA-REQUEST will be sent by the layer 3 entity whereas DL-DATA-INDICATION will indicate to the layer 3 entity that a message arrived over the line.

4.1.2.4 DL-UNIT DATA -

The DL-UNIT DATA primitives are used to pass layer 3 messages to and from the Data Link layer the layer 3 messages which are to be transmitted, or have been received, using unacknowledged operation. Same as above: DL-UNIT DATA-REQUEST and DL-UNIT DATA-INDICATION will be used to carry the information accross the interface.

4.1.2.5 MDL-ASSIGN -

The MDL-ASSIGN-REQUEST primitive is used by the management entity to request that the Data Link layer associate the TEI value contained with the message portion of the primitive with the specified connection endpoint(s). The MDL-ASSIGN-INDICATION primitive is used by the Data Link layer to indicate to the management entity the need for a TEI value.

4.1.2.6 MDL-REMOVE -

The MDL-REMOVE-REQUEST primitive is used by the management entity to request that the Data Link layer remove the association of the specified TEI value with the specified connection endpoints. The TEI and connection endpoints are specified by the REMOVE primitive message unit.

4.1.2.7 MDL-ERROR -

The MDL-ERROR-INDICATION primitives are used to notify the management entity that an error has occured, associated with a previous management function request or detected as a result of communication with the data link layer peer entity, which cannot be corrected by the Data Link layer. The management entity may respond with an ERROR primitive if the management entity cannot obtain a TEI value.

4.1.2.8 MDL-UNIT DATA -

The MDL-UNIT DATA primitives are used to pass to and from the Data Link layer the management entity messages which are to be transmitted, or have been received, using unacknowledged operation. As described for DL-UNIT DATA primitives both MDL-UNIT DATA-REQUEST and MDL-UNIT DATA-INDICATION are used across the interface.

4.1.2.9 PH-DATA -

The PH-DATA primitives are used to pass to and from the physical layer, message units containing frames used for Data Link layer peer-to-peer communications. PH-DATA-REQUEST are sent by the Data Link layer entity to the physical layer, PH-DATA-INDICATION are sent in the opposite direction.

4.1.2.10 PH-ACTIVATE -

The PH-ACTIVATE primitives are used to request activation of the physical layer connection or to indicate that the physical layer connection has been activated.

The REQUEST primitive is used to ask from the PCSN the resuming of framing on the link.

4.1.2.11 PH-DEACTIVATE -

The PH-DEACTIVATE-INDICATION primitive is used to indicate that the physical layer connection has been deactivated.

4.1.3 Parameter definition -

4.1.3.1 Priority indicator -

Since several SAPs may exist within a PCSN or a TE, protocol messages units sent by one SAP may contend with those of service access points for the physical resources available for message transfer. The priority indicator is used to determine which message unit will have greater priority when contention exists.

4.1.3.2 Message unit -

The message unit contains additional layer-to-layer information concerning actions and results associated with requests. In the case of the data primitive, the message unit contains the requesting layer peer-to-peer messages. For example the DL-DATA message unit contains layer 3 information. The PH-DATA message unit contains the Data Link layer frame.

Note
The operations across the data link/layer 3 boundary shall be such that the layer sending the DATA or UNIT DATA primitive can assume a temporal order of the bits within the message unit and that the layer receiving the primitive can reconstruct the message with its assumed temporal order.

4.1.3.3 Connection Endpoint Identifier (CEI) -

The CEI is passed as a parameter information between layer 3 and Management entities and the Data Link layer entity. It contains the SAPI information and the CES (Connection Endpoint Suffix) information such as described in 1.4.4.1. An example of the use of CEI and CES is given in Appendix D.

Generic Name	Type				Parameters		Message Unit Contents
	Request	Indication	Response	Confirm-ation	Priority Indicator	Message Unit	
L3 ↔ L2							
DL-ESTABLISH	x	x	–	x	–	–	
DL-RELEASE	x	x	–	x	–	–	
DL-DATA	x	x	–	–	–	x	network layer peer-to-peer message
DL-UNIT DATA	x	x	–	–	–	x	network layer peer-to-peer message
M ↔ L2							
MDL-ASSIGN	x	x	–	–	–	x	TEI value
MDL-REMOVE	x	-	–	–	–	x	TEI value
MDL-ERROR	–	x	x	–	–	x	reason for error message
MDL-UNIT DATA	x	x	–	–	–	x	management function peer-to-peer message
L2 ↔ L1							
PH-DATA	x	x	–	–	x	x	Data Link layer peer-to-peer message
PH-ACTIVATE	x	x	–	–	–	–	
PH-DEACTIVATE	–	x	–	–	–	–	

L3 ↔ L2 = Layer 3 / Data Link layer boundary L2 ↔ L1 = Data Link layer / Physical layer boundary M ↔ L2 = Management Entity /Data Link layer boundary

Table 1: Primitives associated with the Data Link layer

4.2 Primitive procedures

4.2.1 Layer 3 - Data Link layer Representation -

As seen by the layer 3 entity, a point-to-point Data Link layer connection appears to have two states (Link Released and Link Established). Two transient states are also shown on Figure 23 to describe the Data Link layer representation. In the Link established State peer-to-peer communication can be accomplished using either the Unacknowledged Information Transfer mode (DL-UNIT DATA-REQUEST) or the Acknowledged Information Transfer mode (DL-DATA-REQUEST). The method used by the Data Link layer to convey acknowledged information, i.e. multiple frame procedures is not known to the layer 3 entity. In the transient states (establish waiting and disconnecting), no acknowledged information tranfer is permitted.

The state of the point-to-point data link is dependent on:

- Layer 3 request primitives (DL-ESTABLISH-REQUEST, DL-RELEASE-REQUEST)

- Peer to peer mode setting control commands (SABM, DISC, ect.) which are seen by the layer 3 entity as DL-ESTABLISH-INDICATION, and DL-RELEASE-INDICATION.

When a layer 3 entity wishes to use acknowledged information and the Data Link layer is not in the Link Established state, the layer 3 entity will issue a DL-ESTABLISH-REQUEST primitive in order to establish this communication mode. The layer 3 entity will receive a DL-ESTABLISH-CONFIRM after the multiple frame mode has been established and may begin transmitting a series of DL-DATA-REQUESTs. The release of this multiple frame mode is accomplished when the layer 3 entity issues a DL-RELEASE-REQUEST primitive (acknowledged by a DL-RELEASE-CONFIRM) or a DL-RELEASE-INDICATION primitive is received from the Data Link layer entity.

When a layer 3 entity receives a DL-ESTABLISH-INDICATION (or CONFIRM), it can expect information arriving from its peer and passed via the DL-DATA-INDICATION primitive. It can also transmit information to its peer entity by means of the DL-DATA-REQUEST primitive.

When a layer 3 entity wishes to use the Unacknowledged information transfer, it may do so by means of the DL-UNIT DATA-REQUEST primitive. This request will be possible in any state where the TEI is assigned. The arrival of an Unacknowledged frame will be indicated by a DL-UNIT DATA-INDICATION.

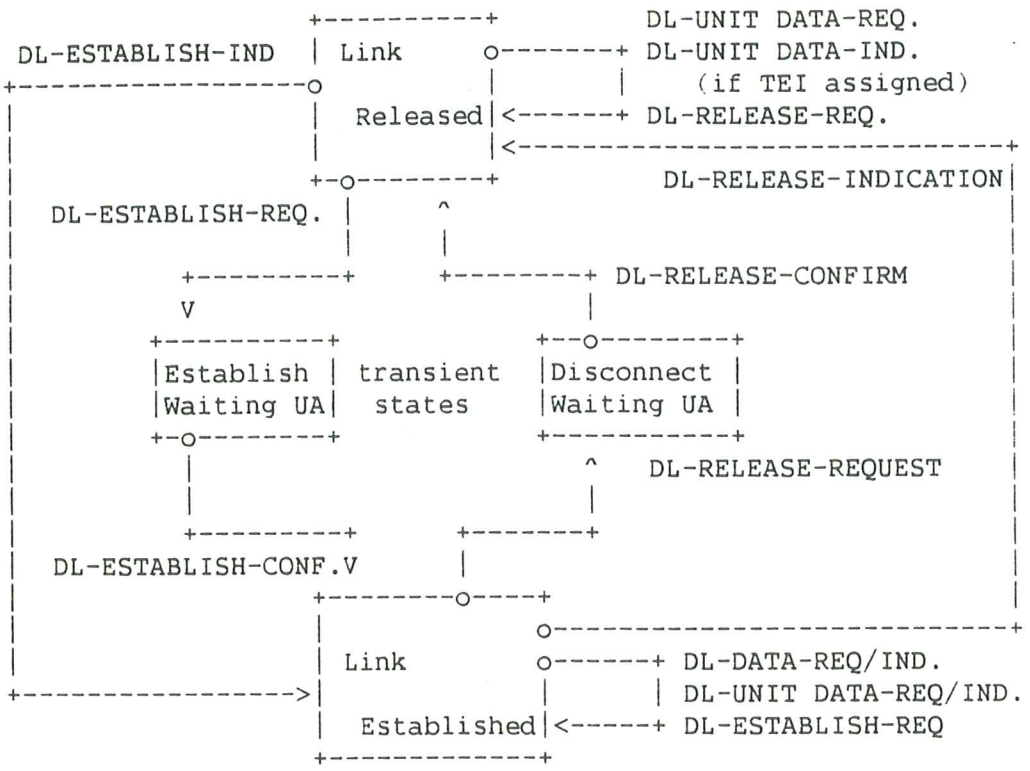


FIGURE 23: Layer 2 as seen from layer 3

4.2.2 Data Link - Data Link layer Representation -

As indicated in 1.4.4.2, the link establishment contains three basic states (excluding transient states): the TEI Unassigned State, the TEI Assigned State, and the Multiple Frame Established State (see Figure 24). The state of the Data Link layer representation of the point to point data link connection is dependent on:

- Layer 3 request primitives (DL-ESTABLISH-REQUEST, DL-RELEASE-REQUEST),
- Peer to peer mode setting commands (SABM, DISC), and
- Management function control commands (MDL-ASSIGN-REQUEST, MDL-REMOVE-REQUEST).

The information transfer capabilities are dependent on the particular state into which the data link has been placed by the above controls. The three states of a point-to-point data link and their information transfer capabilities are:

- TEI Unassigned State; No peer-to-peer information transfer capability.

- TEI Assigned State; only one mode of information transfer is possible:

  Unacknowledged Information Transfer using UI frames. The layer 3 and Management entities may request this service by using the DL-UNIT DATA-REQUEST and MDL-UNIT DATA-REQUEST primitives respectively.
  note: A broadcast link is considered to be always in a TEI assigned state.

- Multiple Frame established State; two modes of information transfer are possible:

  a. Unacknowledged Information Transfer mode using UI frames. The layer 3 and Management entities may request this service by using the DL-UNIT DATA-REQUEST and MDL-UNIT DATA-REQUEST primitives respectively.

  b. Acknowledged Information Transfer mode using I frames. The layer 3 entity may request this service by using the DL-DATA-REQUEST primitive.

When a DL-ESTABLISH-REQUEST or DL-UNIT DATA-REQUEST is received by the Data Link layer entity and the TEI is not assigned, a TEI assignement procedure is initiated by the Data Link layer prior to achieving the layer 3 request. An example of the use of primitives can be found in Appendix D.
When a DL-ESTABLISH-REQUEST is made, the TEI assignement procedure will be followed by a link establishment. When a DL-UNIT DATA-REQUEST is made, transmission of UI frames will start as soon as the TEI assignement procedure is completed.

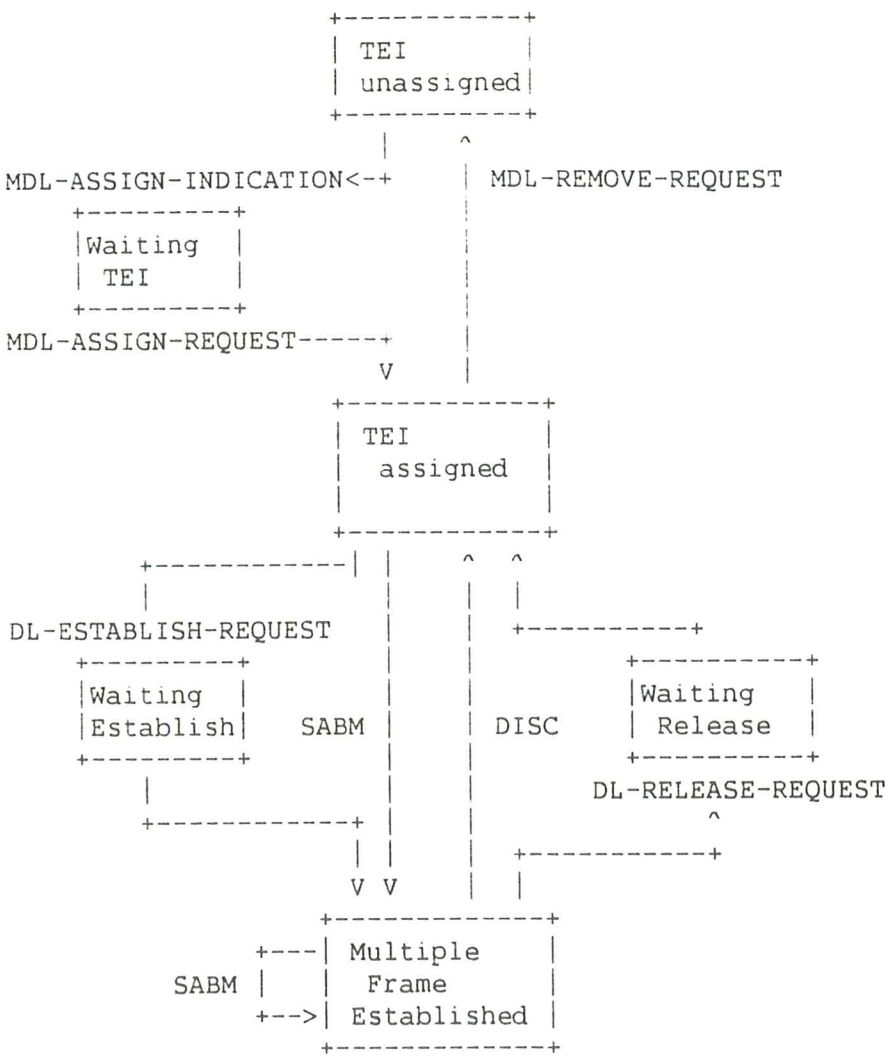


FIGURE 24: Internal Data Link layer Representation

4.2.3 Overview of Primitive Procedures -

This section gives an overview of the actions undertaken by the Data Link layer entity on receipt of primitives issued by the layer 3, management and Physical layer entities.

A complementary information on these procedures is to be found in the state transition tables given in appendix B

An illustration of the use of certain primitives is given Appendix D.

4.2.3.1 DL- primitives -

i) DL-ESTABLISH-REQUEST/CONFIRM on the TE Side

When the layer 3 entity on the TE side issues the DL-ESTABLISH-REQUEST primitive, the Data Link layer entity will send a PH-ACTIVATE-REQUEST to the Physical layer to make sure it is activated. On receipt of the PH-ACTIVATE-INDICATION, if the TEI value has not been previously assigned, the Data Link layer entity shall ask the management entity to start TEI assignment procedures via the MDL-ASSIGN-INDICATION primitive. The management entity will obtain a TEI value and pass it to the data link layer entity via the MDL-ASSIGN-REQUEST. The link establishment procedure will be initiated by the Data Link layer entity sending a SABM to its peer entity to notify it that an establishment procedure is being executed. The data link will then respond to the layer 3 entity upon a successful establishment procedure indication from its peer entity (i.e. UA response) by means of a DL-ESTABLISH-CONFIRM.

If any error is detected (e.g. TEI denied, or link cannot be setup) the layer 3 entity shall be notified via the DL-RELEASE-INDICATION and the Data Link layer shall remain in its appropriate state.

ii) DL-ESTABLISH-REQUEST/CONFIRM on the PCSN Side (tutorial)

When the layer 3 entity on the PCSN side issues the DL-ESTABLISH-REQUEST primitive, if the Data Link layer is in the TEI assigned state, the data link layer will send a SABM towards the TE. If the TE responds with a UA response, the Data Link layer will enter the multiple frame state and send a DL-ESTABLISH-CONFIRM to the layer 3 entity.

If the Data Link layer entity does not receive a response or recieves a DM response, it will send a DL-RELEASE-INDICATION to the layer 3 entity.

If the Data Link layer is already in the multiple frame

established state, it will return a DL-ESTABLISH-CONFIRM to the layer 3 entity.

iii) DL-RELEASE-REQUEST/CONFIRM

When a layer 3 entity issues a DL-RELEASE-REQUEST, the Data Link layer entity, if it is in the multiple frame established state, will send a DISC command as specified in the link release procedures. When this procedure is completed, the Data Link layer entity will respond to the layer 3 entity with a DL-RELEASE-CONFIRM.

If the Data Link layer entity is not in the multiple frame established state, it will return a DL-RELEASE-CONFIRM.

iv) DL-DATA-REQUEST

When the layer 3 entity issues a DL-DATA-REQUEST, the information will be transmitted via I command frames according to the multiple frame procedures. If the Data Link layer entity is not in the multiple frame state, the layer 3 entity will be notified by the DL-RELEASE-INDICATION primitive.

v) DL-UNIT DATA-REQUEST on the TE Side

When a Data Link layer entity receives the DL-UNIT DATA-REQUEST, it will send a PH-ACTIVATE-REQUEST to the Physical layer to make sure it is activated. On receipt of the PH-ACTIVATE-INDICATION, if the TEI value has not been previously assigned, the Data Link layer entity shall ask the management entity to start TEI assignment procedures via the MDL-ASSIGN-INDICATION primitive. The management entity will obtain a TEI value and pass it to the Data Link layer entity via the MDL-ASSIGN-REQUEST.

When the TEI is assigned, the Data Link layer entity will transfer the layer 3 message via UI frames.

vi) DL-UNIT DATA-REQUEST on the PCSN Side (tutorial)

When a Data Link layer entity receives the DL-UNIT DATA-REQUEST, the Data Link layer entity will transfer the layer 3 message via UI frames.
Broadcast will be possible via UI frames even if the Data Link layer entity is not in the TEI assigned state.

