INTERNATIONAL TELECOMMUNICATION UNION

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CONSULTATIVE COMMITTEE

RED BOOK

VOLUME VI – FASCICLE VI.9

DIGITAL ACCESS SIGNALLING SYSTEM

RECOMMENDATIONS Q.920-Q.931

VIIITH PLENARY ASSEMBLY
MALAGA-TORREMOLINOS, 8-19 OCTOBER 1984

Geneva 1985

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Recommendations Q.920 to Q.931

Digital access signalling system

1 The strict observance of the specifications for standardized international signalling and switching equipment is of the utmost importance in the manufacture and operation of the equipment. Hence these specifications are obligatory except where it is explicitly stipulated to the contrary.

The values given in Fascicles VI.1 to VI.9 are imperative and must be met under normal service conditions.

2 The Questions entrusted to each Study Group for the Study Period 1985-1988 can be found in Contribution No. 1 to that Study Group.

3 In this Volume, the expression "Administration" is used for shortness to indicate both a telecommunication Administration and a recognized private operating agency.

FASCICLE VI.9

Recommendations Q.920 to Q.931

DIGITAL ACCESS SIGNALLING SYSTEM

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Recommendation Q.920 [1]

ISDN USER-NETWORK INTERFACE DATA LINK LAYER – GENERAL ASPECTS

1 General

This Recommendation describes in general terms the Link Access Procedure on the D-channel, LAPD. The application of this protocol to other channel types is for further study. Details are provided in Recommendation Q.921(I.441) [1].

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

The definition of LAPD uses the principles and terminology of:

- CCITT Recommendations X.200 [2] and X.210 [3] – the reference model for Open Systems Interconnection (OSI);
- CCITT Recommendation X.25 [4] LAPB – user-network interface for packet mode terminals; and
- ISO 3309 [5] and ISO 4335 [6] – 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 Recommendation I.320 [7].

Note 1 – The physical layer is defined in Recommendation I.430 [8] and I.431 [9] and layer 3 is defined in Recommendation Q.931(I.451) [10]. Reference should be made to these Recommendations for the complete definition of the procotols and procedures across the ISDN user-network interface.

Note 2 – The term "data link layer" is used in the main text of this Recommendation. However, mainly in figures and tables, the terms "layer 2" and "L2" are used as abbreviations. Furthermore, in accordance with Recommendations Q.930(I.450) [11] and Q.931(I.451) [10], the term "layer 3" is used to indicate the layer above the data link layer.

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

The characteristics of the D-channel are defined in Recommendation I.412 [14].

Section 2 below describes basic concepts used in this Recommendation and Recommendation Q.921(I.441).

Section 3 gives an overview description of LAPD functions and procedures.

Section 4 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 5 provides an overview of the data link layer structure.

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 partitioned into an ordered set of layers represented in a vertical sequence as shown in Figure 1/Q.920.

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. The services provided by the data link layer are the combination of the services and functions provided by both the data link layer and the physical layer.

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[1] This Recommendation appears in the Series I Recommendations as Recommendation I.440.

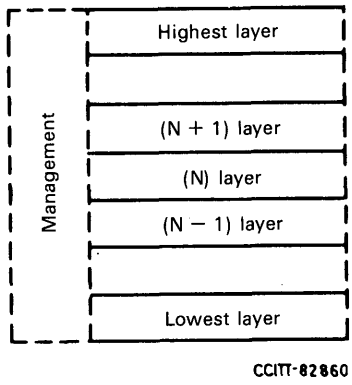


FIGURE 1/Q.920

Layering

A data link layer Service Access Point (SAP) is the point at 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/Q.920. A data link connection endpoint is identified by a data link connection endpoint identifier as seen from layer 3 and by a Data Link Connection Identifier (DLCI) as seen from the data link layer.

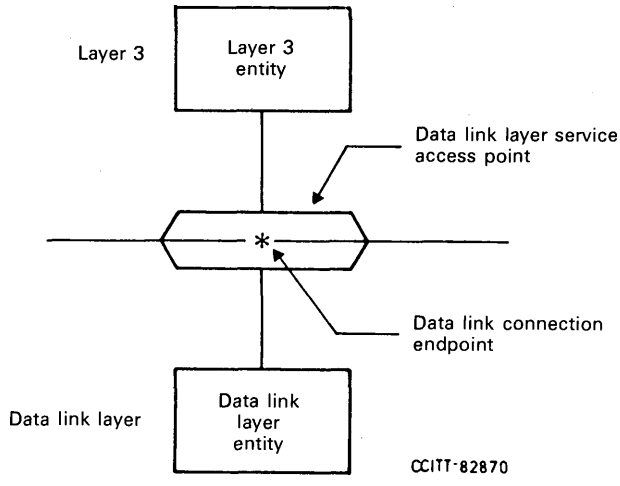


FIGURE 2/Q.920

Entities, service access points and endpoints

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 a 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 (see Figure 3/Q.920).

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 implementation.

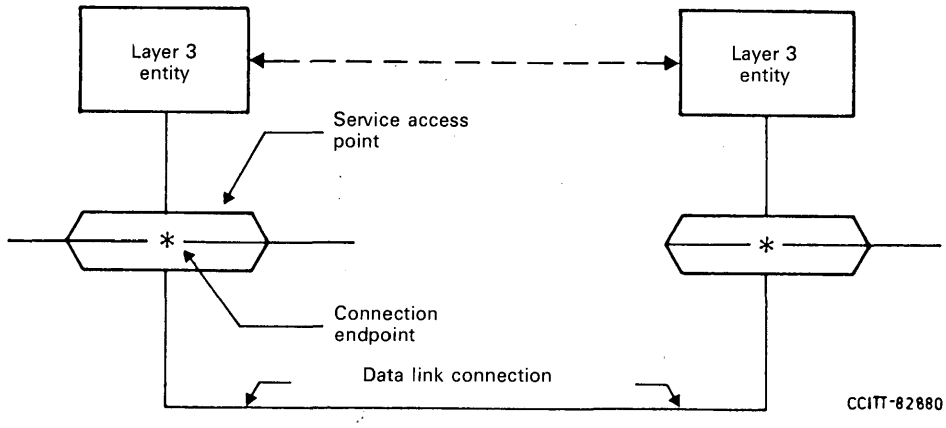


FIGURE 3/Q.920

Peer-to-peer relationship

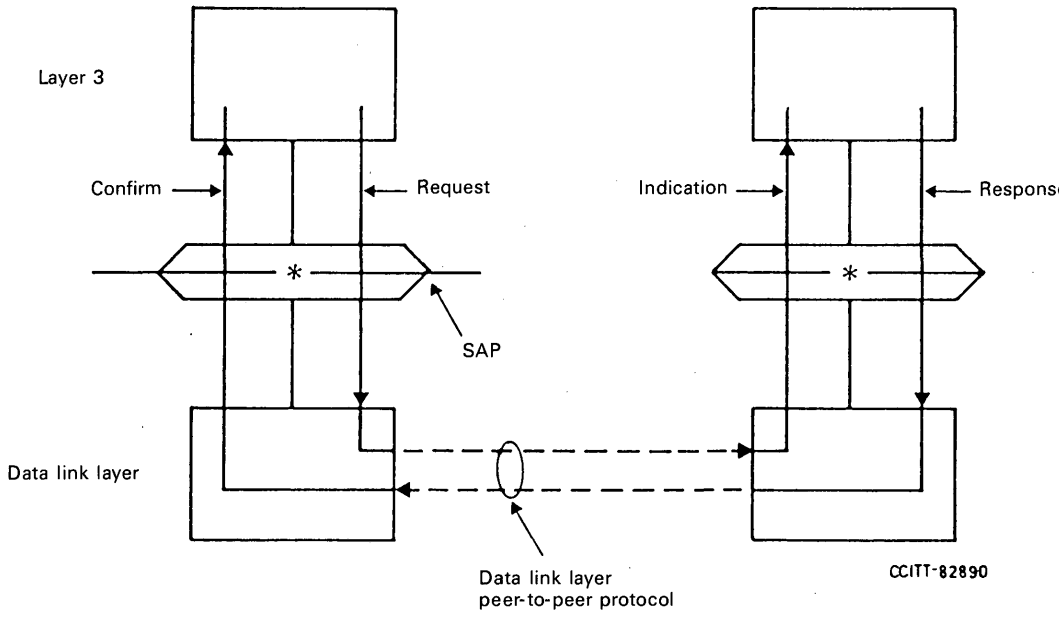
The primitives that are exchanged between the data link layer and adjacent layers are of the following four types (see also Figure 4/Q.920):

a) request;

b) indication;

c) response; and

d) confirm.



Note 1 — The same principle applies for data link layer — physical layer interactions.
Note 2 — Not all of these primitive types are used in this Recommendation.

FIGURE 4/Q.920

Primitive action sequence

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 activities related to the primitive type REQUEST.

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 to confirm that the activity has been completed.

Layer-to-layer interactions are specified in Recommendation Q.921(I.441).

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 Recommendation specifies (see also Figure 5/Q.920):

a) the peer-to-peer protocol for the transfer of information and control between any pair of data link layer service access points; and

b) the interactions between the data link layer and layer 3, and between the data link layer and the physical layer.

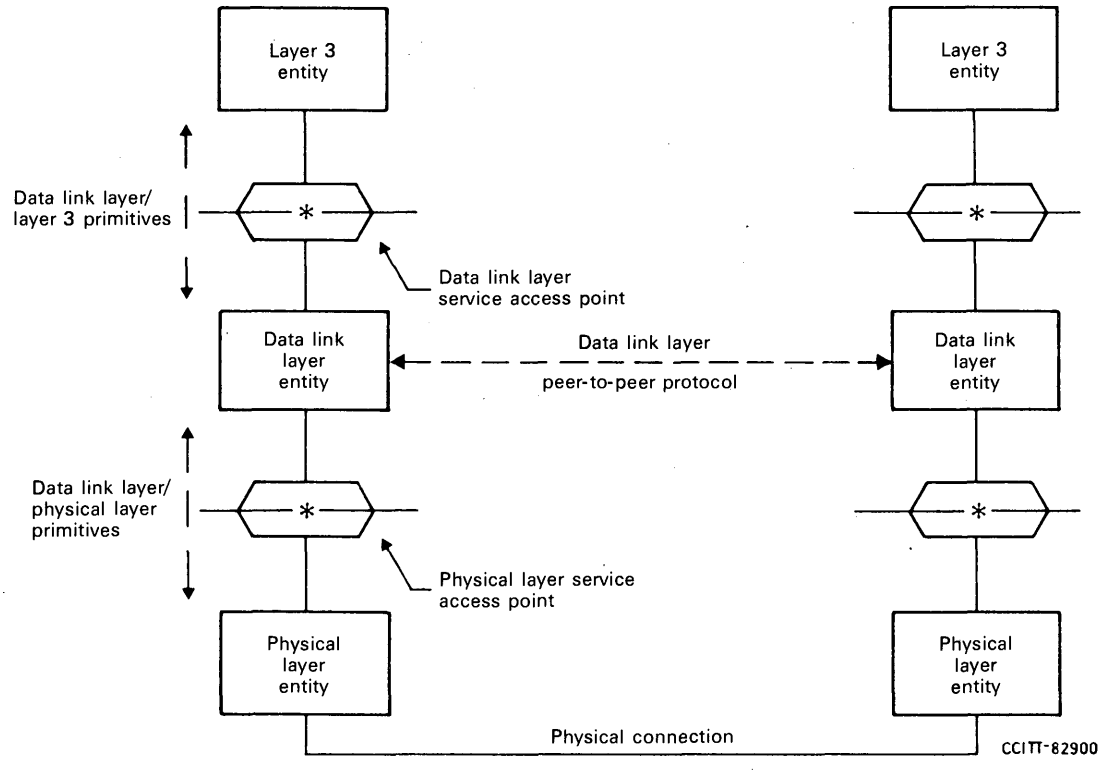


FIGURE 5/Q.920

Data link layer reference model

3 Overview description of LAPD functions and procedures

3.1 *General*

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

- multiple terminal installations at the user-network interface;
- multiple layer 3 entities.

All data link layer messages are transmitted in frames which are delimited by flags. (A flag is a unique bit pattern.) [The frame structure is defined in Recommendation Q.921(I.441).]

LAPD includes functions for:

a) the provision of one or more data link connections on a D-channel. Discrimination between the data link connections is by means of a data link connection identifier (DLCI) contained in each frame;

b) frame delimiting, alignment and transparency, allowing recognition of a sequence of bits transmitted over a D-channel as a frame;

c) sequence control, to maintain the sequential order of frames across a data link connection;

d) detection of transmission, format and operational errors on a data link;

e) recovery from detected transmission, format, and operational errors. Notification to the management entity of unrecoverable errors; and

f) flow control.

Data link layer functions provide the means for information transfer between multiple combinations of data link 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 the case of broadcast information transfer, a frame is directed towards one or more endpoints.

Figure 6/Q.920 shows two examples of point-to-point information transfer. Figure 7/Q.920 shows an example of broadcast information transfer.

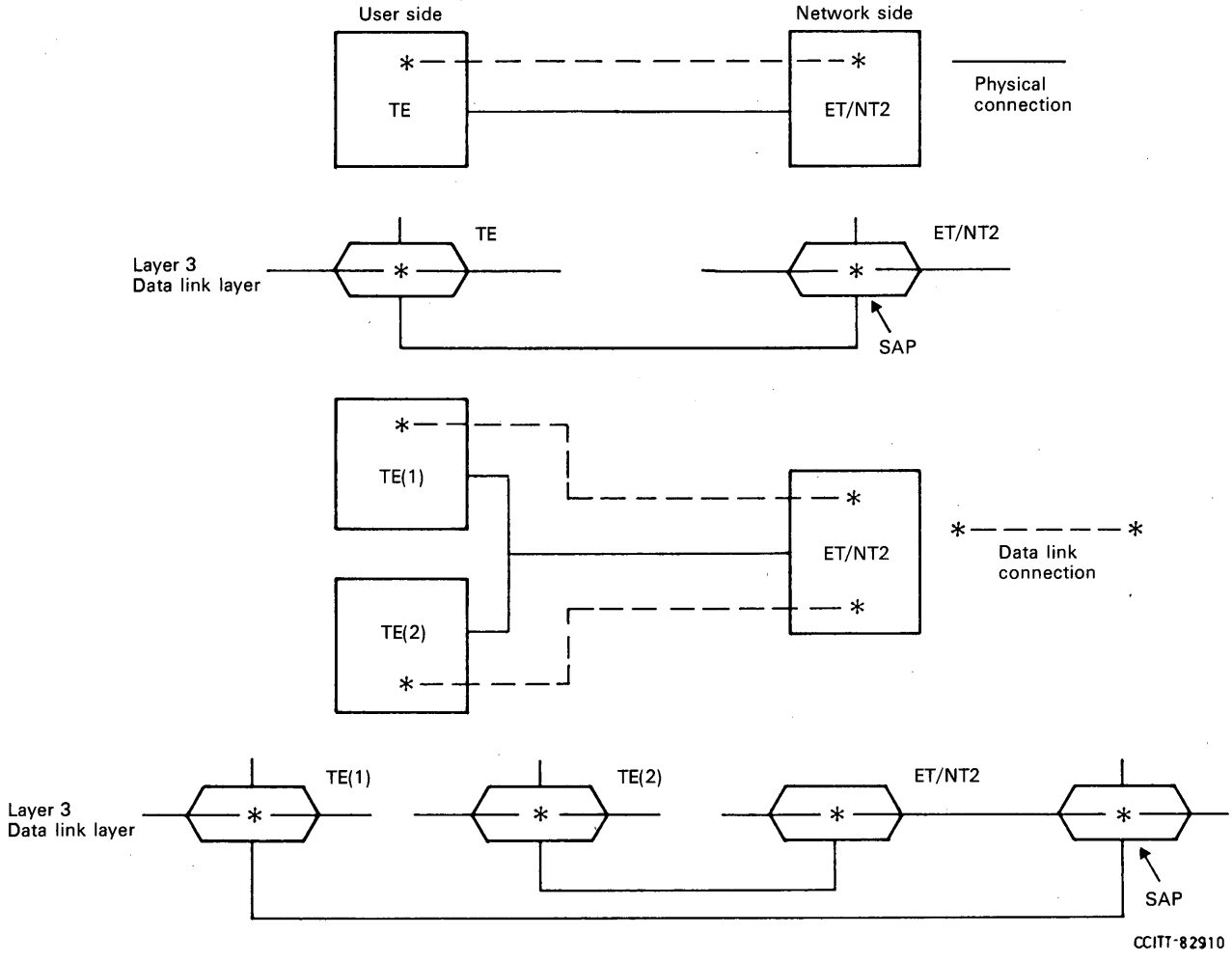


FIGURE 6/Q.920

Point-to-point data links

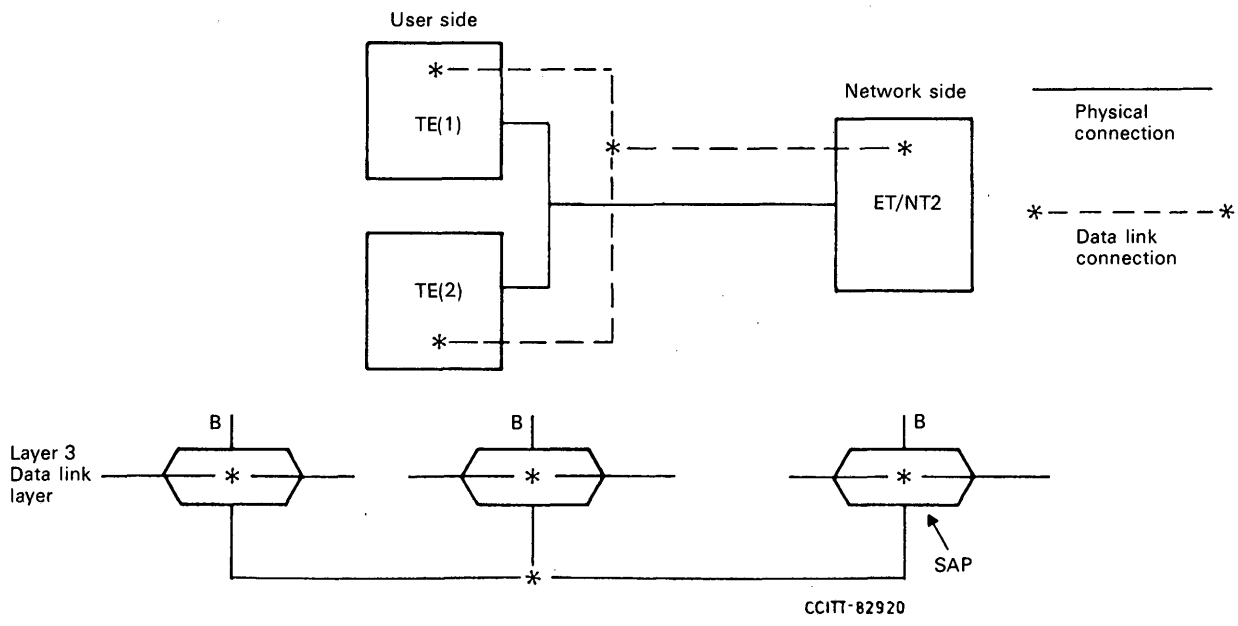


FIGURE 7/Q.920

Broadcast data link

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.

3.2 *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 endpoint or broadcast to multiple endpoints associated with a specific Service Access Point Identifier (SAPI).

3.3 *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.

Two forms of acknowledged information transfer are defined.

a) single frame operation; and

b) multiple frame operation.

Note – In order to assist terminal portability, it is desirable that networks support both types of operation. On the user side, either or both types of operation may be supported.

In the case of single frame operation, layer 3 information is sent in Sequenced Information 0 (SI0) and Sequenced Information 1 (SI1) frames.

No new frame is sent until an acknowledgement has been received for a previously sent frame; that is, only one unacknowledged frame may be outstanding at a time.

In the case of 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 a Set Asynchronous Balanced Mode/Set Asynchronous Balanced Mode Extended (SABM/SABME) command.

Note 1 – The provision of extended multiple frame operation (modulo 128 sequence numbering) is optional and may not be supported by every network.

Note 2 – Further study is required on the need for acknowledged single frame operation beyond an interim period.

3.4 *Establishment of information transfer modes*

3.4.1 *Data link connection identification*

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

The data link connection identifier is associated with a connection endpoint identifier at the two ends of the data link (see Figure 8/Q.920).

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.

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 network side or the user side of the user-network interface.

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

The TEI may be assigned automatically by means of a separate TEI assignment procedure (see § 3.4.3) or it may be assigned at the time of subscription and may be entered into the user equipment, for example, by the user or the manufacturer.

In the latter case, the TEI value must be verified to ensure that the TEI is not already used by another user equipment. This verification is performed making use of the same procedure used for TEI assignment. The preset TEI value is not considered to have been assigned to the terminal until it has been verified.

3.4.2 *Data link states*

A point-to-point data link may be in one of four basic states, see Figure 9/Q.920:

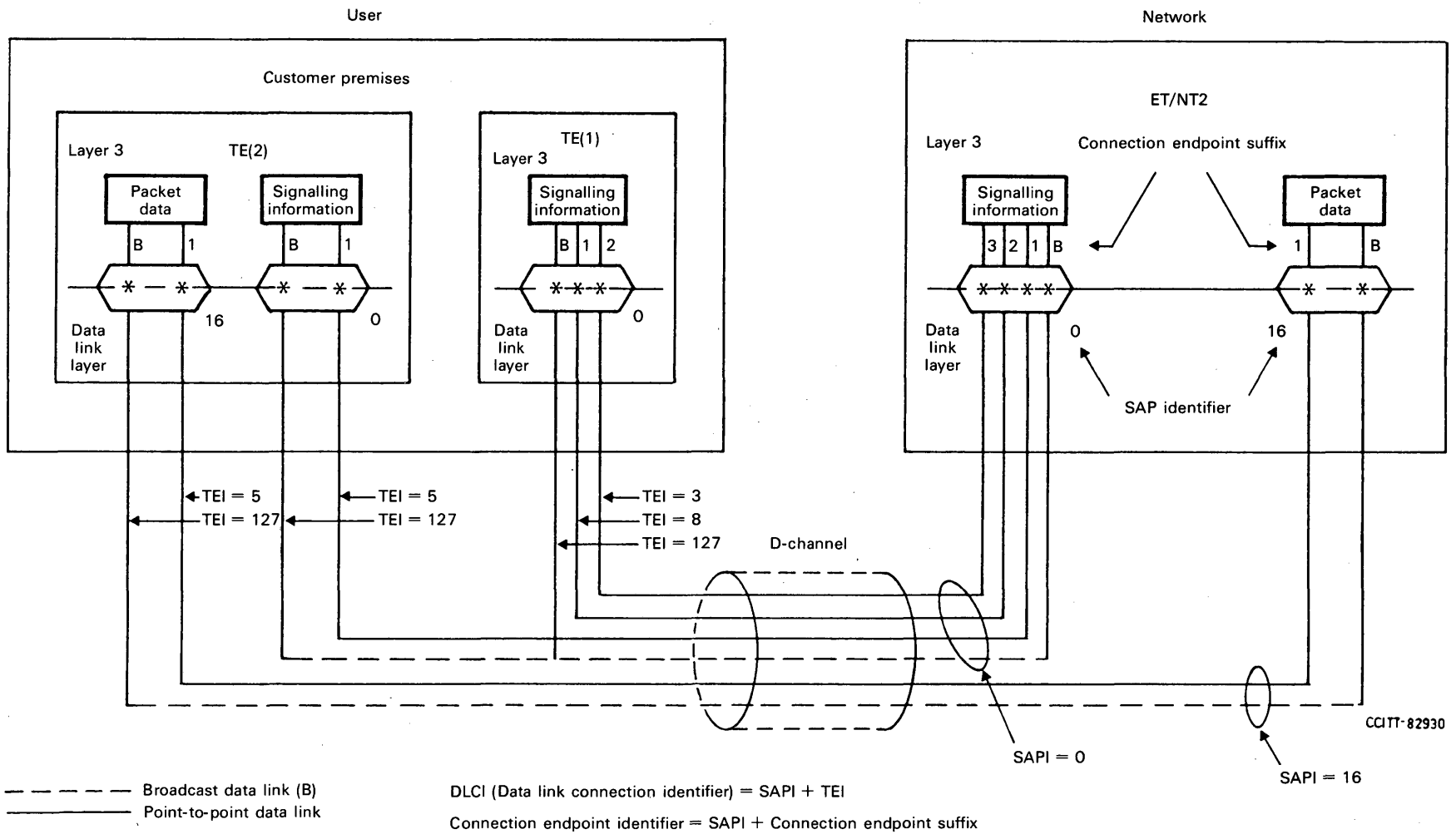
i) TEI-unassigned state. In this state a TEI has not been assigned or verified. No layer 3 information transfer is possible; or

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) single-frame-established state. Acknowledged single frame and unacknowledged information transfer are possible; or

iv) multiple-frame-established state. This state is established by means of a multiple frame establishment procedure. Acknowledged multiple frame and unacknowledged information transfer are possible.

A broadcast data link is always in an information transfer state capable of only unacknowledged information transfer (that is, TEI-assigned state).



Note — The management entity is not shown in this figure.

FIGURE 8/Q.920

Overview description of the relation between SAPI, TEI and data link connection endpoint identifier

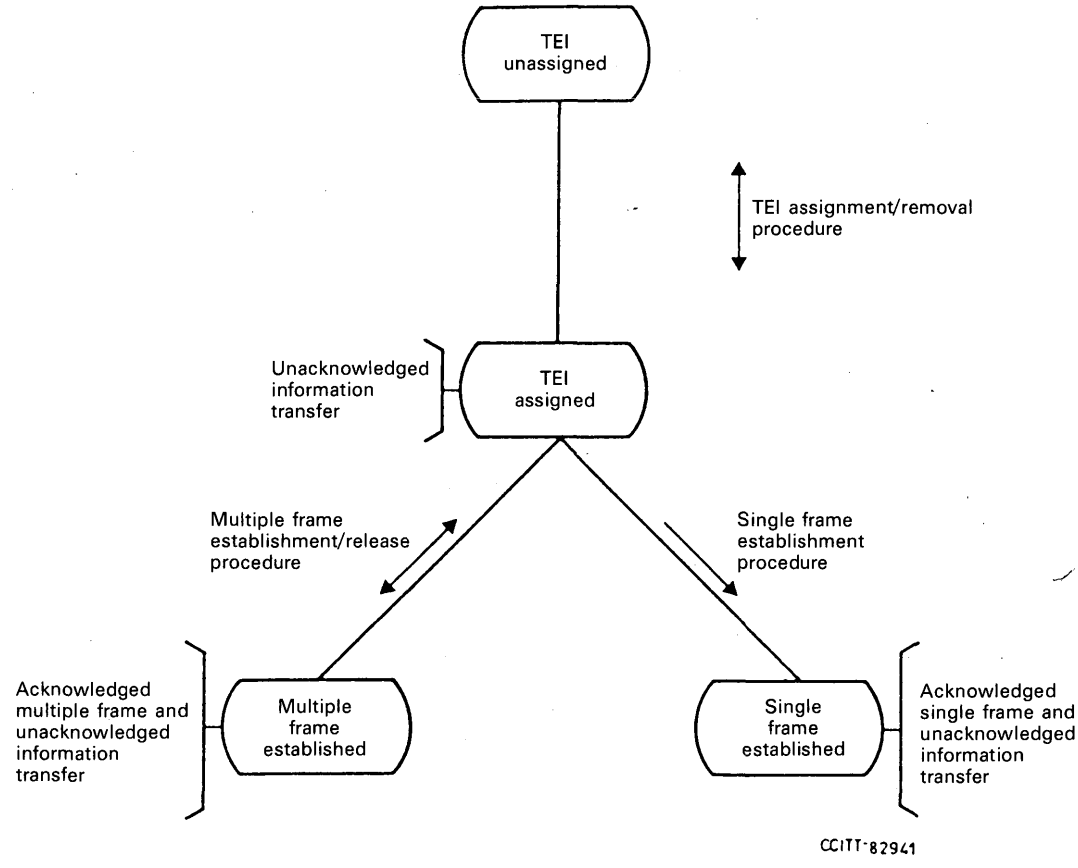


FIGURE 9/Q.920

Illustrating basic data link states on the user side for point-to-point data links

3.4.3 *TEI assignment procedure*

The purpose of this procedure is to:

a) allow a user equipment to request the network to assign a TEI value that the data link layer entities within the requesting user equipment will use in subsequent communications over the data link; and

b) allow a user equipment to request the network to verify a TEI value, already present in the user equipment, that the data link entities within the requesting user equipment will use in subsequent communications over the data link.

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

When a TEI has been assigned/verified, the user establishes an association between the TEI and a connection endpoint suffix in each SAP; that is, the data link connection identifier is associated with a connection endpoint identifier. In the network, 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.

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

a) in the network, on request from layer 3, or by the data link layer itself; and

b) in the user equipment, 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, the multiple-frame-established state or the single-frame-established state, the TEI assignment procedure may be used to check the status of a TEI; for example, to determine if a user equipment has been disconnected from an installation.

Examples of criteria for initiation of the TEI assignment procedure and for the removal of TEI values are described in Recommendation Q.921(I.441) together with the detailed specification of the TEI assignment procedure.

Note – This section is not intended to provide a complete specification of possible criteria for establishing and removing an association between the data link connection identifier and connection endpoint identifier.

3.4.4 *Establishment of single frame operation*

The single frame operation is established upon request from the local layer 3 or upon receipt of an SI0/SI1 frame.