4.2.3.2 MDL- primitives -

i) MDL-ASSIGN-REQUEST

On receipt of the MDL-ASSIGN-REQUEST from the management entity, the Data Link layer entity will associate the provided TEI (i.e as part of the DLCI) value to the

connection end point (i.e CEI).
The association DLCI/CEI will remain as long as the management entity has not issued a MDL-REMOVE-REQUEST or there has been a loss of power at TE level.

ii) MDL-REMOVE-REQUEST

When the management entity issues MDL-REMOVE-REQUEST, the data link layer will release the TEI value associated to a specified connection end point.

iii) MDL-UNIT DATA-REQUEST on the TE side

On receipt of a MDL-UNIT DATA-REQUEST, if the TEI has been previously assigned, the Data Link layer entity will transfer the management message via UI frames provided the Physical layer is activated.

iv) MDL-UNIT DATA-REQUEST on the PCSN side (tutorial)

On receipt of a MDL-UNIT DATA-REQUEST, if the TEI has been previously assigned, the Data Link layer entity will transfer the management message via UI frames. If the TEI has not been assigned, broadcast transfers are still possible.

v) MDL-ERROR-RESPONSE

This primitive is used by the management entity to inform the data link layer entity that the TEI assignment failed. If the TEI assignment was related to a DL-ESTABLISH-REQUEST, the Data Link layer will respond to the layer 3 request with a DL-RELEASE-INDICATION.

4.2.3.3 PH- primitives -

i) PH-ACTIVATE-REQUEST

This primitive is systematically sent by the Data Link layer entity on receipt of a DL-ESTABLISH-REQUEST or DL-UNIT DATA-REQUEST to check/request the activation of the Physical layer.

ii) PH-ACTIVATE-INDICATION

If the Data Link layer is in the TEI unassigned state and a TEI assignement has been previously required, the management entity will be asked to proceed with TEI assignement by means of a MDL-ASSIGN-INDICATION primitive. On receipt of a TEI value, the TEI assigned state will be entered and the link establishment procedures will be initiated by sending SABM to the peer entity if the initial request was a DL-ESTABLISH-REQUEST.

iii) PH-DEACTIVATE-INDICATION

On receipt of this primitive, a Data Link layer entity in the multiple established frame will reenter the TEI assigned state and issue a DL-RELEASE-INDICATION and MDL-ERROR-INDICATION.

iii) PH-DATA-INDICATION (Receiving frames)

All frames received by the Physical layer entity will be passed to the Data Link layer entity by means of a PH-DATA-INDICATION primitive. Two sort of frames have to be considered: Information frames (I and UI formats) and the other ones. The actions taken on receipt of the second sort of frames (Supervisory or Unnumbered except UI) are described in detail in section 5 (procedures). When they cause a change in the state of the link, the proper INDICATION primitive (DL-ESTABLISH or DL-RELEASE) will be used to inform the layer 3 entity and in some cases the MDL-ERROR-INDICATION will be used to report to the management entity an erroneous situation.

The case of Information frames can be summarized as follows:

* I Frames: The I frames will be processed depending on the Data Link layer entity state. If the Data Link layer is in the multiple frame established state the information contained in the I frame will be passed to the Layer 3 entity via the primitive DL-DATA-INDICATION.

* UI Frames: The Data Link layer entity receiving the UI frame shall pass the information contained in its frame to the Layer 3 entity via the DL-UNIT DATA-INDICATION. If the UI frame is addressed to the maintenance SAPI, it will be passed to the management entity via MDL-UNIT DATA-INDICATION.

4.2.3.4 Error recovery -

Any error situation will be reported to the management entity by means of a MDL-ERROR-INDICATION primitive. If the erroneous situation occurs while the Data Link layer entity is processing a request from an other entity, it will report the failure with the appropriate primitive (for example a DL-RELEASE-INDICATION will be sent as error recovery to a DL-ESTABLISH-REQUEST).

During a link failure the Information frames in transit may be lost or duplicated. A full specification of the information frames handling in error recovery situations requires further study.

5 PEER-TO-PEER PROCEDURES

The procedures for use by the Data Link layer are specified below: following sections.

The elements of procedure (frame types) which apply are:

- For unacknowledged information transfer (5.2);
  - . UI-command

- For multiple-frame acknowledged information transfer (5.5 to 5.9);
  - . SABM-command,
  - . UA-response,
  - . DM-response,
  - . DISC-command,
  - . RR-command/response,
  - . RNR-command/response,
  - . REJ-command/response,
  - . I-command,
  - . FRMR-response.

5.1 Procedure for the use of the P/F bit

5.1.1 Unacknowledged Information Transfer -

For Unacknowledged Information Transfer, the P/F bit is not used and shall be set to ZERO.

5.1.2 Multiple-Frame Acknowledged Information Transfer -

A Data Link layer entity receiving an SABM, DISC, RR, RNR, REJ or I frame, with the P bit set to ONE, shall set the F bit to ONE in the next response frame it transmits, as defined in Table 2.

Command received with P bit = 1	Response transmitted with F bit = 1
SABM, DISC	UA, DM
I, RR, RNR, REJ	RR, RNR, REJ, FRMR, DM

Table 2: Immediate response operation of P/F bit.

The following general guidelines are used in the implementation of the multiple frame established mode.

- In general the Poll bit is not set to ONE in the information frames. This allows greater link efficiency in that Information frames may be acknowledged via N(R) transmitted by the peer entity in either I frames (if the peer entity has an I frame available at the time an I frame is received from its peer) or in a Supervisory (S) frame if no I frame is available (see 5.5.2). However the P bit could be set to ONE in an I frame if a unique response via a Supervisory frame is desired from the peer entity.

- The P bit is always set to ONE in all supervisory command frames. For those command frames the timer T200 is normally running.

- When the received frame (command or response) of any type evokes a DM response (in TEI assigned state) or an FRMR response (in multiple established state), this response (DM or FRMR) frame should be sent with the F bit set equal to the P/F bit in the received frame.

- The Final bit of a response frame shall be set equal to the P bit in the received command frame in the case of a valid frame

received or any frame (command or response) in the case of an invalid frame received.

5.2 Procedures for Unacknowledged Information Transfer

5.2.1 General -

The procedures which apply to the transmission of information in unacknowledged operation are defined below.

No Data Link layer error recovery procedures are defined for unacknowledged operation.

5.2.2 Transmission of Unacknowledged Information -

The term "transmission of a UI frame", refers to the delivery of a UI frame by the Data Link layer to the Physical layer.

Unacknowledged information is passed to the Data Link layer entity by Layer 3 entity or management entity using the primitives DL-UNIT DATA-REQUEST or MDL-UNIT DATA-REQUEST respectively. The layer 3 or management message unit shall be transmitted in a UI command frame at the earliest opportunity with the P bit set to ZERO.

For broadcast operation, the TEI value in the UI command address field shall be set to 127 (binary 111 1111, the group value).

For point-to-point operation the appropriate TEI value shall be used.

5.2.3 Receipt of Unacknowledged Information -

On receipt of a UI command frame with a SAPI which is supported by the receiver, the contents of the information field shall be passed to the Layer 3 entity or management entity using the DL-UNIT DATA-INDICATION or MDL-UNIT DATA-INDICATION respectively. Otherwise, the UI command frame shall be discarded.

5.3 Assignment and removal of terminal endpoint identifier (TEI)

5.3.1 General -

The general principles for assignment and removal of TEI have been described in 1.4.4.

The management entity shall use the MDL-REMOVE-REQUEST to ask the Data Link layer to remove one of its TEIs. The actions taken by a Data Link layer entity receiving a MDL-REMOVE-REQUEST are included in 5.3.4.1. The TE management entity shall instruct the Data Link layer to remove all TEI values when it detects that the terminal is disconnected at the interface (as defined in CCITT Rec. I.430).

The initiation of the assignment procedures occurs on the receipt of DL-ESTABLISH-REQUEST or DL-UNIT DATA-REQUEST from a layer 3 entity while in the TEI unassigned state. The Data Link layer entity shall inform the management entity by using the MDL-ASSIGN-INDICATION. Alternatively, the management entity may initiate these procedures for its own reasons.

Note:
In the case of initialization from a no power condition, the TE should postpone the start of the TEI assigned procedure until an outgoing or incoming call is to be handled.

All management entity messages used for these procedures are transmitted to, or received from, the Data Link layer entity using the MDL-UNIT DATA-REQUEST or MDL-UNIT DATA-INDICATION respectively. The Data Link layer entity shall transmit management entity messages in UI command frames. The SAPI value shall be 63. The TEI value shall be 127.

5.3.2 TEI assignment procedure -

Upon initiation of the procedure, the TE side management entity shall transmit a message to its peer containing the following elements:

- Management entity identifier;
- Message type = Identity request;
- Request reference number (Ri);and
- Action indicator (Ai).

The Request reference number Ri shall be used to differentiate between a number of TEs which may simultaneously request intialization of a TEI value. Ri shall be 2 octets in length and shall be randomly generated for each request message by the TEs.

All values in the range 0 to 65535 shall be available from the random number generator.

Note:
The design of the random number generator should minimize the probability of identical reference numbers being generated by terminals which initiate their TEI assignment procedures simultaneously.

The single-octet Action indicator, Ai, shall be used to indicate a request to the Assignment Source Point (ASP) for the assignment of any TEI value available.

The Ai field will contain the Group address (127). This Ai value requests the ASP to assign any TEI value.

A timer T202 shall be started.

The ASP, on receipt of the Identity request message, shall either:

a) select and verify a TEI value, or

b) ignore the identity request message if a previous identity request message that contains an identical Ri has been received and no TEI has been assigned. In this case, the ASP shall not assign a TEI value.

Verification shall be on the basis of information stored at the ASP and/or by means of the check routines defined in 5.3.3.

The ASP, after having selected/verified the TEI value, shall transmit a message containing the following elements:

- Management entity identifier;
- Message type = Identity assigned;
- Request reference number Ri; and
- The assigned TEI value in the Ai field.

The TE management entity receiving this Identity assigned message shall discard the value of Ri and inform the TE Data Link layer by means of MDL-ASSIGN-REQUEST.

The TE Data Link layer entity shall:

- enter the TEI assigned state; and
- continue with link establishment procedures if a DL-ESTABLISH-REQUEST is outstanding, or the transmission of a UI command if a DL-UNIT DATA-REQUEST is outstanding.

If a TEI is not available the ASP shall transmit a message containing the following elements:

- Management entity identifier;
- Message type = Identity denied;
- Request reference number (Ri); and
- The value of 127 which indicates that no TEI is available.

The TE management entity receiving the Identity denied message may reinvoke the assignment procedure to obtain a TEI value; but otherwise, the management entity shall inform the Data Link layer entity using MDL-ERROR-RESPONSE. The Data Link layer entity receiving MDL-ERROR-RESPONSE shall inform Layer 3 entity using the primitive DL-RELEASE-INDICATION.

5.3.2.1 Expiry of timer T202 -

If TE receives no response to its Identity request message before the expiry of timer T202, the timer shall be restarted and the Identity request message with a new Ri value shall be retransmitted.

After N202 retransmissions of the Identity Request message the management entity shall inform the Data Link layer entity using the MDL-ERROR-RESPONSE primitive. The Data Link layer entity

receiving the MDL-ERROR-RESPONSE shall inform layer 3 using the primitive DL-RELEASE-INDICATION.

The values of T202 and N202 are specified in 5.9.7 and 5.9.4.

The TEI assignment procedure is illustrated in Figure 25 where:

SAPI = Service access point identifier = 63.
TEI = Group TEI = 127
ID request = Identity request
ID denied = Identity denied
ID assigned= Identity assigned
Ai = Action indicator, see Table 3
Ri = Reference number
( ) = Contents of the Data Link layer address field
[ ] = Contents of the Information field

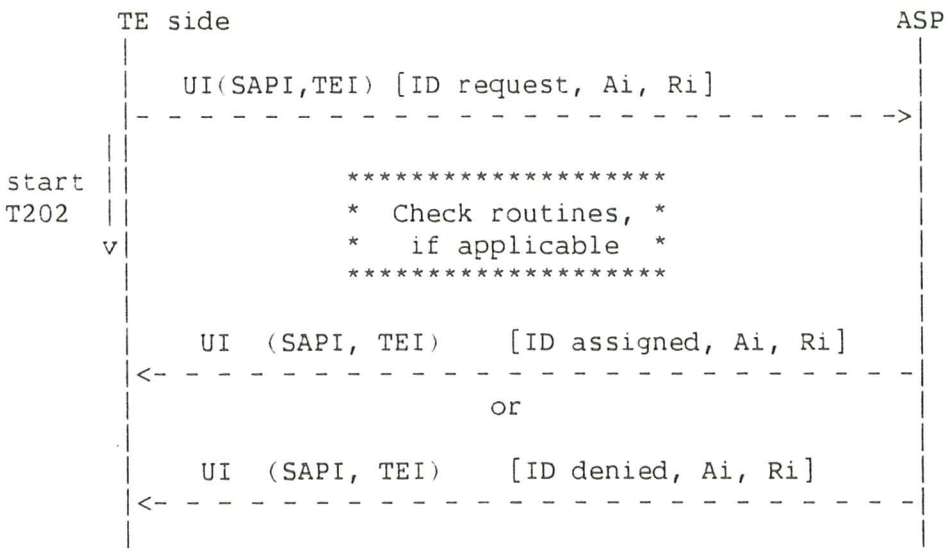


Figure 25: TEI assignment procedure.

5.3.3 Check routine procedure -

5.3.3.1 Use of the check routine procedure -

The check routine procedure may be used in the following cases:

- in connection with an Identity request, as described in 5.3.2; and

- for updating of TEI status data, as an audit procedure.

5.3.3.2 Operation of the check procedure -

The check routine procedure is illustrated in Figure 26.

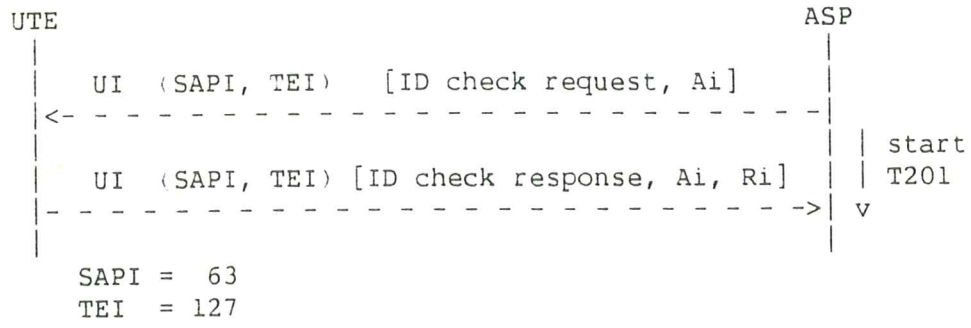


Figure 26: Check routine.

The ASP shall transmit a message containing the following elements:

- Message type = Identity check request; and
- the TEI value to be checked in the Ai field.

Timer T201 shall be started.

If any TE has been assigned the TEI value specified in the check message, it shall respond by transmitting a message containing the following elements:

- Management entity identifier;
- Message type = Identity check request;
- The TEI value in the Ai field; and
- Reference number (Ri).

The identity check response informs the ASP that the specific TEI value is already assigned.

If no Identity check response is received within T201, the request shall be repeated once and T201 restarted. T201 is defined in 5.9.6.

If no response is received after the second Identity check request, the TEI value may be assumed to be free and can therefore be assigned to the requesting TE.

5.3.4 TEI removal procedure -

When the PCSN management entity determines that the removal of a TEI is necessary (for example, on the receipt of multiple Identity check responses with identical values of Ai, but differing values of Ri, or for other reasons like unknown TEI), the ASP shall transmit a message containing the following elements:

- Management entity identifier;
- Message type = Identity remove; and
- TEI value which is to be removed as indicated in the Ai field; (the value 127 indicates that all TEs should remove their TEI; otherwise, the specific TEI should be removed).

Optionally, the ASP may invoke the check routine procedures to verify that the duplication no longer exists.

All TE side management entities receiving the Identity remove message containing the currently assigned TEI value or the group TEI value, in the Ai field shall instruct the Data Link layer entity to discard the TEI, using the MDL-REMOVE-REQUEST primitive.

Note:
In case the same TEI is used in combination with different SAPIs, the removal procedure will affect all DLCIs.

5.3.4.1 Action taken on receipt of MDL-REMOVE-REQUEST -

A Data Link layer entity receiving MDL-REMOVE-REQUEST shall:

- inform layer 3 using the primitive DL-RELEASE-INDICATION; and
- enter the TEI unassigned state.

5.3.5 Formats and codes -

5.3.5.1 General -

All messages used for TEI assignment procedure are carried in the information field of UI command frames with a SAPI value set to 63 (binary "11 111") TEI value set to 127 (binary "111 111").

All messages are of fixed length and have the structure depicted in Figure 27.

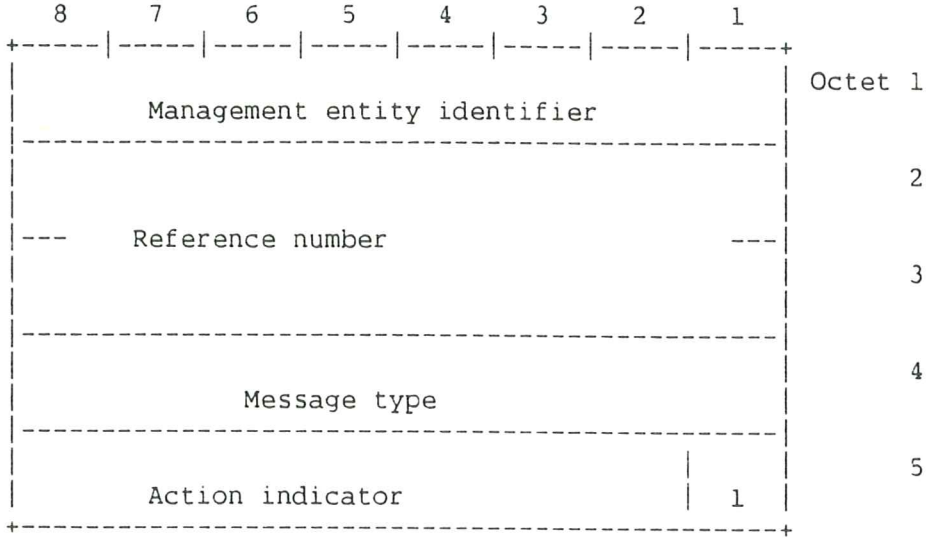


Figure 27: Structure of identity messages

Fields that are not used in a specific message are coded all zeroes.

The coding of each field for the various messages is specified in Table 3.

Message name	Management entity identifier	reference number Ri	Message type	Action indicator Ai
Identity Request TE -> PCSN	0000 1111	0- 65535	0000 0001	Ai=127
Id. assigned PCSN -> TE	0000 1111	0- 65535	0000 0010	Ai=64-126 assigned TEI
Id. denied PCSN -> TE	0000 1111	0- 65535	0000 0011	Ai=0-127 denied TEI
Identity check request PCSN -> TE	0000 1111	not used (coded 0)	0000 0100	Ai=0-126 TEI to be checked
Identity check response TE -> PCSN	0000 1111	0- 65535	0000 1001	Ai=64-126 TEI value in use
Identity remove PCSN -> TE	0000 1111	not used (coded 0)	0000 0110	Ai=127 all TEIs or Ai=64-126 TEI to be removed

Table 3: Codes for messages concerning TEI assignment

5.3.5.2 Management entity identifier -

Octet 1 contains the management entity identifier. Presently coded as binary "0000 1111".

5.3.5.3 Reference number (Ri) -

Octets 2 and 3 contain the Reference number (Ri). When used, it can assume any value between 0 and 65535.

5.3.5.4 Message types -

Octet 4 contains the message type. The purpose of the message type is to identify the function of the message being sent.

5.3.5.5 Action indicator (Ai) -

Octet 5 is coded as follows:

- bit 1 shall be set to ONE;

- bits 2 to 8 contain the Action indicator.

The purpose of the Action indicator is to identify the concerned TEI values.

5.4 Procedures for establishment and release of multiple frame operation

5.4.1 Establishment of multiple frame operation -

5.4.1.1 General -

These procedures shall be used to establish multiple frame operation between the PCSN and a designated TE entity.

The layer 3 will indicate a request for establishment of the multiple- frame operation by the use if the DL-ESTABLISH-REQUEST primitive. Re-establishment may be initiated as a result for the Data Link layer procedures defined in 5.6.
All frame formats other than unnumbered frame formats received during the establishment procedures shall be ignored.

5.4.1.2 Establishment procedures -

A Data Link layer entity shall initiate a request for the multiple- frame operation to be set by transmitting the Set Asynchronous Balanced Mode (SABM) command.

All existing exception conditions shall be cleared, the retransmission counters shall be reset and timer T200 shall then be started (timer T200 is defined in 5.9.1). All mode setting commands shall be transmitted with the P bit set to ONE.

A Data Link layer entity receiving a SABM command, if it is able to enter the multiple frame established state, shall:

- respond with an Unnumbered Acknowledgement (UA) response with the F bit set to the same binary value as the P bit in the received SABM command;
- set the send state variable V(S), receive state variable V(R) and acknowledge state variable V(A) to 0;
- enter the multiple frame established state and inform the layer 3 using the primitive DL-ESTABLISH-INDICATION;
- reset the retransmission counter;
- start timer T203 if T200 is not running (T203 is defined in 5.9.8).
- clear the existing exception conditions; and
- clear any existing peer and own receiver busy condition.

If the Data Link layer entity is unable to enter the multiple-frame established state, it shall respond to the SABM

command with a DM response with the F bit set to the same binary value as the P bit in the received SABM command.

Upon reception of the UA response with the F bit set to ONE, the originator of the SABM command shall:

- reset timer T200;
- set the send state variable V(S), receive state variable V(R) and acknowledge state variable V(A) to 0;
- enter the multiple frame established state and inform the layer 3 using the primitive DL-ESTABLISH-INDICATION; and
- start the supervision timer T203.

Upon reception of a DM response with F bit set to ONE the originator of the SABM command shall indicate this to layer 3 and the management entity by means of the primitives DL-RELEASE-INDICATION and MDL-ERROR-INDICATION, respectively and reset timer T200. It shall then enter the TEI assigned state. Any other procedural invalid or unexpected frame format will be discarded.

5.4.1.3 Procedure on expiry of timer T200 -

If timer T200 expires before the UA or DM response is received the Data Link layer entity shall:

- retransmit the SABM command as above;
- restart timer T200; and
- increment the retransmission counter.

After retransmission of the SABM command N200 times, the Data Link Layer entity shall indicate this to layer 3 and the management entity by means of the primitives DL-RELEASE-INDICATION and MDL-ERROR-INDICATION , respectively and enter the TEI assigned state.

The value of N200 is defined in 5.9.2.

5.4.2 Information transfer -

Having either, transmitted the UA response to a received SABM command, or received the UA response to a transmitted SABM command, I frames and supervisory frames shall be transmitted and received according to the procedures described in 5.5.

If an SABM command is received while in the multiple frame

established state the Data Link layer entity shall conform to the re-establishment procedure described in 5.6.

On receipt of a UI command, the procedures defined in 5.2 shall be followed.

5.4.3 Termination of multiple frame operation -

5.4.3.1 General -

These procedures shall be used to terminate the multiple-frame operation between the PCSN and a designated TE entity.

A layer 3 entity shall indicate a request for termination of the multiple frame operation by use if the DL-RELEASE-REQUEST primitive.

All frame formats other than unnumbered frames received during the release procedures shall be ignored.

5.4.3.2 Release procedure -

A Data Link layer entity shall initiate a request for release of multiple frame operation by transmitting the Disconnect (DISC) command with the P bit set to ONE. Timer T200 shall then be started, a "waiting for acknowledge" transient state will be entered and the retransmission counter reset.

A Data Link layer entity receiving a DISC command while in the multiple-frame established state shall transmit a UA response with the F bit set to the same binary value as the P bit in received DISC command. A DL-RELEASE-INDICATION shall be passed to the layer 3, and the TEI assigned state shall be entered.

If the originator of the DISC command receives either:

- a UA response; with F bit set to ONE, or
- a DM response; with the F bit set to ONE indicating that the peer Data Link layer entity was in the TEI assigned state,

it shall enter the TEI assigned state and reset timer T200.

The Data Link layer entity which issued the DISC command will now be in the TEI assigned state. The conditions relating to this state are defined in 5.4.4. Any other unexpected frame format received while in the "waiting for acknowledge" state will be discarded.

5.4.3.3 Procedure on expiry of timer T200 -

If timer T200 expires before a UA or DM with the F bit set to ONE response is received, the originator of the DISC command shall:

- retransmit the DISC command as defined in 5.4.3.2;
- restart timer T200; and
- increment the retransmission counter.

If the Data Link layer entity has not received the correct response as defined in 5.4.3.2, after N200 attempts to recover, the Data Link Layer shall indicate this to the management entity by means of the primitive MDL-ERROR-INDICATION and the Layer 3 entity by means of a DL-RELEASE-INDICATION. It will then enter the TEI assigned state. The value of N200 is defined in 5.9.2.

5.4.4 TEI assigned state -

While in the TEI assigned state:

- the receipt of a DISC command shall result in the transmission of a DM response;
- the receipt of an I frame or supervisory frame with the P bit set to ONE shall result in the transmission of a DM response with the F bit set to ONE (as defined in 5.1.2);
- the contents of any received I frame shall be discarded;
- on receipt of an SABM command, the procedures defined in 5.4.1 shall be followed;
- on receipt of UI commands, the procedures defined in 5.2 shall be followed;
- all other frame types shall be discarded; and
- no timer other than T201 is running.

5.4.5 Collision of unnumbered commands -

Collision situations shall be resolved in the following ways.

5.4.5.1 Identical transmitted and received commands -

If the transmitted and received unnumbered commands (SABM or DISC) are the same, the Data Link layer entities shall send the

UA response (with the F bit = P bit received) at the earliest possible opportunity.

The indicated state shall be entered after receiving the UA response. The Data Link layer entities shall each notify its respective Layer 3 entity by means of the appropriate indication primitive.

5.4.5.2 Different transmitted and received commands -

If the transmitted and received unnumbered commands (SABM or DISC) are different, the Data Link layer entities shall enter the TEI assigned state and issue a DM response (with F bit = P bit received) at the earliest possible opportunity.

The Data Link layer entities shall each notify its respective Layer 3 entity by means of the DL-RELEASE-INDICATION primitive.

5.4.5.3 Unsolicited DM response and SABM or DISC command -

In order to avoid misinterpretation of the DM response received (unsolicited response with F bit set to ZERO), a Data Link layer entity shall always send its SABM or DISC command with the P bit set to ONE.

Under these circumstances ,a DM response received with F bit set to ZERO is to be considered as a procedurally invalid frame on the TE side and shall be discarded.

5.5 Procedures for information transfer in multiple frame operation

The procedures which apply to the transmission of I frames are defined below.

Note 1
The term "transmission of an I frame" refers to the delivery of an I frame by the Data Link layer to the Physical Layer.

Note 2
In the following text of this Standard, the term own/peer receiver busy refers to the peer-to-peer flow control state in the Data Link layer entities.

5.5.1 Transmitting I frames -

Information received by the Data Link layer entity by means of a DL-DATA-REQUEST primitive shall be transmitted in an I frame. The control field parameters N(S) and N(R) shall be assigned the values of the send and receive state variables V(S) and V(R) respectively. The value of the send state variable V(S) shall be incremented by 1 at the end of the transmission of the I frame.

If timer T200 is not running at the time of transmission of an I frame, it shall be started. If timer T200 expires, the procedures defined in 5.5.7 shall be followed.

If the send state variable V(S) is equal to V(A) plus k (where k is the maximum number of outstanding I frames - see 5.9.5), the Data Link layer entity shall not transmit any new I frames, but may retransmit an I frame as a result of the error recovery procedures as described in 5.5.4 and 5.5.7.

When the PCSN side or TE side is in the own receiver busy condition, it may still transmit I frames, provided that a peer receiver busy condition does not exist.

When the PCSN side or TE side is in the frame rejection condition, it shall stop transmitting I frames.

5.5.2 Receiving I frames -

When a Data Link layer entity is not in a receiver busy condition and receives an acceptable I frame (see 2.9, 3.6.10 and 5.8.4) the send sequence number of which is equal to the current receive state variable V(R), the data link layer entity shall:

- pass the information field of this frame to the layer 3 using the primitive DL-DATA-INDICATION,

- increment by 1 its receive state variable V(R), and act as indicated below.

i) If the P bit of the received I frame was set to ONE, the data link layer entity shall respond to its peer in one of the following ways.

o If the Data Link layer entity receiving the I frame is still not in an own receiver busy condition, it shall send a RR response with the F bit set to ONE.

o If the Data Link layer entity receiving the I frame enters the own receiver busy condition upon receipt of the I frame, it shall send an RNR response with the F bit set to ONE.

ii) If the P bit of the received I frame is set to ZERO and;

a) if the Data Link layer entity is still not in an own receiver busy condition:

o if no I frame is available for transmission or if an I frame is available for transmission but a peer receiver busy condition exists , the Data Link layer entity shall transmit an RR response with the F bit set to ZERO; or

o if an I frame is available for transmission and no peer receiver busy condition exists, the Data Link layer entity shall transmit the I frame with the value of N(R) set to the current value of V(R) as defined in 5.5.1.; or

b) on receipt of this I frame, the Data Link layer entity is now in an own receiver busy condition, it shall transmit an RNR response with the F bit set to ZERO.

When the Data Link layer entity is in an own receiver busy condition, it shall process any received I frame according to 5.5.6.

5.5.3 Receiving acknowledgement -

On receipt of a valid I frame or supervisory frame (RR, RNR or REJ), even in the own receiver busy, timer recovery or frame

rejection conditions, the Data Link layer entity shall treat the N(R) contained in this frame as an acknowledgement for all the I frames it has transmitted with an N(S) up to and including the received N(R) - 1. The value of the acknowledge state variable V(A) shall be set to the value of N(R). The Data Link layer entity shall reset the timer T200 on receipt of a valid I frame or supervisory frame with the N(R) higher than V(A) (actually acknowledging some I frames), or a REJ frame with an N(R) equal to the V(A).

Note:
If a supervisory frame with P bit set to ONE has been transmitted and not acknowledged, the timer T200 shall not be reset.

If timer T200 has been reset by the receipt of an I or RR frame (and if there are outstanding I frames still unacknowledged), or the receipt of an RNR frame, the Data Link layer entity shall restart timer T200. If timer T200 then expires, the Data Link layer entity shall follow the recovery procedure as defined in 5.5.7 with respect to the unacknowledged I frames.

If timer T200 has been reset by the receipt of a REJ frame, the Data Link Layer entity shall follow the retransmission procedures in 5.5.4

5.5.4 Receiving REJect -

On receipt of a valid REJ frame, the Data Link layer entity shall set its send state variable V(S) and its acknowledge state variable V(A) to the value of the N(R) contained in the REJ frame control field. A peer busy condition will be cleared. If the Data Link layer entity is not in the timer recovery condition, timer T200 shall be reset.
The Data Link layer entity shall transmit the corresponding I frame as soon as possible as defined in 5.5.1.
In the timer recovery condition, a REJ response received with a F bit set to ZERO will be ignored.
Note: However a peer busy condition will be cleared.

Transmission shall take account of the following:

i) if the Data Link layer entity is transmitting a supervisory frame when it receives the REJ frame, it shall complete that transmission before commencing transmission of the requested I frame;
ii) if the Data Link layer entity is transmitting an SABM or DISC command or an UA,DM or FRMR response when it receives the REJ frame, it shall ignore the request for retransmission;
iii) if the Data Link layer entity is not transmitting a frame when the REJ frame is received, it shall immediately commence transmission of the requested I frame.

All outstanding I frames that have not been yet acknowledged, commencing with the I frame identified in the received REJ frame shall be transmitted. Other I frames not yet transmitted may be

transmitted following the retransmitted I frames.

5.5.5 Receiving RNR frames -

After receiving a valid RNR command or response, if the Data Link Layer entity is not engaged in a mode setting operation, it shall set a peer receiver busy condition and then:

- if it was an RNR command with the P bit set to ONE, it shall respond with an RR response with the F bit set to ONE if the Data Link layer entity is not an own receiver busy condition and shall respond with an RNR response with the F bit set to ONE if the Data Link layer entity is in an own receiver busy condition; and

- if it was an RNR response with the F bit set to ONE, an existing timer recovery condition and/or status enquiry shall be cleared.

I frames shall not be transmitted towards a peer which has indicated a busy condition with an RNR frame.

The N(R) in the received supervisory response with F bit set to ONE will be used, to update the send state variable V(S).

Note 1
The N(R) in any received supervisory command (including RNR) with a P bit set to ONE will not be used to update the send state variable V(S).

Note 2
On receipt of an RNR response with F bit set to ZERO, the send state variable V(S) is not updated.

The Data Link layer entity shall then:

- treat the receive sequence number N(R) contained in the received RNR frame as an acknowledgement for all the I frames that have been (re)transmitted with an N(S) up to and including N(R) minus 1. Then, set its acknowledge state variable V(A) to the value of the N(R) contained in the RNR frame, and

- restart timer T200.

Upon expiry of timer T200 the Data Link layer entity shall:

- if it is not yet in a timer recovery condition or status enquiry (see 5.7), enter either a status enquiry if no subsequent I frames will be transmitted or a timer recovery condition, and reset the retransmission counter;

- if it is already in a timer recovery condition or status enquiry add one to its retransmission count variable.

- The Data Link layer entity shall then:

  o if the value of retransmission count variable is less than N200 transmit
  * an RR command with the P bit set to ONE if the Data Link layer entity is not in an own receiver busy condition; or
  * an RNR command with the P bit set to ONE if the Data Link layer entity is in an own receiver busy condition
  and restart timer T200.

  Note:
  On the PCSN side the peer entity might instead retransmit the last transmitted I frame (V(S)-1) with the P bit set to ONE.

  o if the value of the retransmission count variable is equal to N200, it shall initiate the re-establishment procedure described in 5.6. The management entity shall be notified via the MDL-ERROR-INDICATION primitive.The Layer 3 entity may be informed by DL-RELEASE-INDICATION. N200 is the system parameter defined in 5.9.2.

The peer Data Link layer entity receiving the supervisory frame with the P bit set to ONE shall respond, at the earliest opportunity, with a supervisory response frame (RR, RNR, REJ) with the F bit set to ONE, to indicate whether or not its own receiver busy condition still exists.

Upon receipt of the supervisory response with the F bit set to ONE, the Data Link layer entity shall:

* reset timer T200; and
* use the N(R) of the received frame to update the state variables V(A) and V(S); and:

- if the response is an RR or REJ response, the peer receiver busy condition is cleared and the Data Link layer entity may transmit new I frames or retransmit I frames as defined in 5.5.1 or 5.5.4 respectively; or

- if the response is an RNR response, the Data Link layer entity receiving the response shall proceed according to this 5.5.5.

If a supervisory command (RR,RNR or REJ) is received during the status inquiry process, the Data Link layer entity shall:

- if the command is an RR or REJ command, clear the peer receiver busy condition;

- if the command is an RNR command, retain the peer receiver busy condition. The inquiry of the peer status shall be repeated following the expiry of timer T200 or following the receipt of the response with the F bit set to ONE.

Should the received supervisory command contain the P bit set to ONE, the appropriate response frame with the F bit set to ONE must be transmitted before the Data Link layer entity can action the received frame.

Receiving an SABM command, the Data Link layer entity shall clear the peer receiver busy condition.

Note:
I frames shall not be transmitted immediately following the receipt of an RR or REJ command, if a poll/final status enquiry has not been completed.

5.5.6 Data Link layer own receiver busy condition -

When the Data Link layer entity enters an own receiver busy condition, it shall transmit an RNR frame at the earliest opportunity. The RNR frame may be a response frame with the F bit set to ZERO. Alternatively, the RNR command frame with P bit set to ONE may be sent in order to enter a status enquiry if a timer recovery condition is not present.

All received I frames with the P bit set to ZERO may be discarded, after updating the acknowledge state variable V(A).

All received supervisory frames with the P/F bit set to ZERO shall be processed, including updating the acknowledge state variable V(A).

All received I frames with the P bit set to ONE may be discarded, after updating the acknowledge state variable V(A). However, an RNR response frame with the F bit set to ONE shall be transmitted.

All received supervisory frames with the P bit set to ONE will be processed including updating the acknowledge state variable V(A). An RNR response with the F bit set to ONE shall be transmitted.

To indicate to the peer Data Link layer entity the clearance of the own receiver busy condition, the Data Link layer entity shall transmit an RR frame or, if a previously detected N(S) sequence number error gap has not yet been reported a REJ response frame with the N(R) set to the current value of the receive state variable V(R).

The transmission of an SABM command or a UA response (in reply to an SABM command) also indicates to the peer Data Link layer entity the clearance of the own receiver busy condition.

5.5.7 T200 Time out while Waiting acknowledgement -

The Data Link layer entity shall maintain an internal retransmission count variable.

If timer T200 expires the Data Link layer entity shall:

- if it is not yet in the timer recovery condition, enter the timer recovery condition and reset the retransmission count variable; or

- if it is already in the timer recovery condition add one to its retransmission count variable.

The Data Link layer entity shall then:

- If the value of the retransmission count variable is less than N200:

  o restart timer T200, and

  o transmit an appropriate supervisory command(*) with the P bit set to ONE.
  Note: On the PCSN side the Data Link layer entity might instead: retransmit the last transmitted I frame (V(S) - 1) with the P bit set to ONE.

- If the value of the retransmission count variable is equal to N200, the Data Link layer entity shall initiate a re-establishment procedure as defined in 5.6 and indicate this by means of the primitive MDL-ERROR-INDICATION to the management entity. The Layer 3 entity may be informed by means of a DL-RELEASE-INDICATION primitive. N200 is the system parameter defined in 5.9.2.

The timer recovery condition is cleared when the Data Link layer entity receives a procedural valid supervisory frame response with the F bit set to ONE. If the received supervisory frame N(R) is within the range from its current state variable V(A) to its current send state variable V(S) inclusive, it shall set its send state variable V(S) to the value of the received N(R).