3.4.5 *Establishment of multiple frame operation*

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

The multiple frame establishment procedure is specified in detail in Recommendation Q.921(I.441).

4 Service characteristics

4.1 *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 accross 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.

4.2 *Services provided to layer 3*

The specification of the interactions with layer 3, (primitives) provides a description of the services that the data link layer, plus the physical layer, offer to layer 3, as viewed from layer 3.

Two forms of information transfer service 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 also 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.

Note – Primitives defined in this Recommendation need to be harmonized with those to be defined in other Recommendations, for example, I.431 [8], I.432 [9], Q.930(I.451) [10] and Q.710 [13].

4.2.1 *Unacknowledged information transfer service*

Note – In this case the information transfer is not acknowledged at the data link layer. Acknowledgement procedures may be provided at higher layers.

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

The characteristics of the unacknowledged information transfer service are summarized in the following:

a) provision of a data link connection between layer 3 entities for unacknowledged information transfer of layer 3 message units;

b) identification of data link connection endpoints to permit a layer 3 entity to identify another layer 3 entity; and

c) 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 an unacknowledged information transfer.

4.2.2 *Acknowledged information transfer services*

Two modes of operation are defined: single frame and multiple frame.

The characteristics of these services are summarized in the following:

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

b) identification of data link connection endpoints to permit a layer 3 entity to identify another layer 3 entity; and

c) sequence integrity of data link layer message units in the absence of machine malfunctions.

In addition, multiple frame operation offers the following services:

d) notification to the peer entity in the case of machine errors; for example, loss of sequence;

e) notification to the management entity of unrecoverable errors detected by the data link layer; and

f) flow control.

The primitives associated with the acknowledged information transfer services are:

a) 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 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 both single frame and multiple frame operations.

b) Establishment of single or multiple frame operation

DL-ESTABLISH-REQUEST/INDICATION

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

c) Termination of single or multiple frame operation

DL-RELEASE-REQUEST/INDICATION

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

4.2.3 *Administrative services*

The characteristics of the administrative services are summarized in the following:

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

b) data link connection parameter passing between the network and the user.

Note – The procedures for parameter passing are for further study.

Some of these services are considered to be conceptually provided by management entities either on the user side or the network side. The method of describing these administative 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 this Recommendation together with its representation method using "MDL". The appropriateness of the name and the representation method are for further study.

The primitives associated with these services are:

a) 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 user data link layer entities can begin to communicate with the network data link layer entities using the assigned TEI value.

b) 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.

c) Notification of error

MDL-ERROR-INDICATION/RESPONSE

d) Data transfer

MDL-UNIT DATA-REQUEST/INDICATION

4.3 *Services required from the physical layer*

The services provided by the physical layer are described in detail in Recommendation I.430 [8] or I.431 [9]. They are summarized in the following:

a) physical layer connection for the transparent transmission of bits in the same order in which they are submitted to the physical layer;

b) indication of the physical status of the D-channel; and

c) 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 user side or network 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:

a) Data transfer

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.

b) 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.

c) PH-DEACTIVATE-REQUEST/INDICATION

These primitives are used to request deactivation of the physical layer connection and to indicate that the physical layer connection has been deactivated.

5 Overview of data link layer structure

Figure 10/Q.920 is a functional block diagram of the data link layer supported on a single D-channel that could exist on the network side of the interface.

The user configuration may be a subset of this figure.

Figure 10/Q.920 illustrates two procedural types: the data link procedure and the multiplex procedure.

5.1 *Data link procedure*

This procedure analyses the control field of the received frame [see Recommendation Q.921(I.441)] 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 commands and responses.

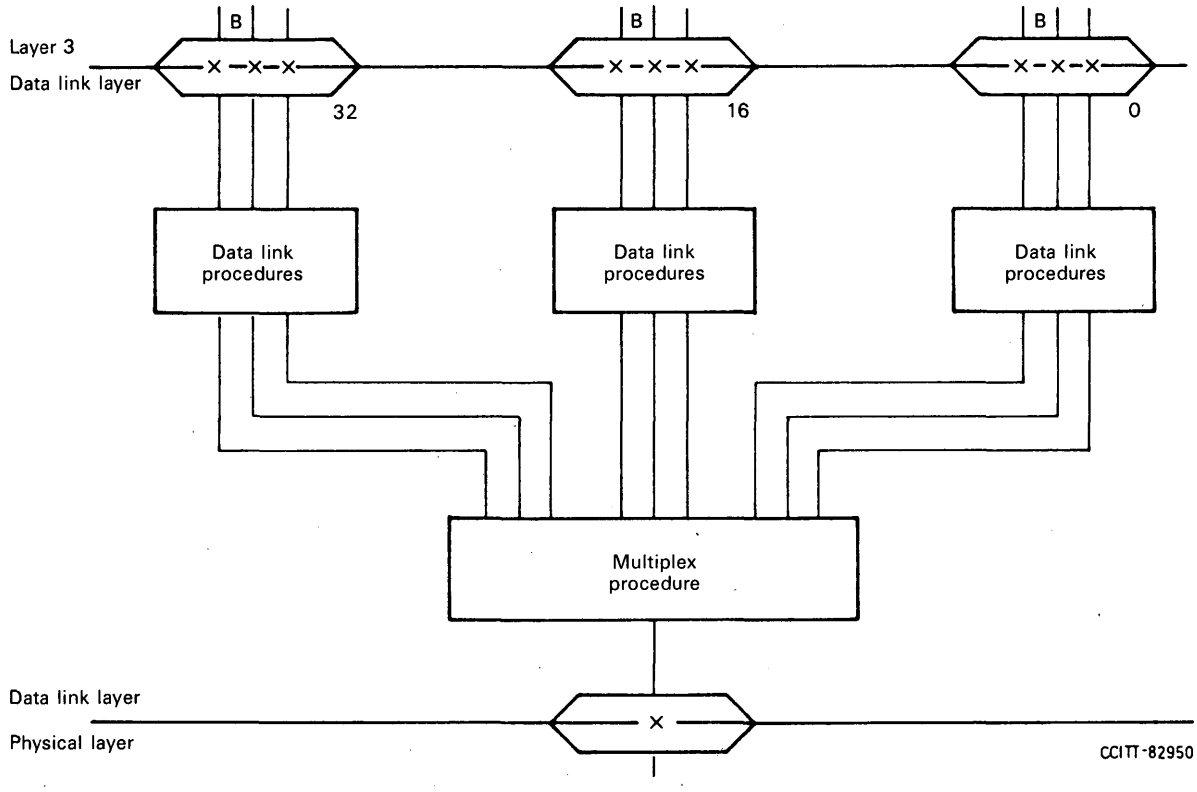


FIGURE 10/Q.920

Functional block diagram of the data link layer

5.2 *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 procedures block based on the data link connection identifier (see Recommendation Q.921(I.441)).

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.

5.3 *Structure of the data link procedure*

The functional model of the data link procedure is shown in Figure 11/Q.920. 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.

6 Application guidelines

For further study.

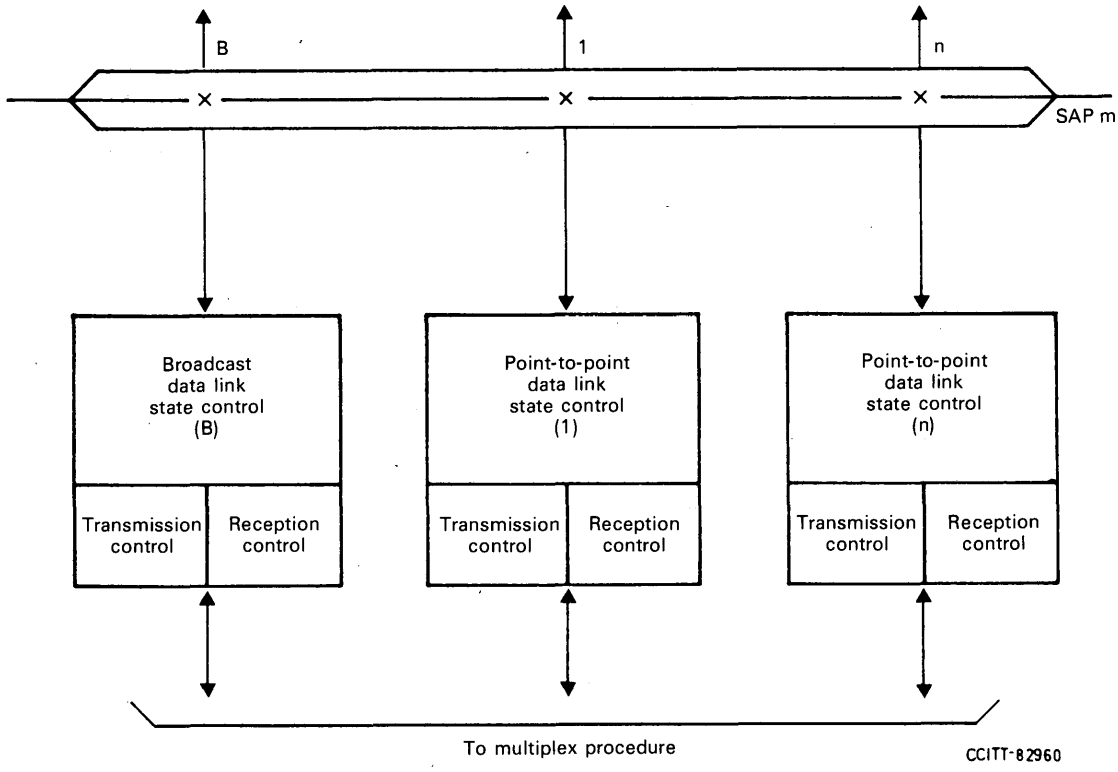


FIGURE 11/Q.920

Data link procedure structure

References

[1] CCITT Recommendation Q.921(I.441) *ISDN user-network interface data link layer specification.*

[2] CCITT Recommendation X.200 *Reference model of open systems interconnection for CCITT applications.*

[3] CCITT Recommendation X.210 *OSI layer service conventions.*

[4] CCITT Recommendation X.25 *Interface between data terminal equipment (DTE) and data circuit terminating (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

[5] ISO 3309 *Data communication – High-level data link control procedures – Frame structure.*

[6] ISO 4335 *Data communication – High-level data link control procedures – Consolidation of elements of procedures.*

[7] CCITT Recommendation I.320 *ISDN protocol reference model.*

[8] CCITT Recommendation I.430 *Basic user-network interface layer 1 specification.*

[9] CCITT Recommendation I.431 *Primary rate user-network interface layer 1 specification.*

[10] CCITT Recommendation Q.931(I.451) *ISDN user-network interface layer 3 specification.*

[11] CCITT Recommendation Q.930(I.450) *ISDN user-network interface layer 3 – general aspects.*

[12] CCITT Recommendation I.411 *ISDN user-network interfaces – reference configurations.*

[13] CCITT Recommendation Q.710 *Use of Signalling System No. 7 for PABX application.*

[14] CCITT Recommendation I.412 *ISDN user-network interfaces interface structure and access capabilities.*

Recommendation Q.921 [1]

ISDN USER-NETWORK INTERFACE DATA LINK LAYER SPECIFICATION

1 General

This Recommendation specifies the frame structure, elements of procedure, format of fields and procedures for the proper operation of the Link Access Procedure on the D-channel, LAPD.

The concepts, terminology, overview description of LAPD functions and procedures, and the relationship with other Recommendations are described in general terms in Recommendation Q.920(I.440) [1].

Note – As stated in Recommendation Q.920(I.440), the term "data link layer" is used in the main text of this Recommendation. However, mainly in figures and tables, the terms "layer 2" and "L2" are used as abbreviations. Furthermore, in accordance with Recommendations Q.930(I.450) [2] and Q.931(I.451) [3], the term "layer 3" is used to indicate the layer above the data link layer.

2 Frame structure for peer-to-peer communication

2.1 *General*

All data link layer peer-to-peer exchanges are in frames conforming to one of the formats shown in Figure 1/Q.921. Two format types are shown in the figure; Format A for frames where there is no information field and Format B for frames containing an information field.

2.2 *Flag sequence*

All frames shall start and end with the flag sequence consisting of one "0" bit followed by six contiguous "1" bits and one "0" bit. 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 1/Q.921. The address field identifies the intended receiver of a command frame and the transmitter of a response frame. The format of the address field is defined in § 3.2. A single octet address field is reserved for LAPB operation.

2.4 *Control field*

The control field shall consist of one or two octets. Figure 1/Q.921 illustrates the two frame formats (A and B), each with a control field of one or two octets, depending upon the type of operation being used.

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 below). The contents of the information field shall consist of an integer number of octets. See § 3.6.12 for the coding and grouping of bits in the information field as defined in this Recommendation.

The maximum number of octets in the information field is defined in § 5.10.3.

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[1] This Recommendation appears in the Series I Recommendations as Recommendation I.441.

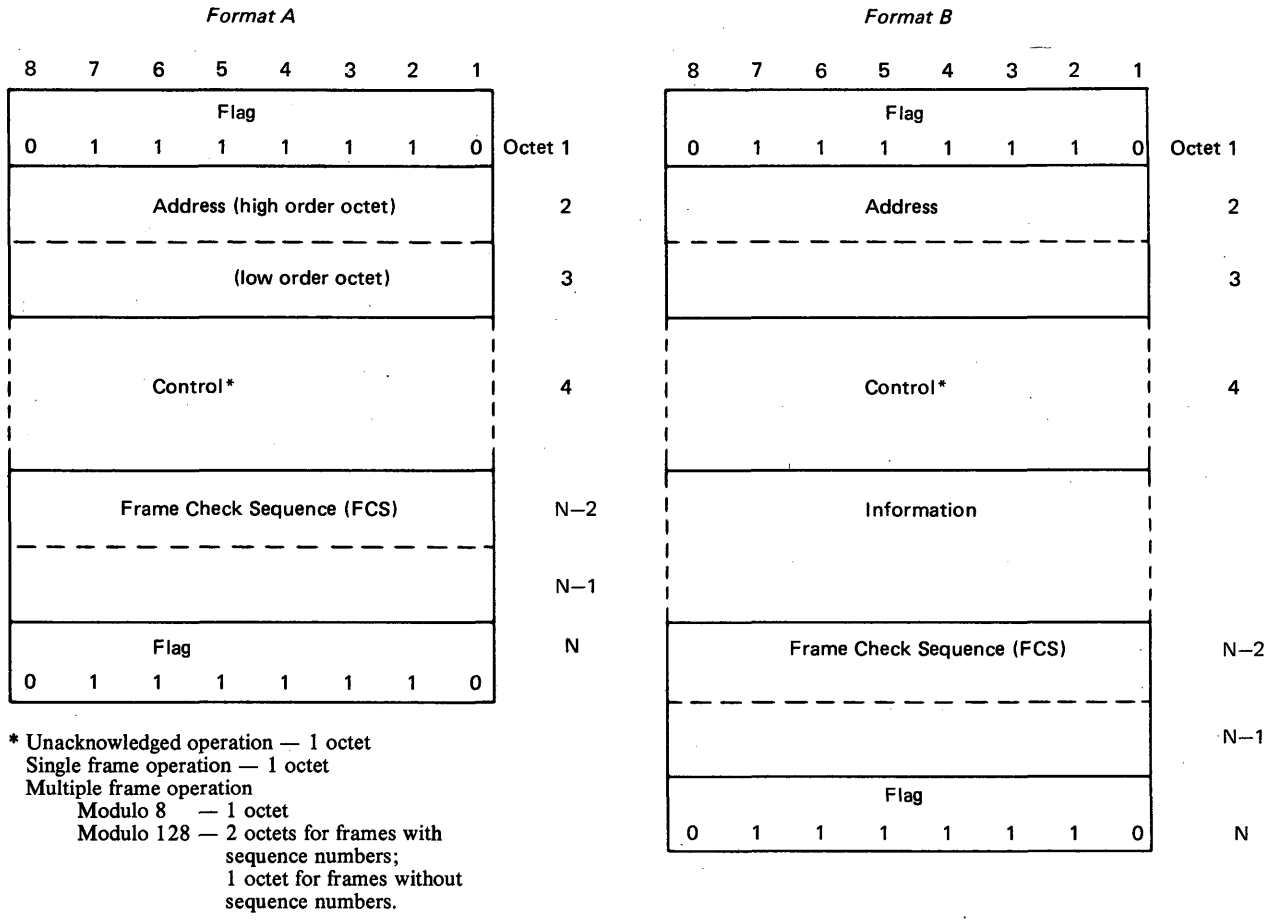


FIGURE 1/Q.921

Frame formats

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 "0" bit after all sequences of five contiguous "1" bits (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 "0" bit which directly follows five contiguous "1" bits.

2.7 *Frame checking sequence (FCS) field*

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

1) the remainder of (x raised to k power) ($x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x^1 + 1$) divided (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, 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

2) the remainder of the division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, of the product of x^{16} 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 "1"s and is then modified by division by the generator polynomial (as described above) of the address, control and information fields; the "1"s complement of the resulting remainder is transmitted as the sixteen-bit FCS sequence.

As a typical implementation at the receiver, the initial content of the register of the device computing the remainder is preset to all "1"s. The final remainder after multiplication by x^{16} and then division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits and the FCS, will be "0001 1101 0000 1111" (x^{15} through x^0, 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 2/Q.921. 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.

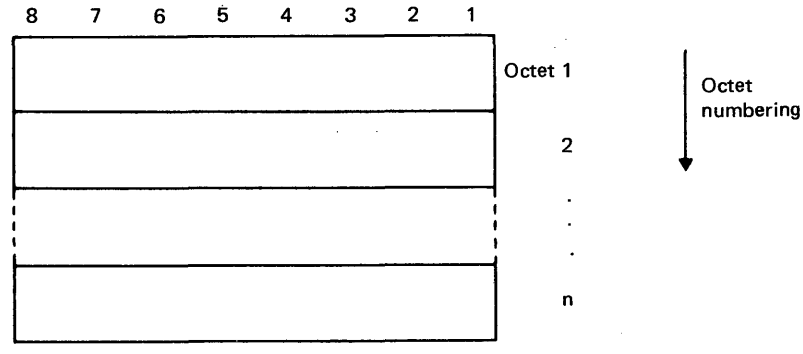


FIGURE 2/Q.921

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 3/Q.921 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).

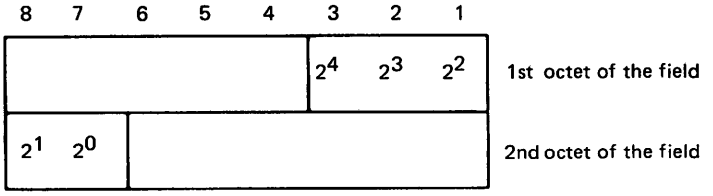


FIGURE 3/Q.921

Field mapping convention

An exception to the preceding 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 4/Q.921).

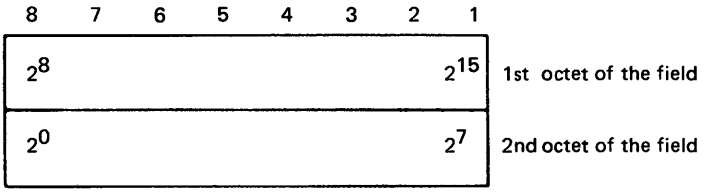


FIGURE 4/Q.921

FCS mapping convention

2.9 *Invalid frames*

An invalid frame is a frame which:

a) is not properly bounded by two flags, or

b) for unacknowledged operation, single frame acknowledged operation and modulo 8 multiple frame acknowledged operation has fewer than five octets between flags, and for modulo 128 multiple frame acknowledged operation has fewer than 6 octets between flags of frames that contain sequence numbers and fewer than 5 octets between flags of frames that do not contain sequence numbers, or

c) does not consist of an integral number of octets prior to zero bit insertion or following zero bit extraction, or

d) 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 "1" bits shall be interpreted as an abort and the data link layer entity shall ignore the frame currently being received.

The need for and method of aborting a frame on the sender side is a subject for further study.

3 Elements of procedures and formats of fields for data link layer peer-to-peer communication

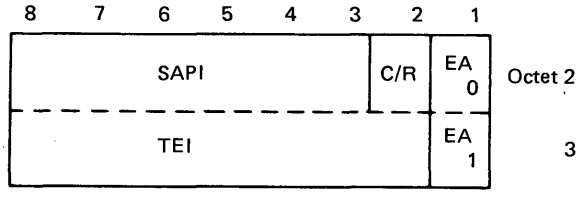
3.1 *General*

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 format*

The address field format shown in Figure 5/Q.921 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

Note – Single octet address field is reserved for LAPB operation.

FIGURE 5/Q.921

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 "1" 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 a "0" and bit 1 of the second octet set to "1".

3.3.2 *Command/response field bit (C/R)*

The C/R bit identifies a frame as either a command or a response. The user side shall send commands with the C/R bit set to "0", and responses with the C/R bit set to "1". The network side shall do the opposite; that is commands are sent with C/R set to "1", and responses are sent with C/R set to "0". The combinations for the network side and user side are shown in Table 1/Q.921.

TABLE 1/Q.921

C/R field bit usage

	Network side C/R value	User side C/R value
Commands from	1	0
Responses to	1	0
Commands to	0	1
Responses from	0	1

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, the addresses of the network side and the user side take the form:

	C/R	SAPI	TEI
Network	0	X	Y
User	1	X	Y

where X and Y 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 point at which data link layer services are 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 64 service access points to be specified, where 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
16	Packet communication procedures
32-47	Reserved for national use
63	Management procedures (see Note 1)
All others	Reserved for future standardization

Note 1 – Depending on the outcome of studies on testing and maintenance, a different specific SAPI may be allocated or an already defined SAPI may also be used for these functions.

Note 2 – Other layer 3 entity assignments are a subject for further study.

3.3.4 *Terminal endpoint identifier (TEI)*

The terminal endpoint identifier (TEI) for a point-to-point data link connection may be associated with a single 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 range of TEI values shall be allocated in the following manner:

TEI Value	User type
0-63	Non-automatic TEI assignment user equipment
64-126	Automatic TEI assignment user equipment

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; numbered information transfer (I format), supervisory functions (S format), and unnumbered information transfers and control functions (U format). The control field formats for basic (modulo 8) operation and extended (modulo 128) operation are shown in Table 2/Q.921.

TABLE 2/Q.921

Control field formats

Control field bits (modulo 8)	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

Control field bits (modulo 128)	8	7	6	5	4	3	2	1	
I format	N(S)							0	Octet 4
	N(R)							P	5
S format	X	X	X	X	S	S	0	1	Octet 4
	N(R)							P/F	5
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
X Reserved and set to 0

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, 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 "0" or "1". The use of N(S), N(R) and P is defined in § 5.

3.4.2 *Supervisory format – S*

The S format shall be used to perform data link supervisory control functions such as; 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 "0" or "1".

3.4.3 *Unnumbered format – U*

The U format shall be used to provide additional data link control functions and unnumbered information transfers (including both unacknowledged information transfer and single frame acknowledged information transfer). This format does not contain sequence numbers. It does include a P/F bit that may be set to "0" or "1". The unnumbered frames have the same control field length (one octet) in both basic (modulo 8) operation and extended (modulo 128) operation.

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.

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 response 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 "1" is used by a data link layer entity to create (poll) a response frame from the peer data link layer entity. The F bit set to "1" is used by a data link layer entity 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.

3.5.2 *Multiple frame operation – variables and sequence numbers*

3.5.2.1 *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 either 8 or 128 and the sequence numbers cycle through the entire range, 0 through 7 or 0 through 127.

3.5.2.2 *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 through "n" 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 of $1 \leqslant k \leqslant 7$ for basic (modulo 8) operation and $1 \leqslant k \leqslant 127$ for extended (modulo 128) operation.

3.5.2.3 *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 identifies 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 through modulus minus 1. The value of the acknowledge state variable shall be updated by the valid N(R) values received from its peer (see § 3.5.2.6). A valid N(R) value is one that is in the range $V(A) \leqslant N(R) \leqslant V(S)$.

3.5.2.4 *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).

3.5.2.5 *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 through modulus minus 1. The value of the receive state variable shall be incremented by one with the receipt of an error-free, in-sequence I frame whose send sequence number N(S) equals the receive state variable V(R).

3.5.2.6 *Receive sequence number N(R)*

All I frames and supervisory frames contain N(R), the expected send 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.

3.5.3 *Single frame operation variables and parameters*

3.5.3.1 *Sequence bit*

The sequence bit, bit 8 of the SI0 and SI1 command and response control fields, provides the modulo 2 sequencing function for the single frame operation. In SI0/SI1 command frames, bit 8 of the control field performs the send sequencing function N(SI). In SI0/SI1 response frames, bit 8 of the control field performs the receive sequencing function N(RI).

3.5.3.2 *Send state variable V(SI)*

Each point-to-point data link connection end point shall have an associated send state variable V(SI). The send state variable V(SI) shall denote the value of N(SI) in the next SI0/SI1 command to be transmitted. The value of V(SI) shall be complemented each time a transmitted SI0/SI1 command frame is correctly acknowledged in accordance with the procedures defined in § 5.5.

3.5.3.3 *Receive state variable V(RI)*

Each point-to-point data link connection endpoint shall have an associated receive state variable V(RI). The receive state variable V(RI) shall denote the expected value of N(SI) in the next SI0/SI1 command frame to be received. If the N(SI) value in the next received SI0/SI1 command frame is equal to the current value of V(RI), the value of V(RI) shall be complemented prior to sending an acknowledging SI0/SI1 response.

3.5.4 *Unacknowledged operation variables and parameters*

No variables or parameters are defined.

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 Tables 3/Q.921 and 4/Q.921. Each data link connection supports the appropriate set of commands and responses for the type of operation desired (see § 5).

For purposes of the LAPD procedures, the supervisory function bit encoding "11" and those encodings of the modifier function bits in Table 2/Q.921 not identified in Tables 3/Q.921 and 4/Q.921 are identified as "invalid or not implemented" command and response control fields.

The commands and responses are defined in Tables 3/Q.921 and 4/Q.921.

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 the multiple frame operation on point-to-point data link connections.

3.6.2 *Set asynchronous balanced mode (SABM) command/Set asynchronous balanced mode extended (SABME) command*

The SABM/SABME unnumbered command is used to place the addressed user side or network side into the modulo 8/modulo 128 multiple frame acknowledged operation.

TABLE 3/Q.921

Commands and responses – unacknowledged, single frame acknowledged and multiple frame acknowledged (modulo 8) operation

Format	Commands	Responses	Encoding 8	7	6	5	4	3	2	1	Octet
Information transfer	I (information)		N(R)			P	N(S)			0	4
Supervisory	RR (receive ready)	RR (receive ready)	N(R)			P/F	0	0	0	1	4
	RNR (receive not ready)	RNR (receive not ready)	N(R)			P/F	0	1	0	1	4
	REJ (reject)	REJ (reject)	N(R)			P/F	1	0	0	1	4
Unnumbered	SABM (set asynchronous balance mode)		0	0	1	P	1	1	1	1	4
		DM (disconnect mode)	0	0	0	F	1	1	1	1	4
	SI0 (sequenced information 0)	SI0 (sequenced information 0)	(0)*	1	1	P/F	0	1	1	1	4
	SI1 (sequenced information 1)	SI1 (sequenced information 1)	(1)*	1	1	P/F	0	1	1	1	4
	UI (unnumbered information)		0	0	0	P	0	0	1	1	4
	DISC (disconnect)		0	1	0	P	0	0	1	1	4
		UA (unnumbered acknowledge)	0	1	1	F	0	0	1	1	4
		FRMR (frame reject)	1	0	0	F	0	1	1	1	4

* See § 3.5.3.1.

No information field is permitted with the SABM/SABME command. A data link layer entity confirms acceptance of a SABM/SABME 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/SABME command indicates the clearance 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 by the transmission of a UA response. The data link layer entity sending the DISC command terminates the multiple frame operation when it receives the acknowledging UA or DM response.

TABLE 4/Q.921

Commands and responses – multiple frame acknowledged (modulo 128) operation

Format	Commands	Responses	Encoding 8	7	6	5	4	3	2	1	Octet
Information transfer	I (information)		N(S)							0	4
			N(R)							P	5
Supervisory	RR (receive ready)	RR (receive ready)	0	0	0	0	0	0	0	1	4
			N(R)							P/F	5
	RNR (receive not ready)	RNR (receive not ready)	0	0	0	0	0	1	0	1	4
			N(R)							P/F	5
	REJ (reject)	REJ (reject)	0	0	0	0	1	0	0	1	4
			N(R)							P/F	5
Unnumbered	SABME (set asynchronous balance mode extended)		0	1	1	p	1	1	1	1	4
		DM (disconnect mode)	0	0	0	F	1	1	1	1	4
	DISC (disconnect)		0	1	0	P	0	0	1	1	4
		UA (unnumbered acknowledge)	0	1	1	F	0	0	1	1	4
		FRMR (frame reject)	1	0	0	F	0	1	1	1	4

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 *Sequenced information 0 and 1 (SI0 and SI1) commands*

The function of the SI0/SI1 commands is to transfer information between data link entities using sequentially acknowledged frames containing information fields provided by layer 3. Sequenced information commands are sequenced-verified by the means of N(SI); that is, by alternating the SI0 and SI1 commands. SI0/SI1 commands shall have the P bit set to "1". An information field may or may not be present in SI0/SI1 commands.

3.6.6 *Receive ready (RR) command/response*

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

a) indicate it is ready to receive an I frame;

b) acknowledge previously received I frames numbered up to and including N(R) – 1 (as defined in § 5);

c) 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 "1" may be used by the data link layer entity to ask for the status of its peer data link layer entity.

3.6.7 *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 I 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.

In addition to indicating the status of a data link layer entity, the REJ command with P bit set to "1" may be used by the data link layer entity to ask for the status of its peer data link layer entity.

3.6.8 *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, a 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 "1" may be used by the data link layer entity to ask for the status of its peer data link layer entity.

3.6.9 *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/SABME 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.

3.6.10 *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 received which it cannot action.

3.6.11 *Sequenced information 0 and 1 (SI0 and SI1) responses*

When the data link connection is operating in single frame operation, the SI0 and SI1 responses are used to:

a) acknowledge the receipt of SI1 and SI0 command frames, respectively, and

b) to report the loss of sequence synchronization if a data link layer reset or power discontinuity has occurred.

There is no information field contained in SI0 and SI1 response frames.

3.6.12 *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:

a) the receipt of a command or response control field that is undefined or not implemented;

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

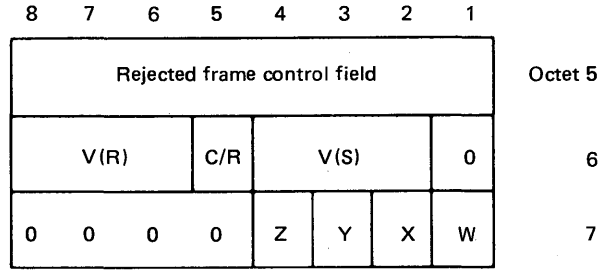
c) the receipt of an invalid N(R); or

d) 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 Tables 3/Q.921 and 4/Q.921.

A valid N(R) value is one that is in the range $V(A) \leqslant N(R) \leqslant V(S)$.

An information field which immediately follows the control field and consists of three or five octets (modulo 8 (basic) operation or modulo 128 (extended) operation, respectively), is returned with this response and provides the reason for the FRMR response. This information field format is given in Figures 6/Q.921 and 7/Q.921.



— 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 use side or network side reporting the rejection condition.
— C/R is set to "1" if the frame rejected was a response, and is set to "0" 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 "1" indicates that the control field received and returned in octet 5 was undefined or not implemented.
— X set to "1" 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 set to "1" in conjunction with this bit.
— Y set to "1" 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 "1" 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 through 8 shall be set to "0".

FIGURE 6/Q.921

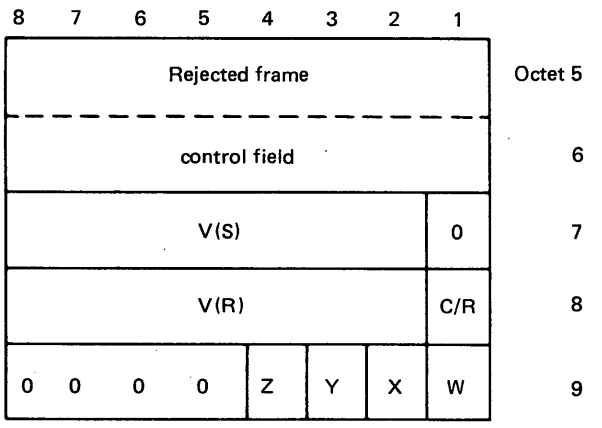
FRMR information field format — basic (modulo 8) operation

4 Elements for layer-to-layer communication

4.1 *General*

Communications between layers and, for this Recommendation, 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 implementations.



— Rejected frame control field is the control field of the received frame which caused the frame reject. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in octet 5, with octet 6 set to "0000 0000".
— 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 "1" if the frame rejected was a response and is set to "0" 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 "1" indicates that the control field received and returned in octets 5 and 6 was undefined or not implemented.
— X set to "1" indicates that the control field received and returned in octets 5 and 6 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 "1" in conjunction with this bit.
— Y set to "1" 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 "1" indicates that the control field received and returned in octets 5 and 6 contained an invalid N(R).
— Octet 7 bit 1 and octet 9 bits 5 through 8 shall be set to "0".

FIGURE 7/Q.921

FRMR information field format — extended (modulo 128) operation

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 Recommendation 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.

Note 1 – The full specification of the management entity to data link layer interface is a subject for further study.

Note 2 – The semantics of primitives require further study.

Note 3 – For the definition of primitives, harmonization must be sought with other CCITT Recommendations, such as X.200 [4], X.210 [5], I.430 [6], I.431 [7], Q.931(I.451) [2] and Q.710 [8].

4.1.1 *Generic names*

The generic name specifies the activity that the identified layer should perform. Table 5/Q.921 illustrates the primitives defined in this Recommendation. Note that not all primitives have associated parameters.

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

TABLE 5/Q.921

Primitives associated with the data link layer

Generic name	Type				Parameters		Message unit contents
	Request	Indication	Response	Confirm	Priority indicator	Message unit	
L3 ⟷ L2							
DL-ESTABLISH	X	X	*	*	–	*	Choice of single/multiple frame operation
DL-RELEASE	X	X	*	*	–	*	Choice of single/multiple frame operation
DL-DATA	X	X	–	–	–	X	Network layer peer-to-peer message
DL-UNIT DATA	X	X	–	–	–	X	
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**	X	–	–	–	–	

* For further study.
** Use requires further study.

L3 ⟷ L2: Layer 3/data link layer boundary
M ⟷ L2: Management entity/data link layer boundary
L2 ⟷ L1: Data link layer/physical layer boundary

4.1.1.1 *DL-ESTABLISH*

The DL-ESTABLISH primitives are used to request and indicate the outcome of the procedures for establishing single or multiple frame operation.

4.1.1.2 *DL-RELEASE*

The DL-RELEASE primitives are used to request and indicate the outcome of the procedures for terminating a previously established single or multiple frame operation. In the case of a data link layer malfunction, layer 3 will be notified by a RELEASE indication.

4.1.1.3 *DL-DATA*

The DL-DATA primitives are used to pass to and from the data link layer 3 messages which are to be transmitted, or have been received, using acknowledged operation.

4.1.1.4 *DL-UNIT DATA*

The DL-UNIT DATA primitives are used to pass to and from the data link layer layer 3 messages which are to be transmitted, or have been received, using unacknowledged operation.

4.1.1.5 *MDL-ASSIGN*

The MDL-ASSIGN primitives are used by the management entity to request that the data link layer associate the TEI value contained within the message portion of the primitive with the specified connection endpoint(s). The MDL-ASSIGN primitive is used by the data link layer to indicate to the management entity the need for a TEI value.

4.1.1.6 *MDL-REMOVE*

The MDL-REMOVE primitives are 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.

4.1.1.7 *MDL-ERROR*

The MDL-ERROR primitives are used to notify the management entity that an error has occurred, 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.

4.1.1.8 *MDL-UNIT DATA*

The MDL-UNIT DATA primitives are used to pass to and from the data link layer management entity messages which are to be transmitted, or have been received, using unacknowledged operation.

4.1.1.9 *PH-DATA*

The PH-DATA primitives are used to pass message units containing frames used for data link layer peer-to-peer communications to and from the physical layer.

4.1.1.10 *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 use of the REQUEST primitive is for further study.

4.1.1.11 *PH-DEACTIVATE*

The PH-DEACTIVATE primitives are used to request deactivation of the physical layer connection or to indicate that the physical layer connection has been deactivated. The use of the REQUEST primitive is for further study.

Note – The provision of additional primitives is for further study.

4.1.2 *Primitive types*

The primitive types defined in this Recommendation are:

4.1.2.1 *REQUEST*

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

4.1.2.2 *INDICATION*

The INDICATION primitive type is used by a layer providing a service to notify the next higher layer of activities related to the REQUEST primitive type.

4.1.2.3 *RESPONSE*

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

4.1.2.4 *CONFIRM*

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

Figure 8/Q.921 illustrates the relationship of the primitive types to the layer 3 and the data link layer.

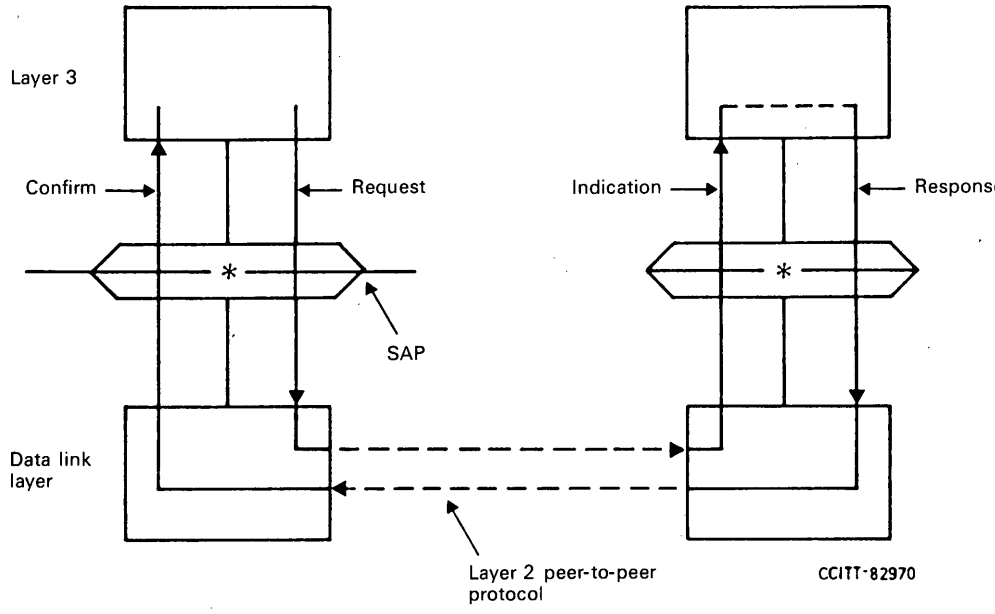


FIGURE 8/Q.921

Relationship of the primitive types to the layer 3 and the data link layer

4.1.3 *Parameter definition*

4.1.3.1 *Priority indicator*

Since several SAPs may exist on the network side or user side, protocol messages units sent by one SAP may contend with those of other 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/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.

4.2 *Primitive procedures*

A subject for further study.

5 Definition of the peer-to-peer procedures of the data link layer

The procedures for use by the data link layer are specified in the following sections.

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

a) for unacknowledged information transfer (§ 5.2):
UI-command,

b) for single frame acknowledged information transfer (§ 5.5):
SI0-command/response
SI1-command/response, and

c) for multiple frame acknowledged information transfer (§§ 5.6 to 5.10);
SABM/SABME-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 "0".

5.1.2 *Acknowledged single frame information transfer*

SI0 and SI1 command frames shall have the P bit set to "1". SI0 and SI1 response frames normally have the F bit set to "1". An SI0 or SI1 frame with the F bit set to "0" causes an exception condition, reporting the loss of synchronization following a data link layer reset or power discontinuity (see § 5.5.4.2).

5.1.3 *Acknowledged multiple frame information transfer*

A data link layer entity receiving an SABM, SABME, DISC, RR, RNR, REJ or I frame, with the P bit set to "1", shall set the F bit to "1" in the next response frame it transmits, as defined in Table 6/Q.921.

TABLE 6/Q.921

Immediate response operation of P/F bit

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

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*

Note – 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 by layer 3 or management entities 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.

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.

The P bit shall be set to "0".

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 or management entity using the data link layer to layer 3 primitive DL-UNIT DATA-INDICATION or the data link layer to management primitive 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*

A user equipment 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 management entity on the network side is referred to as the Assignment Source Point (ASP) in this Recommendation.

The purpose of this procedure is to:

a) allow a user equipment to request the network to assign a TEI value that the data link layer entities within the requesting user equipment will use in their subsequent communications;

b) allow a user equipment to request the network to verify a TEI value already present in the user equipment, which the data link layer entities within the requesting user equipment will use in their subsequent communications; and

c) allow a network to remove a previously assigned TEI from specific or all user equipments.

The user 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 Recommendation I.430).

Additionally, the user management entity should instruct the user data link layer entity to remove a TEI value for its own internal reasons; for example, losing the ability to communicate with the network or a no power condition. Other internal reasons (for example, local monitoring, or detection of malfunctions) require further study. The management entity shall use the MDL-REMOVE-REQUEST for these purposes.

Section 5.3.4.1 includes the actions taken by a data link layer entity receiving a MDL-REMOVE-REQUEST.

Typically, one TEI value would be used by the user equipment (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 user to maintain the association between TEI and SAPI values.

The initiation of these 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 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 user equipment should postpone the start of the TEI assignment 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 the 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 user side management entity shall transmit a message to its peer containing the following elements:

a) message type = Identity request;

b) Reference number (Ri); and

c) Action indicator (Ai).

The Reference number, Ri, shall be used to differentiate between a number of user equipments which may simultaneously request initialization of a TEI value. Ri shall be 2 octets in length and shall be randomly generated for each request message by the user equipments.

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 possibility 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) either for the assignment of any TEI value available, or for the verification of a preferred TEI value.

The coding of the Ai shall be as follows:

a) Ai = Group address TEI (127):

(This Ai value requests the ASP to assign any TEI value); and

b) Ai = Preferred TEI

(This Ai value requests the ASP to verify the preferred 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 if no preferred value was indicated;

b) verify the indicated preferred value; or

c) 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:

a) message type = Identity assigned;

b) Reference number (Ri); and

c) the assigned TEI value in the Ai field.

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

The user data link layer entity shall:

a) enter the TEI-assigned state; and

b) set the single frame operation variables, V(SI) and V(RI), to "0", if applicable; or

c) 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 (or the preferred TEI value is not available), the ASP shall transmit a message containing the following elements:

a) message type = Identity denied;

b) Reference number (Ri); and

c) the value of TEI which is denied in the Ai field (a value of 127 indicates that no TEIs are available).

The user 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 using the primitive DL-RELEASE-INDICATION.

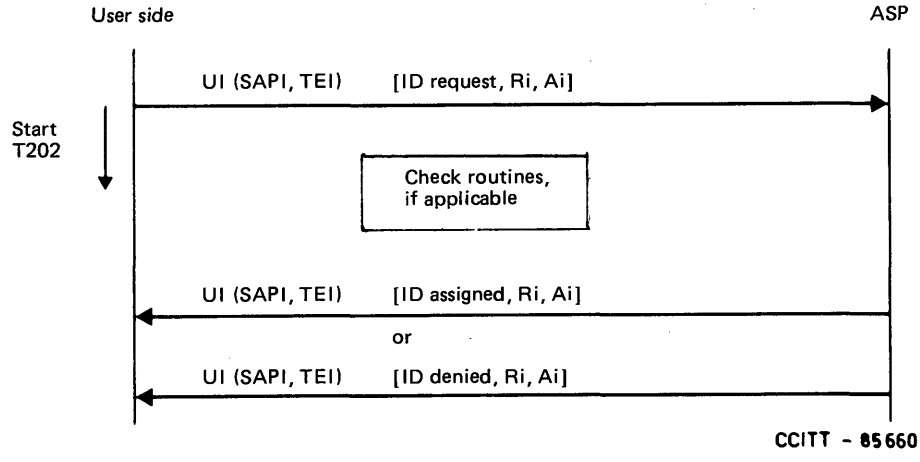
5.3.2.1 *Expiry of timer T202*

If the user 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 value of Ri shall be retransmitted.

After N202 unsuccessful attempts to acquire a TEI value, 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 using the primitive DL-RELEASE-INDICATION.

The value of T202 is specified in § 5.10.7. The value of N202 is for further study.

The TEI assignment is illustrated in Figure 9/Q.921.



SAPI	Service access point identifier = 63
TEI	Group TEI = 127
ID request	Identity request
ID assigned	Identity assigned
ID denied	Identity denied
Ai	Action indicator, see table 7/Q.921
Ri	Reference number
( )	Contents of the data link layer command address field
[ ]	Contents of the data link layer command information field

FIGURE 9/Q.921

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:

a) in connection with an Identity request, as described in § 5.3.2; and

b) 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 10/Q.921.

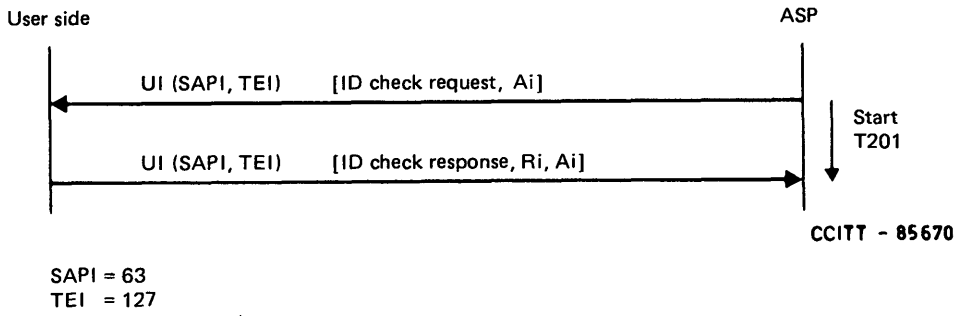


FIGURE 10/Q.921

Check routine

The ASP shall transmit a message containing the following elements:

a) message type = Identity check request; and

b) the TEI value to be checked in the Ai field.

Timer T201 shall be started.

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

a) message type = Identity check response;

b) the TEI value in the Ai field; and

c) 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 § 5.10.6.

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 user.

5.3.4 *TEI removal procedure*

When the network 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), the ASP shall transmit a message containing the following elements:

a) message type = Identity remove; and

b) TEI value which is to be removed, as indicated in the Ai field (the value 127 indicates that all user equipments 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 user 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 value, using the MDL-REMOVE-REQUEST primitive.

5.3.4.1 *Action taken by the data link layer entity receiving MDL-REMOVE-REQUEST*

A data link layer entity receiving MDL-REMOVE-REQUEST shall:

a) inform layer 3 using the primitive DL-RELEASE-INDICATION; and

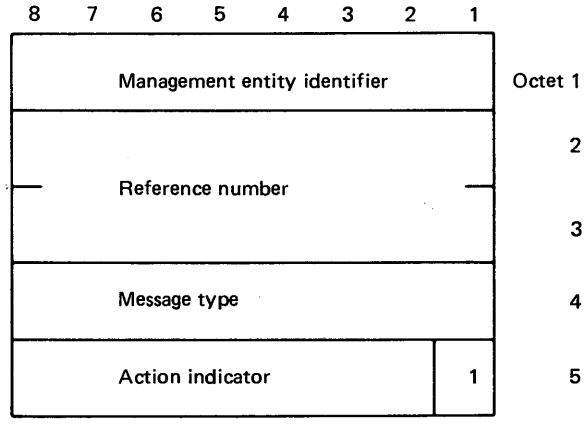
b) enter the TEI-unassigned state.

5.3.5 *Formats and codes*

5.3.5.1 *General*

All messages used for TEI assignment procedures are carried in the information field of UI command frames with a SAPI value set to 63 (binary "11 1111") and TEI value set to 127 (binary "111 1111").

All messages are of fixed length and have the following structure:



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

The coding of each field for the various messages is specified in Table 7/Q.921.

TABLE 7/Q.921

Codes for messages concerning TEI assignment

Message name	Management entity identifier	Reference number Ri	Message type	Action indicator Ai
Identity request (user to network)	0000 1111	0-65535	0000 0001	Ai = 127 = Any TEI acceptable Ai = 0-126 = Preferred TEI value
Identity assigned (network to user)	0000 1111	0-65535	0000 0010	Ai = 0-126 = Assigned TEI value
Identity denied (network to user)	0000 1111	0-65535	0000 0011	Ai = 0-127 = Denied TEI value
Identity check request (network to user)	0000 1111	Not used (coded 0)	0000 0100	Ai = 0-126 = TEI value to be checked
Identity check response (user to network)	0000 1111	0-65535	0000 0101	Ai = 0-126 = TEI value in use
Identity remove (network to user)	0000 1111	Not used (coded 0)	0000 0110	Ai = 127 = Request for removal of all TEI values Ai = 0-126 = TEI value to be removed

5.3.5.2 *Management entity identifier*

Octet 1 contains the management entity identifier. Its use is for further study.

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 type*

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:

a) bit 1 shall be coded "1"; and

b) bits 2 to 8 contain the Action indicator.

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

5.4 *Automatic negotiation of data link layer parameter values*

The automatic negotiation of data link layer parameter values is for further study.

5.5 *Procedures for single frame operation*

5.5.1 *General*

The following procedures are used for single frame acknowledged information transfer. The procedures make use of SI0/SI1 command and response frames.

Note – These procedures provide the capability for the transmitting data link layer entity, to establish synchronization prior to initiating interchange, or to re-establish synchronization following the occurrence of a resetting operation or a power discontinuity. The procedures also provide the capability for the receiving data link layer entity to report a loss of synchronization caused by similar occurrences by responding with an SI0/SI1 response frame with the F bit set to "0", thereby creating an exception condition at the peer data link layer entity.

5.5.2 *Initialization*

To ensure synchronization prior to initiating information transfer (i.e., receipt of DL-ESTABLISH-REQUEST from layer 3 or reception of an SI0/SI1 information frame when in the TEI-assigned state) or following the occurrence of loss of synchronization (e.g., power failure, reset, etc.) each data link layer entity (transmitter of SI0/SI1 commands) shall transmit an SI0 command with a zero length information field and the P bit set to "1" to solicit the remote data link layer entity receive sequence status. The transmitting data link layer entity shall then set V(SI) equal to the N(RI) received in the response frame and indicate to layer 3 by means of the primitive DL-ESTABLISH-INDICATION that the data link has been initialized.

5.5.3 *Transmitting SI0/SI1 command frames*

Layer 3 will pass information for transmission to the data link layer entity by means of the primitive DL-DATA-REQUEST.

Note – The term "transmission of an SI0/SI1 frame" refers to the delivery of an SI0/SI1 frame by the data link layer to the physical layer.

The data link layer shall:

- set N(SI) to the current value of V(SI);
- start timer T200;
- maintain a retransmission count variable which is set to 0 when a new SI0/SI1 command is transmitted; and
- transmit an SI0/SI1 command frame with the P bit set to "1".

5.5.4 *Receiving an SI0/SI1 command frame*

5.5.4.1 *In sequence, N(SI) = V(RI)*

When a data link layer entity receives a SI0/SI1 command frame with N(SI) equal to the current value of its receive state variable V(RI), it shall:

- pass the contents of the information field, if present, to layer 3 by means of the primitive DL-DATA-INDICATION;
- complement the value of V(RI); and
- transmit an SI0/SI1 response with N(RI) set to the current value of state variable V(RI) and the F bit set to "1".

If an SIO/SI1 command frame having no information field is received while the data link layer entity is in the TEI-assigned state, the data link layer entity shall:

- enter the single-frame-established state; and
- indicate this to layer 3 using the primitive DL-ESTABLISH-INDICATION.

If an SI0/SI1 command frame having no information field is received while the data link layer entity is in the single-frame-established state, no primitive shall be passed to layer 3.

5.5.4.2 *Out of sequence, N(SI) ≠ V(RI)*

When a data link layer entity receives an SI0/SI1 command frame with N(SI) not equal to V(RI) (that is, out of sequence) it shall, depending upon whether it has experienced an intervening reset or power off/on transition:

- if the receiver has *not* been reset or powered off/on:
  - discard the SI0/SI1 command frame [V(RI) is not complemented]; and
  - retransmit the previous SI0/SI1 response frame with N(RI) set to the current value of V(RI) and the F bit set to "1"; or
- if the receiver has been reset or powered off/on:
  - discard the SI0/SI1 command frame [V(RI) is not complemented]; and
  - transmit an SI0/SI1 response with N(RI) set to the current value of V(RI), and with the F bit set to "0".

Note – Improvements in the notification to the peer entity of reset or power off/on are for further study.

5.5.4.3 *Receiving an unrecognized command*

When a data link layer entity receives a command other than SI0 or SI1, it shall:

- discard the frame [V(RI) is not complemented]; and
- transmit an SI0/SI1 response with N(RI) set to the current value of V(RI) and with the F bit set to "0".

5.5.5 *Receiving an SI0/SI1 response frame*

5.5.5.1 *In sequence, N(RI) = V(SI) + 1*

A data link layer entity, on receipt of an SI0/SI1 response frame with N(RI) equal to V(SI) + 1 (that is, in the expected sequence) shall, depending upon the setting of the F bit:

- if the F bit is set to "1":
  - complement the value of V(SI);
  - reset timer T200; and
  - set the retransmission count variable to 0; or
- if the F bit is set to "0":
  - reset timer T200;
  - complement the value of V(SI); and
  - if the previously transmitted SI0/SI1 command frame had no information field, retransmit the SI0/SI1 command frame with N(SI) set to the value of V(SI); or
  - if the previously transmitted SI0/SI1 command frame contained an information field, pass the primitive DL-RELEASE-INDICATION to layer 3.

5.5.5.2 *Out of sequence, N(RI) ≠ V(SI) + 1*

A data link layer entity, on receipt of an SI0/SI1 response frame with N(RI) *not* equal to V(SI) + 1, that is, *not* in the expected sequence, shall:

– discard (ignore) the frame (timer T200 is not reset).

5.5.5.3 *Receiving an unrecognized response*

A data link layer entity, on receipt of a response other than SI0 or SI1, shall discard (ignore) the frame (timer T200 is not reset).

5.5.6 *Expiry of timer T200*

If timer T200 expires before an SI0/SI1 response frame is received, acknowledging a transmitted SI0/SI1 command frame, and if the retransmission count variable is less than N200, the data link layer entity shall:

– retransmit the SI0/SI1 command frame with N(SI) set to the existing value of V(SI);
– start timer T200; and
– increment the retransmission count variable for each retransmission of the frame; that is, upon expiry of timer T200.

When the retransmission count variable reaches N200 (see § 5.10.2), the data link layer entity shall inform the management entity by means of MDL-ERROR-INDICATION, and inform layer 3 using the primitive DL-RELEASE-INDICATION.

5.6 *Procedures for establishment and release of multiple frame operation*

5.6.1 *Establishment of multiple frame operation*

5.6.1.1 *General*

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

Layer 3 will indicate a request for establishment of the multiple frame operation by the use of the DL-ESTABLISH-REQUEST primitive. Re-establishment may be initiated as a result of the data link layer procedures defined in § 5.8. All frames other than unnumbered frame formats received during the establishment procedures shall be ignored. The treatment of SI0/SI1 frames received during the establishment of multiple frame operation is for further study.

5.6.1.2 *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 or Set Asynchronous Balanced Mode Extended (SABME) command. All existing exception conditions shall be cleared, the retransmission counter shall be reset, and timer T200 shall then be started (timer T200 is defined in § 5.10.1). All mode setting commands shall be transmitted with the P bit set to "1".

A data link layer entity receiving an SABM/SABME command 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/SABME 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 layer 3 using the primitive DL-ESTABLISH-INDICATION;
– reset the retransmission counter;
– clear all existing exception conditions; and
– clear an existing peer receiver busy condition.

If the data link layer entity is unable to enter the multiple-frame-established state, it shall respond to the SABM/SABME command with a DM response with the F bit set to the same binary value as the P bit in the received SABM/SABME command.

Upon reception of the UA response with the F bit set to "1", the originator of the SABM/SABME 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; and
- enter the multiple-frame-established state and inform the layer 3 using the primitive DL-ESTABLISH-INDICATION.

Upon reception of a DM response with F bit set to "1", the originator of the SABM/SABME 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.

5.6.1.3 *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/SABME command as above;
- restart timer T200; and
- increment the retransmission counter.

After retransmission of the SABM/SABME 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 § 5.10.2.

5.6.2 *Information transfer*

Having either transmitted the UA response to a received SABM/SABME command or received the UA response to a transmitted SABM/SABME command, I frames and supervisory frames shall be transmitted and received according to the procedures described in § 5.7.

If an SABM/SABME command is received while in the multiple-frame-established state, the data link layer entity shall conform to the re-establishment procedure described in § 5.8.

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

5.6.3 *Termination of multiple frame operation*

5.6.3.1 *General*

These procedures shall be used to terminate the multiple frame operation between the network and a designated user entity.

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

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

5.6.3.2 *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 "1". Timer T200 shall then be started 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 the received DISC command. A DL-RELEASE-INDICATION shall be passed to layer 3, and the TEI-assigned state shall be entered.

If the originator of the DISC command receives either:

- a UA response with the F bit set to "1"; or
- a DM response with F bit set to "1", 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 § 5.6.4.

5.6.3.3 *Procedure on expiry of timer T200*

If timer T200 expires before a UA or DM response is received, the originator of the DISC command shall:

- retransmit the DISC command as defined in § 5.6.3.2;
- restart timer T200; and
- increment the retransmission counter.

If the data link layer entity has not received the correct response as defined in § 5.6.3.2, after N200 attempts to recover, the data link layer entity shall indicate this to the management entity by means of the primitive MDL-ERROR-INDICATION and enter the TEI-assigned state.

The value of N200 is defined in § 5.10.2.

5.6.4 *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 "1" shall result in the transmission of a DM response with the F bit set to "1" (as defined in § 5.1.1);
- the content of any received I frame shall be discarded;
- on receipt of an SABM/SABME command, the procedures defined in § 5.6.1. shall be followed;
- on receipt of UI commands, the procedures defined in § 5.2 shall be followed;
- on receipt of SI0/SI1 commands and responses, the procedures defined in § 5.5 shall be followed; and
- all other frame types shall be discarded.

5.6.5 *Collision of unnumbered commands and responses*

Collision situations shall be resolved in the following way:

5.6.5.1 *Identical transmitted and received commands*

If the transmitted and received unnumbered commands (SABM/SABME or DISC) are the same, the data link layer entities shall send the UA response 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.

5.6.5.2 *Different transmitted and received commands*

If the transmitted and received unnumbered commands (SABM/SABME or DISC) are different, the data link layer entities shall enter the TEI-assigned state and issue a DM response 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.