Timer T200 shall be reset if the received supervisory frame response is an RR or REJ response, and then the Data Link layer entity shall resume with I frame transmission or retransmission as appropriate. Timer T200 shall be reset and restarted if the received supervisory response is an RNR response, to proceed with the enquiry process according to 5.5.5.

(*) What constitutes an "appropriate supervisory command" depends on the state that exists in the Data Link layer entity:

- If the Data Link layer entity (not being in the receiver busy condition) is in an N(S) sequence error exception condition and/or a REJ frame has been sent, but the requested I frame has not been received, the "appropriate supervisory command" is the RR; or

- If the Data Link layer entity is in it's own receiver busy condition, the "appropriate supervisory command" is the RNR command.

5.6 Re-establishment of multiple frame operation

5.6.1 Criteria for re-establishment -

The procedures for re-establishing the multiple frame-operation are defined in this section and are initiated by the receipt of the DL-ESTABLISH-REQUEST from the Layer 3 entity in the multiple frame established state or by the following conditions:

- the receipt of a frame with procedure errors as defined in 5.8.4;
- the receipt, while in the multiple frame established state of an FRMR response or an unsolicited DM response;
- the receipt, while in the multiple-frame established state of a UA response or other unsolicited response with the F bit set to ONE,
- N200 retransmission failures while in the multiple-frame established state.

5.6.2 Procedures -

The Data Link layer entity shall initiate the re-establishment procedures as defined below and indicate this by means of the primitive MDL-ERROR-INDICATION to the management entity and a DL-RELEASE-INDICATION to the Layer 3 entity.

In any of the conditions listed in 5.6.1, except for the frame rejection condition, the procedures defined in 5.4.1 shall be used to re-establish multiple-frame operation.

Whenever a frame reject condition is entered (see 3.6.10) a Data Link layer entity shall request re-establishment of the data link by transmitting an FRMR response such as indicated in 5.8.4.

Note:
On the PCSN side the Data Link layer entity detecting a receive sequence number error may re-establish multiple frame operation directly by immediate transmission of an SABM command. The frame rejection condition is cleared when the Data Link layer entity receives or transmits an SABM or DISC command or receives a DM response.

5.7 Data Link layer supervision in the multiple frame established state

5.7.1 Link Supervision -

The connection verification is a service provided by the Data Link Layer to layer 3. This implies that layer 3 is informed in the "normal" exchange of information and may become more efficient than a procedure based on the involvement of layer 3.

The procedure is called STATUS ENQUIRY and is based on supervisory command frames (RR command, RNR command) and a timer T203. It will be activated only when the multiple frame mode of operation has been established, is in the a stable information transfer phase and T200 is not running. The concerned states are: information transfer state, own receiver busy, peer busy and both ends busy. It operates in the multiple established state as follows:

- If there are no frames being exchanged on the data link connection (neither new nor outstanding I frames or no supervisory frames with a P bit set to ONE, etc.), there is no means to detect a faulty data link connection condition or if a TE has been unplugged. Timer T203 represents the maximum time allowed without frames being exchanged.

- If timer T203 expires, a supervisory command (RR or RNR) with a P bit set to ONE is transmitted to start a STATUS ENQUIRY. Such a status enquiry is protected against transmission errors, making use of the normal timer T200 procedure including retransmission count and N200 attempts.

5.7.2 Supervision procedures -

5.7.2.1 Restart of timer T203 -

Upon receiving a frame, timer T203 will be restarted. It has to be noted that if the received frame causes a state transition to a "non stable state" the timing out ot timer T203 will be ineffective.

5.7.2.2 Expiry of timer T203 -

Timer T203 supports a supervisory mechanism to detect a faulty data link connection condition or if a TE has been unplugged during intervals when there are no outstanding frames in either direction. It represents the maximum time allowed without frames being exchanged on a Data Link layer connection.

If timer T203 expires and if the Data Link layer entity is in one of the states identified in 5.7.1, it will act as follows. (It should be noted that timer T200 is neither running nor expired):

- set the retransmission count variable to 0;
- set STATUS ENQUIRY condition and enter Timer recovery state;
- transmit a supervisory command with the P bit set to 1 as follows:
  - if there is not a receiver busy condition (own receiver not busy), transmit an RR command; or
  - if there is a receiver busy condition (own receiver busy), transmit an RNR command; and
- start timer T200.

5.7.2.3 Clearing of Status Enquiry Condition -
The status enquiry condition will be cleared on receipt of a supervisory response frame with the F bit set to ONE.

5.8 Exception condition reporting and recovery

Exception conditons may occur as the result of Physical Layer errors or Data Link layer procedural errors.

The error recovery procedures which are available to effect recovery following the detection of an exception condition at the Data Link layer are defined in this section.
Note:
Any additional action, for example, error rate monitoring to be taken by the Data Link layer, is for further study.

5.8.1 N(S) sequence error -

An N(S) sequence error exception condition occurs in the receiver when a valid I frame is received which contains an N(S) value which is not equal to the receive state variable V(R) at the receiver. The information field of all I frames whose N(S) does not equal the receive state variable V(R) shall be discarded.

The receiver shall not acknowledge (nor increment its receive state variable) the I frame causing the sequence error, not any I frames which may follow, until an I frame with the correct N(S) is received.

A Data Link layer entity which receives one or more I frames having sequence errors but otherwise error-free, or subsequent supervisory frames (RR, RNR and REJ) shall use the control field information contained in the N(R) field and the P or F bit to perform data link control functions; for example, to receive acknowledgement of previously transmitted I frames and to cause the Data Link layer entity to respond if the P bit is set to ONE. Therefore, the retransmitted I frame may contain an N(R) field value and P bit that are updated from, and therefore different from, the ones contained in the originally transmitted I frame.

The REJ response frame shall be sent at the earliest opportunity by a receiving Data Link layer entity to initiate an exception condition recovery (retransmission) following the detection of an N(S) sequence error.

Only one REJ exception condition for a given direction of information transfer shall be established at a time.

A Data Link layer entity receiving a REJ command or response shall initiate sequential transmission (retransmission) of I frames starting with the I frame indicated by the N(R) contained in the REJ frame.

A REJ exception condition is cleared when the requested I frame is received or when an SABM or DISC command is received.

5.8.2 Time-out recovery -

If a Data Link layer entity due to a transmission error, does not receive a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an out-of-sequence exception condition and therefore will not transmit a REJ frame.

The Data Link layer which transmitted the unacknowledged I frame(s) shall, on the expiry of timer T200, take appropriate recovery action as defined in 5.5.7 to determine at which I frame retransmission must begin.

5.8.3 Invalid frame condition -

Any frame received which is invalid (as defined in 2.9) shall be discarded and no action shall be taken as a result of that frame.
Note:
Any additional action, (for example error rate monitoring) to be taken by the Data Link layer is for further study.

5.8.4 Frame rejection condition -

A frame rejection condition shall be established upon the receipt of an error free frame with one of the conditions listed in 3.6.10.

At either side, this frame rejection condition shall be indicated by transmission of an FRMR response for appropriate action by the other side. This indication will be followed by the transmission of an SABM or DISC command.
Note:
At the PCSN side, rather than establishing a frame rejection condition link re-establishment may be initiated directly by transmission of an SABM command.

Once the frame rejection condition has been established, no additional I or supervisory frames shall be processed (except for examination of the P bit) until the condition is reset.

Any other command received while in the frame rejection condition shall cause the Data Link layer entity to retransmit the FRMR response with the same information field as originally transmitted.

The FRMR response may be repeated at each opportunity until recovery is effected.

5.9 List of system parameters

The system parameters listed below are associated with each individual service access point.

A method of assigning these parameters is defined in 5.4. Other methods of assigning these parameters may be available, but are not part of this Standard.

5.9.1 Timer T200 -

The default (this term implies that the value defined should be used in the absence of any assignment or negotiation of alternative values) value for timer T200 at the end of which transmission of a frame may be initiated according to the procedure described in 5.5, 5.6.2 and 5.7 shall be one second.

Note:
The proper operation of the procedure requires that timer T200 be greater than the maximum time between transmission of command frames and the reception of their corresponding response or acknowledgement frames.

5.9.2 Maximum number of retransmissions (N200) -

The maximum number of retransmissions of a frame (N200) is a system parameter. The default value of N200 shall be 3.

5.9.3 Maximum number of octets in an I field (N201) -

The maximum number of octets in an I field frame information (N201) is a system parameter. (See also 2.5).

For a SAP supporting signalling, the default value shall be 192 octets (provisional value).

Note:
For applications requiring large signalling messages, a single value greater than 192 (for example 260) may be specified.

Note:
If and when other SAP types are defined, the appropriate default values will be included in the standard.

5.9.4 Maximum number of Retransmissions of the Identity Request Message(N202) -

The maximum number of retransmission of an Identity Request

message (when the TE requests a TEI) is a system parameter. The default value of N202 shall be 3.

5.9.5 Maximum number of outstanding I frames (k) -

The maximum number (k) of sequentially numbered I frames that may be outstanding (that is unacknowledged) at any given time is a system parameter which shall not exceed 7.

- for a SAP supporting signalling on the basic access the default value shall be 1,

- for a SAP supporting signalling on the primary rate access the default value shall be 7.

5.9.6 Timer T201 -

The minimum time between retransmission of the TEI-identity check messages (T201) is a system parameter which shall be set to T200 seconds.

This timer is not used on the TE side.

5.9.7 Timer T202 -

The minimum time between retransmission of the TEI-identity request messages (T202) is a system parameter which shall be set to 4 x T200 seconds.

5.9.8 Timer T203 -

The minimum time between activation of link supervision sequences (T203) is a system parameter which shall be set to 10 seconds.

APPENDIX A

ACRONYMS USED IN THIS STANDARD

Ai	Action Indicator
ASP	Assignment Source Point
CEI	Connection Endpoint Indentifier
CES	Connection Endpoint Suffix
C/R	Command/Respons field
DISC	DISConnect
DL-	Data Link layer entity boundary with Layer 3
DLCI	Data Link Connection Identifier
DM	Disconnect Mode
DPE	Data Processing Equipment
EA	Extended Address (field bit)
ET	Exchange Termination
FCS	Frame Check Sequence
FRMR	FRaMe Reject
I	Information
ID	IDentity
ISDN	Integrated Services Digital Networks
L3	Layer 3
L2	Layer 2
LAPD	Link Access Procedure on he D-Channel
MDL-	Between Management entity and Data Link layer
OSI	Open System Interconnection
P/F	Poll/Final bit
PH-	Between Data Link layer and PHysical layer
PT	PCSN Termination
REJ	REJect
Ri	Request refence number
RNR	Receiver Not Ready
RR	Receiver Ready
S	Supervisory (frame)
SABM	Set Asynchronous Balanced Mode
SAP	Service Access Point
SAPI	Service Access Point Identifier
TE	Terminal Equipment
TEI	Terminal Equipment Identifier
U	Unnumbered
UA	Unnumbered Acknowledgement
UI	Unnumbered Information

APPENDIX B

DATA LINK LAYER STATE TRANSITION TABLES

LEVEL 2 PROTOCOL STATE TRANSITION TABLES (USER SIDE)

These tables are provided as complementary information. Whenever a doubt subsists the text should preempt.

The following legal states for the LAP-D protocol in a DPE/PCSN interface have been identified:

D0:	TEI unassigned
D0.1:	waiting for TEI on DL-UNIT DATA-REQUEST
D0.2:	waiting for TEI on DL-ESTABLISH-REQUEST
D1:	TEI assigned
D2:	Setting up (wait for UA)
D3:	Disconnecting (wait for UA)
D4:	Peer busy (RNR RX)
D5:	Frame reject condition
D6:	Busy
D7:	T200 recovery
D8:	Both ends busy (RNR RX)
D9:	Busy, T200 recovery
D10:	I-phase
D11:	Peer busy and T200 recovery

The following keys are used:

XXXrf:	XXX response frame with F#bit set
YYYcp:	YYY command frame with P#bit set
XXX or YYY	frame with P/F not set

The following events are expected:

1) Frames received: SABMcp DISCcp UArf DMrf

RRc	RRcp	RRr	RRrf
RNRc	RNRcp	RNRr	RNRrf
REJc	REJcp	REJr	REJrf
FRMR	UI		

I-frame OK I-frame(P) OK

I-frame with N(S) error

Invalid frame or frame with unexpected F#bit set

2) Primitives

PH-ACTIVE-INDICATION

PH-DEACTIVATION-INDICATION

DL-ESTABLISH-REQUEST

DL-RELEASE-REQUEST

DL-UNIT DATA-REQ

DATA LINK LAYER STATE TRANSITION TABLES

MDL-UNIT DATA-REQ
DL-DATA-REQUEST
MDL-ASSIGN-REQUEST
MDL-REMOVE-REQUEST

2) Other events
T200 timeout
T200 timeout N200 times
T203 timeout
End of busy (self)

In the state tables:
content of the boxes = frame and/or primitives to send
Number in bottom right corner = next state

The following abbreviations are used:
c = command r = response p or f P/F bit = 1
* = F bit = same as P#bit received
X = no external action (i.e frame or primitive)
N.D not defined (impossible)
ASN = assign ACT = activate DEA = deactivate
REL = release REQ = request EST = establish
ERR = error IND = indication

STATE / EVENT	TEI unassigned 0	TEI assigned 1	setting up 2	disconn-ecting 3	Peer busy 4	frame reject 5	Busy 6	T200 recovery 7	Both ends busy 8	busy & T200 recovery 9	I-phase 10	peer busy T200 recovery 11
SABM	X	UAr* 10	UAr*	DMr* 1	UAr* 10	UAr* 10	UAr* 10	UAr* 10	UA r* 10	UAr* 10	UAr*	UAr* 10
DISC	X	DMr*	DMr* 1	UAr*	UAr* 1	UAr* 1	UAr* 1	UAr* 1	UAr* 1	UAr* 1	UAr* 1	UAr* 1
UA(F)	X	MDL-ERR X	MDL-ERR DL-EST -CONF 10	MDL-ERR DL-REL -CONF 1	MDL-ERR SABMcp 2	FRMFrf	MDL-ERR SABMcp 2	MDL-ERR SABMcp 2	MDL-ERR SABMcp 2	MDL-ERR SABMcp 2	MDL-ERR SABMcp 2	MDL-ERR SABMcp 2
DM(F)	X	X	MDL-ERR 1	MDL-ERR 1	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2
FRMR	X	X	MDL-ERR	MDL-ERR	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2	MDL-ERR SABMcp REL-IND 2
T200 timeout	ND	ND	SABMcp	DISCcp	RRcp 11	X	RNRcp 9	RRcp	RNRcp 9	RNRcp	RRcp 7	RRcp
T200 timeout N200 times	ND	ND	MDL-ERR 1	MDL-ERR 1	ND	MDL-ERR SABMcp 2	ND	MDL-ERR SABMcp 2	ND	MDL-ERR SABMcp 2	ND	MDL-ERR SABMcp 2
T203 timeout	ND	ND	ND	ND	RRcp 11	ND	RNRcp 9	ND	RNRcp 9	ND	RRcp 7	ND

EVENT \ STATE	TEI unassigned 0	TEI assigned 1	setting up 2	disconn-ecting 3	Peer busy 4	frame reject 5	Busy 6	T200 recovery 7	Both ends busy 8	busy & T200 recovery 9	I-phase 10	peer busy T200 recovery 11
RRc	X	X	X	X	10	FRMRr	X	X	6	X	X	7
RRcp	X	DMrf	X	X	RRrf 10	FRMRrf	RNRrf	RRrf or REJrf	RNRrf 6	RNRrf	RRrf	7
RRr	X	X	X	X	10	FRMRr	X	X	6	X	X	7
RRrf	X	X	X	X	10	FRMRr	X	I 10	6	6	X	I 10
RNRc	X	X	X	X	X	FRMRr	8	11	X		4	X
RNRcp	X	DMrf	X	X	RRrf	FRMRrf	RNRrf 8	RRrf or REJrf 11	RNRrf	RNRrf 8	RRrf 4	RRrf or REJrf
RNRr	X	X	X	X	X	FRMRr	8	11	X		4	X
RNRrf	X	X	X	X	X	FRMRr	8	4	X	8	4	4
REJc	X	X	X	X	I 10	FRMRr	I	X	I 6		I	7
REJcp	X	DMrf	X	X	RRrf & I 10	FRMRrf	RNRrf & I	RRrf or REJrf	RNRrf & I 6	RNRrf	RRrf & I	RRrf & I or REJrf 7

STATE / EVENT	0	1	2	3	4	5	6	7	8	9	10	11
	TEI unassi-gned	TEI assigned	setting up	disconn--ecting	Peer busy	frame reject	Busy	T200 recovery	Both ends busy	busy & T200 recovery	I-phase	peer busy T200 recovery
REJr	ND	X	X	X	I 10	FRMRr	I	X	I 6	X	I	X
REJrf	ND	X	X	X	I 10	FRMRrf	I	I 10	I 6	I 6	I	I 10
I- OK	ND	X	X	X	RRr DL-DATA	FRMR	I or RNRr or X	RRr DL-DATA	RNRr or X	RNRr or X	RRr or I DL-DATA	RRr DL-DATA
I(P)- OK	ND	DMrf	X	X	RRrf DL-DATA	FRMRrf	RNRrf	RRrf DL-DATA	RNRrf	RNRrf	RRrf DL-DATA	RRrf DL-DATA
I-frame N(S) error	ND	X	X	X	REJr*	FRMRr*	RNRr*	REJr*	RNRr*	RNRr*	REJr*	REJr*
Station goes busy	ND	ND	X	X	RNRr, RNRc or RNRcp 8	X	X	RNRr, RNRc or RNRcp 9	X	X	RNRr, RNRc or RNRcp 6	RNRr, RNRc or RNRcp 5
Invalid or unexpexted F bit	ND	X	X	X	FRMRr* 5	FRMRr*	FRMRr* 5	FRMRr* 5	FRMRr* 5	FRMRr* 5	FRMRr* 5	FRMRr* 5
End of Own receiver busy	ND	ND	X	ND	ND	ND	RRr, RRcp or REJr 10	ND	RRr,RRcp or REJr 4	RRr,RRcp or REJr 7	ND	ND
UI-frame	MDL UN-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND	MDL or DL UNIT-DATA -IND

EVENT / STATE	TEI unassigned 0	waiting TEI on Data Req 0.1	waiting TEI on Est.Req 0.2	TEI assigned 1	setting up 2	disconn-ecting 3	Multiple frame Establ. 4-11
PH-ACTIV. -INDICATION	X	MDL ASSGN -IND	MDL ASSGN -IND	SABMcp 2 or UI 1 (note)	X	X	X
PH-DEACTIV. -INDICATION	X	MDL-ERR -IND 0	MDL-ERR -IND 0	MDL-ERR -IND	MDL-ERR DL-REL -IND 1	MDL-ERR DL-REL -IND 1	MDL-ERR DL-REL -IND 1
DL-EST. -REQUEST	PH-ACT -REQ 0.2	PH-ACTIV -REQ 0.2	X	PH-ACTIV -REQ	X	DL-REL -IND	DL-EST -CONF
DL-RELEASE -REQUEST	X	X	0.1	DL-REL -CONF	DISCcp 3	X	DISCcp 3
DL-UNIT DATA-REQ	PH-ACT. REQUEST 0.1	PH-ACTIV REQUEST	X	PH-ACTIV -REQ	UI	UI	UI
DL-DATA REQUEST	DL-REL. -IND	DL-REL. -IND	DL-REL. -IND	DL-REL. -IND	X	DL-REL. -IND	I
MDL-ASSIGN REQUEST	1	UI 1	SABMcp +UI 2	X	MDL-ERROR -IND	MDL-ERROR -IND	MDL-ERROR -IND
MDL-REMOVE REQUEST	X	0	0	0	DL-RELEAS IND. 0	DL-RELEAS IND. 0	DL-RELEAS IND. 0

note: in the TEI assigned state unsolicited indication will be discarded.