5.6.5.3 *Unsolicited DM response and SABM/SABME or DISC command*

When a DM response with the F bit set to "0" is issued by a data link layer entity at the user side, a collision between an SABM/SABME or DISC command and the unsolicited DM response may occur. This is typically caused by a terminal applying a protocol procedure according to X.25 LAPB [9], to ask for a mode-setting command.

In order to avoid misinterpretation of the DM response received, a data link layer entity shall always send its SABM/SABME or DISC command with the P bit set to "1".

A DM response with the F bit set to "0" colliding with an SABM/SABME or DISC command shall be ignored.

5.7 *Procedures for information transfer in multiple frame operation*

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

Note – The term "transmission of an I frame" refers to the delivery of an I frame by the data link layer to the physical layer.

5.7.1 *Transmitting I frames*

Information received by the data link layer entity from layer 3 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 § 5.7.7 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 § 5.10.5), 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 §§ 5.7.4 and 5.7.7.

When the network side or user side is in the own receiver busy[1] condition, it may still transmit I frames, provided that a peer receiver busy condition does not exist.

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

5.7.2 *Receiving I frames*

When a data link layer entity is not in a receiver busy condition and receives a valid I frame whose send sequence number is equal to the current receive state variable V(R), the data link layer entity shall:

- pass the information field of this frame to layer 3 using the primitive DL-DATA-INDICATION;
- increment by 1 its receive state variable V(R),

and act as indicated below:

5.7.2.1 If the P bit of the received I frame was set to "1", the data link layer entity shall respond to its peer in one of the following ways:

- If the data link layer entity receiving the I frame is still not in an own receiver busy condition, it shall send an RR response with the F bit set to "1".
- 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 "1".

5.7.2.2 If the P bit of the received I frame was set to "0" and:

a) if the data link layer entity is still not in an own receiver busy condition:
   - 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 "0"; or
   - 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 § 5.7.1; or

b) if, 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 "0".

When the data link layer entity is in an own receiver busy condition, it shall process any received I frame according to § 5.7.6.

5.7.3 *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 an REJ with an N(R) equal to the V(A).

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[1] In the following text in this Recommendation, the term own/peer receiver busy refers to the peer-to-peer flow control state in the data link layer entities.

Note – If a supervisory frame with P bit set to "1" has been transmitted and not acknowledged, timer T200 shall not be reset.

If timer T200 has been reset by the receipt of an I, RR or RNR frame, and if there are outstanding I frames still unacknowledged, 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 § 5.7.7 with respect to the unacknowledged I frames.

If timer T200 has been reset by the receipt of an REJ frame, the data link layer entity shall follow the retransmission procedures in § 5.7.4.

5.7.4 *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. If it is not in the timer recovery condition, T200 shall be reset. The actions to be taken on receipt of an REJ frame in the timer recovery condition requires further study. It shall transmit the corresponding I frame as soon as possible as defined in § 5.7.1. Transmission shall take account of the following:

1) 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;
2) if the data link layer entity is transmitting an SABM/SABME or DISC command or a UA, DM or FRMR response when it receives the REJ frame, it shall ignore the request for retransmission; and
3) if the data link layer entity is not transmitting a frame when the REJ is received, it shall immediately commence transmission of the requested I frame.

All outstanding unacknowledged I frames, 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.

5.7.5 *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 "1", it shall respond with an RR response with the F bit set to "1" if the data link layer entity is not in an own receiver busy condition, and shall respond with an RNR response with the F bit set to "1" 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 "1", an existing timer recovery condition and/or status enquiry shall be cleared.

Note 1 – The N(R) in the received supervisory response with F bit set to "1" may be used to update the send state variable V(S).

Note 2 – Further study is needed on whether the N(R) in a received supervisory RNR command with a P bit set to "1" may be used to update the send state variable V(S).

Note 3 – In order to optimize the procedures, I frames should not be transmitted towards a peer which has indicated a busy condition with an RNR frame.

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, and 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, enter either a status enquiry if no subsequent I frames will be transmitted (see Note 3 above) or a timer recovery condition, and reset the retransmission counter; or
- 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:

- if the value of the retransmission count variable is less than N200, either:

  a) transmit an RR or REJ command as appropriate with the P bit set to "1" if the data link layer entity is not in an own receiver busy condition, and an RNR command with the P bit set to "1" if the data link layer entity is in an own receiver busy condition, or

  b) transmit an available I frame with the P bit set to "1" according to § 5.7.7 (however, see Note 3 above),

and restart timer T200; or

- if the value of the retransmission count variable is equal to N200, it shall initiate the re-establishment procedure described in § 5.8. The management entity shall be notified via the MDL-ERROR INDICATION primitive. (N200 is a system parameter; see § 5.10.2).

The peer data link layer entity receiving the supervisory frame with the P bit set to "1" shall respond, at the earliest opportunity, with a supervisory response frame (RR, RNR, REJ) with the F bit set to "1", to indicate whether or not its own receiver busy condition still exists.

Upon receipt of the supervisory response with the F bit set to "1", the data link layer entity shall reset timer T200, 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 §§ 5.7.1 or 5.7.4, respectively; or
- if the response is an RNR response, the data link layer entity receiving the response shall proceed according to this § 5.7.5, first paragraph.

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

- if the command is an RR or REJ command, clear the peer receiver busy condition. The data link layer entity may transmit new I frames or re-transmit I frames as specified in §§ 5.7.1 or 5.7.4, respectively; or
- 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 after expiry of timer T200 following the receipt of the RNR response with the F bit set to "1."

  Should the received supervisory command contain the P bit set to "1", the appropriate response frame with the F bit set to "1" must be transmitted before the data link layer entity can action the received frame.

Note – Whether I frames may be transmitted immediately following the receipt of an RR or REJ command, even if a poll/final status enquiry has not been completed, requires further study.

Receiving an SABM/SABME command the data link layer entity shall clear the peer receiver.

5.7.6 *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 either a response or command frame with the F or P bit set to "0". Alternatively, the RNR frame may be a command frame with the P bit set to "1", if a confirmed transfer of the own receiver busy condition is required.

All received I frames with the P bit set to "0" may be discarded, after updating the acknowledge state variable V(A).

All received supervisory frames with the P/F bit set to "0" shall be processed, including updating the acknowledge state variable V(A).

All received I frames with the P bit set to "1" may be discarded, after updating the acknowledge state variable V(A). However, an RNR response frame with the F bit set to "1" shall be transmitted.

All received supervisory frames with the P bit set to "1" shall be processed including updating the acknowledge state variable V(A). An RNR response with the F bit set to "1" 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 error has not yet been reported, an REJ frame with the N(R) set to the current value of the receive state variable V(R).

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

5.7.7 *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:

a) if the value of the retransmission count variable is less than N200:
   - restart timer T200, and either
   - transmit an appropiate supervisory command with the P bit set to "1", or
   - retransmit the last transmitted I frame (V(S)−1) with the P bit set to "1"; or

b) if the value of the retransmission count variable is equal to N200, initiate a re-establishment procedure as defined in § 5.8 and indicate this by means of the primitive MDL-ERROR-INDICATION to the management entity.

The timer recovery condition is cleared when the data link layer entity receives a valid supervisory frame response with the F bit set to "1". 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 § 5.7.5.

Note – The timer recovery condition may also be cleared by the receipt of a supervisory frame response with the F bit set to "0" or by an I frame if they acknowledge *all* outstanding I frames. However, this implies that a data link layer entity has to accept a subsequent supervisory frame response with the F bit set to "1" acknowledging the command transmitted during timer recovery condition without causing an exception condition.

5.8 *Re-establishment of multiple frame operation*

5.8.1 *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 in the normal state or by the following conditions:

- the receipt of a frame with procedure errors as defined in § 5.9.4;
- the receipt, while in the multiple-frame-established state, of an unsolicited DM response or an FRMR response;
- the receipt, while in the multiple-frame-established state, of a UA response or other unsolicited response with the F bit set to "1"; or
- N200 retransmission failures while in the multiple-frame-established state.

5.8.2 *Procedures*

5.8.2.1 Under normal conditions, the procedures defined in § 5.6.1 shall be used to re-establish multiple frame operation.

5.8.2.2 Under certain conditions listed in § 5.8.1, either side may request re-establishment of the data link by transmitting an FRMR response. The data link layer entity detecting a receive sequence number error may re-establish multiple frame operation directly by transmission of an SABM/SABME command.

After transmitting an FRMR response, the data link layer entity shall enter the frame rejection condition: the frame rejection condition is cleared when the data link layer entity receives or transmits an SABM/SABME or DISC command, or receives a DM response.

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.

After receiving an FRMR response (even during a frame rejection condition), the data link layer entity shall initiate the re-establishment procedures as defined in § 5.6.1 and indicate this by means of the primitive MDL-ERROR-INDICATION to the management entity.

5.9 *Exception condition reporting and recovery*

Exception conditions 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.

5.9.1 *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, nor 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 "1". 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 frame is used 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.

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

5.9.2 *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 an 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 § 5.7.7 to determine at which I frame retransmission must begin.

5.9.3 *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.

5.9.4 *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 § 3.6.12.

Note – Upon the receipt of an invalid N(R), link re-establishment may be performed rather than establishing a frame rejection condition. Further study is required on which of the alternatives is the preferred method.

At either side, this frame rejection condition shall be indicated by transmission of an FRMR response for appropriate action, by the other side, followed by the transmission of an SABM, SABME or DISC command. Rather than establishing a frame rejection condition, link re-establishment may be initiated directly (see § 5.8.2).

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

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

5.10 *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 Recommendation.

5.10.1 *Timer T200*

The default[2)] value for timer T200 at the end of which transmission of a frame may be initiated according to the procedures described in §§ 5.5 and 5.6 shall be one second.

Note 1 – 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.

Note 2 – When an implementation includes multiple terminals on the user side together with a satellite connection in the transmission path, a value of T200 greater than 1 second may be necessary. A value of 2.5 seconds is suggested.

5.10.2 *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.

5.10.3 *Maximum number of octets in an I frame information field (N201)*

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

- For an SAP supporting signalling, the default value shall be 128 octets (provisional value).

  Note – For applications requiring large signalling messages, a single value greater than 128 (for example, 260) may be specified.
- For SAPs supporting packet information, the default value shall be 260 octets (provisional value).

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

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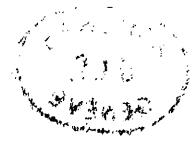
2) The term default implies that value defined should be used in the absence of any assignment or negotiation of alternative values.



5.10.4 *Maximum number of TEI assignment requests (N202)*

Value for further study.

5.10.5 *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 basic (modulo 8) operation.

- For an SAP supporting signalling, the default value shall be 1.

  Note – The default value for primary rate interface structures requires further study.

- For SAPs supporting packet information, the default value shall be 7.

For extended (modulo 128) operation (for example, when using LAPD over satellite links), the permissible maximum number of outstanding I frames may be increased to any value up to 127.

5.10.6 *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.

5.10.7 *Timer T202*

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

APPENDIX I

(to Recommendation Q.921)

I.1 *Introduction*

The procedural elements defined in § 5 of Recommendation Q.921 allow for the supervision of the data link layer resource. This Appendix describes procedures which may be used to provide this supervision function. Procedures for both the single frame operation and the multiple frame operation are described. The use of this function is optional.

I.2 *Link layer supervision in the multiple frame established state*

The procedures specified herein propose a solution which is already identified in the HDLC classes of procedures. The connection verification is a service provided by data link layer to layer 3. This implies that layer 3 is informed in case of a failure only. Furthermore, the procedure may be incorporated in the "normal" exchange of information and may become more efficient than a procedure based on the involvement of layer 3.

The procedure specified herein is called STATUS ENQUIRY and is based on supervisory command frames (RR command, RNR command) and a timer T203 and operates in the multiple-frame-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 "1", 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 with a P bit set to 1 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.

I.2.1 *Connection verification procedures*

I.2.1.1 *Restart of timer T203*

Upon receiving a frame timer T203 will be restarted.

I.2.1.2 *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 oustanding frames in either direction. It represents the maximum time allowed without frames being exchanged on a data link layer connection.

If timer T203 expires, the data link layer entity will act as follows (it should be noted that timer T200 is neither running nor expired):

1) set the retransmission count variable to 0;

2) set STATUS ENQUIRY;

3) 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

4) start timer T200.

Note – Timer T203 may not be needed at the user side.

I.3 *Data Link layer supervision in the single-frame-established state*

Data link supervision in the single-frame-established state may be performed as follows. A data link layer entity which detects that no frames have been exchanged on the data link for a period of time would send an SI0/SI1 command frame with a zero-length information field. The entity receiving the SI0/SI1 command would respond with a SI1/SI0 response. Both transmission and reception of these frames should conform to the procedures defined in § 5.5. The DL-DATA-INDICATION primitive should not be passed to the layer 3, since there is no information field in the received SI0/SI1 frames.

References

[1] CCITT Recommendation Q.920(I.440) *ISDN user-network interface data link layer – General aspects.*

[2] CCITT Recommendation Q.930(I.450) *ISDN user-network interface layer 3 – General aspects.*

[3] CCITT Recommendation Q.931(I.451) *ISDN user-network interface layer 3 specification.*

[4] CCITT Recommendation X.200 *Reference model of open systems interconnection for CCITT applications.*

[5] CCITT Recommendation X.210 *OSI layer service conventions.*

[6] CCITT Recommendation I.430 *Basic user-network interface layer 1 specification.*

[7] CCITT Recommendation I.431 *Primary rate user-network interface layer 1 specification.*

[8] CCITT Recommendation Q.710 *Use of Signalling System No. 7 for PABX application.*

[9] CCITT Recommendation X.25 *Interface between data terminal equipment (DTE) and data circuit terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

Abbreviation	*Meaning*
Ai	*A*ction *i*ndicator
ASP	*A*ssignment *S*ource *P*oint
C/R	*C*ommand/*R*esponse field bit
DISC	*DISC*onnect
DL-	Between layer 3 and *D*ata *L*ink layer
DLCI	*D*ata *L*ink *C*onnection *I*dentifier
DM	*D*isconnect *M*ode
EA	*E*xtended *A*ddress field bit
ET	*E*xchange *T*ermination
FCS	*F*rame *C*heck *S*equence
FRMR	*FRaMe R*eject
I	*I*nformation
ID	*ID*entity
ISDN	*I*ntegrated *S*ervices *D*igital *N*etwork
ISO	*I*nternational *O*rganization for *S*tandardization
L3	*L*ayer 3
L2	*L*ayer 2
L1	*L*ayer 1
LAPD	*L*ink *A*ccess *P*rocedure on the D-channel
M	*M*odifier function bit
MDL-	Between *M*anagement entity and *D*ata *L*ink layer
NT2	*N*etwork *T*ermination *2*
OSI	*O*pen *S*ystems *I*nterconnection
P/F	*P*oll/*F*inal bit
PH-	Between Data link layer and *Ph*ysical layer
REJ	*REJ*ect
Ri	*R*eference number
RNR	*R*eceive *N*ot *R*eady
RR	*R*eceive *R*eady
S	*S*upervisory
S	*S*upervisory function bit
SABM	*S*et *A*synchronous *B*alanced *M*ode
SABME	*S*et *A*synchronous *B*alanced *M*ode *E*xtended
SAP	*S*ervice *A*ccess *P*oint
SAPI	*S*ervice *A*ccess *P*oint *I*dentifier
SI0	*S*equenced *I*nformation *0*
SI1	*S*equenced *I*nformation *1*
TE	*T*erminal *E*quipment
TEI	*T*erminal *E*ndpoint *I*dentifier
U	*U*nnumbered
UA	*U*nnumbered *A*cknowledgement
UI	*U*nnumbered *I*nformation

Recommendation Q.930 [1]

ISDN USER-NETWORK INTERFACE LAYER 3 – GENERAL ASPECTS

1 General

1.1 *Introduction*

This Recommendation describes in general terms the D-channel layer 3 functions and protocol employed across an ISDN user-network interface. Details are provided in Recommendation Q.931(I.451) [1].

The term "Layer 3" is a general term used in these Recommendations to refer to the procedures described in Recommendation Q.931(I.451) [1]. These procedures shall also be applicable to the E-channel of a primary rate interface structure at an ISDN user-network interface.

The layer 3 protocol provides the means to establish, maintain and terminate network connections across an ISDN between communicating application entities. The detailed description of the layer 3 protocol in Recommendation Q.931(I.451) makes use of the definition and terminology concepts of the ISDN protocol reference model given in Recommendation I.311. Recommendation Q.931(I.451) does not at present cover all functions which may be specified for layer 3. Recommendation Q.931(I.451) [1] and Recommendation I.320 [2] are not presently completely consistent in their structure of protocols. Further study is required to enhance these Recommendations in order to resolve these inconsistencies.

1.2 Connection control by the user of an ISDN requires:

a) application of layer 3 protocol for control of circuit-switched connections and/or packet-switched connections, in combination with;

b) application of an appropriate data link layer service (supported by an appropriate physical layer service).

Layer 3 provides to the user the functions associated with the establishment and operation of a network connection. Layer 3 makes invisible to the user how it utilizes underlying resources such as data link connections to provide a network connection.

1.3 Layer 3 utilizes functions and services provided by the data link layer as defined in Recommendations Q.920(I.440) [3] and Q.921(I.441) [4]. These services are summarized below:

a) establishment of data link connections;

b) error-protected transmission of data;

c) notification of unrecoverable data link errors;

d) release of data link connections;

e) notification of data link layer failures;

f) recovery from certain error conditions;

g) indication of data link layer status.

1.4 The layer 3 protocols may also utilize the functions and services provided by the lower-layer protocols of the E-channel of a primary rate interface structure (see Recommendation Q.710 [5]).

1.5 Although the layer 3 protocol is not fully symmetrical, to enable direct user-to-user communication (e.g. PABX-to-PABX communication over a leased circuit), it is intended that the protocol is symmetrical as much as possible.

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[1] This Recommendation appears in the Series I Recommendations as Recommendation I.450.

Further study is required so that this approach will facilitate the definition of protocol for direct user-to-user communication taking the layer 3 protocol as a basis and with a minimum change.

2 Structure of layer 3

2.1 *Categories of functions*

There are two categories of functions performed at layer 3 and services provided by layer 3 in the establishment of network connections. The first category contains those functions which directly control the connection establishment.

The second category contains those functions relating to the transport of messages additional to the functions provided by the data link layer. An example of the additional layer 3 functions is the provision of re-routing of signalling messages on an alternate D-channel (where provided) in the event of D-channel failure. Other possible functions in this category may include multiplexing and message segmenting and blocking.

It is intended that the communications between these two categories will be aligned as far as possible with the primitives used between the user parts and the message transfer part in Signalling System No. 7.

Further study is required to determine the functions to be included in each category.

2.2 *Layer 3 functions*

The layer 3 protocol described in this Recommendation is designed to effect the establishment and control of circuit-switched and packet-switched connections. The functions support procedures for both basic call control and call control in conjunction with network-provided supplementary facilities. Furthermore, services involving the use of connections of different types, according to user's specification, may be effected through "multi-media" call control procedures.

Functions performed by layer 3 include the following:

a) processing of primitives for communicating with the data link layer;

b) generation and interpretation of layer 3 messages for peer-level communication;

c) administration of timers and logical entities (e.g., call-references) used in the call control procedures;

d) administration of access resources including B-channels and packet-layer logical channels (e.g., Recommendation X.25 [6]);

e) checking to ensure that services provided are consistent with user requirements (e.g., compatibility, addresses, service indicators).

This list of layer 3 functions is not exhaustive, and it is not intended to imply that all functions are provided on both the terminal and the network side of the user-network interface.

2.2.1 The following general functions may also be performed by layer 3:

a) routing and relaying;

b) network connections;

c) conveying user-to-network and user-to-user information;

d) network connection multiplexing;

e) segmenting and blocking;

f) error detection;

g) error recovery;

h) sequencing;

i) flow control;

j) reset.

2.2.1.1 *Routing and relaying*

Network connections exist between either users and ISDN exchanges, or between users. Network connections may involve intermediate systems which provide relays to other interconnecting subnetworks and which facilitate interworking with other networks. Routing functions determine an appropriate route between layer 3 addresses.

2.2.1.2 *Network connections*

This function includes mechanisms for providing network connections making use of data link connections provided by the data link layer.

2.2.1.3 *Conveying user information*

This function may be carried out with or without the establishment of a circuit-switched connection.

2.2.1.4 *Network connection multiplexing*

Layer 3 provides multiplexing of call control information for multiple calls onto a single data link connection.

2.2.1.5 *Segmenting and blocking*

Layer 3 may segment and/or block layer 3 information for the purpose of facilitating the transfer.

2.2.1.6 *Error detection*

Error detection functions are used to check for procedural errors in the layer 3 protocol. Error detection in layer 3 uses, among other information, error notification from the data link layer.

2.2.1.7 *Error recovery*

This function includes mechanisms for recovering from detected errors.

2.2.1.8 *Sequencing*

This function includes mechanisms for providing the service of sequenced delivery of layer 3 information over a given network connection when requested. In normal conditions layer 3 ensures the delivery of information in the sequence it is submitted by the user.

2.2.1.9 *Flow control*

Flow control for user-to-user signalling messages is described in Recommendation Q.931(I.451) [1].

2.2.1.10 *Reset*

This function is for further study.

References

[1] CCITT Recommendation Q.931(I.451) *ISDN user-network interface layer 3 specification.*

[2] CCITT Recommendation I.320 *ISDN protocol reference model.*

[3] CCITT Recommendation Q.920(I.440) *ISDN user-network interface data link layer – General Aspects.*

[4] CCITT Recommendation Q.921(I.441) *ISDN User-Network interface data link layer specification.*

[5] CCITT Recommendation Q.710 *Recommendation on the use of Signalling System No. 7 for PABX application.*

[6] CCITT Recommendation X.25 *Interface between data terminal equipment (DTE) and data circuit terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

ABBREVIATIONS USED IN RECOMMENDATIONS Q.930(I.450) AND Q.931(I.451)

See the list at the end of Recommendation Q.931.

Recommendation Q.931 [1)]

ISDN USER-NETWORK INTERFACE LAYER 3 SPECIFICATION

1 General

This Recommendation specifies the procedures for the establishing, maintaining and clearing of network connections at the ISDN user-network interface. These procedures are defined in terms of messages exchanged over the D-channel of basic and primary rate interface structures and the E-channel of the primary rate interface defined in Recommendation I.412 [1]. The functions and procedures of this protocol, and the relationship with other layers, are described in general terms in Recommendation Q.930(I.450) [2]. In this Recommendation, all references to the D-channel protocol should be assumed to apply to the E-channel unless otherwise specified.

Note – It is intended that this Recommendation will specify the essential features, procedures and messages required for call control in the D-channel. However, there are many details of procedure which have not yet been specified, and which will be the subject of further study.

The attention of implementors is drawn to the fact that many call related facilities are not currently supported by the services of the OSI Network Layer as defined in Recommendation X.213. Consideration of whether the signalling protocol supporting such facilities should be implemented as network layer (OSI layer 3) or application layer (OSI layer 7) is a subject for further study. Resolution of this matter may impact the layering of the protocol defined in Recommendation Q.931.

1.1 *Scope of the Recommendation*

The procedures currently described in this Recommendation are for the control of circuit-switched connections, user-to-user signalling connections, and packet-switched connections. The carriage of other message-based information flows (telemetry, etc.) on the D-channel is a subject for further study and will be included in later versions of this Recommendation.

Note – The term "layer 3" is used for the functions and protocol described in this Recommendation (see § 1 of Recommendation Q.930(I.450) [2]). Alignment of the functions and protocol with those of OSI network layer is for further study. The terms "data link layer" and "layer 2" are used interchangeably to refer to the layer immediately below layer 3.

1.2 *Application to interface structures*

The layer 3 procedures apply to the interface structures defined in Recommendation I.412 [1]. They use all of the functions and services provided by layer 2 with the exception of the unacknowledged information transfer service which is used only on basic access interface structures to provide point-to-multipoint operation at layer 3.

Note – Further study is required to determine whether facilities not related to a call and associated messages (see §§ 3.2, 4.5.9, 5.1.6.1 and 5.1.6.3) should be identified by a different protocol discriminator coding.

2 Overview of call control

In this Recommendation the terms "incoming" and "outgoing" are used to describe the call as viewed by the user side of the interface.

2.1 *Circuit-switched calls*

This section provides the definition for states that individual calls may have, and provides overview SDL diagrams for the user and network side of the interface. These definitions do not apply to the state of the interface itself, any attached equipment, the D-channel, or the logical links used for signalling on the D-channel and do not apply to the state of the call reference. They are call states. Because several calls may exist simultaneously at a user-network interface, and each call may be in a different state, the state of the interface itself cannot be unambiguously defined.

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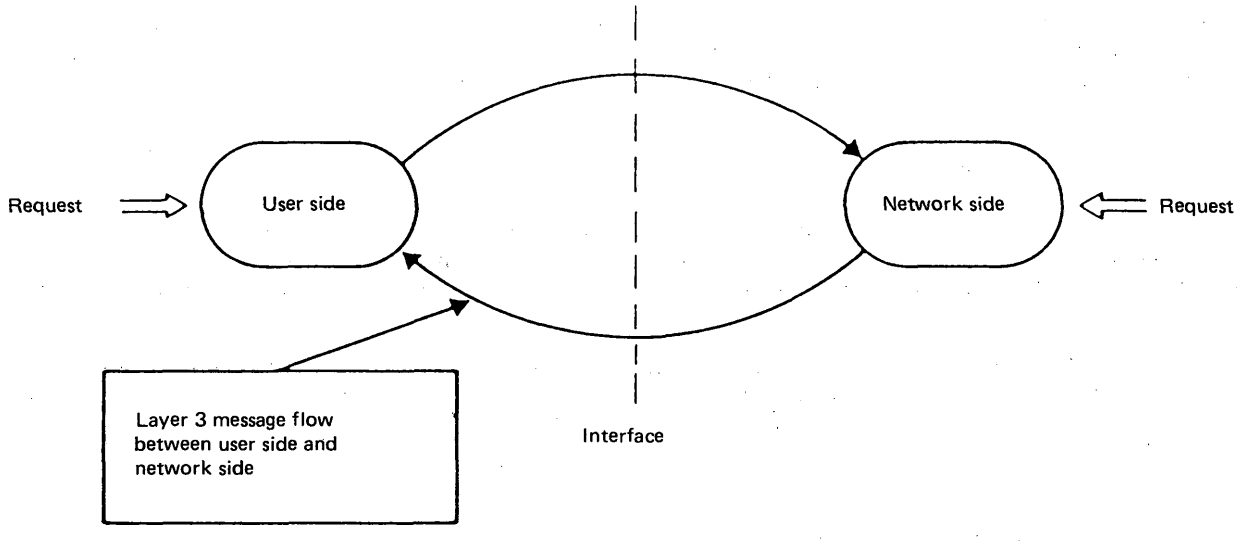
1) This Recommendation appears in the Series I Recommendations as Recommendation I.451.

The overview SDL diagrams (Figure 1/Q.931 and Figure 3/Q.931) are provided to give an overview of the procedures for a circuit-switched call. The diagrams do not show all details and show only some of the messages possible at each state, generally those messages most likely to occur at each state. Similarly, to provide a simple overview, timers and their operation are not in general shown explicitly. Internal requests from the network and user sides are shown where necessary for comprehension, but other internal messages at the user and network sides are not shown. The call reference may vary during a call and is not necessarily held for the duration of a call (e.g. call suspension).

Detailed description of the procedures for call control are given in § 5.1 in terms of the sequence of messages defined in § 3 which are transferred across the user-network interface, and the information processing and actions that take place in the terminal and the exchange in the process of call establishment and clearing. Transitions between the states defined in this section are included with the message definitions in § 3. Detailed SDL diagrams for call control of circuit-switched calls are contained in § 5.

Throughout this Recommendation, reference to B-channels is made as far as circuit-switched calls are concerned. The application of the call control procedures defined in this Recommendation to other channel types is not excluded. Further study on extending the application to other channel types is needed.



Convention for message transmission

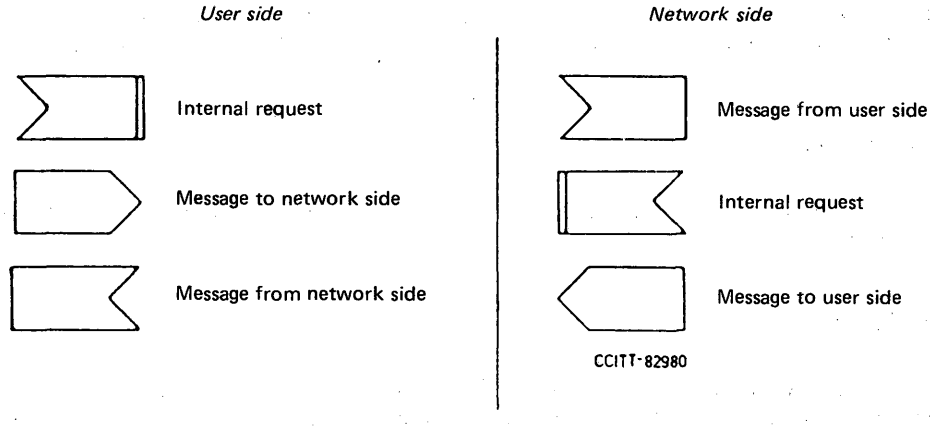


FIGURE 1/Q.931

Key to call control overview SDL diagrams

2.1.1 *Call states at the user side of the interface*

The states which may exist on the user side of the user-network interface are defined in this section.

2.1.1.1 *Null (State U0)*

No call exists.

2.1.1.2 *Call init (U1)*

This call state exists for an outgoing call, as a result of user action requesting call establishment.

2.1.1.3 *Overlap sending (U2)*

This state exists for an outgoing call while the user is sending call set-up information to the network in the overlap mode.

2.1.1.4 *Outgoing call proceeding (U3)*

This state exists for an outgoing call when the network has acknowledged receipt of the information required for the call to proceed and the user is awaiting further network response.

2.1.1.5 *Call delivered (U4)*

This state exists for an outgoing call, when the network has completed processing the call to the point of receiving alerting from the user-network interface indicated by the called address, or an alternate interface specified either by the called user or the network. In addition, in-band tones or announcements may be provided by the network.

2.1.1.6 *Negotiate (U5)*

This state exists for an incoming call, while negotiation for a suitable B-channel is in progress.

2.1.1.7 *Call received (U7)*

This state exists for an incoming call when a response/answer from the called user is awaited while alerting.

2.1.1.8 *Connect request (U8)*

This state exists for an incoming call while awaiting receipt from the network of a connect acknowledgement.

2.1.1.9 *Incoming call proceeding (U9)*

This state exists for an incoming call when the user has acknowledged receipt of the information required for the call to proceed and the network is awaiting further user response.

2.1.1.10 *Active (U10)*

This state exists when a call is in the end-to-end communication mode.

2.1.1.11 *Disconnect request (U11)*

This state exists in response to a request by the user to disconnect a call, prior to acknowledgement by the network.

2.1.1.12 *Disconnect indication (U12)*

This state exists when the network has indicated disconnect and the user has not yet indicated release or detach.

2.1.1.13 *Detach request (U13)*

This state exists when the user has requested a call be detached, prior to acknowledgement by the network.

2.1.1.14 *Detach (U14)*

This state exists when the B-channel has been released but the call has not been cleared.

2.1.1.15 *Suspend request (U15)*

This state exists in response to user action to initiate terminal move procedures locally, prior to acknowledgement by the network.

2.1.1.16 *Local suspend (U16)*

This state exists in response to a suspend request, following receipt of the acknowledgement of the suspend request by the network.

2.1.1.17 *Resume request (U17)*

This state exists in response to a request to resume a previously suspended call, prior to acknowledgement by the network.

2.1.1.18 *Release request (U19)*

This state exists in response to a release request, prior to acknowledgement by the network.

2.1.1.19 *Remote facility request (U20)*

This state exists in response to a request from the network for the activation of a facility, prior to user response.

2.1.1.20 *Local facility request (U21)*

This state exists after a request by the user to the network for the activation of a facility, prior to network response.

2.1.2 *Network call states*

The call states that may exist on the network side of the user-network interface are defined in this section.

2.1.2.1 *Null (State N0)*

No call exists.

2.1.2.2 *Dial tone sending (N1)*

This state exists for an outgoing call when the network sends dial tone prior to the receipt of the first INFO message.

2.1.2.3 *Overlap-sending (N2)*

This state exists for an outgoing call when the network is awaiting further information from the user before attempting call establishment.

2.1.2.4 *Outgoing call proceeding (N3)*

This state exists for an outgoing call when the network has acknowledged receipt of the information required for the call to proceed, and the user is awaiting further network response.

2.1.2.5 *Call-delivered (N4)*

This state exists for an outgoing call when the network is aware that compatible user equipment exists at the called user interface which can accept the call.

2.1.2.6 *Negotiate (N5)*

This state exists for an incoming call when the user and the network are attempting to select a B-channel on which to complete the call.

2.1.2.7 *Call-present (N6)*

This state exists for an incoming call when the call has been indicated by the network but no user has indicated whether the call can be accepted.

2.1.2.8 *Call-received (N7)*

This state exists for an incoming call after user equipment has indicated the start of user alerting.

2.1.2.9 *Connect request (N8)*

This state exists when an incoming call is awaiting a response to a connect message to the user.

2.1.2.10 *Incoming call proceeding (N9)*

This state exists for an incoming call when the user has acknowledged receipt of the information required for the call to proceed and the network is awaiting further user response.

2.1.2.11 *Active (N10)*

This state exists when a call is in the end-to-end communication mode.

2.1.2.12 *Disconnect-request (N11)*

This state exists after a user has indicated disconnect and the network has not yet cleared the connection.

2.1.2.13 *Disconnect-indication (N12)*

This state exists when the network has indicated disconnect and the user has not yet indicated disconnect.

2.1.2.14 *Detach Request (N13)*

This state exists when the network has requested a call be detached, prior to acknowledgement by the user.

2.1.2.15 *Detach (N14)*

This state exists when the B-channel has been released but the call has not been cleared by either the network or the user.

2.1.2.16 *Suspend request (N15)*

This state exists when the network has received a suspend request but has not yet sent a response to the user.

2.1.2.17 *Local suspend (N16)*

This state exists when the network has positively acknowledged a request for call suspension.

2.1.2.18 *Resume request (N17)*

This state exists when the network has received a resume request but has not yet sent a response to the user.

2.1.2.19 *Tone active (N18)*

This state exists after a network disconnect request when the option of sending in-band tone is used.

2.1.2.20 *Release request (N19)*

This state exists when the network has initiated the release of a call (that is, disconnection of the B-channel and release of the call reference value) and is awaiting user acknowledgement.

2.1.2.21 *Remote facility request (N20)*

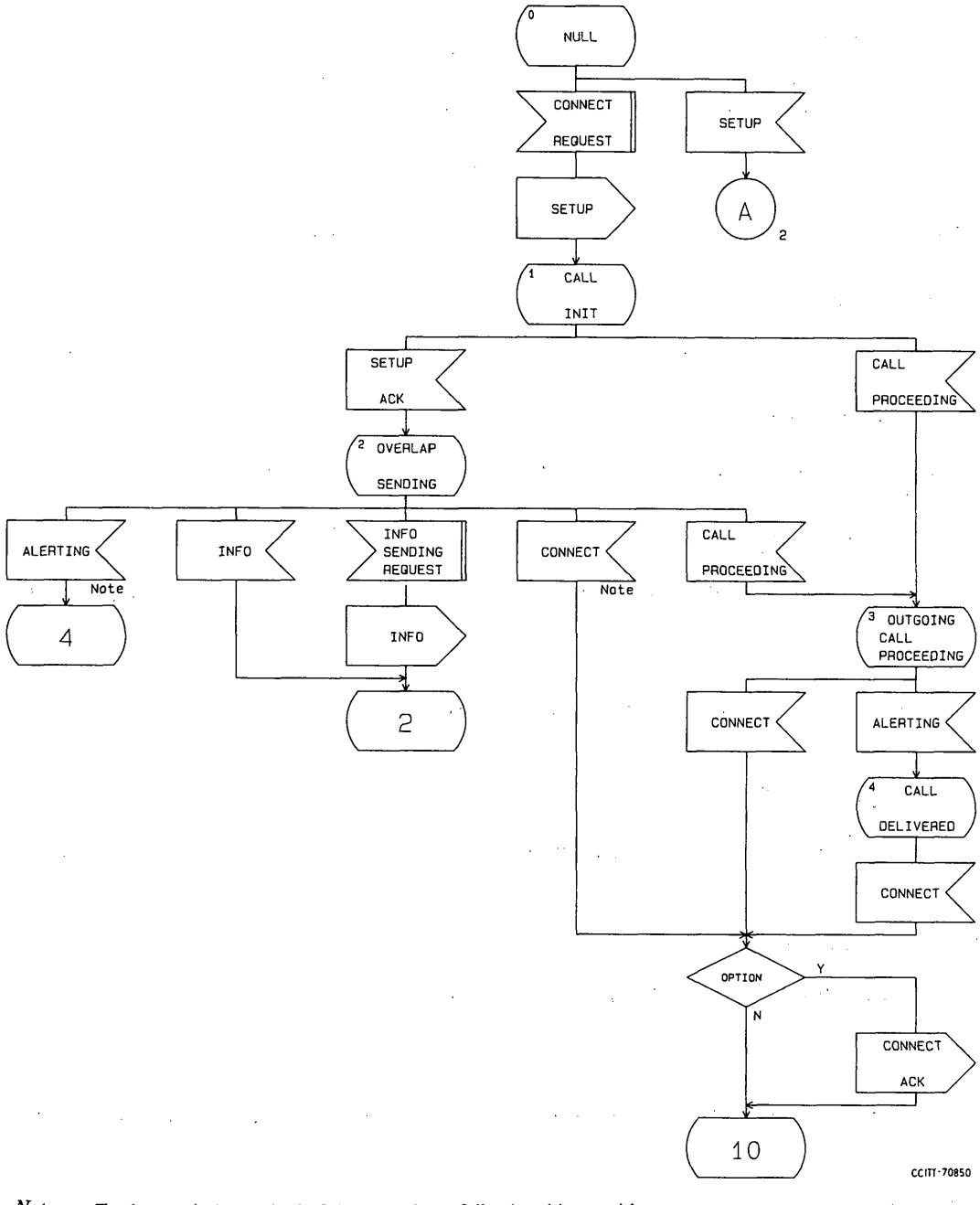
This state exists after a request from the network for the activation of a facility, prior to user response.

2.1.2.22 *Local facility request (N21)*

This state exists after a request from the user for the activation of a facility, prior to the network response.

2.1.3 *User side call control overview*

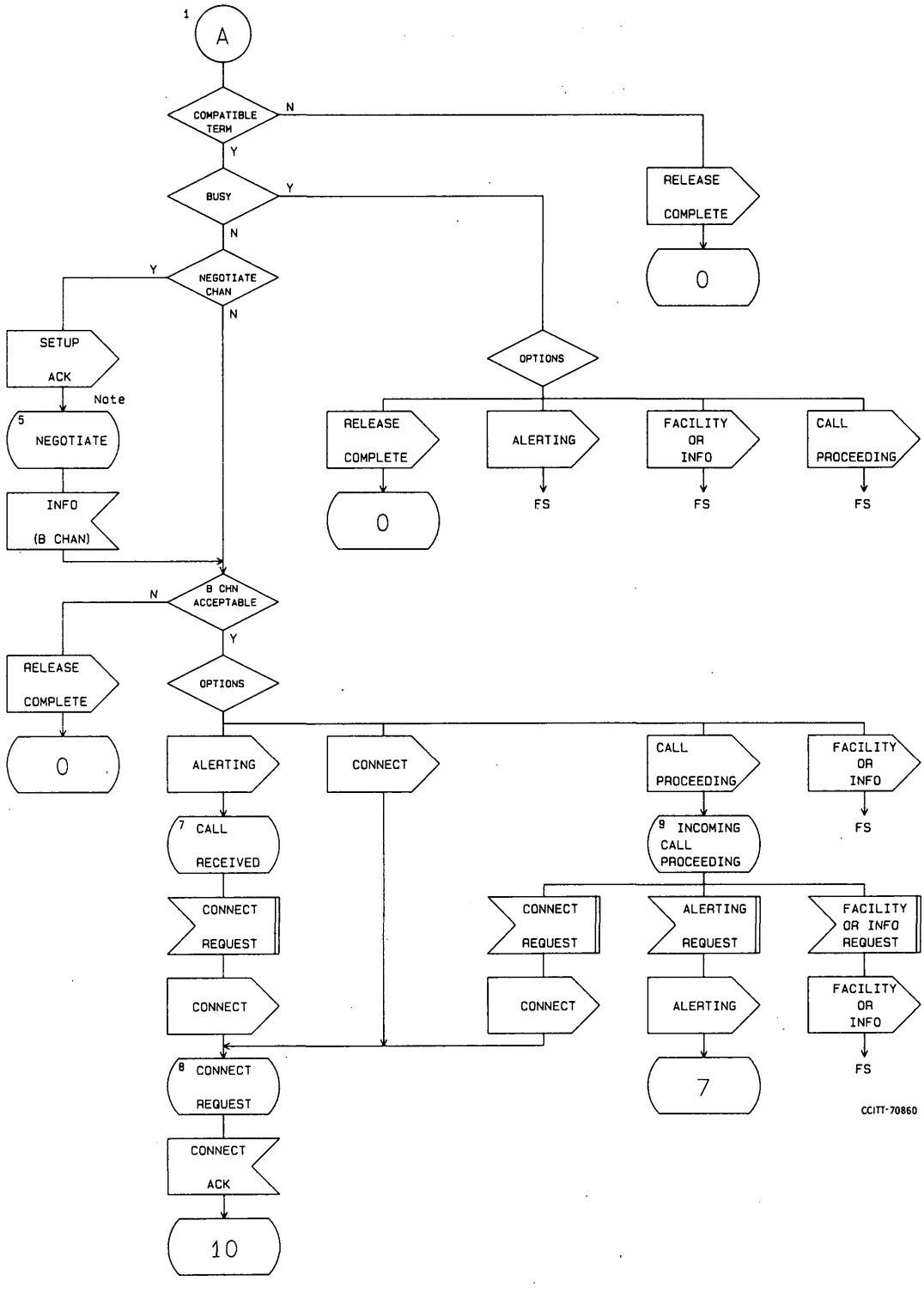
See Figure 2/Q.931.



Note — Further study is required of the procedures following this transition.

FIGURE 2/Q.931 (1 of 4)

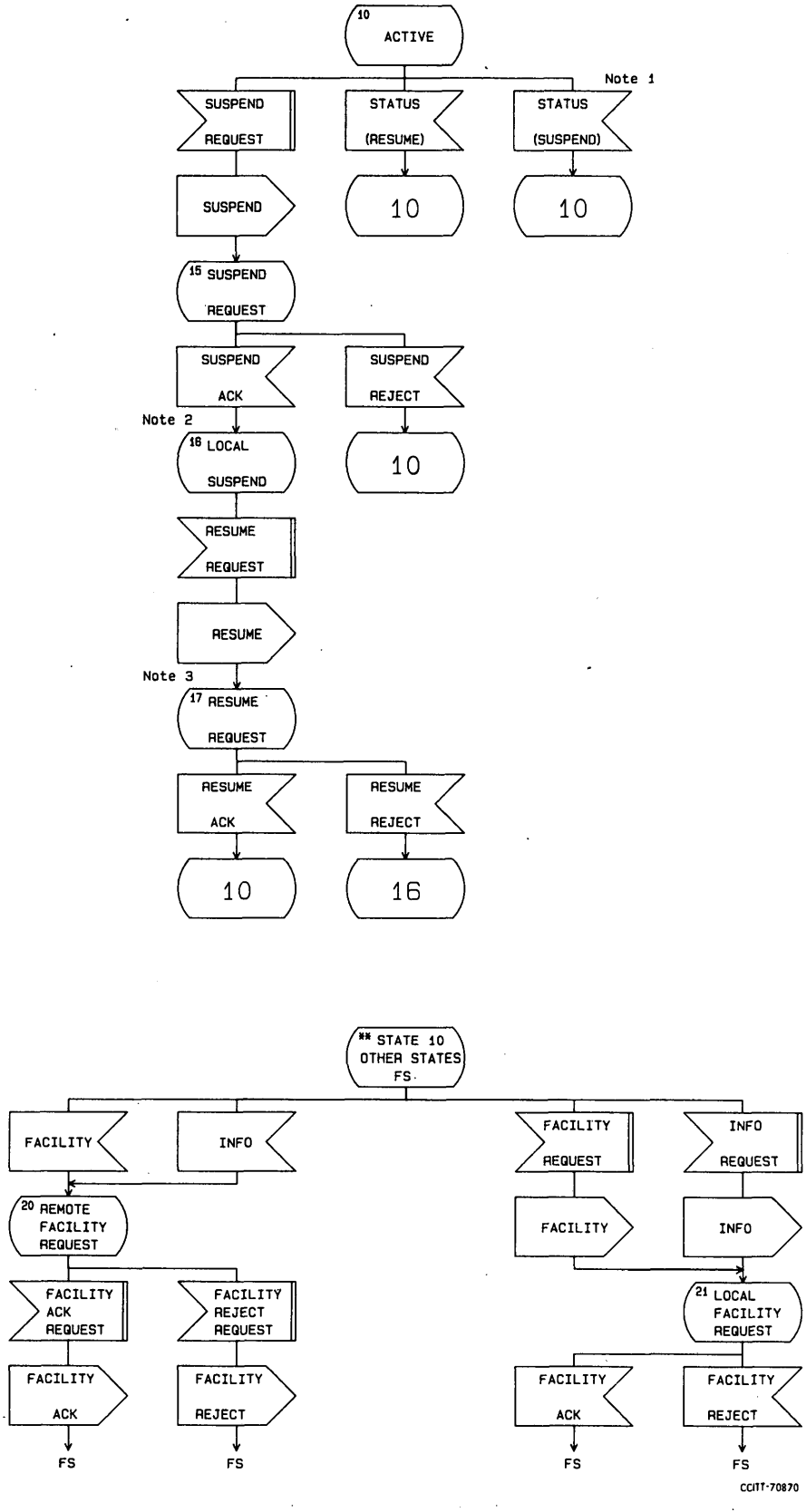
Call control overview SDL diagram (user side)



Note — Overlap sending of DDI or subaddress requires further study.

FIGURE 2/Q.931 (2 of 4)

Call control overview SDL diagram (user side)



Note 1 — Basic interface only.
Note 2 — Call reference is released at this stage.
Note 3 — B-Channel selection may take place at this stage.

FIGURE 2/Q.931 (3 of 4)

Call control overview SDL diagram (user side)

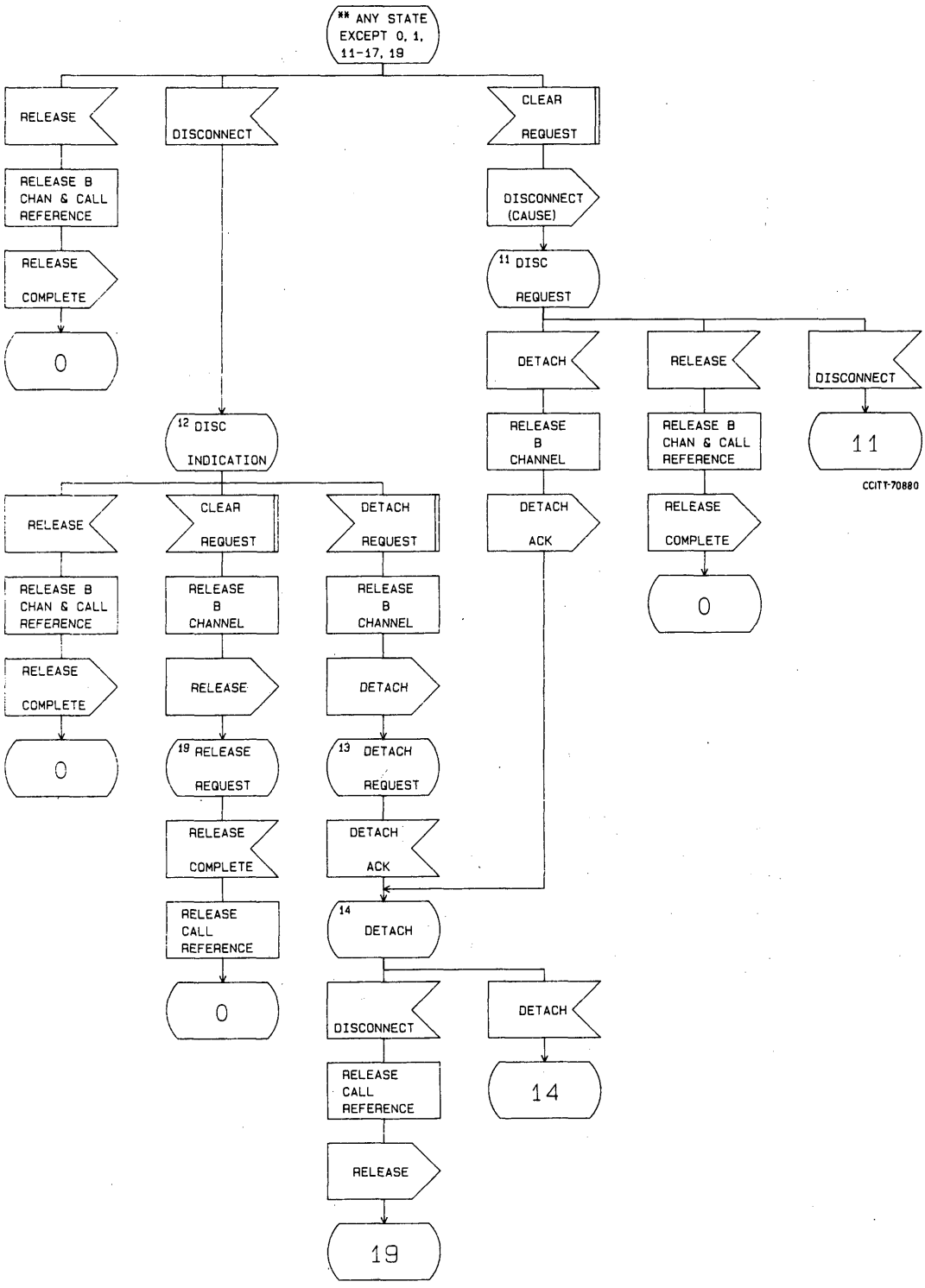
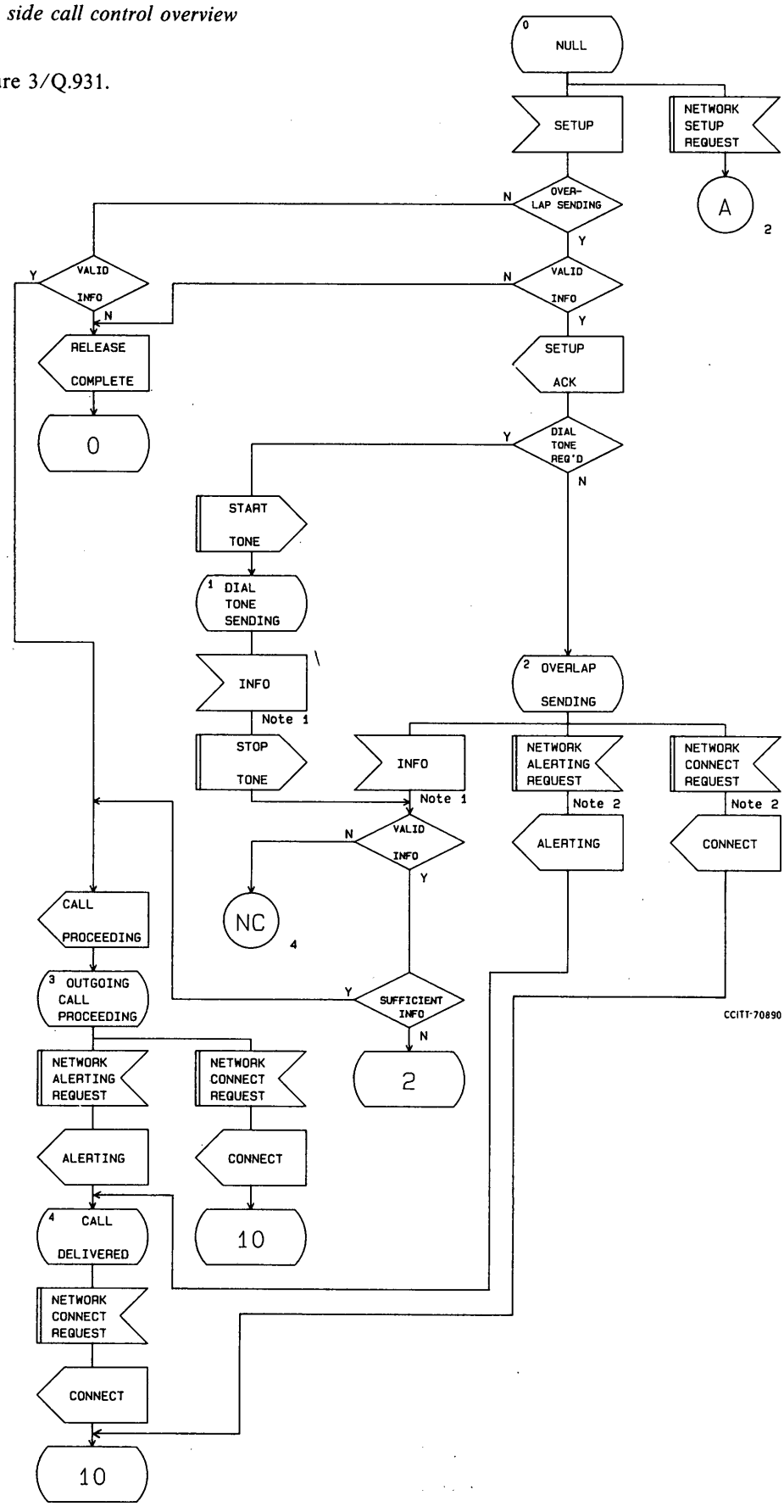


FIGURE 2/Q.931 (4 of 4)

Call control overview SDL diagram (user side)

2.1.4 *Network side call control overview*

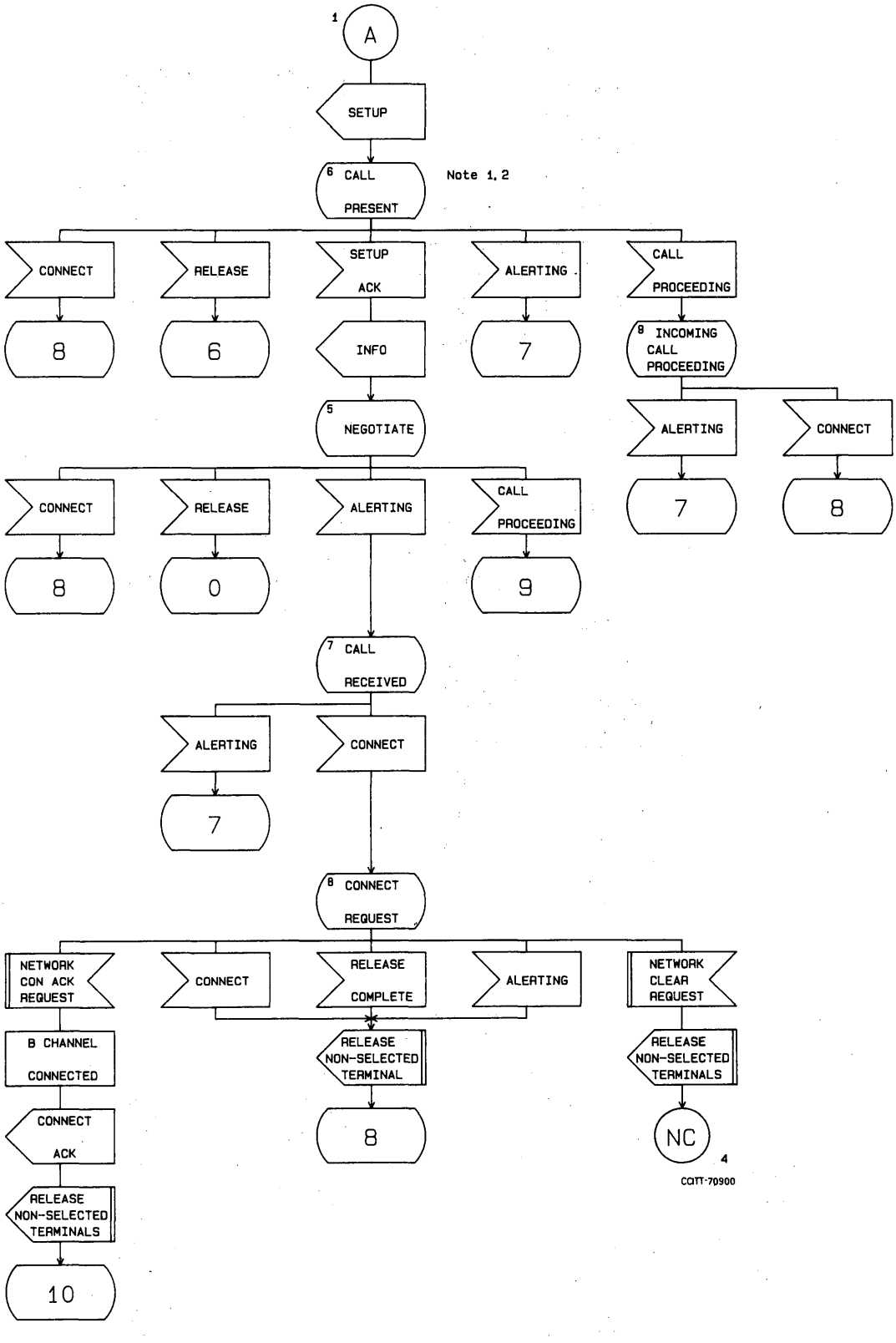
See Figure 3/Q.931.



Note 1 — The network may optionally echo each INFO (see § 6.1.1).
Note 2 — Further study is required of the procedure following this transition.

FIGURE 3/Q.931 (1 of 4)

Call control overview SDL diagram (network side)



Note 1 — For some (stimulus) terminals the network may respond with an INFO (see § 6.2).
Note 2 — Further study is required of techniques to transfer DDI and subaddress via overlap INFO messages.