DATA LINK LAYER STATE TRANSITION TABLES

LEVEL 2 MANAGEMENT STATE TRANSITION TABLES (USER SIDE)

The following legal states for the level 2 management protocol in a DPE/PCSN interface have been identified with regard to the TEI assignement procedures:

M0: TEI unassigned
M1: waiting for a TEI
M2: TEI assigned

The following events are expected:

MDL-ASSIGN-INDICATION
MDL-UNIT DATA-INDICATION: UI-frame RX with ID assigned
MDL-UNIT DATA-INDICATION:UI-frame RX with ID removed
MDL-UNIT DATA-INDICATION:UI-frame RX with ID check
MDL-UNIT DATA-INDICATION:UI-frame RX with ID denied
T202 timeout
T202 timeout N202 times

In the state tables:
^ = start T202 v = stop T202 and reset N202
+ = increment N202
X = no change

The following abbreviations are used for primitives :
ASN = assign ACT = activate DEA = deactivate
REL = release REQ = request EST = establish
ERR = error IND = indication

STATE / EVENT	TEI unassigned 0	WAITING for TEI 1	TEI assigned 2
UI Received ID assigned with own RI	X	MDL-ASSIGN REQUEST V 2	X
UI Received ID denied with own RI	X	MDL-ERROR RESPONSE 0	X
UI Received ID check	X	X	TX UI Id check response
UI Received ID removed	X	MDL-ERROR RESPONSE 0	MDL-REMOVE REQUEST 0
UI received with wrong RI	X	X	X
MDL-ASSIGN-IND.	TX UI Id req ^ 1	X	MDL-ASSIGN REQUEST with TEI
T202 timeout	X	TX UI ^+	 V
T202 timeout N202 times	X	MDL-ERROR RESPONSE 0	 V

APPENDIX C

SDL DIAGRAMS FOR THE DATA LINK LAYER PROTOCOL

Provisional detailed specification and description language (SDL) diagrams for the procedures specified in section 5 are presented hereafter. When there is an ambiguity in the narrative text, the SDL diagrams in the following pages should be used to resolve the ambiguity. Where the text and the SDL are in disagrement, the text should be used as the prime source.

C.1 STATES

The following states formed the basis for this SDL representation for the point to point link state control:

TEI Assigned State	- A TEI has been assigned, but the link has not been established.
Established Waiting State	- A Data Link layer entity has begun the establishment process, but establishment is yet to be completed.
Multiple Frame Established State	- Multiple frame mode of information transfer has been established.
Timer Recovery State	- Timer T200 has expired, without an acknowledgement from the peer data link layer entity.
Release Waiting State	- A Data Link layer entity has begun the link release process by transmitting a DISC command.

C.2 SYMBOLS

The SDL representations enclosed here depict the current Data Link layer procedures as described in the text. They cover the link procedures for the Multiple Frame Acknowledged mode of operation, after a TEI has been assigned. These SDLs shall form

the basis for future enhancements to represent the protocol specifically

1) The TEI Assignment and Check Procedures,

2) Unacknowledged Information Transfer Procedures are yet to be provided.

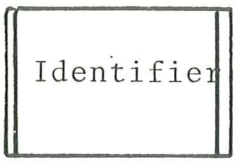
The SDL symbols used

The SDL symbols used in the formal description of the Data Link layer, are those which are defined within the 1984 Z series of recommendations. Presented below is a brief summary of the symbols, which will be new to those who are currently familiar only with the 1980 Z series.

The SDL procedure

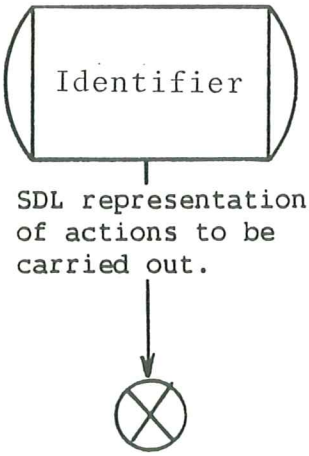
This can be viewed in the same way as the procedure facility adopted within most high level languages.

The procedure call



The procedure call is placed where the actions of the procedure are to be carried out. An identifier is used to associate the call with it's definition.

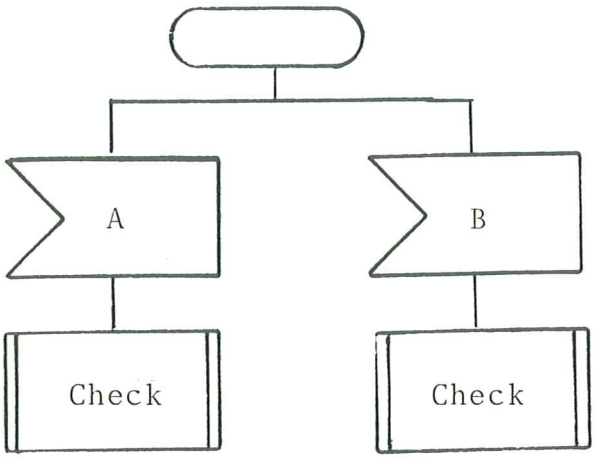
The procedure definition

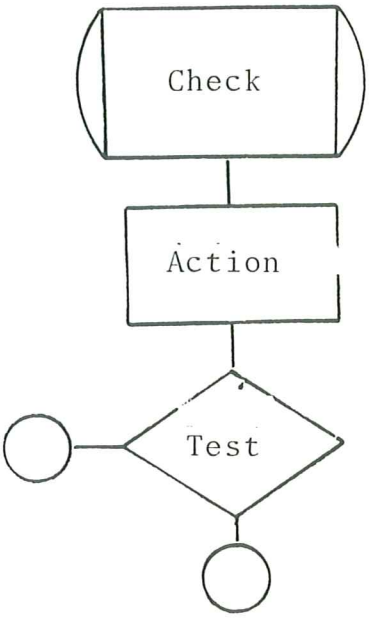


The SDL representation of the actions to be carried out by the procedure are placed between the symbols shown opposite.

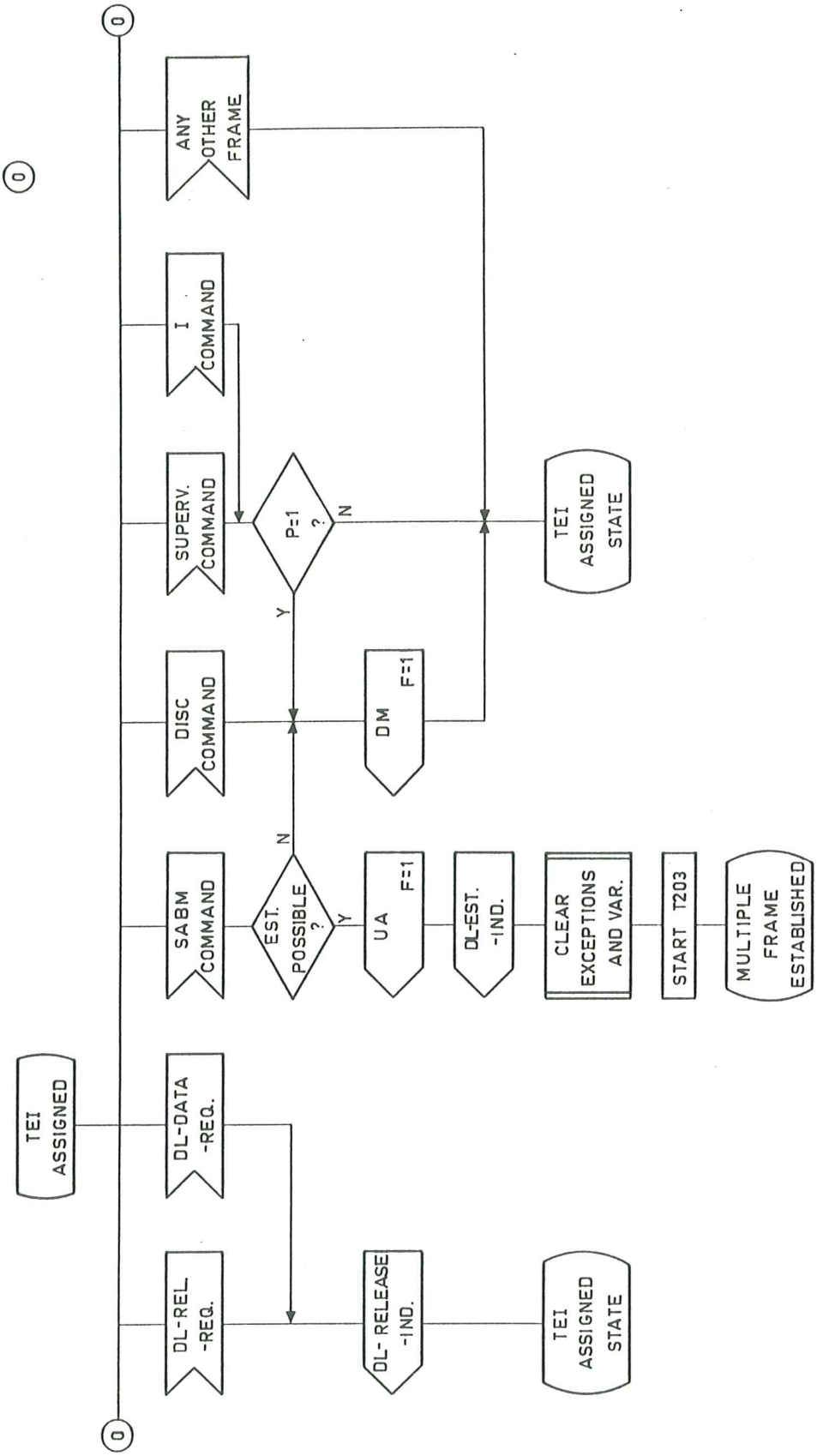
SDL DIAGRAMS FOR THE DATA LINK LAYER PROTOCOL