FIGURE 3/Q.931 (2 of 4)

Call control overview SDL diagram (network side)

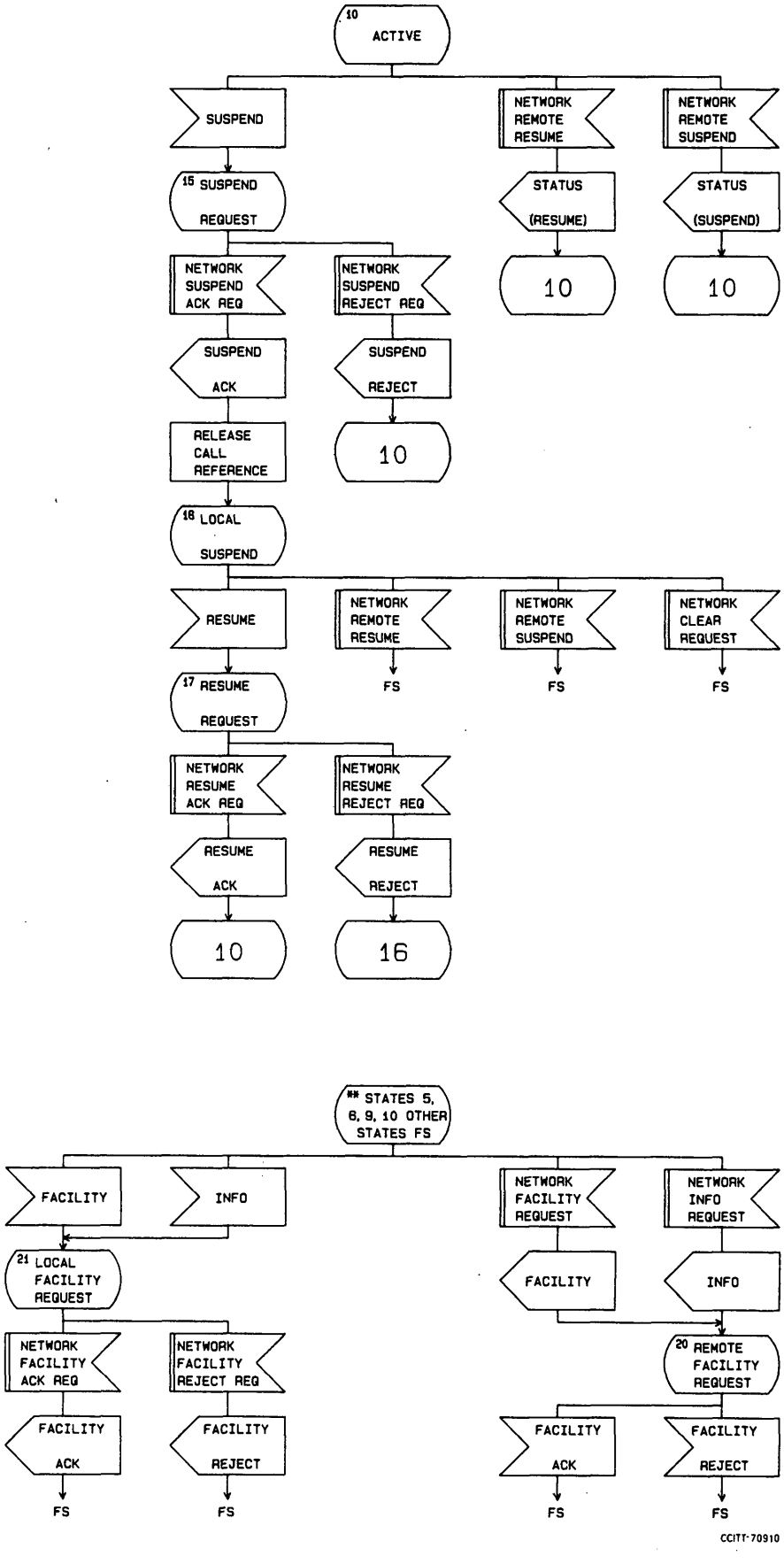
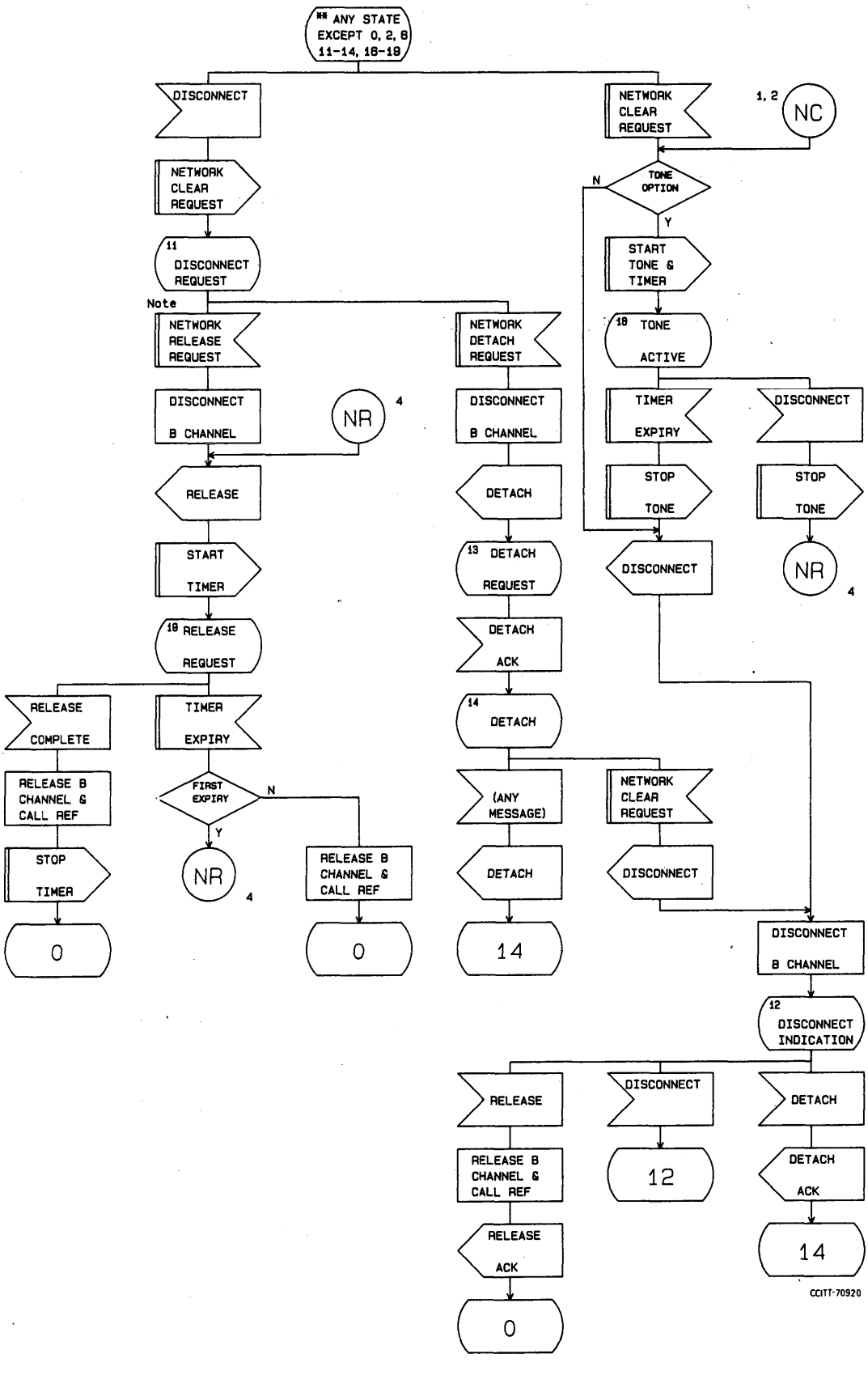


FIGURE 3/Q.931 (3 of 4)

Call control overview SDL diagram (network side)



Note — Procedures for DELAYED DISCONNECT require further study.

FIGURE 3/Q.931 (4 of 4)

Call control overview SDL diagram (network side)

2.2 *Packet-switched calls*

For further study.

2.3 *Other network services*

For further study.

3 Message functional definitions

3.1 *Overview*

Each definition includes:

a) a brief description of the message direction and use;

b) a table listing the information elements contained in the message. For each information element, the table indicates:

1) the section of this Recommendation describing the information element,

2) the direction in which it may be sent; i.e., user to network ('u→n') network to user ('n→u') or both,

3) whether inclusion is mandatory ('M') or optional ('O');

4) the length(s), in octets. '?' means the maximum length is undefined.

The information elements are listed in order of appearance in the message. The relative order of information elements is the same for all message types.

Note – All messages may contain network-specific information elements and these have not been included in any of the tables in § 3.

c) further explanatory notes, as necessary.

3.2 *Messages for circuit-mode connections*

Table 1/Q.931 summarizes the messages for circuit-mode connections.

TABLE 1/Q.931

Messages for circuit-mode connection

	Reference
Call establishment messages:	
ALERTing.	3.2.1
CALL PROCeeding.	3.2.2
CONNect.	3.2.7
CONNect ACKnowledge.	3.2.8
SETUP.	3.2.24
SETUP ACKnowledge.	3.2.25
Call information phase messages:	
RESume.	3.2.21
RESume ACKnowledge.	3.2.22
RESume REJect.	3.2.23
SUSPend.	3.2.27
SUSPend ACKnowledge.	3.2.28
SUSPend REJect.	3.2.29
USER INFOrmation.	3.2.30
Call disestablishment messages:	
DETach.	3.2.9
DETach ACKnowledge.	3.2.10
DISConnect.	3.2.11
RELease.	3.2.19
RELease COMplete.	3.2.20
Miscellaneous messages:	
CANCel.	3.2.3
CANCel ACKnowledge.	3.2.4
CANCel REJect.	3.2.5
CONgestion CONtrol.	3.2.6
FACility.	3.2.12
FACility ACKnowledge.	3.2.13
FACility REJect.	3.2.14
INFOrmation.	3.2.15
REGister.	3.2.16
REGister ACKnowledge.	3.2.17
REGister REJect.	3.2.18
STATUS.	3.2.26

3.2.1 *ALERTing*

This message is sent by the called user to the network, and by the network to the calling user, to indicate that called user alerting has been initiated.

This message is sent by called, stimulus terminals to indicate the reception of a SETUP message (see Table 2/Q.931).

TABLE 2/Q.931

ALERTing message content

Message type: ALERTing
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	O	3 – ?
Channel identification	4.5.10	u → n	O	3 – ?
Terminal capabilities	4.5.25	u → n	Note 3	3 – ?
Display	4.5.14	n → u	O	3 – ?
Redirecting address	4.5.22	both	O	4 – ?
User-user information	4.5.27	See Note 1	O	3 – Note 2

Note 1 – User-user information may be included for outgoing calls and when an incoming call was offered with the point-to-point procedure. Further study is needed on whether user-user information may be included for incoming calls offered with point-to-multipoint procedures.

Note 2 – The maximum length of the user-user information element is network dependent and is either 34 or 130 octets.

Note 3 – "M" for stimulus terminal with ALERTing is the first response to an incoming SETUP message; otherwise not included. Not included by functional equipment.

3.2.2 *CALL PROCeeding*

This message is sent to indicate that requested call establishment has been initiated, and no more call establishment information will be accepted (see Table 3/Q.931).

TABLE 3/Q.931

CALL PROCeeding message content

Message type: CALL PROCeeding
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	O	3 – ?
Channel identification	4.5.10	u → n / n → u	O / O	3 – ?
Display	4.5.14	n → u	O	3 – ?

3.2.3 *CANCel*

This message is sent by a user to request discontinuation of a facility (see Table 4/Q.931).

TABLE 4/Q.931

CANCel message content

Message type: CANCel
Direction: user to network

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	u → n	M	1
Call reference	4.3	u → n	M	1 – ?
Message type	4.4	u → n	M	1
CCITT-standardized facilities	4.5.9	u → n	See Note 1	3 – ?
Network-specific facilities	4.5.20	u → n	See Note 1	3 – ?

Note 1 – Either the CCITT-standardized facilities or network-specific facilities information element must be present.

Note 2 – The inclusion of other information elements is for further study.

3.2.4 *CANCel ACKnowledge*

This message is sent by the network to indicate discontinuation of a facility (see Table 5/Q.931).

TABLE 5/Q.931

CANCel ACKnowledge message content

Message type: CANCel ACKnowledge
Direction: network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 – ?
Message type	4.4	n → u	M	1

Note – The inclusion of other information elements is for further study.

3.2.5 *CANCel REJect*

This message is sent by the network to indicate failure to discontinue a facility (see Table 6/Q.931).

TABLE 6/Q.931

CANCel REJect message content

Message type: CANCel REJect
Direction: network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 – ?
Message type	4.4	n → u	M	1
Cause	4.5.8	n → u	M	3 – ?

Note – The inclusion of other information elements is for further study.

3.2.6 *CONgestion CONtrol*

This message is sent by the network or the user * to indicate the establishment or termination of flow control on the transmission of USERINFO messages (see Table 7/Q.931).

TABLE 7/Q.931

CONgestion CONtrol message content

Message type: CONgestion CONtrol
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both *)	M	1
Call reference	4.3	both *)	M	1 – ?
Message type	4.4	both *)	M	1
Congestion level	4.5.11	both *)	M	1
Cause	4.5.8	both *)	M	3 – ?
Display	4.5.14	both *)	O	3 – ?

*) *Note* – Application of flow control procedures by the user is for further study.

3.2.7 *CONNect*

This message is sent by the called user to the network and by the network to the calling user to indicate call acceptance by the called user (see Table 8/Q.931).

TABLE 8/Q.931

CONNect message content

Message type: CONNect
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	O	3 – ?
Connected address	4.5.12	both	O	4 – ?
Channel identification	4.5.10	u → n	O	3 – ?
CCITT-standardized facilities	4.5.9	both	O	3 – ?
Network-specific facilities	4.5.20	both	O	3 – ?
Terminal capabilities	4.5.25	u → n	Note 3	3 – ?
Display	4.5.14	n → u	O	3 – ?
Switchhook	4.5.24	u → n	O	3
Redirecting address	4.5.22	both	O	4 – ?
User-user information	4.5.27	both	O	See Note 2

Note 1 – The inclusion of bearer service and compatibility information elements for negotiation of call characteristics at establishment is for further study.

Note 2 – The maximum length of the user-user information element is network dependent and may be 34 or 130 octets.

Note 3 – "M" for stimulus terminal when CONNect is the first response to an incoming SETUP message; otherwise not included. Not included by functional equipment.

3.2.8 *CONNect ACKnowledge*

This message is sent by the network to the called user and may be sent by the calling user to the network (see Figure 9/Q.931).

TABLE 9/Q.931

CONNect ACKnowledge message content

Message type: CONNect ACKnowledge
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Channel identification	4.5.10	n → u	Note	3 – ?
Display	4.5.14	n → u	O	3 – ?
Signal	4.5.23	n → u	O	3 – ?

Note – This information element is mandatory for stimulus mode of operation.

3.2.9 *DETach*

This message is sent, from either the user or the network, to indicate that the equipment sending this message has disconnected the channel (but retain call reference), and the receiving equipment shall release the channel (but retained the call reference). (See Table 10/Q.931.)

TABLE 10/Q.931

DETach message contents

Message type: DETach
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
CCITT-standardized facilities	4.5.9	both	O	3 – ?
Network-specific facilities	4.5.20	both	O	3 – ?
Display	4.5.14	n → u	O	3 – ?
User-user information	4.5.27	both	O	3 – Note

Note – 34 or 130 octets, the value being network dependent.

3.2.10 *DETach ACKnowledge*

This message is sent by either the user or the network to indicate that the equipment sending the message has released the channel (another channel is now available for reuse). The Call Reference is retained. (See Table 11/Q.931.)

TABLE 11/Q.931

DETach ACKnowledge message contents

Message type: DETach ACKnowledge
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1

3.2.11 *DISConnect*

This message is sent by either the user or the network as an invitation to release the channel and call reference (if any). (See Table 12/Q.931.) The channel and call reference (if any) are still retained at this time.

TABLE 12/Q.931

DISConnect message contents

Message type: DISConnect
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 – ?
Display	4.5.14	n → u	O	3 – ?
User-user information	4.5.27	both	O	3 – Note

Note – 34 or 130 octets, the value being network dependent.

3.2.12 *FACility*

This message is sent by a user to initiate access to a network facility and by the network to a user when access to the facility requires user agreement (see Table 13/Q.931).

TABLE 13/Q.931

FACility message content

Message type: FACility
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
CCITT-standardized facilities	4.5.9	both	See Note 1	3 – ?
Network-specific facilities	4.5.20	both	See Note 1	3 – ?
Display	4.5.14	n → u	O	3 – ?
Origination address	4.5.2	both	O	4 – ?

Note 1 – Either the CCITT-standardized facilities or network-specific facilities information element must be present.

Note 2 – The inclusion of other information elements is for further study.

3.2.13 *FACility ACKnowledge*

This message is sent by the network to indicate start of a requested facility to a call, and by a user to indicate agreement to the use of a network facility to a call (see Table 14/Q.931).

TABLE 14/Q.931

FACility ACKnowledge message content

Message type: FACility ACKnowledge
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Display	4.5.14	n → u	O	3 – ?

Note – The inclusion of other information elements is for further study.

3.2.14 *FACility REJect*

This message is sent from the network, or a user, to indicate failure of a facility request (see Table 15/Q.931).

TABLE 15/Q.931

FACility REJect message content

Message type: FACility REJect
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 – ?
Display	4.5.14	n → u	O	3 – ?

Note – The inclusion of other information elements is for further study.

3.2.15 *INFOrmation*

This message is sent from the user to the network, or from the network to the user, to provide additional information. It may be used to provide information for call establishment (e.g. direct-dialling-in (DDI)), identify channels in channel negotiation, and to request and provide status on facilities (see Table 16/Q.931).

TABLE 16/Q.931

INFOrmation message content

Message type: INFOrmation
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Channel identification	4.5.10	both	O	3 – ?
CCITT-standardized facilities	4.5.9	u → n	O	3 – ?
Network-specific facilities	4.5.20	u → n	O	3 – ?
Display	4.5.14	n → u	O	3 – ?
Keypad	4.5.16	u → n	O	3 – ?
Keypad echo	4.5.17	n → u	O	3 – ?
Signal	4.5.23	n → u	O	3 – ?
Destination address	4.5.13	both	O	4 – ?
Transit network selection	4.5.26	u → n	O	3 – ?

Note – The need to include the compatibility information elements is for further study.

3.2.16 *REGister*

This message is sent by a user to initiate registration of a network facility, and by the network to a user when registration requires user agreement (see Table 17/Q.931).

TABLE 17/Q.931

REGister message contents

Message type: REGister
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
CCITT-standardized facilities	4.5.9	both	See Note 1	3 – ?
Network-specific facilities	4.5.20	both	See Note 1	3 – ?

Note 1 – Either the CCITT-standardized facilities or the network-specific facilities information element must be present.

Note 2 – The inclusion of other information elements is for further study.

3.2.17 *REGister ACKnowledge*

This message is sent by the network to confirm a user facility registration and by a user to indicate agreement to a facility registration when required (see Table 18/Q.931).

TABLE 18/Q.931

REGister ACKnowledge message content

Message type: REGister ACKnowledge
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Display	4.5.14	n → u	O	3 – ?

Note – The inclusion of other information elements is for further study.

3.2.18 *REGister REJect*

This message is sent by the network to indicate failure of a facility registration requested by a user, and is sent by a user to indicate refusal of the registration of a facility (see Table 19/Q.931).

TABLE 19/Q.931

REGister REJect message content

Message type: REGister REJect
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 – ?
Display	4.5.14	n → u	O	3 – ?

Note – The inclusion of other information elements is for further study.

3.2.19 *RELease*

This message is sent, from either the user or the network, to indicate that the equipment sending the message has disconnected the channel and intends to release the call reference, and that the receiving equipment should release the channel and call reference and abort any call in the process of being set up. (See Table 20/Q.931.)

TABLE 20/Q.931

RELease message content

Message type: RELease
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 – ?
Display	4.5.14	n → u	O	3 – ?
Signal	4.5.23	n → u	O	3 – ?
User-user information	4.5.27	both	O	3 – Note 1

Note 1 – The maximum length of user-user information element is network dependent and is 34 or 130 octets.

3.2.20 *RELease COMplete*

This message is sent, from either the user or the network, to indicate that the equipment sending the message has released the channel and call reference (if any), the channel is available for reuse, and the receiving equipment shall release the call reference. (See Table 21/Q.931.)

TABLE 21/Q.931

RELease COMplete message content

Message type: RELease COMplete
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 – ?
Display	4.5.14	n → u	O	3 – ?
Signal	4.5.23	n → u	O	3 – ?

3.2.21 *RESume*

This message is sent from the user to the network to request resumption of a suspended call (see Table 22/Q.931).

TABLE 22/Q.931

RESume message content

Message type: RESume
Direction: user to network

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	u → n	M	1
Call reference	4.3	u → n	M	1 – ?
Message type	4.4	u → n	M	1
Call identity	4.5.6	u → n	O	3 – ?
Channel identification	4.5.10	u → n	O	3 – ?
Terminal capabilities	4.5.25	u → n	O	3

3.2.22 *RESume ACKnowledge*

This message is sent by the network to the user to indicate completion of a request for call resumption (see Table 23/Q.931).

TABLE 23/Q.931

RESume ACKnowledge message content

Message type: RESume ACKnowledge
Direction: network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 – ?
Message type	4.4	n → u	M	1
Channel identification	4.5.10	n → u	M	3 – ?

3.2.23 *RESume REJect*

This message is sent by the network to indicate failure to complete a requested resumption of a suspended call (see Table 24/Q.931).

TABLE 24/Q.931

RESume REJect message content

Message type: RESume REJect
Direction: network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 – ?
Message type	4.4	n → u	M	1
Cause	4.5.8	n → u	M	3 – ?

3.2.24 *SETUP*

This message is sent, from either the user or the network, to indicate call establishment (see Table 25/Q.931).

TABLE 25/Q.931

SETUP message content

Message type: SETUP
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Bearer capability	4.5.5	both	M	4 – ?
Channel identification	4.5.10	u → n / n → u	O / M	3 – ?
CCITT-standardized facilities	4.5.9	both	O	3 – ?
Network-specific facilities	4.5.20	both	O	3 – ?
Terminal capabilities	4.5.25	u → n	Note 3	3
Display	4.5.14	n → u	O	3 – ?
Keypad	4.5.16	u → n	O	3 – ?
Signal	4.5.23	n → u	O	3 – ?
Switchhook	4.5.24	u → n	O	3
Origination address	4.5.21	both	O	4 – ?
Destination address	4.5.13	both	O	4 – ?
Redirecting address	4.5.22	n → u	O	4 – ?
Transit network selection	4.5.24	u → n	O	3 – ?
Low layer compatibility	4.5.18	both	O	4 – ?
High layer compatibility	4.5.15	both	O	3 – ?
User-user information	4.5.27	both	O	3 – Note 1

Note 1 – The maximum length of user-user information element is network dependent and is 34 or 130 octets.

Note 2 – The bearer service and compatibility information elements may be used to describe a CCITT telecommunication service, if appropriate.

Note 3 – "M" for stimulus terminals; not included by functional equipment.

3.2.25 *SETUP ACKnowledge*

This message is sent by the network to the calling user, and by the called user (on a primary interface structure) to the network, to indicate call establishment has been initiated but will not proceed until additional information is exchanged (see Table 26/Q.931).

TABLE 26/Q.931

SETUP ACKnowledge message content

Message type: SETUP ACKnowledge
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	n → u	O	3 – ?
Channel identification	4.5.10	both	M	3 – ?
CCITT-standardized facilities	4.5.9	both	O	3 – ?
Network-specific facilities	4.5.20	both	O	3 – ?
Display	4.5.14	n → u	O	3 – ?
Signal	4.5.23	n → u	O	3 – ?

3.2.26 *STATUS*

This message may be sent from either the user or the network at any time during a call when an unexpected message is received or to report other conditions of the call (see Table 27/Q.931).

TABLE 27/Q.931

STATUS message content

Message type: STATUS
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
Cause	4.5.8	both	M	3 – ?
Call state	4.5.7	both	M	3

3.2.27 *SUSPend*

This message is sent from the user to request suspension of a call (see Table 28/Q.931).

TABLE 28/Q.931

SUSPend message content

Message type: SUSPend
Direction: user to network

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	u → n	M	1
Call reference	4.3	u → n	M	1 – ?
Message type	4.4	u → n	M	1
Call identity	4.5.6	u → n	O	3 – ?

3.2.28 *SUSPend ACKnowledge*

This message is sent from the network to the user to indicate completion of a requested suspension of a call (see Table 29/Q.931).

TABLE 29/Q.931

SUSPend ACKnowledge message content

Message type: SUSPend ACKnowledge
Direction: network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 – ?
Message type	4.4	n → u	M	1
Display	4.5.14	n → u	O	3 – ?

3.2.29 *SUSPend REJect*

This message is sent from the network to the user to indicate failure of a requested call suspension (see Table 30/Q.931).

TABLE 30/Q.931

SUSPend REJect message content

Message type: SUSPend REJect
Direction: network to user

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	n → u	M	1
Call reference	4.3	n → u	M	1 – ?
Message type	4.4	n → u	M	1
Cause	4.5.8	n → u	M	3 – ?
Display	4.5.14	n → u	O	3 – ?

3.2.30 *USER INFOrmation*

This message is sent by a user to the network to transmit information to another user, and by the network to a user to deliver information from another user (see Table 31/Q.931).

TABLE 31/Q.931

USER INFOrmation message content

Message type: USER INFOrmation
Direction: both

Information element	Reference	Direction	Type	Length
Protocol discriminator	4.2	both	M	1
Call reference	4.3	both	M	1 – ?
Message type	4.4	both	M	1
More data indication	4.5.19	both	O	1
Display	4.5.14	n → u	See Note 1	3 – ?
User-user information	4.5.27	both	See Note 1	3 – Note 2

Note 1 – Either display or user-user information element, but not both, must be present.

Note 2 – See § 4.5.27.

3.3 *Messages for other types of connections*

Note – Other types of circuit-mode connections include leased connections as well as connections whose establishment/clearing may not occur immediately following the relevant user-to-network signalling. The exact terminology for these other types of connections is for further study by CCITT.

3.3.1 The following messages, defined in § 3.2 are used for temporary user-to-user signalling connections:

a) ALERTing,
b) CALL PROCeeding,
c) CONGestion CONTrol,
d) CONNect,
e) CONNect ACKnowledge,
f) DISConnect,
g) RELease,
h) RELease COMplete,
i) SETUP,
j) STATUS,
k) USER INFOrmation.

Note – The need for possible changes in the contents of these messages is for further study.

3.3.2 The following messages, defined in § 3.2, are used for permanent user-to-user signalling connections:

a) CONGestion CONTrol,

b) STATUS,

c) USER INFOrmation.

Note – The need for possible changes in the contents of these messages is for further study.

3.3.3 The following messages, defined in § 3.2, are used for the support of Recommendation X.25 packet-mode connections via the D-channel:

a) RELease,

b) RELease COMplete,

c) SETUP,

d) SETUP ACKnowledge,

e) STATUS.

Note – The need for possible changes in the contents of these messages is for further study.

3.3.4 The following messages, defined in § 3.2, are used for support of Recommendation X.25 packet-mode connections via the B-channel:

a) ALERTing,

b) CALL PROCeeding,

c) CONNect,

d) CONNect ACKnowledge,

e) DETach,

f) DETach ACKnowledge,

g) DISConnect,

h) RELease,

i) RELease COMplete,

j) INFOrmation,

k) SETUP,

l) STATUS.

Note – The need for possible changes in the contents of these messages is for further study.

4 Message structure

The figures and text in this section describe message contents. Within each octet, the bit designated "bit 1" is transmitted first, followed by bits 2, 3, 4, etc. Similarly, the octet shown at the top of each figure is sent first.

4.1 *Overview*

Within this protocol, every message may consist of the following parts:

a) protocol discriminator;

b) call reference;

c) message type;

d) mandatory information elements, as required;

e) additional information elements, when required.

Elements a), b) and c) are common to all the messages and must always be present, while elements d) and e) are specific to each message type.

This organization is illustrated in the example shown in Figure 4/Q.931.

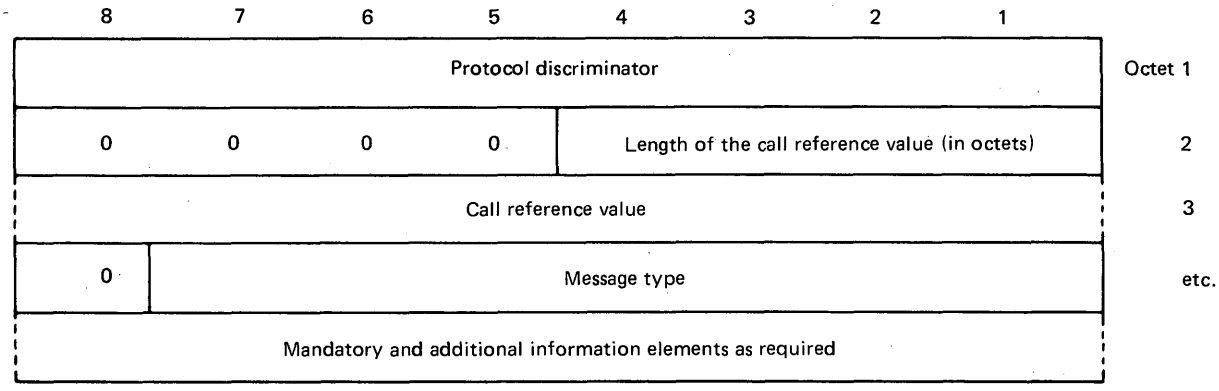


FIGURE 4/Q.931

General message organization example

A particular message may contain more information than a particular (user or network) equipment needs or can understand. All equipment should be able to ignore any extra information, present in a message, which is not required for the proper operation of that equipment. For example, a TE may ignore the originating address if that address is of no interest to the TE when a SETUP is received.

Unless specified otherwise, a particular information element may be present only once in a given message.

A particular information element may be present, but empty. For example, it is allowed to send a destination address information element which is of zero length. This should be interpreted by the receiver as equivalent to that information element being absent. Similarly, an absent information element should be interpreted by the receiver as equivalent to that information element being empty.

The term "default" implies that the value defined should be used in the absence of any assignment, or the negotiation of alternative values.

When a field, such as the call reference value, extends over more than one octet, the order of bit values progressively decreases as the octet number increases. The least significant bit of the field is represented by the lowest-numbered bit of the highest-numbered octet of that field.

4.2 *Protocol discriminator*

The purpose of the protocol discriminator is to distinguish messages for user-network call control from other messages (to be defined) within this Recommendation. It also distinguishes messages of this Recommendation from those OSI network layer protocol units which are coded to other CCITT Recommendations and other standards.

The protocol discriminator is the first part of every message. The protocol discriminator is coded according to Figure 5/Q.931 and Table 32/Q.931.

Note – The need for and the definition of a special protocol discriminator (or another mechanism) for defining layer 3 messages for testing and maintenance is for further study.

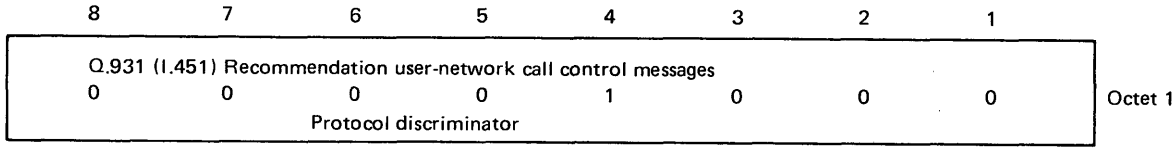


FIGURE 5/Q.931

Protocol discriminator

The protocol discriminator value is taken from Table 32/Q.931.

TABLE 32/Q.931

Protocol discriminator

	8	7	6	5	4	3	2	1	
	0	0	0	0	0	0	0	0	reserved.
through	0	0	0	0	0	0	0	1	reserved for other network layer or layer 3 protocols.
	0	0	0	0	0	1	1	1	
	0	0	0	0	1	0	0	0	Q.931 (I.451) Recommendation user-network call control messages.
through	0	0	0	0	1	0	0	1	reserved for other messages within this Recommendation.
	0	0	0	0	1	1	1	1	
through	0	0	0	1	0	0	0	0	reserved for other network layer or layer 3 protocols, including Recommendation X.25.
	0	0	1	1	1	1	1	1	
through	0	1	0	0	0	0	0	0	national use.
	0	1	0	0	1	1	1	1	
through	0	1	0	1	0	0	0	0	reserved for other network layer or layer 3 protocols, including Recommendation X.25.
	1	1	1	1	1	1	1	0	
	1	1	1	1	1	1	1	1	reserved for extension.

4.3 *Call reference*

The purpose of the call reference is to identify the call or facility registration/cancellation request at the local user-network interface to which a particular message applies. The call reference does not have end-to-end significance across ISDNs.

The call reference is the second part of every message. The call reference is coded as shown in Figure 6/Q.931. The call reference may be one or more octets long.

Provisionally, the default maximum length of the call reference for a basic user-network interface is one octet, and the default maximum length of the call reference for a primary rate multiplexed user-network interface is two octets. The term "default" shall be interpreted as in § 4.1.

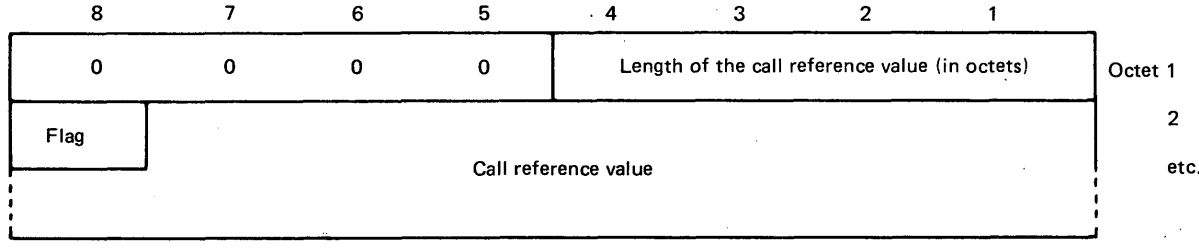
Note – Another procedure for establishing the maximum length of the call reference on an interface is for further study.

The call reference information element comprises two fields: the call reference value and the call reference flag.

Call reference values are assigned by the origination side of the interface for a call. These values are unique to the origination side only within a particular D-Channel layer two logical link connection. The call reference value is assigned at the beginning of a call and remains fixed for the lifetime of a call (except during suspension). After a call ends, or, after a successful suspension, the associated call reference value may be reassigned to a later call. Two identical call reference values on the same D-Channel layer two logical link connection may be used when each value pertains to a call originated at opposite ends of the link.

The call reference flag can take the values "0", or, "1". The call reference flag is used to identify which end of the layer two logical link originated a call. The origination side always sets the call reference flag to "0". The destination side always sets the call reference flag to a "1".

Note – The call reference information element containing a dummy call reference is one octet long and is coded "0000 0000". The dummy call reference is used for stimulus operation, and in some other cases such as certain STATUS messages.



Call reference flag

0 origination side
1 destination side

FIGURE 6/Q.931

Call reference information element

4.4 *Message type*

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

The message type is the third part of every message. The message type is coded as shown in Figure 7/Q.931 and Table 33/Q.931.

Bit 8 is reserved for possible future use as an extension bit.

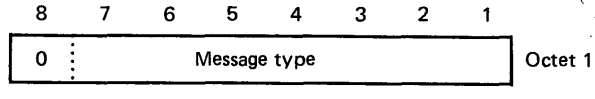


FIGURE 7/Q.931

Message type

TABLE 33/Q.931

Message types

8	7	6	5	4	3	2	1	
0	0	0	–	–	–	–	–	*Call establishment messages:*
			0	0	0	0	1	– ALERTing.
			0	0	0	1	0	– CALL PROCeeding.
			0	0	1	1	1	– CONNect.
			0	1	1	1	1	– CONNect ACKnowledge.
			0	0	1	0	1	– SETUP.
			0	1	1	0	1	– SETUP ACKnowledge.
0	0	1	–	–	–	–	–	*Call information phase messages:*
			0	0	1	1	0	– RESume.
			0	1	1	1	0	– RESume ACKnowledge.
			0	0	0	1	0	– RESume REJect.
			0	0	1	0	1	– SUSPend.
			0	1	1	0	1	– SUSPend ACKnowledge.
			0	0	0	0	1	– SUSpend REJect.
			0	0	0	0	0	– USER INFOrmation.
0	1	0	–	–	–	–	–	*Call disestablishment messages:*
			0	0	0	0	0	– DETach.
			0	1	0	0	0	– DETach ACKnowledge.
			0	0	1	0	1	– DISConnect.
			0	1	1	0	1	– RELease.
			1	1	0	1	0	– RELease COMplete.
0	1	1	–	–	–	–	–	*Miscellaneous messages:*
			0	0	0	0	0	– CANCel.
			0	1	0	0	0	– CANCel ACKnowledge.
			1	0	0	0	0	– CANCel REJect.
			1	1	0	0	1	– CONgestion CONtrol.
			0	0	0	1	0	– FACility.
			0	1	0	1	0	– FACility ACKnowledge.
			1	0	0	1	0	– FACility REJect.
			1	1	0	1	1	– INFOrmation.
			0	0	1	0	0	– REGister.
			0	1	1	0	0	– REGister ACKnowledge.
			1	0	1	0	0	– REGister REJect.
			1	1	1	0	1	– STATUS.

4.5 *Other information elements*

4.5.1 *Coding rules*

The coding of other information elements follows the coding rules described below. These rules are formulated to allow each equipment which processes a message to find information elements important to it, and yet remain ignorant of information elements not important to that equipment.

Two categories of information elements are defined:

a) single octet information elements (see Figure 8a)/Q.931);

b) variable length information elements (see Figure 8b)/Q.931).

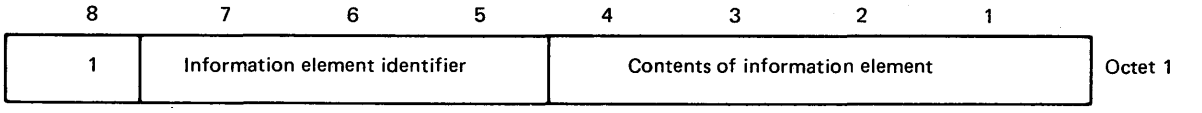
For the information elements listed below, the coding of the information element identifier bits is summarized in Table 34/Q.931.

The descriptions of the information elements below are organized in alphabetical order. However, there is a particular order of appearance for each information element in a message. The code values of the information element identifier for the variable length formats are assigned in ascending numerical order, according to the actual order of appearance of each information element in a message. This allows the receiving equipment to detect the presence or absence of a particular information element without scanning through an entire message.

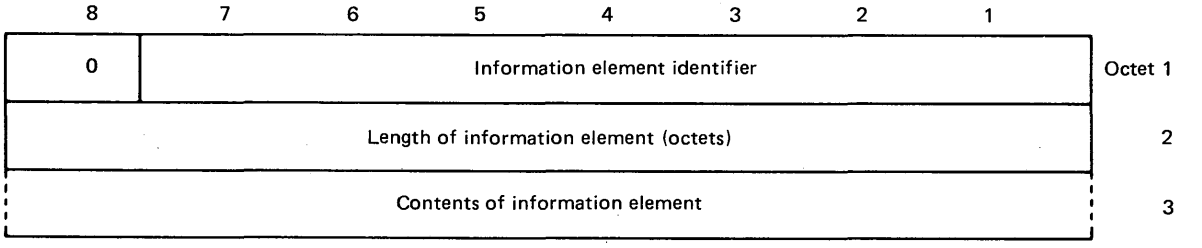
Information elements using the single octet information element identifier may appear at any point in the message.

Where the description of information elements in this Recommendation contains spare bits, these bits are indicated as being set to "0". In order to allow compatibility with future implementation, messages should not be rejected simply because a spare bit is set to "1".

The second octet of a variable length information element indicates the total length of the contents of that information element. It is the binary coding of the number of octets of the contents, with bit 1 as the least significant bit (2°).



a) Single octet information element format



b) Variable length information element format

FIGURE 8/Q.931

Formats of information elements

TABLE 34/Q.931

Information element identifier coding

8	7	6	5	4	3	2	1		Section reference
1	:	:	:	–	–	–	–	*Single octet information elements:*	
	0	0	0	–	–	–	–	reserved	
	0	0	1	–	–	–	–	shift	4.5
	0	1	0	0	0	0	0	more data	4.5.19
	0	1	1	–	–	–	–	congestion level	4.5.11
0	:	:	:	:	:	:	:	*Variable length information element:*	
	0	0	0	0	1	0	0	bearer capability	4.5.5
	0	0	0	1	0	0	0	cause	4.5.8
	0	0	0	1	1	0	0	connected address	4.5.12
	0	0	1	0	0	0	0	call identity	4.5.6
	0	0	1	0	1	0	0	call state	4.5.7
	0	0	1	1	0	0	0	channel identification	4.5.10
	0	0	1	1	1	0	0	CCITT-standardized facilities	4.5.9
	0	1	0	0	0	0	0	network-specific facilities	4.5.20
	0	1	0	0	1	0	0	terminal capabilities	4.5.25
	0	1	0	1	0	0	0	display	4.5.14
	0	1	0	1	1	0	0	keypad	4.5.16
	0	1	1	0	0	0	0	keypad echo	4.5.17
	0	1	1	0	1	0	0	signal	4.5.23
	0	1	1	0	1	1	0	switchhook	4.5.24
	1	1	0	1	1	0	0	origination address	4.5.21
	1	1	1	0	0	0	0	destination address	4.5.13
	1	1	1	0	1	0	0	redirecting address	4.5.22
	1	1	1	1	0	0	0	transit network selection	4.5.26
	1	1	1	1	1	0	0	low layer compatibility	4.5.18
	1	1	1	1	1	0	1	high layer compatibility	4.5.15
	1	1	1	1	1	1	0	user-user information	4.5.27
	1	1	1	1	1	1	1	reserved (escape)	

All other values are reserved.

4.5.2 *Extensions of codesets*

There are 136 possible information element identifier values using the formatting rules described in Section 4.5.1: 8 from the single octet information element format and 128 from the variable length information element format.

One value in the single octet format is specified for shift operations described below. One other value in both the single octet and variable format is reserved. This leaves 133 information element identifier values available for assignment.

It is possible to expand this structure to eight codesets of 133 information element identifier values each. One common value in the single octet format is employed in each codeset to facilitate shifting from one codeset to another. The contents of this shift item identifies the codeset to be used for the next information element or elements. The codeset in use at any given time is referred to as the "active codeset". By convention, codeset 0 is the initially active codeset.

Two codeset shifting procedures are supported: locking shift and non-locking shift.

Codeset 6 is reserved for information elements specific to the local serving network.

Codeset 7 is reserved for user-specific information elements.

4.5.3 *Locking shift procedure*

The locking shift procedure employs an information element to indicate the new active codeset. The specified codeset remains active until another locking shift information element is encountered which specifies the use of another codeset. For example, codeset 0 is active at the start of message content analysis. If a locking shift to codeset 7 is encountered, the next information elements will be interpreted according to the information element identifiers assigned in codeset 7, until another shift information element is encountered.

The locking shift is valid only within that message which contains the locking shift information element. At the start of every message content analysis, the active codeset is codeset 0.

The locking shift information element uses the single octet information element format and coding shown in Figure 9/Q.931 and Table 35/Q.931.

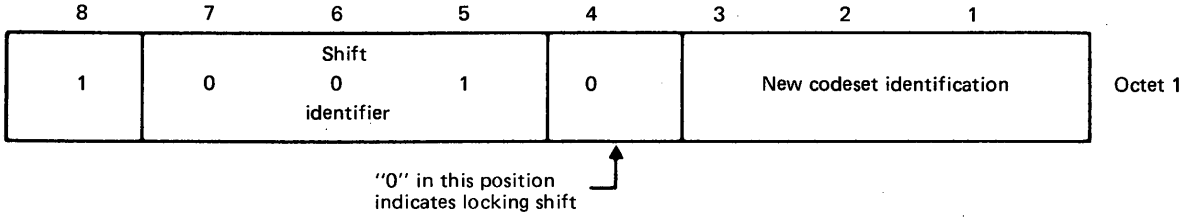


FIGURE 9/Q.931

Locking shift element

TABLE 35/Q.931

Locking shift element

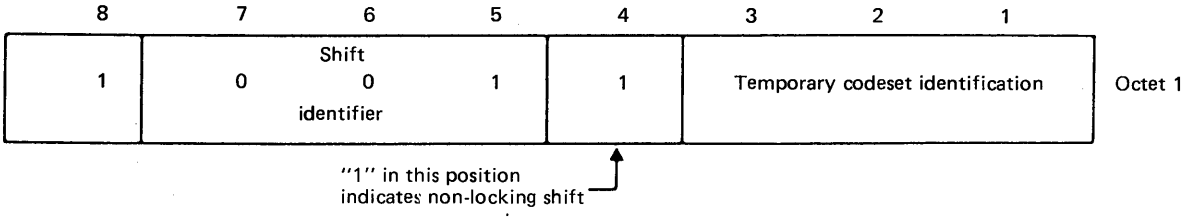
Codeset identification (bits 3 to 1):

3	2	1	
0	0	0	codeset 0 (initially active): Q.931 (I.451) information elements
0	0	1	reserved
to			
1	0	1	
1	1	0	codeset 6: information elements specific to the local serving network
1	1	1	codeset 7: user-specific information elements

4.5.4 *Non-locking shift procedure*

The non-locking shift procedure provides a temporary shift to the specified codeset. The non-locking shift procedure uses a single octet information element to indicate the codeset to be used to interpret the next single information element. After the interpretation of the next single information element, the active codeset is again used for interpreting any following information elements. For example, codeset 0 is active at the beginning of message content analysis. If a non-locking shift to codeset 6 is encountered, *only* the next information element is interpreted according to the information element identifiers assigned in codeset 6. After this information element is interpreted, codeset 0 will again be used to interpret the following information elements.

The non-locking shift information element uses the single octet information element format and coding shown in Figure 10/Q.931.



Note — The codeset identification is coded as shown in Figure 9/Q.931.

FIGURE 10/Q.931

Non-locking shift element

4.5.5 *Bearer capability*

The purpose of the bearer capability information element is to indicate provision, by the network, of one of the bearer capabilities as defined in Recommendation I.201.

The bearer capability information element is coded as shown in Figure 11/Q.931 and Tables 36a/Q.931 to 36d/Q.931. The bearer capability information element may be repeated in a message to identify multiple services, e.g., in individual transit networks.

No default bearer capability may be assumed by the absence of this information element.

8	7	6	5	4	3	2	1	
0	Bearer capability 0	0	0	0	1	0	0	Octet 1
	Information element identifier							
Length of the bearer service identification								2
1	Coding standard		Information transfer capability					3
0/1 Ext.	Transfer mode		Information transfer rate					4
0/1 Ext.	Structure			Configuration		Establishment		4a[a]
0/1 Ext.	Symmetry		Information transfer rate (destination → origination)					4b[b]
0/1 Ext.	Multiplier or layer identification		Bearer capability multiplier/protocol identification					5[c]

a) This octet may be omitted, unless octet 4b is present.

b) This octet may be omitted. If present, octet 4a shall also be present.

c) This octet may be omitted. This octet may be repeated; e.g., to identify several protocols at one or more layers.

FIGURE 11/Q.931

Bearer capability information element

TABLE 36a/Q.931

Bearer capability information element

Extension bit (octets 4, 4a, 5,)

Bit 8	
0	this octet continues through the next octet (e.g., octet 4 continues to octet 4a, or octet 4a to 4b)
1	last octet

Coding standard (octet 3):

Bits 7 6	
0 0	CCITT standardized in this Recommendation
0 1	reserved for other international standards
1 0	national standard
1 1	standard specific to the network present on the network side of the interface

Information transfer capability (octet 3)

Bits 5 4 3 2 1	
0 1 0 0 0	unrestricted digital information
0 1 0 0 1	restricted digital information (Note 1)
1 0 0 0 0	3.1 kHz audio
1 0 0 0 1	7 kHz audio
1 0 0 1 0	15 kHz audio
1 1 0 0 0	Video

All other values are reserved.

Note 1 – Only permitted in conjunction with 64 kbit/s information transfer rate; see Recommendation I.340, Appendix 1, for details.

Note 2 – The coding of these fields has been aligned with Recommendation I.211.

Transfer mode (octet 4)

Bits 7 6	
0 0	circuit mode
1 0	packet-mode

All other values are reserved for further study.

Information transfer rate (octet 4 and 4b, bits 5 to 1)

Bits 5 4 3 2 1	*Circuit mode*	*Packet-mode*
0 0 0 0 0	channel size	(Note 1)
1 0 0 0 0	64 kbit/s	–
1 0 0 1 1	384	–
1 0 1 0 1	1536	–
1 0 1 1 1	1920	–

All other values are for further study.

Note 1 – The definition of throughput rates for packet-mode bearer capabilities is for further study; "00000" shall be used for packet-mode calls.

Note 2 – When octet 4b is omitted, the bearer capability is bidirectional symmetric at the information transfer rate specified in octet 4. When octet 4b is included, the information transfer rate in octet 4 refers to the origination $\longrightarrow$ destination direction.

TABLE 36b/Q.931

Bearer capability information element

Structure (octet 4a)

Bits 7 6 5	
0 0 0	default (see Note 1)
0 0 1	8 kHz integrity (Note 2)
1 0 0	service data unit integrity
1 1 1	unstructured

Note 1 – If octet 4a is omitted, or the structure field is coded "000", then the value of the structure attribute is according to the following:

transfer mode	*transfer capability*	*structure*
circuit	speech	8 kHz integrity
circuit	unrestricted digital	8 kHz integrity
circuit	restricted digital	8 kHz integrity
circuit	audio	8 kHz integrity
circuit	video	8 kHz integrity
packet	unrestricted digital	service data unit integrity

Note 2 – Terminology has been aligned with Recommendation I.130.

Configuration (octet 4a)

Bits 4 3	
0 0	point-to-point
1 0	multipoint

All other values are reserved for further study.

Note – If octet 4a is omitted, the configuration is assumed to be point-to-point.

Establishment (octet 4a)

Bits 2 1	
0 0	demand

further study: reserved permanent

All other values are reserved for further study.

Note – If octet 4a is omitted, the method of establishment is assumed to be "demand".

TABLE 36c/Q.931

Bearer capability information element

Symmetry (octet 4b)

Bits 7 6	
0 0	bidirectional symmetric
0 1	bidirectional asymmetric
1 0	unidirectional (origination → destination)
1 1	unidirectional (destination → origination)

Note – If octet 4b is omitted, bidirectional symmetric is assumed.

Layer and protocol identification (octet 5)

Bits 7 6	
0 0	bearer capability multiplier: bits 5-1 represent the number (binary encoding) of instances of bearer capability requested; e.g. "00010" means two instances of the described bearer capability are requested.
0 1	user information layer 1 protocol.

Bits 5 4 3 2 1	
0 0 0 0 0	Recommendation I.412; no additional layer 1 protocol specified for this bearer capability.
0 0 0 0 1	Rate adaption: the extension bit in this octet is set to "0" and the following octet is coded:

8	7	6	5	4	3	2	1
1	0	0					
	spare						
			rate				

The rate is encoded as follows:

Bits 5 4 3 2 1	synchronous rate
0 0 0 0 0	–
0 0 0 0 1	0.6 kbit/s, Recommendation X.1 and I.461
0 0 0 1 0	1.2 kbit/s, Recommendation X.1 and I.461
0 0 0 1 1	2.4 kbit/s, Recommendation X.1 and I.461
0 0 1 0 0	3.6 kbit/s, Recommendation V.6 and I.463
0 0 1 0 1	4.8 kbit/s, Recommendation X.1 and I.461
0 0 1 1 0	7.2 kbit/s, Recommendation V.6 and I.463
0 0 1 1 1	8 kbit/s, Recommendation I.460
0 1 0 0 0	9.6 kbit/s, Recommendation X.1 and I.461
0 1 0 0 1	14.4 kbit/s, Recommendation V.6 and I.463
0 1 0 1 0	16 kbit/s, Recommendation I.460
0 1 0 1 1	19.2 kbit/s, Recommendation I.463
0 1 1 0 0	32 kbit/s, Recommendation I.460
0 1 1 1 0	48 kbit/s, Recommendation X.1 and I.461
0 1 1 1 1	56 kbit/s, Recommendation I.463

0 0 0 1 0	Recommendation G.711 μ-law speech
0 0 0 1 1	Recommendation G.711 A-law speech
0 0 1 0 0	Recommendation G.721 32 kbit/s ADPCM and Recommendation I.460

All other values are reserved for further study.

TABLE 36d/Q.931

Bearer capability information element

Bits
1 0 User information layer 2 protocol:

Bits 5 4 3 2 1	
0 0 0 0 0	undefined
0 0 0 1 0	Recommendation Q.921 (I.441)
0 0 1 0 0	Recommendation Q.710
0 0 1 1 0	Recommendation X.25, link level

All other values are reserved for further study.

Bits
1 1 User information layer 3 protocol:

Bits 5 4 3 2 1	
0 0 0 0 0	undefined
0 0 0 1 0	Recommendation Q.931/(I.451)
0 0 1 1 0	Recommendation X.25, packet level

All other values are reserved for further study.

Note – If octet 5 is omitted, the user information low layer protocols are assumed to be undefined. Octet 5 *may* be omitted if the transfer mode is "circuit-mode" *and* the information transfer capability is "unrestricted digital information" or "restricted digital information"; otherwise octet 5 must be provided.

4.5.6 *Call identity*

The purpose of the call identity information element is to identify the suspended call. The call identity provided by the user is guaranteed by the network to be unique over a domain of interfaces where the call may be resumed. The call identity is assigned at the start of the call suspension, and is available for re-use after the resume procedure has completed successfully.

The call identity information element is coded as shown in Figure 12/Q.931.

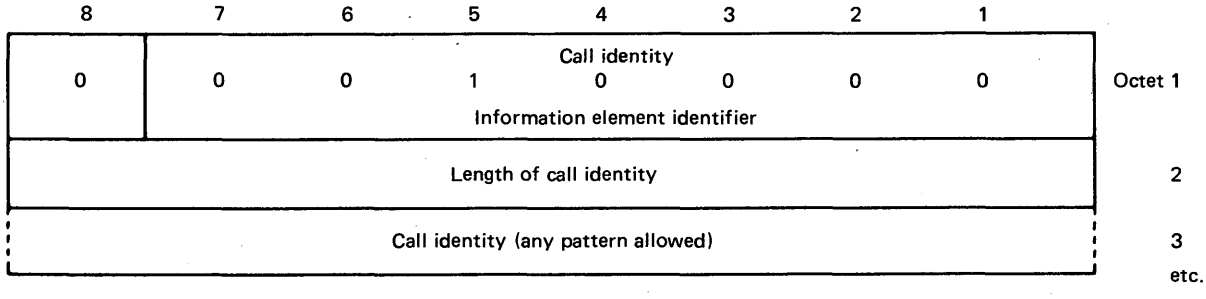


FIGURE 12/Q.931

Call identify information element

4.5.7 *Call state*

The purpose of the call state information element is to describe the current status of a call.

The call state information element is coded as shown in Figure 13/Q.931 and Table 37/Q.931.

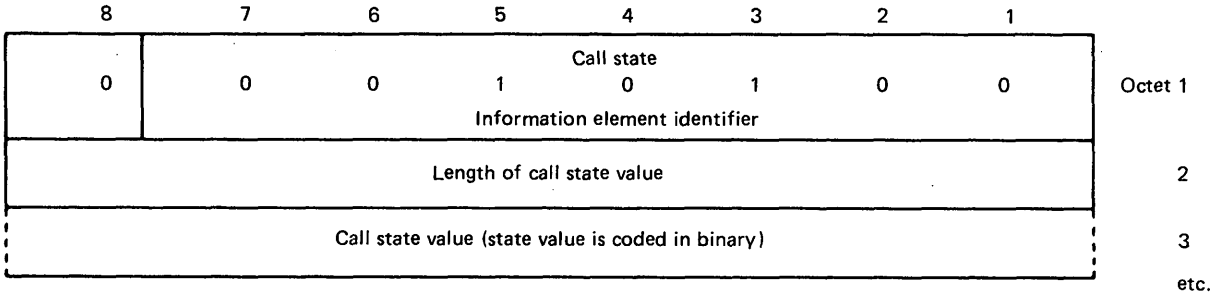


FIGURE 13/Q.931

Call state information element

TABLE 37/Q.931

Call state information element

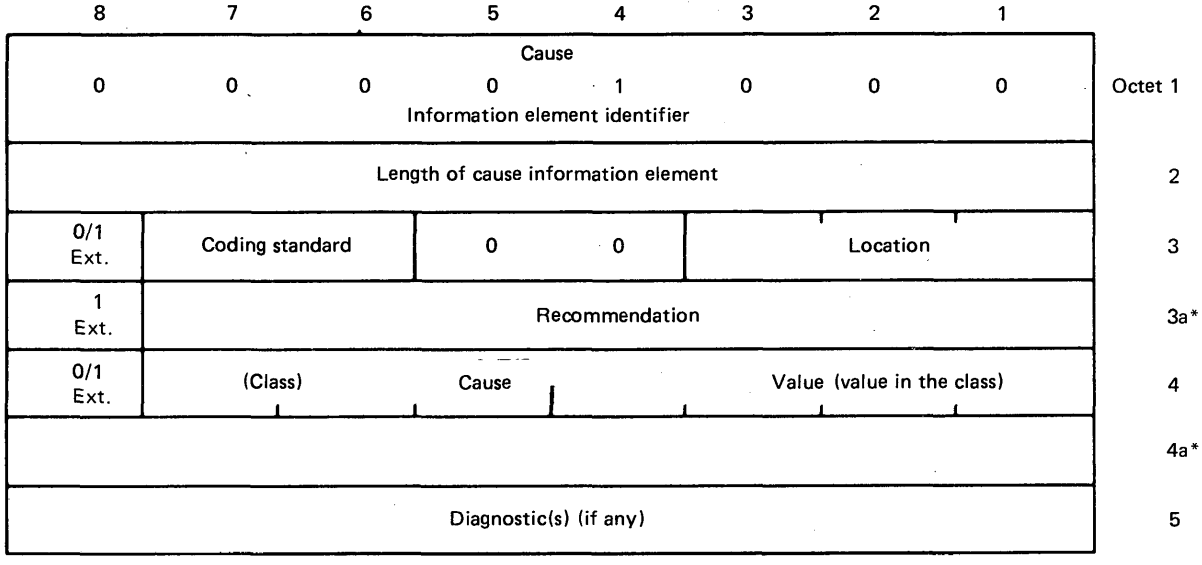
State value (octet 3)	User state	Network state
0	Null	Null
1	Call init	Dial tone sending
2	Overlap-sending	Overlap-sending
3	Outgoing call proceeding	Outgoing call proceeding
4	Call delivered	Call delivered
5	Negotiate	Negotiate
6	–	Call present
7	Call received	Call received
8	Connect request	Connect request
9	Incoming call proceeding	Incoming call proceeding
10	Active	Active
11	Disconnect request	Disconnect request
12	Disconnect indication	Disconnect indication
13	Detach request	Detach request
14	Detach	Detach
15	Suspend request	Suspend request
16	Local suspend	Local suspend
17	Resume request	Resume request
18	–	Tone active
19	Release request	Release request
20	Remote facility request	Remote facility request
21	Local facility request	Local facility request

4.5.8 *Cause*

The purpose of the cause information element is to describe the reason for generating certain messages, to provide diagnostic information in the event of procedural errors and to indicate the location of the cause originator.