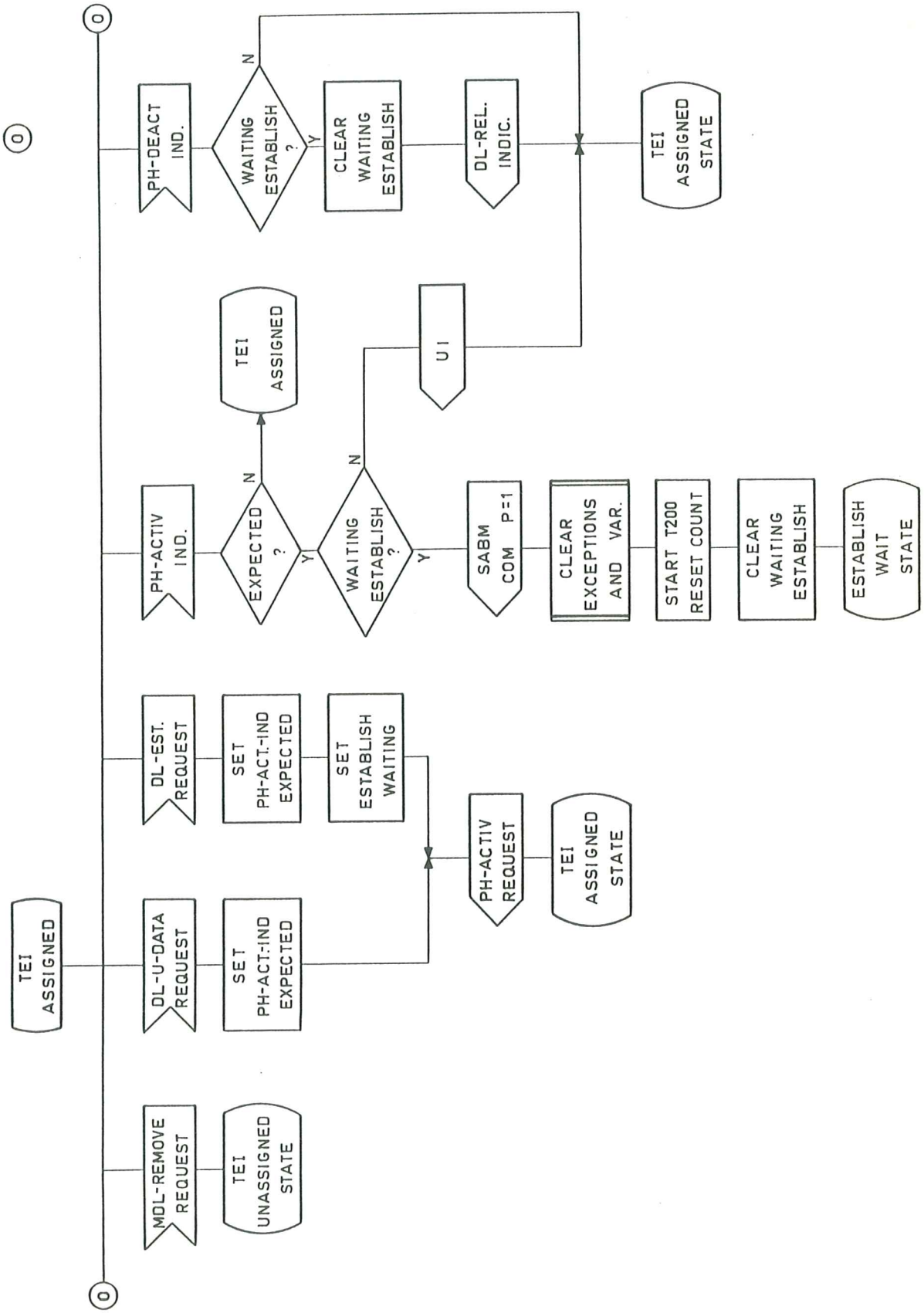
An example of the use of procedures

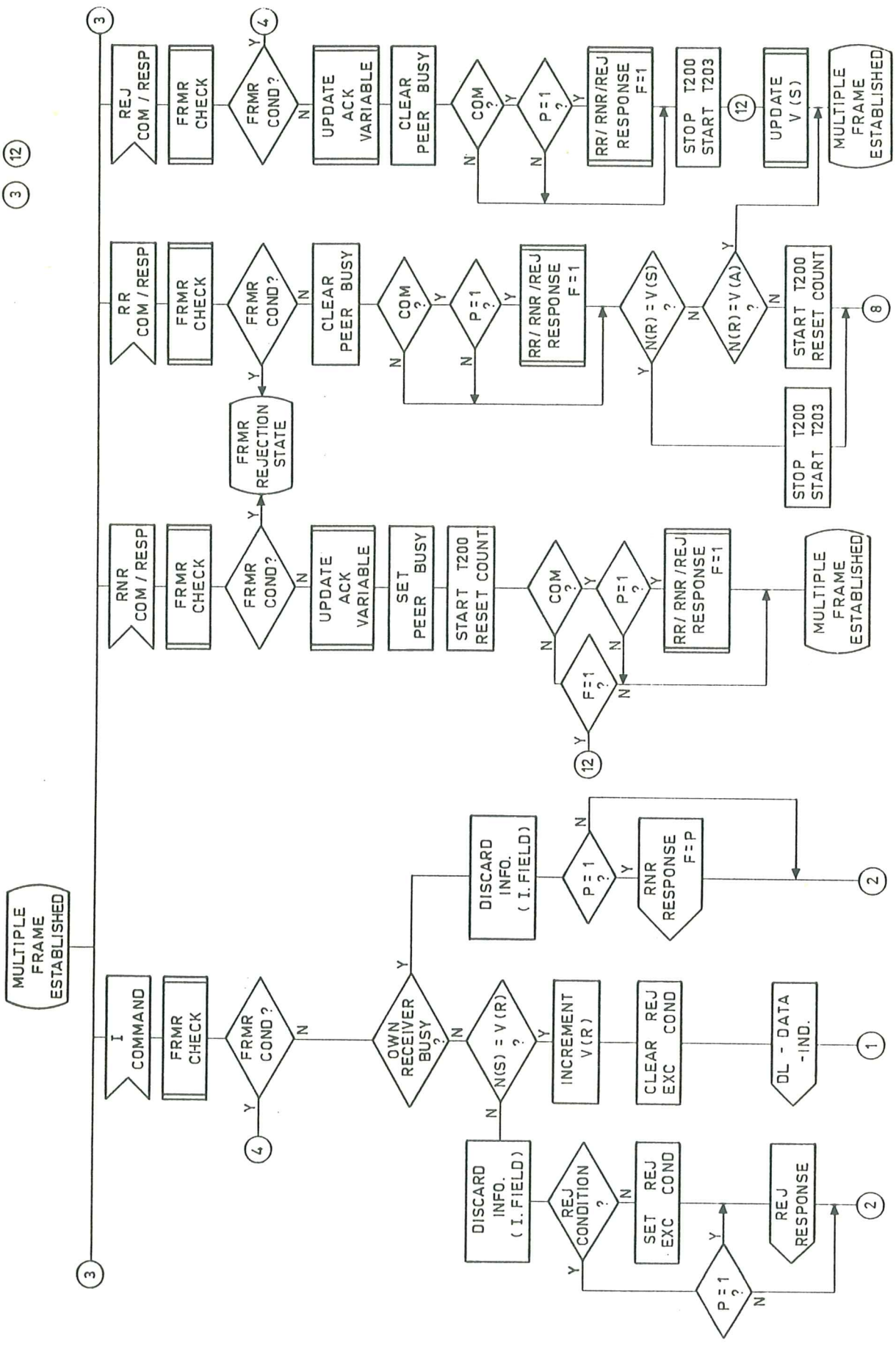


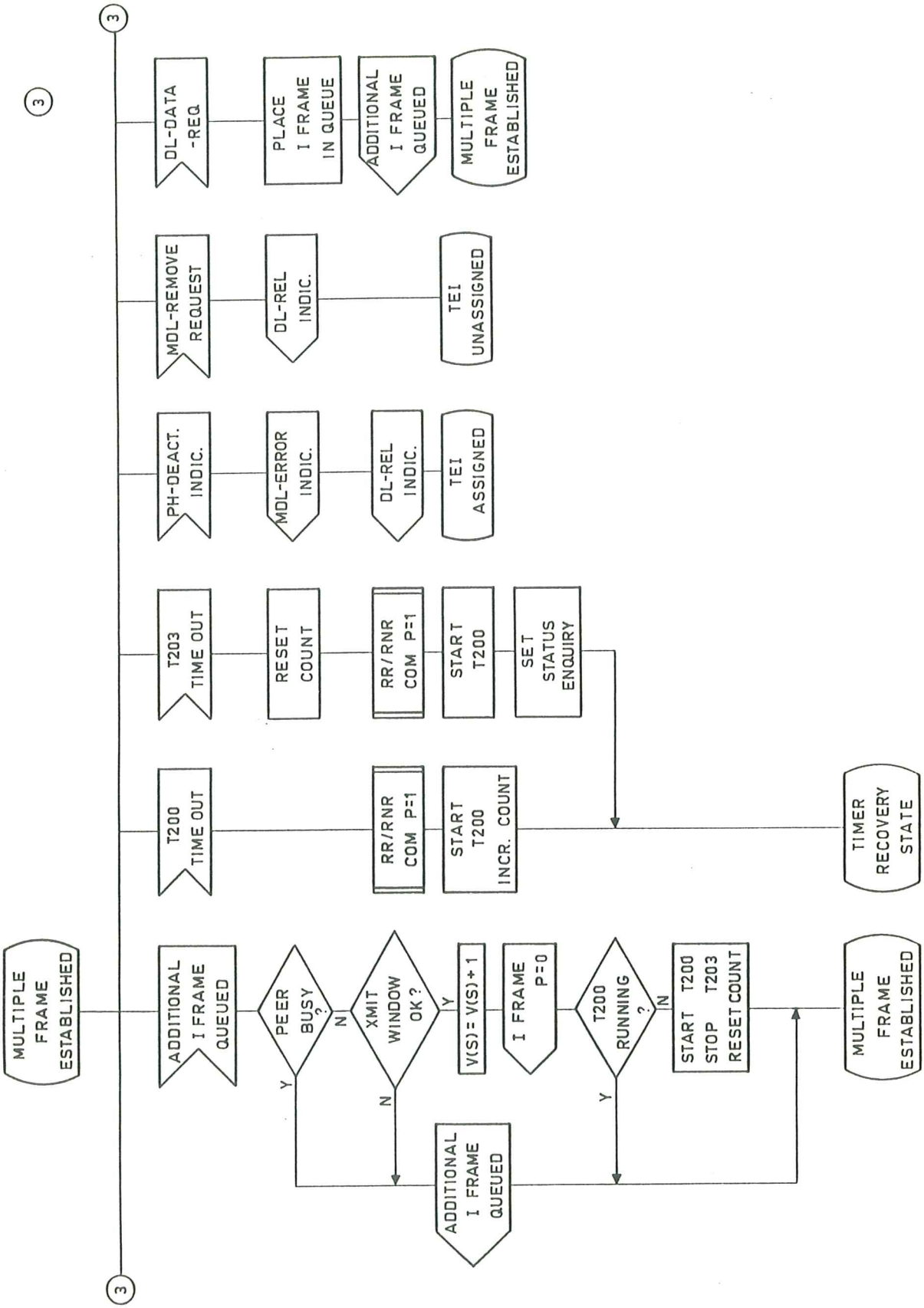


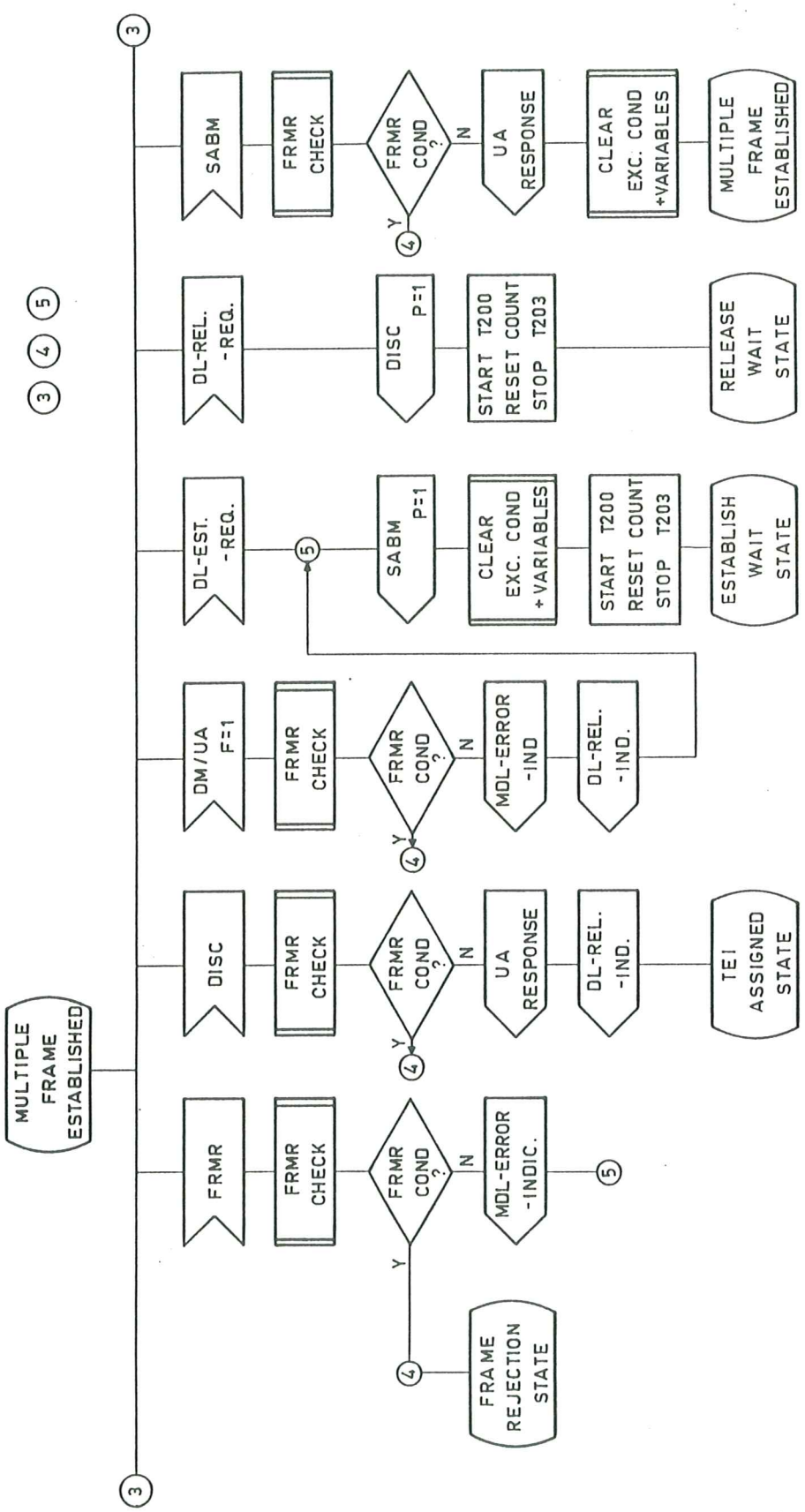
The response to signals A and B within state 1 both include the action defined by the procedure Check.

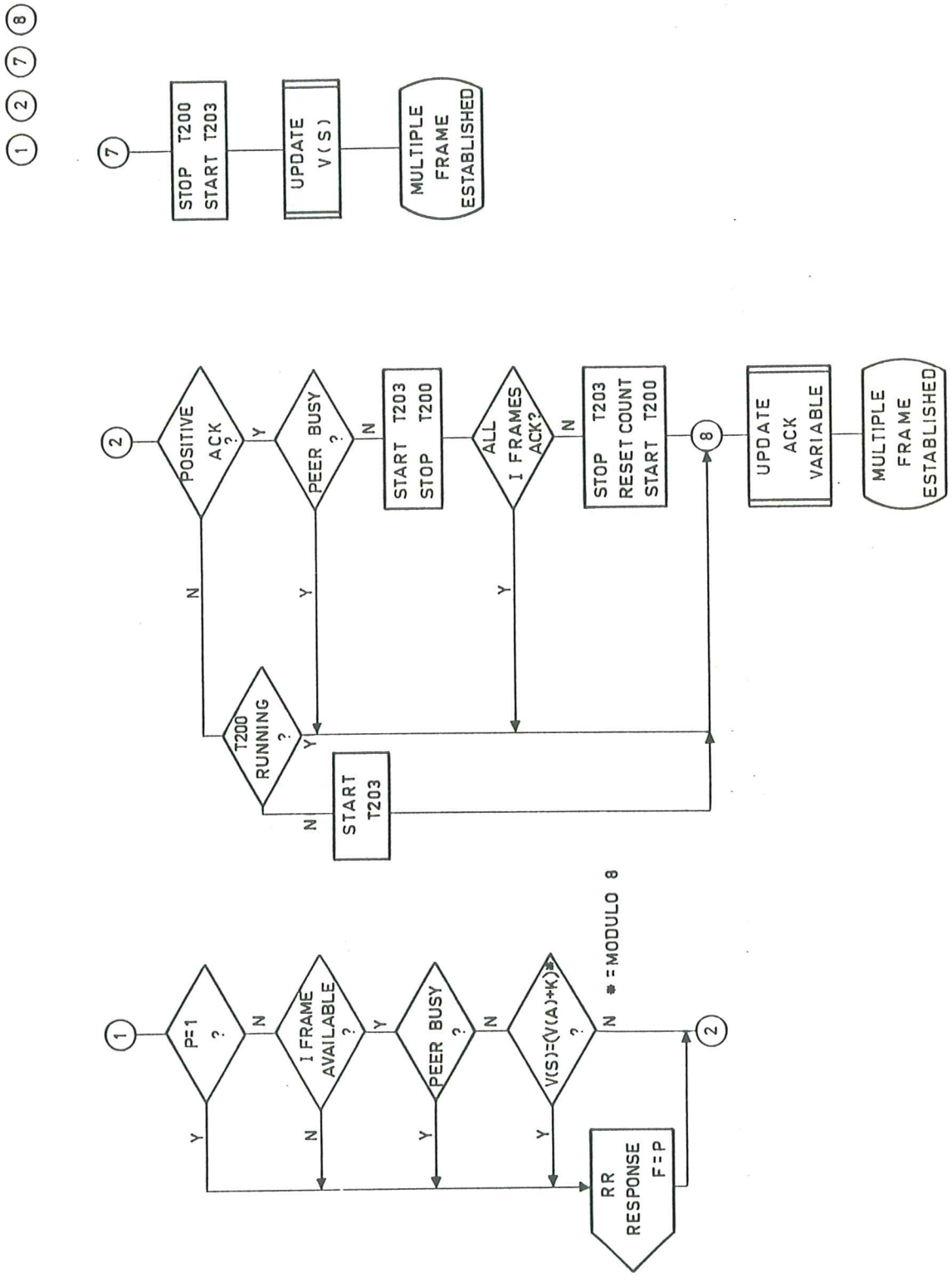

0
0
0
TEI ASSIGNED
DL-DATA -REQ.
DL-REL. -REQ.
SABM COMMAND
DISC COMMAND
SUPERV. COMMAND
I COMMAND
ANY OTHER FRAME
EST. POSSIBLE ?
N
Y
UA F=1
DM F=1
P=1 ?
Y
N
DL-EST. -IND.
DL- RELEASE -IND.
CLEAR EXCEPTIONS AND VAR.
START T203
MULTIPLE FRAME ESTABLISHED
TEI ASSIGNED STATE
TEI ASSIGNED STATE

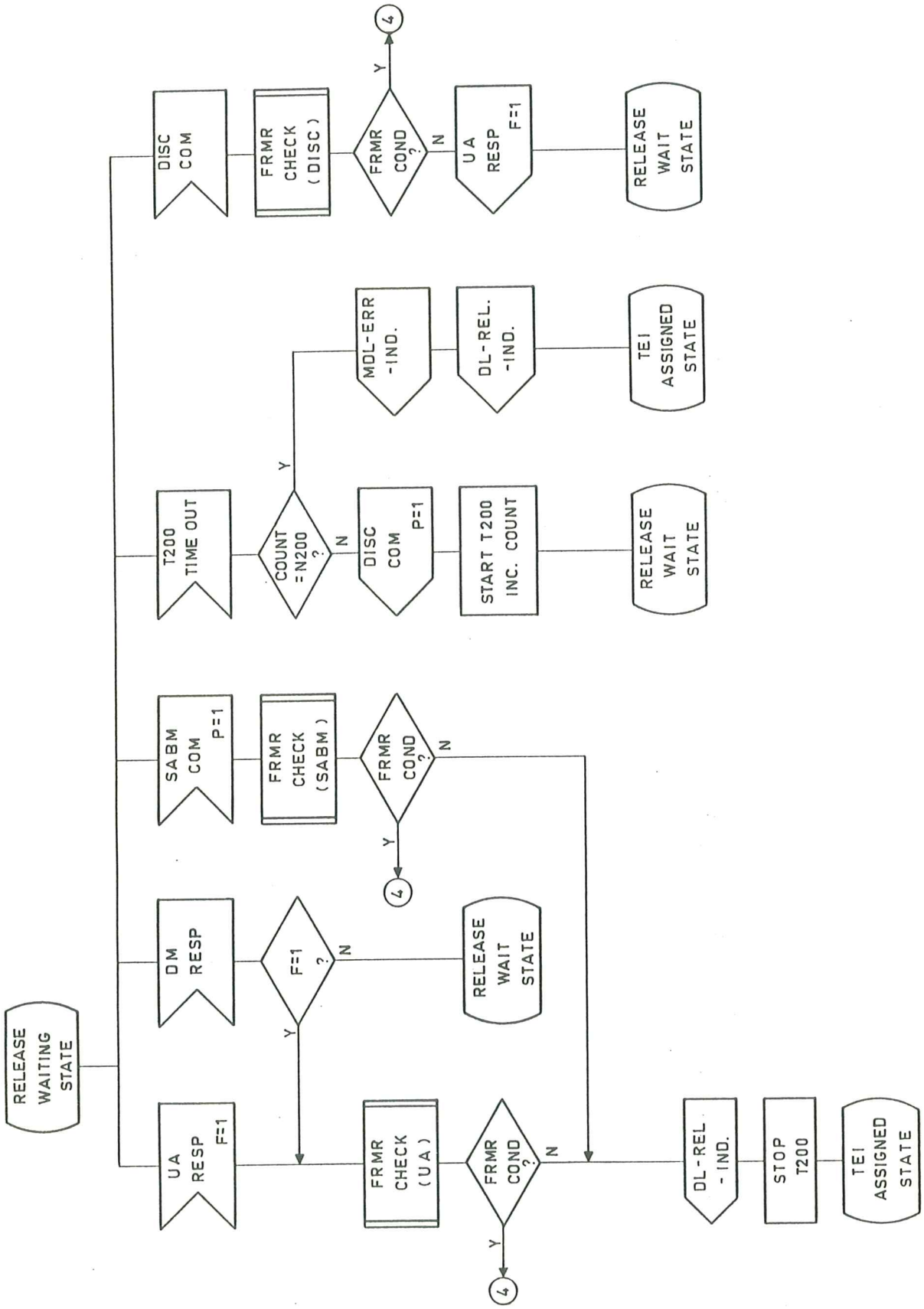

TEI ASSIGNED
DL-U-DATA REQUEST
SET PH-ACT-IND EXPECTED
PH-ACTIV REQUEST
TEI ASSIGNED STATE
DL-EST. REQUEST
SET PH-ACT-IND EXPECTED
SET ESTABLISH WAITING
MDL-REMOVE REQUEST
TEI UNASSIGNED STATE
PH-ACTIV IND.
EXPECTED ?
N
Y
TEI ASSIGNED
WAITING ESTABLISH ?
N
Y
UI
SABM COM P=1
CLEAR EXCEPTIONS AND VAR.
START T200 RESET COUNT
CLEAR WAITING ESTABLISH
ESTABLISH WAIT STATE
PH-DEACT IND.
WAITING ESTABLISH ?
N
Y
CLEAR WAITING ESTABLISH
DL-REL. INDIC.
TEI ASSIGNED STATE
0
0
0

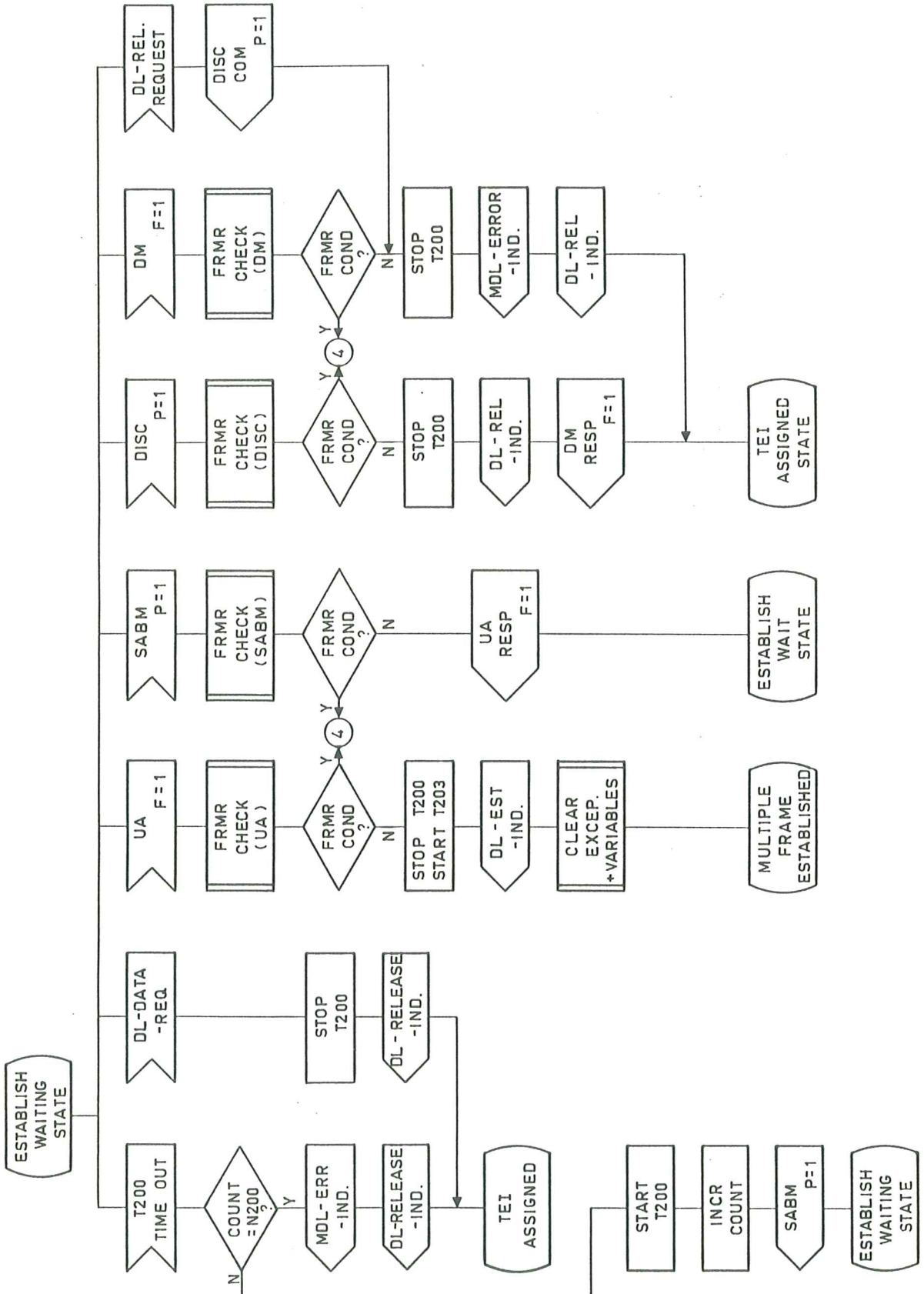

MULTIPLE FRAME ESTABLISHED
I COMMAND
FRMR CHECK
FRMR COND ?
OWN RECEIVER BUSY ?
N(S) = V(R) ?
INCREMENT V(R)
CLEAR REJ EXC COND
DL - DATA -IND.
DISCARD INFO. (I. FIELD)
REJ CONDITION ?
SET REJ EXC COND
P = 1 ?
REJ RESPONSE
DISCARD INFO. (I. FIELD)
P = 1 ?
RNR RESPONSE F = P
RNR COM / RESP
FRMR CHECK
FRMR COND ?
FRMR REJECTION STATE
UPDATE ACK VARIABLE
SET PEER BUSY
START T200 RESET COUNT
COM ?
P = 1 ?
RR / RNR / REJ RESPONSE F = 1
F = 1 ?
MULTIPLE FRAME ESTABLISHED
RR COM / RESP
FRMR CHECK
FRMR COND ?
CLEAR PEER BUSY
COM ?
P = 1 ?
RR / RNR / REJ RESPONSE F = 1
N(R) = V(S) ?
N(R) = V(A) ?
START T200 RESET COUNT
STOP T200 START T203
REJ COM / RESP
FRMR CHECK
FRMR COND ?
UPDATE ACK VARIABLE
CLEAR PEER BUSY
COM ?
P = 1 ?
RR / RNR / REJ RESPONSE F = 1
STOP T200 START T203
UPDATE V (S)
MULTIPLE FRAME ESTABLISHED

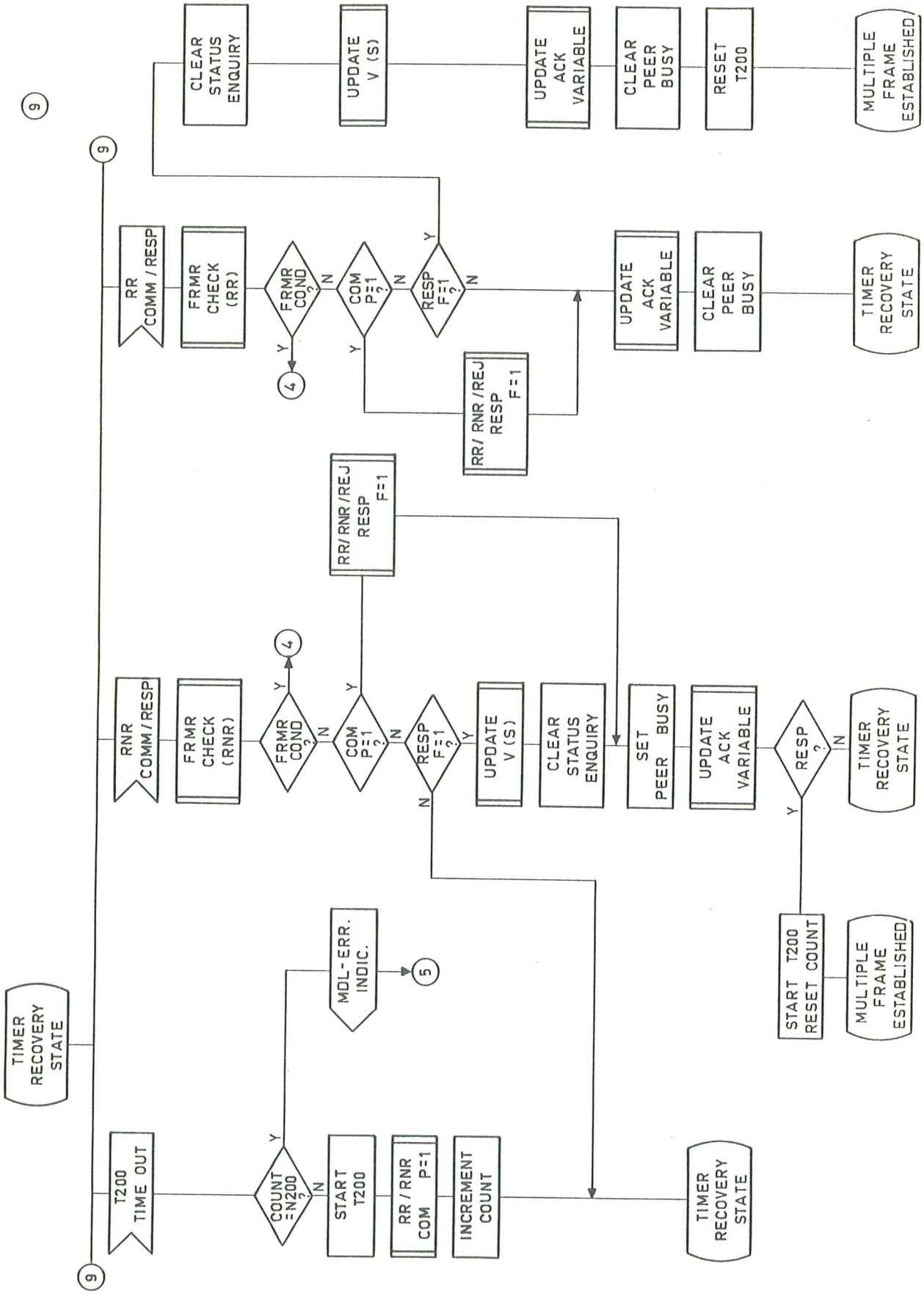

3
3
3
MULTIPLE FRAME ESTABLISHED
ADDITIONAL I FRAME QUEUED
PEER BUSY ?
Y
N
XMIT WINDOW OK ?
N
Y
V(S) = V(S) + 1
I FRAME P=0
T200 RUNNING ?
Y
N
START T200
STOP T203
RESET COUNT
MULTIPLE FRAME ESTABLISHED
ADDITIONAL I FRAME QUEUED
T200 TIME OUT
RR/RNR COM P=1
START T200
INCR. COUNT
TIMER RECOVERY STATE
T203 TIME OUT
RESET COUNT
RR/RNR COM P=1
START T200
SET STATUS ENQUIRY
PH-DEACT. INDIC.
MDL-ERROR INDIC.
DL-REL INDIC.
TEI ASSIGNED
MDL-REMOVE REQUEST
DL-REL INDIC.
TEI UNASSIGNED
DL-DATA -REQ.
PLACE I FRAME IN QUEUE
ADDITIONAL I FRAME QUEUED
MULTIPLE FRAME ESTABLISHED

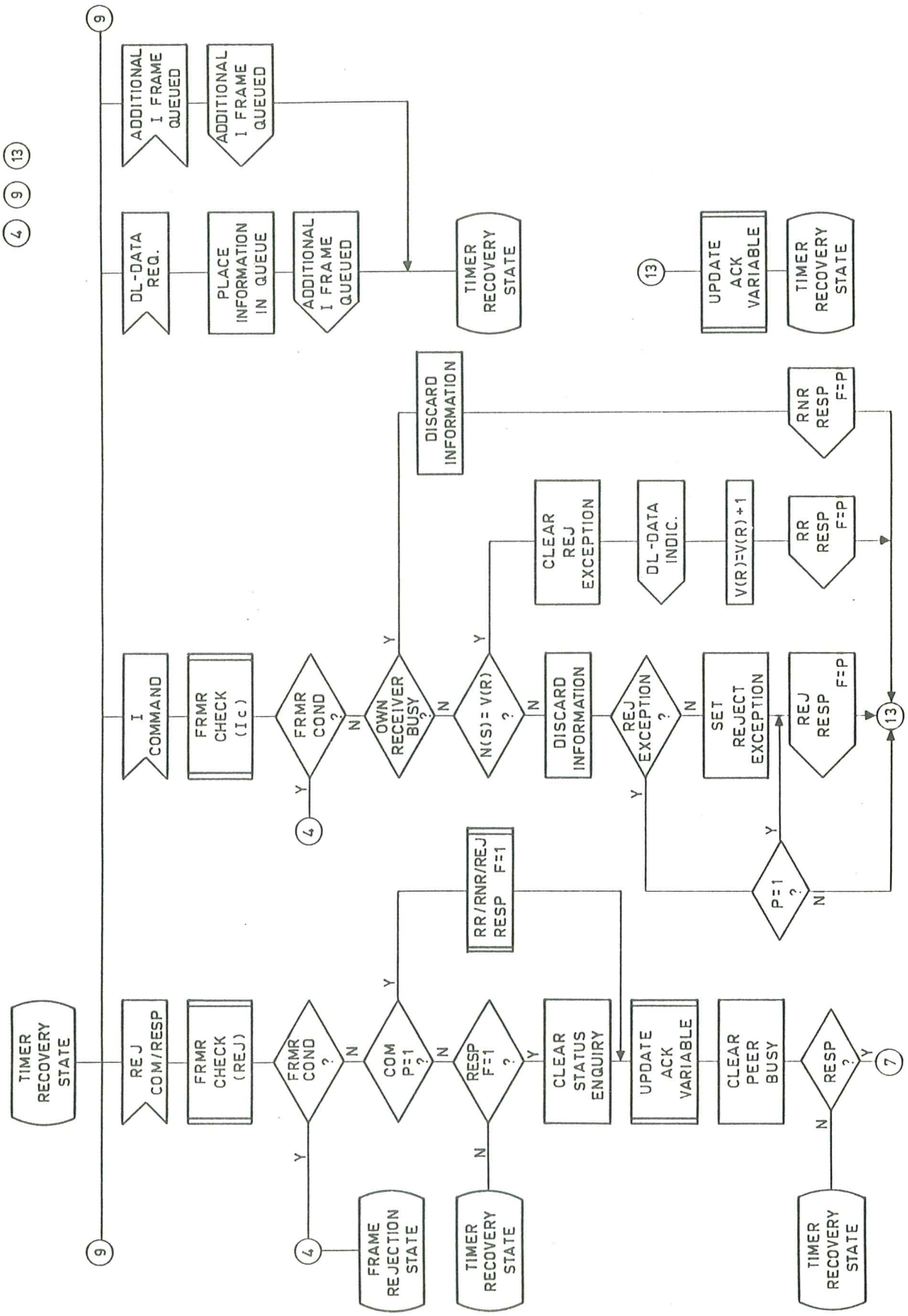

MULTIPLE FRAME ESTABLISHED
FRMR
FRMR CHECK
FRMR COND ?
Y
N
MDL-ERROR -INDIC.
FRAME REJECTION STATE
DISC
UA RESPONSE
DL-REL. -IND.
TEI ASSIGNED STATE
DM/UA F=1
MDL-ERROR -IND
DL-EST. -REQ.
SABM P=1
CLEAR EXC. COND +VARIABLES
START T200 RESET COUNT STOP T203
ESTABLISH WAIT STATE
DL-REL. -REQ.
DISC P=1
RELEASE WAIT STATE
SABM
CLEAR EXC. COND +VARIABLES
MULTIPLE FRAME ESTABLISHED

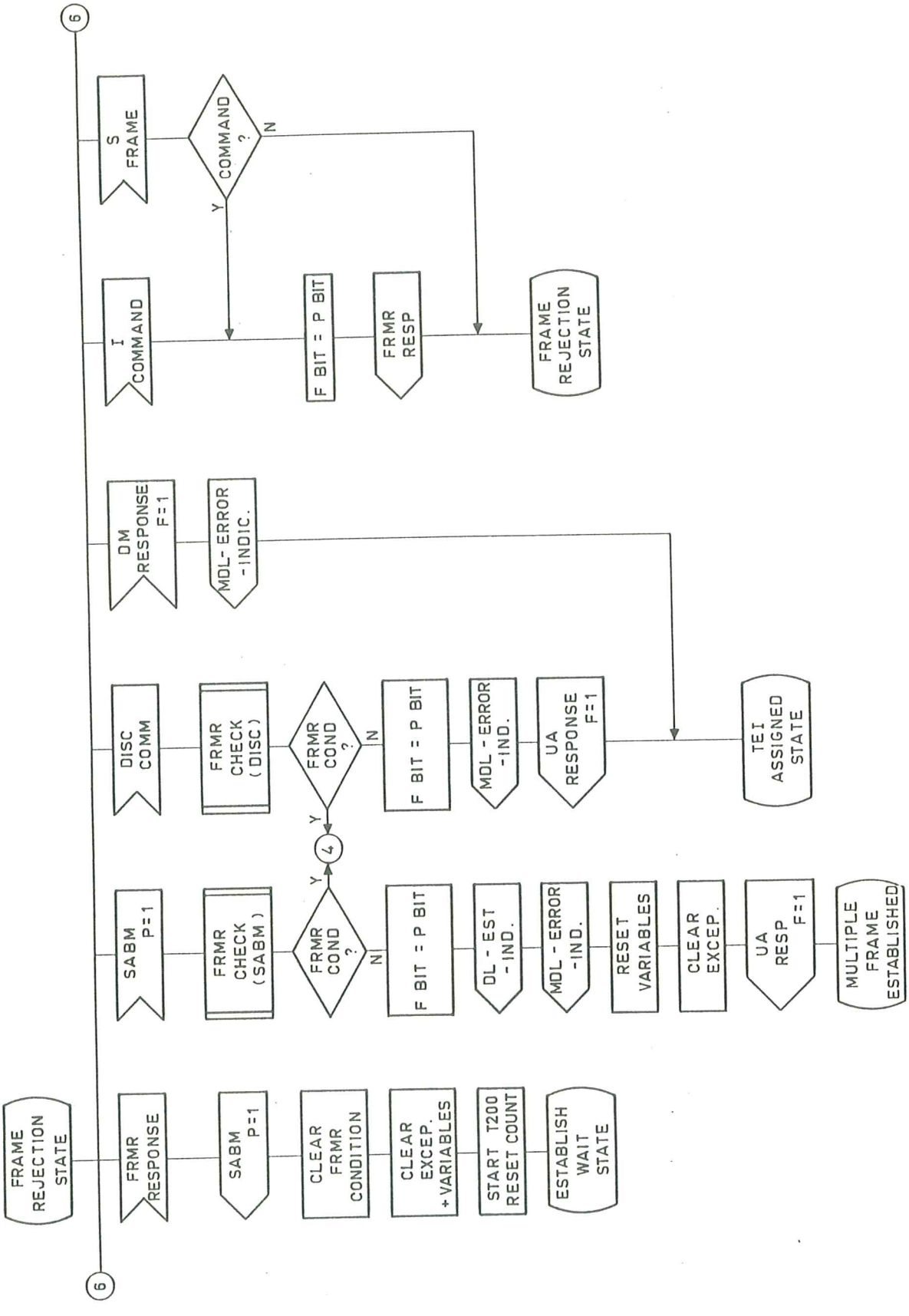

1 2 7 8
7
STOP T200
START T203
UPDATE V(S)
MULTIPLE FRAME ESTABLISHED
2
POSITIVE ACK ?
Y
PEER BUSY ?
N
START T203
STOP T200
ALL I FRAMES ACK?
N
STOP T203
RESET COUNT
START T200
8
UPDATE ACK VARIABLE
MULTIPLE FRAME ESTABLISHED
N
T200 RUNNING ?
Y
N
START T203
Y
Y
1
P=1 ?
N
I FRAME AVAILABLE ?
Y
PEER BUSY ?
N
V(S)=(V(A)+K)* ?
N
* = MODULO 8
2
Y
N
Y
Y
RR RESPONSE F=P

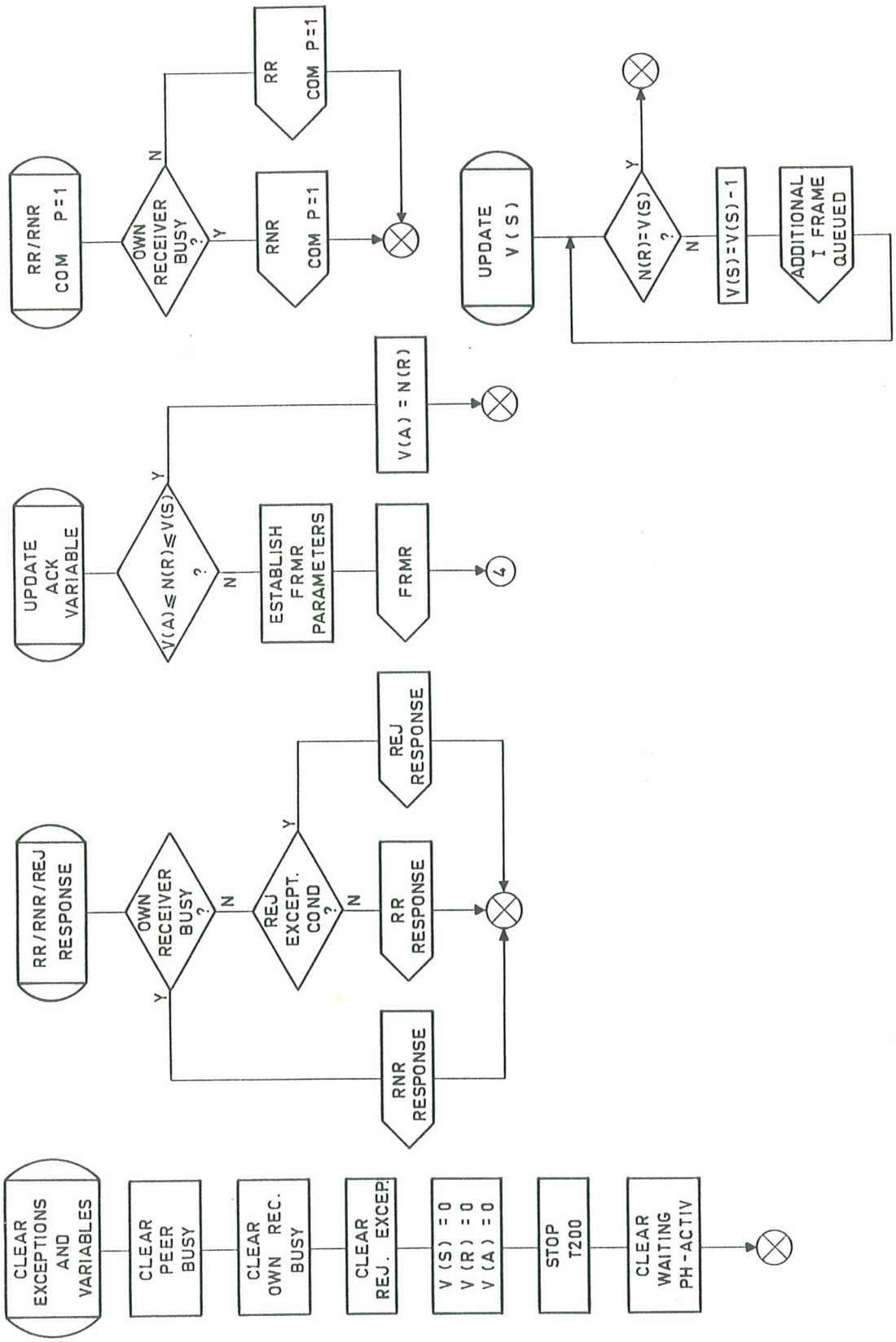

RELEASE WAITING STATE
UA RESP F=1
DM RESP
SABM COM P=1
T200 TIME OUT
DISC COM
F=1 ?
Y
N
FRMR CHECK (UA)
FRMR CHECK (SABM)
FRMR CHECK (DISC)
COUNT =N200 ?
FRMR COND ?
RELEASE WAIT STATE
DISC COM P=1
START T200 INC. COUNT
MDL-ERR -IND.
DL-REL. -IND.
TEI ASSIGNED STATE
UA RESP F=1
DL-REL -IND.
STOP T200
4

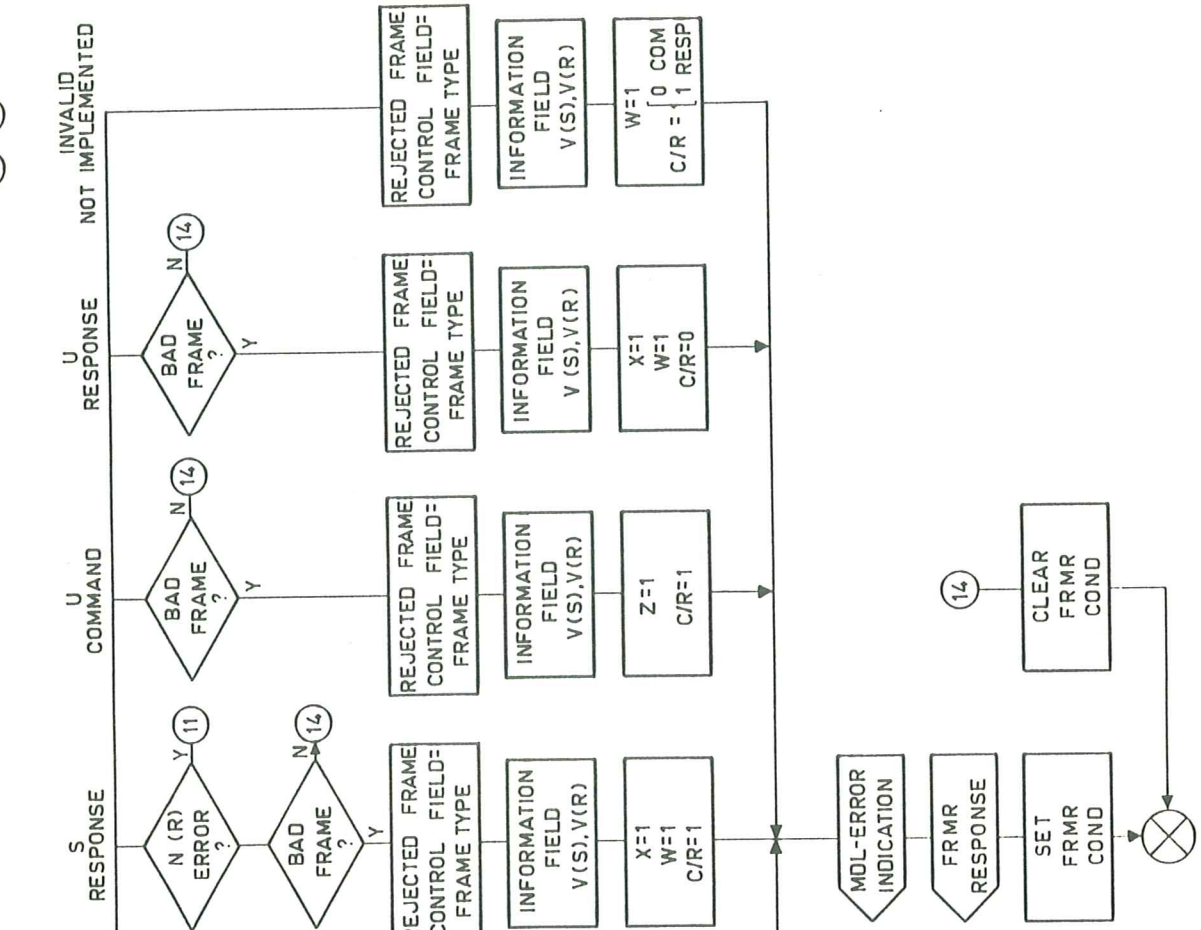

ESTABLISH WAITING STATE
T200 TIME OUT
COUNT = N200 ?
N
Y
MDL-ERR -IND.
DL-RELEASE -IND.
TEI ASSIGNED
START T200
INCR COUNT
SABM P=1
ESTABLISH WAITING STATE
DL-DATA -REQ.
STOP T200
DL-RELEASE -IND.
UA F=1
FRMR CHECK (UA)
FRMR COND ?
STOP T200 START T203
DL-EST -IND.
CLEAR EXCEP. +VARIABLES
MULTIPLE FRAME ESTABLISHED
SABM P=1
FRMR CHECK (SABM)
FRMR COND ?
UA RESP F=1
ESTABLISH WAIT STATE
DISC P=1
FRMR CHECK (DISC)
FRMR COND ?
STOP T200
DL-REL -IND.
DM RESP F=1
TEI ASSIGNED STATE
DM F=1
FRMR CHECK (DM)
FRMR COND ?
STOP T200
MDL-ERROR -IND.
DL-REL -IND.
DL-REL. REQUEST
DISC COM P=1
4
Y
N


TIMER RECOVERY STATE
T200 TIME OUT
COUNT =N200 ?
Y
N
MDL-ERR. INDIC.
5
START T200
RR / RNR COM P=1
INCREMENT COUNT
TIMER RECOVERY STATE
RNR COMM / RESP
FRMR CHECK (RNR)
FRMR COND ?
4
COM P=1 ?
RESP F=1 ?
RR/ RNR /REJ RESP F=1
UPDATE V (S)
CLEAR STATUS ENQUIRY
SET PEER BUSY
UPDATE ACK VARIABLE
RESP ?
START T200 RESET COUNT
MULTIPLE FRAME ESTABLISHED
TIMER RECOVERY STATE
RR COMM / RESP
FRMR CHECK (RR)
FRMR COND ?
4
COM P=1 ?
RESP F=1 ?
RR/ RNR /REJ RESP F=1
UPDATE ACK VARIABLE
CLEAR PEER BUSY
TIMER RECOVERY STATE
CLEAR STATUS ENQUIRY
UPDATE V (S)
UPDATE ACK VARIABLE
CLEAR PEER BUSY
RESET T200
MULTIPLE FRAME ESTABLISHED
9
9
9


TIMER RECOVERY STATE
REJ COM/RESP
FRMR CHECK (REJ)
FRMR COND ?
COM P=1 ?
RESP F=1 ?
CLEAR STATUS ENQUIRY
UPDATE ACK VARIABLE
CLEAR PEER BUSY
RESP ?
FRAME REJECTION STATE
TIMER RECOVERY STATE
TIMER RECOVERY STATE
RR/RNR/REJ RESP F=1
I COMMAND
FRMR CHECK (Ic)
FRMR COND ?
OWN RECEIVER BUSY ?
N(S) = V(R) ?
DISCARD INFORMATION
REJ EXCEPTION ?
SET REJECT EXCEPTION
REJ RESP F=P
P=1 ?
DISCARD INFORMATION
RNR RESP F=P
CLEAR REJ EXCEPTION
DL-DATA INDIC.
V(R):=V(R)+1
RR RESP F=P
DL-DATA REQ.
PLACE INFORMATION IN QUEUE
ADDITIONAL I FRAME QUEUED
TIMER RECOVERY STATE
ADDITIONAL I FRAME QUEUED
ADDITIONAL I FRAME QUEUED
UPDATE ACK VARIABLE
TIMER RECOVERY STATE
Y
N
4
7
9
13


FRAME REJECTION STATE
FRMR RESPONSE
SABM P=1
CLEAR FRMR CONDITION
CLEAR EXCEP. + VARIABLES
START T200 RESET COUNT
ESTABLISH WAIT STATE
SABM P=1
FRMR CHECK (SABM)
FRMR COND ?
Y
N
F BIT = P BIT
DL - EST - IND.
MDL - ERROR - IND.
RESET VARIABLES
CLEAR EXCEP.
UA RESP F=1
MULTIPLE FRAME ESTABLISHED
DISC COMM
FRMR CHECK (DISC)
FRMR COND ?
Y
N
F BIT = P BIT
MDL - ERROR - IND.
UA RESPONSE F=1
TEI ASSIGNED STATE
DM RESPONSE F=1
MDL - ERROR - INDIC.
I COMMAND
F BIT = P BIT
FRMR RESP
FRAME REJECTION STATE
S FRAME
COMMAND ?
Y
N
4
6
6
6

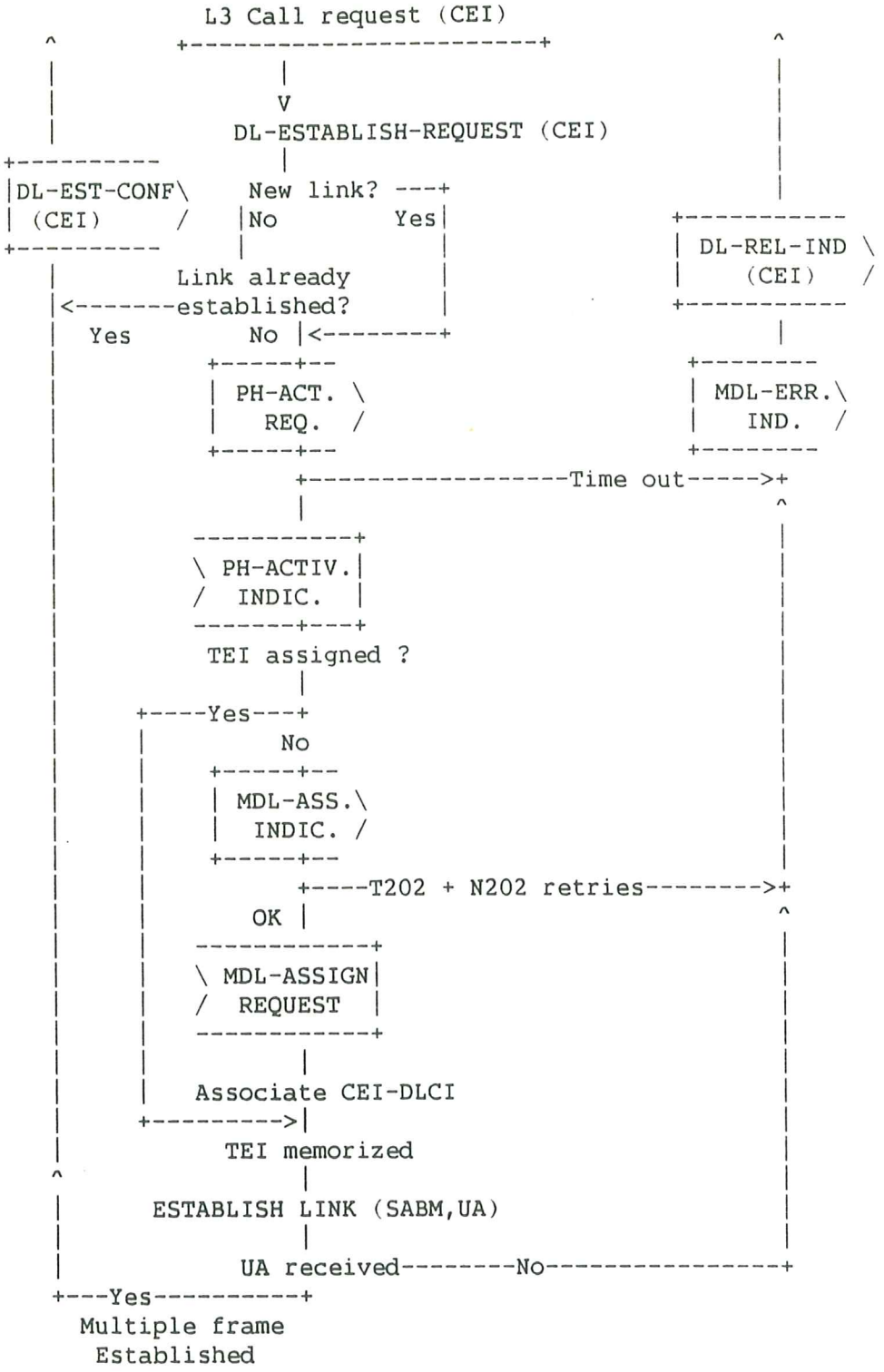

CLEAR EXCEPTIONS AND VARIABLES
CLEAR PEER BUSY
CLEAR OWN REC. BUSY
CLEAR REJ. EXCEP.
V(S) = 0
V(R) = 0
V(A) = 0
STOP T200
CLEAR WAITING PH-ACTIV
RR/RNR/REJ RESPONSE
OWN RECEIVER BUSY ?
N
Y
REJ EXCEPT. COND ?
N
Y
RR RESPONSE
RNR RESPONSE
REJ RESPONSE
UPDATE ACK VARIABLE
V(A)≤N(R)≤V(S) ?
N
Y
ESTABLISH FRMR PARAMETERS
FRMR
4
V(A) = N(R)
RR/RNR COM P=1
OWN RECEIVER BUSY ?
N
Y
RR COM P=1
RNR COM P=1
UPDATE V(S)
N(R)=V(S) ?
Y
N
V(S)=V(S)-1
ADDITIONAL I FRAME QUEUED


FRMR CHECK
I COMMAND
S COMMAND
S RESPONSE
U COMMAND
U RESPONSE
INVALID NOT IMPLEMENTED
N (R) ERROR ?
BAD FRAME ?
REJECTED FRAME CONTROL FIELD= FRAME TYPE
INFORMATION FIELD V(S),V(R)
INFORMATION FIELD V (S),V(R)
Y=1 C/R=0
Z=1 C/R=0
X=1 W=1 C/R=0
Z=1 C/R=1
X=1 W=1 C/R=1
W=1 C/R = 0 COM 1 RESP
X=1 W=1 C/R=0
MDL-ERROR INDICATION
FRMR RESPONSE
SET FRMR COND
CLEAR FRMR COND
Y
N
11
14

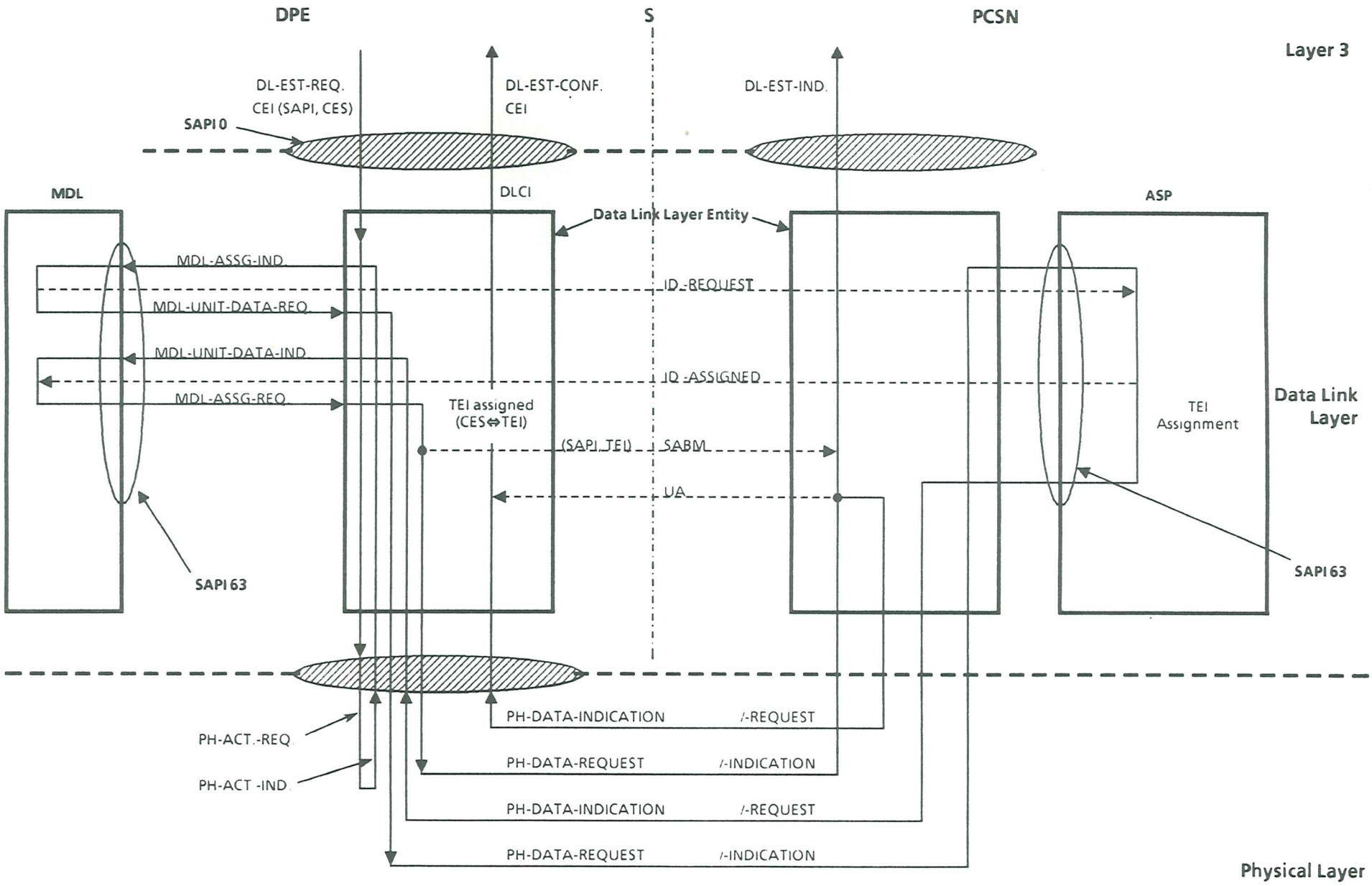
APPENDIX D

EXAMPLES OF THE USE OF PRIMITIVES

EXAMPLES OF THE USE OF PRIMITIVES



Example of the use of primitives
on the TE side on an outgoing call.



Example of the Information Flow on a DATA-LINK ESTABLISHMENT REQUEST (eg. for an outgoing Call)