The cause information element is coded as shown in Figure 14/Q.931 and Tables 38a/Q.931 to 38d/Q.931. Diagnostic information is not available for every cause. When available the coding of the diagnostic(s) is the same as for the corresponding information element in § 4 (some code formats are for further study).

The cause information element and diagnostic may be repeated in a message, e.g. to report multiple errors associated with a single call.



* This octet may be omitted.

FIGURE 14/Q.931

Cause information element

TABLE 38a/Q.931

Cause information element

Coding standard (octet 3)

Bits 7 6	
0 0	CCITT standard
0 1	reserved for other international standards
1 0	national standard
1 1	standard specific to identified location

Location (octet 3)

Bits 3 2 1	
0 0 0	user
0 0 1	local private network
0 1 0	local network
0 1 1	transit network
1 0 0	remote local network
1 0 1	remote private network

All other values are reserved.

Recommendation (octet 3a)

Bits 7 6 5 4 3 2 1	
0 0 0 0 0 0 0	Q.930/I.450 (default if octet 3a is omitted)
0 0 0 0 0 0 1	reserved for I.211, pending further study
0 0 0 0 0 1 0	reserved for I.212, pending further study
0 0 0 0 0 1 1	X.21
0 0 0 0 1 0 0	X.25

All other values are reserved.

TABLE 38b/Q.931

Cause information element

Cause value (octet 4)

The cause value is divided in two fields, a class (bits 5 through 7) and a value within the class (bits 1 through 4).

The class indicates the general nature of the event:

Class (001): normal event
Class (010): network congestion
Class (011): service or option not available
Class (100): service or option not implemented
Class (101): invalid message (e.g. parameter out of range)
Class (110): protocol error (e.g. unknown message)

TABLE 38c/Q.931

Cause information element

Cause value		Cause number	Cause	Diagnostics
Class	Value			
765	4321	–		
001	0001	17	User busy	Destination address
001	0010	18	No user responding	Destination address
001	0011	19	This call waiting at destination	Destination address
001	0100	20	Circuit operational	Circuit identity
001	0101	21	Call rejected	User supplied diagnostic
001	0110	22	Number changed	Destination address, new destination address
001	0111	23	Reverse charging rejected	Destination address
001	1000	24	Call suspended	Suspending address
001	1001	25	Call resumed	Resuming address
010	0001	33	Circuit out of order	Circuit identity
010	0010	34	No channel available	–
010	0011	35	Destination not obtainable	Destination address
010	0100	36	Out of order	Destination address
010	0101	37	Degraded service (e.g., excessive error rate)	–
010	0110	38	Network out of order	Transit network identity
010	0111	39	Transit delay range cannot be achieved	Minimum available transit delay
010	1000	40	Throughput range cannot be achieved	Maximum available throughput
010	1001	41	Network failure	Destination address
010	1010	42	Network congestion	Network identity
010	1011	43	User information discarded	Copy of first 32 octets of user-user information element
011	0001	49	Overlap sending not allowed	–
011	0010	50	Requested facility not subscribed	Network identity, facility
011	0011	51	Reverse charging not allowed	–
011	0100	52	Outgoing calls barred	–
011	0101	53	Outgoing calls barred within CUG	CUG identity
011	0110	54	Incoming calls barred	Destination address; optional user specified information
011	0111	55	Incoming calls barred within CUG	CUG identity, destination address
011	1000	56	Call waiting not subscribed	Destination address
100	0001	65	Bearer service not implemented	Service type
100	0010	66	Channel type not implemented	Channel type
100	0011	67	Transit network selection not implemented	–
100	0100	68	Message not implemented	Message type
100	0101	69	Requested facility not implemented	Network identity, facility
100	0110	70	Only restricted digital information bearer capability is available	–

TABLE 38d/Q.931

Cause information element

Cause value		Cause number	Cause	Diagnostics
Class	Value			
765	4321	–		
101	0001	81	Invalid call reference value	Call reference value
101	0010	82	Identified channel does not exist	Channel identity
101	0011	83	Call identity does not exist	Call identity
101	0100	84	Call identity, in use	Call identity
101	0101	85	Invalid digit value for number	Address information element
101	0110	86	Non-existent closed user group	CUG member
101	0111	87	Destination address not member of CUG	Destination address, CUG member
101	1000	88	Incompatible destination	Destination address, incompatible parameter
101	1001	89	Non-existent abbreviated address entry	Copy of address element
101	1010	90	Destination address missing, and direct call not subscribed	–
101	1011	91	Transit network does not exist	Transit network identity
101	1100	92	Invalid facility parameter	Network identity facility
101	1101	93	Mandatory information element is missing	Information element identifier
110	0001	97	Message type non-existent or not implemented	Message type
110	0010	98	Message not compatible with call state	Message type
110	0011	99	Information element non-existent or not implemented	Information element
110	0100	100	Invalid information element contents	Information element

All other values are reserved.

4.5.9 *CCITT-standardized facilities*

The purpose of the CCITT-standardized facilities information element is to indicate which CCITT-standardized binary facilities are being invoked. "Binary facilities" are those which do not require a parameter. Facilities requiring information elements with parameters are separately invoked. These information elements are for further study.

The facilities information element is coded as shown in Figure 15/Q.931.

The facilities are given in Table 39/Q.931. This table also identifies which facilities may be invoked on a per-call basis, and which may be invoked to apply continuously to all interface operations after invocation.

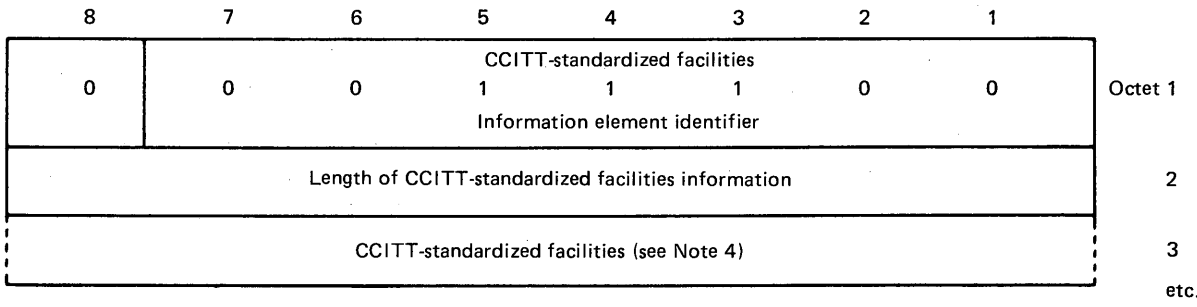


FIGURE 15/Q.931

CCITT-standardized facilities information element

TABLE 39/Q.931

CCITT-standardized facilities information element

Per call	Continuous	CCITT-standardized facility invoked when set to "1"
x	x	Delivery of origination address barred
x	x	Connected address required
x	x	Supply charging information after end of call
x		Reverse charging requested
x	x	Connect outgoing calls when free
x	x	Reverse charging acceptance (allowed)
x		Call redirection/diversion notification. Note 3
x		Call completion after busy request
x		Call completion after busy indication
	x	Origination address required on outgoing calls
	x	Origination address desired on incoming calls
	x	Destination address required on incoming calls
	x	Connect incoming calls when free (waiting allowed)
	x	X.25 extended packet sequence numbering (modulo 128)
	x	X.25 flow control parameter negotiation allowed
	x	X.25 throughput class negotiation allowed
	x	X.25 packet retransmission (allowed)
	x	X.25 fast select (outgoing) (allowed)
	x	X.25 fast select acceptance allowed
	FS	X.25 multilink procedure
	x	Local charging prevention
	x	X.25 extended frame sequence numbering

Note 1 – Names used to describe the above facilities are provisional. Final choice of facility name and definition is for further study.

Note 2 – Other facilities are for further study.

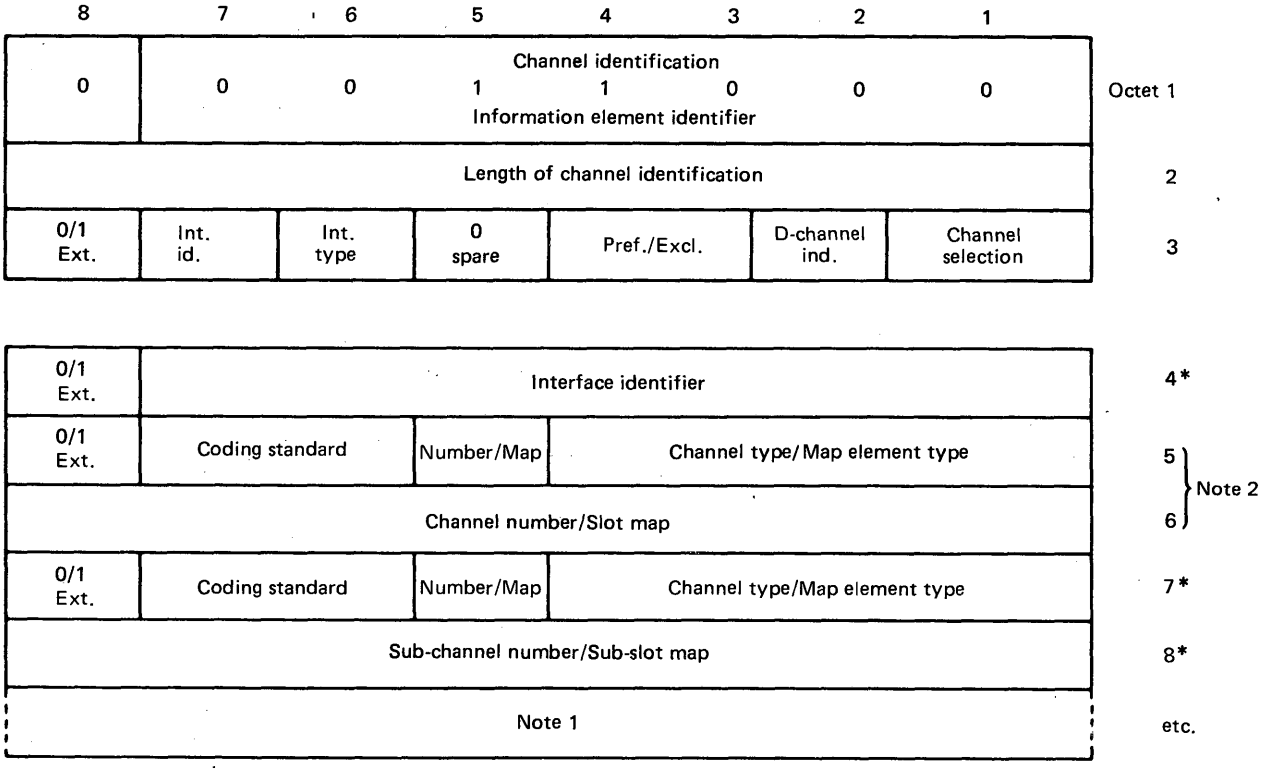
Note 3 – Classification of similarities and differences between redirection and diversion is for further study.

Note 4 – The coding of this information element is for urgent further study.

4.5.10 *Channel identification*

The purpose of the channel identification information element is to identify a channel or subchannel within the interface(s) controlled by these signalling procedures.

The channel identification information element is coded as shown in Figures 16/Q.931, 17/Q.931, 18/Q.931 and 19/Q.931 and Tables 40a/Q.931 to 40c/Q.931. The channel identification information element may be repeated in a message; e.g. to list several acceptable channels during channel negotiation.



Note 1 — Octets 7, 8, etc., can be repeated to indicate the sub-unit (e.g. sub-sub-channel) of the unit inidcated by the preceding format (e.g. sub-channel).

Note 2 — When the "Interface type" field in octet 3 indicates "basic interface", octets 5 and 6 are functionally replaced by the "channel selection" field in octet 3, and thus omitted.

Note 3 — Octets with * may be omitted.

Note 4 — Existence of sub-channel indication (octet 7, 8) is implicitly indicated by "Length of channel identifier" in octet 2.

FIGURE 16/Q.931

Channel identification information element

TABLE 40a/Q.931

Channel identification information element

Extension bit (octet 3, 4, 5, 7)

0: description is extended through the next octet

1: last octet of the description

Interface identifier present (octet 3)

0: interface implicitly identified (Note)

Note – The interface which includes the D-channel carrying this information element is indicated.

1: interface explicitly identified in one or more octets, beginning with octet 3c.
The extension bits are set accordingly.

Interface type (octet 3)

0: basic interface

1: other interface; e.g., primary rate (Note)

Note – The type of interface should be understood because the interface was identified by the interface identifier.

Preferred/Exclusive (octet 3)

0: indicated channel is preferred

1: exclusive; only the indicated channel is acceptable

D-channel indicator (octet 3)

0: the channel identified is not the D-channel

1: the channel identified is the D-channel

Information channel selection (octet 3)

	Basic interface	*Other interface*
0 0:	no channel	no channel
0 1:	B1 channel	as indicated in following octets
1 0:	B2 channel	reserved
1 1:	any channel	any channel

TABLE 40b/Q.931

Channel identification information element

Interface identifier (octet 4)

Binary code assigned to the interface at subscription time.

Note – When the interface is implicitly identified, octet 4 is omitted.

Number/Map (octets 5, 7)

0: (sub-) channel is indicated by the number in the following octet

1: (sub-) channel is indicated by the slot map (Map) in the following octet(s)

Note – If map element type is 8 kbit/s, then only "1" is allowed.

(Sub-) channel type/Map (sub-) element type (octets 5, 7)

0 0 0 1: 8 kbit/s sub-channel units

0 0 1 1: B-channel units

0 1 1 0: H0-channel units

1 0 0 0: H1-channel units

Note – All other values are reserved for further study.

(Sub-) channel number (octets 6, 8)

Binary number assigned to the channel.

Note 1 – Bit 8 is reserved for extension.

Note 2 – Either "Channel Number" or "Slot map" is used exclusively, depending on the "Number/Map" information.

(Sub-) Slot map (octets 6, 8)

Bit position(s) in slot map corresponding to time slot(s) used by the (sub-) channel is set to 1. Some examples are listed below.

Note – Length of the slot-map is decided by combination of channel unit size on which the slot map is mapped (e.g., B-channel) and map element (e.g., 8 kbit/s subchannel).

Case 1: Primary rate interface, map element = B-channel

8	7	6	5	4	3	2	1	Bit
24	23	22	21	20	19	18	17	Octet 6 or 8
16	15	14	13	12	11	10	9	6a or 8a
8	7	6	5	4	3	2	1	6b or 8b

1544 kbit/s

8	7	6	5	4	3	2	1	
31	30	29	28	27	26	25	24	Octet 6 or 8
23	22	21	20	19	18	17	16	6a or 8a
15	14	13	12	11	10	9	8	6b or 8b
7	6	5	4	3	2	1	0	6c or 8c

2048 kbit/s

Case 2: B-channel, map element = 8/kbit/s sub-channel

8	7	6	5	4	3	2	1	
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	Octet 6 or 8

Note — Sub-slot map bit 1 corresponds to the first bit of each octet transmitted within the 64 kbit/s channel across the interface. Sub-slot map bit 8 corresponds to the last bit of each octet transmitted within the 64 kbit/s channel across the interface.

FIGURE 17/Q.931

Channel identification information element

TABLE 40c/Q.931

Channel identification information element

Coding standard (octets 5, 7)

0 0: CCITT standard

0 1: reserved for other international standard

1 0: national standard

1 1: standard specific to the network present on the network side of the interface

Examples of channel identification:

8	7	6	5	4	3	2	1	
0	Channel identification 0	0	1 Information element identifier	1	0	0	0	— Basic interface — Implicit Int. id. — B2-ch. exclusive
0	0	0	0 Length	0	0	0	1	— No sub-channel
1 Ext.	0 Int. id.	0 Int. type	0 Spare	1 Ex-ch.	0 D-ch. ind.	1 Info. channel selection	0	

0	Channel identification 0	0	1 Information element identifier	1	0	0	0	— Basic interface — Implicit Int. id.
0	0	0	0 Length	0	0	0	1	— D- or any B-channel — No sub-channel
1 Ext.	0 Int. id.	0 Int. type	0 Spare	0 Pref.	1 D-ch. ind.	1 Info. channel selection	1	

FIGURE 18/Q.931

Channel identification information element

0	Channel identification 0	0	1 Information element identifier	1	0	0	0	— Other interface — Number 3 interface (e.g. Primary rate)
0	0	0	0 Length	0	1	1	0	
1 Ext.	1 Int. id.	1 Int. type	0 Spare	0 Pref.	0 D-ch. id.	0 Info channel selection	1	— 16 kbit/s sub-channel in Number 12 B-channel preferred
1 Ext.	0	0	0 (Interface number 3)	0	0	1	1	
1 Ext.	0 (CCITT St.)	0	0 number	0	0 (B-channel)	1	1	
1 Ext.	0	0	0 (Channel number 12)	1	1	0	0	
1 Ext.	0 (CCITT St.)	0	1 (Map)	0	0 (8 kbit/s slot map element)	0	1	
1	1	0	0 (16 kbit/s sub-channel)	0	0	0	0	

FIGURE 19/Q.931

Channel identification information element

4.5.11 *Congestion level*

The purpose of the congestion level information element is to describe the congestion status of the call. It is a single octet information element coded as shown in Figure 20/Q.931 and Table 41/Q.931.

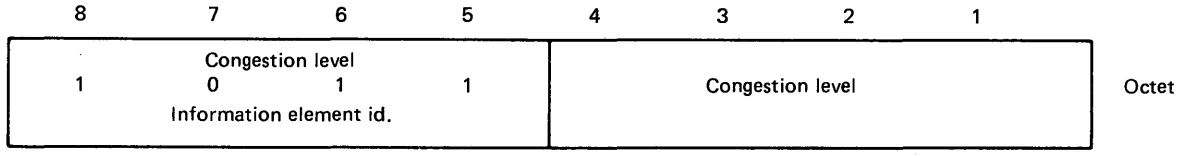


FIGURE 20/Q.931

Congestion level information element

TABLE 41/Q.931

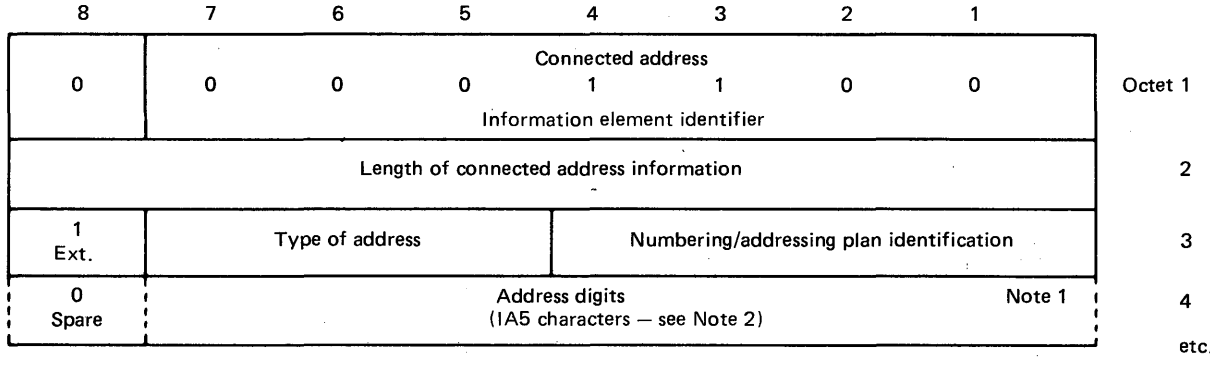
Congestion level information element

Congestion level (octet 1)	
4 3 2 1	
0 0 0 0	receiver ready
0 0 0 1 to 1 1 1 0	for further study
1 1 1 1	receiver not ready

4.5.12 *Connected address*

The purpose of the connected address information element is to indicate which address is connected to a call. The connected address(es) may be different from the origination or destination address(es) because of changes (e.g. call redirection, transfer) during the lifetime of the call.

The connected address information element is coded as shown in Figure 21/Q.931 and Table 42/Q.931. The connected address may be repeated in a message, e.g. for a multipoint call.



Note 1 — The address digit in octet 4 precedes the digit in octet 5, etc. The address digit which would be "dialled" first is located in octet 4.
Note 2 — The use of IA5 or BCD encoding for this field is for further study.

FIGURE 21/Q.931

Connected address information element

TABLE 42/Q.931

Connected address information element

Type of address (octet 3)

7	6	5	
0	0	0	unknown
0	0	1	international number
0	1	0	national number
0	1	1	network-specific number
1	0	0	local (directory) number
1	0	1	subaddress
1	1	0	abbreviated address
1	1	1	continuation of address (e.g., overlap sending)

Note 1 – For the definition of "number", "subaddress" and "address", see Recommendation I.330.

Note 2 – The subaddress, if conveyed, shall be provided as a separate specific address element that immediately follow the address information element conveying the associated number information.

Numbering/addressing plan identification (octet 3)

Note – The need for, and coding of, this field is a subject for further study, especially depending on the results of interworking studies.

4	3	2	1	*Numbering plan (type of address: 001 through 100)*	*Other type of address*
0	0	0	0	unknown	unknown
0	0	0	1	ISDN numbering plan (Recommendation E.164)	
0	0	1	0	Telephony numbering plan (Recommendation E.163)	(other values for further study)
0	0	1	1	Data numbering plan (Recommendation X.121)	
0	1	0	0	Telex numbering plan (Recommendation F.69)	
0	1	0	1	Maritime mobile numbering plan (Recommendations E.120 and E.211)	
0	1	1	0	Land mobile numbering plan (Recommendations E.212 and E.213)	

All other values are reserved

Address digits (octets 4, etc.)

7	6	5	4	3	2	1	*Address digit value*
0	1	1	0	0	0	0	0
0	1	1	0	0	0	1	1
0	1	1	0	0	1	0	2
0	1	1	0	0	1	1	3
0	1	1	0	1	0	0	4
0	1	1	0	1	0	1	5
0	1	1	0	1	1	0	6
0	1	1	0	1	1	1	7
0	1	1	1	0	0	0	8
0	1	1	1	0	0	1	9

In accordance with Recommendations E.164 and I.330, only the decimal digits 0-9 shall be used in number information.

0	1	0	1	0	1	0	*
0	1	0	0	0	1	1	#
1	1	0	0	0	0	1	a
1	1	0	0	0	1	0	b
1	1	0	0	0	1	1	c
1	1	0	0	1	0	0	d

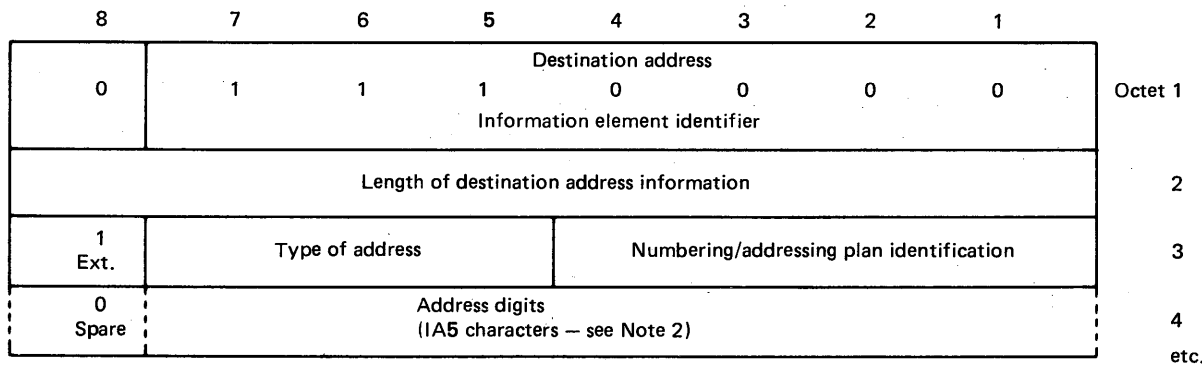
Note 1 – The possible need to allocate an IA5 code to also represent end of address is for further study.

Note 2 – If the type of address is abbreviated address, some networks may allow other IA5 characters to be used.

4.5.13 *Destination address*

The purpose of the destination address information element is to identify one destination of a call.

The destination address information element is coded as shown in Figure 22/Q.931. The destination address information element may be repeated in a message; e.g. for a multipoint call.



Note 1 — The contents of this information element are coded as shown in Figure 21/Q.931 and Table 42/Q.931.
Note 2 — The use of IA5 or BCD encoding for this field is for further study.

FIGURE 22/Q.931

Destination address information element

4.5.14 *Display*

The purpose of the display information element is to supply information. The information contained in this element is coded in IA5 characters.

The display information element is coded as shown in Figure 23/Q.931.

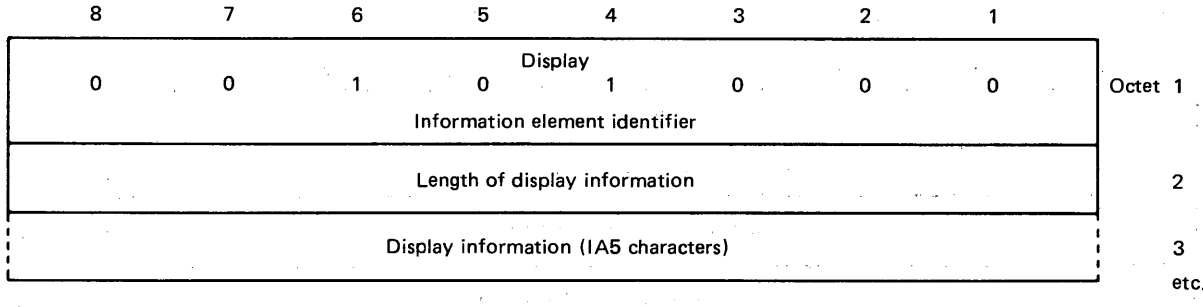


FIGURE 23/Q.931

Display information element

4.5.15 *High layer compatibility*

The purpose of the high layer compatibility information element is to provide a means which, in association with the bearer capability and low layer compatibility information elements may be used by the remote user for compatibility checking. The use and the detailed coding of this information element is for further study.

The high layer compatibility information element is coded as shown in Figure 24/Q.931. The compatibility information element may be repeated in a message to convey information related to more than one CCITT Recommendation.

Note – When an ISDN provides bearer services, this information is not interpreted by the network, but rather is carried transparently and delivered to the remote user(s). If explicitly requested by a user (on a per call basis or at subscription time), a network which provides some capabilities to realize telecommunication services may interpret this information to provide a particular service.

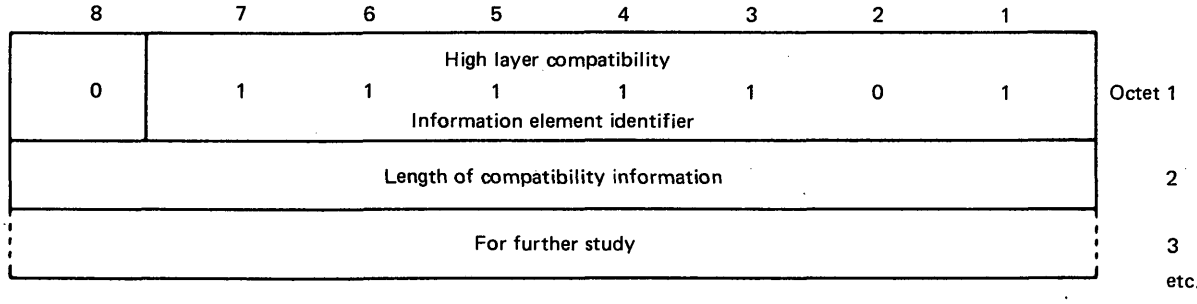


FIGURE 24/Q.931

High layer compatibility information element

4.5.16 *Keypad*

The purpose of the keypad information element is to convey IA5 characters, e.g. entered by means of a terminal keypad.

The keypad information element is coded as shown in Figure 25/Q.931.

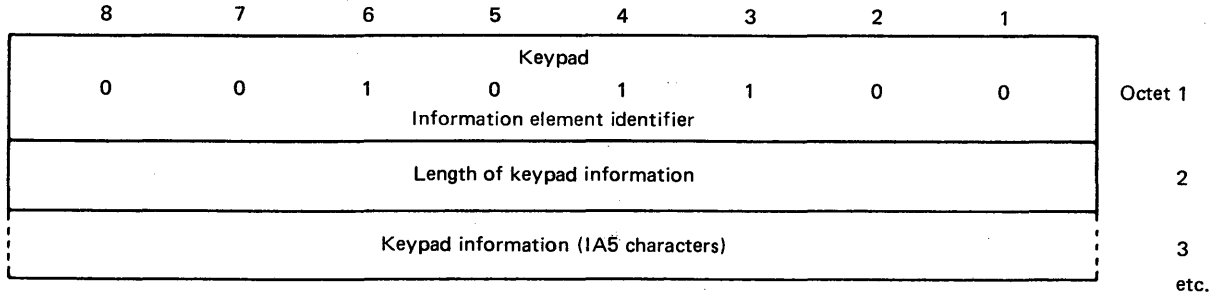


FIGURE 25/Q.931

Keypad information element

4.5.17 *Keypad echo*

The purpose of the keypad echo information element is to convey IA5 information echoed to the user by the network.

The keypad-echo information element is coded as shown in Figure 26/Q.931.

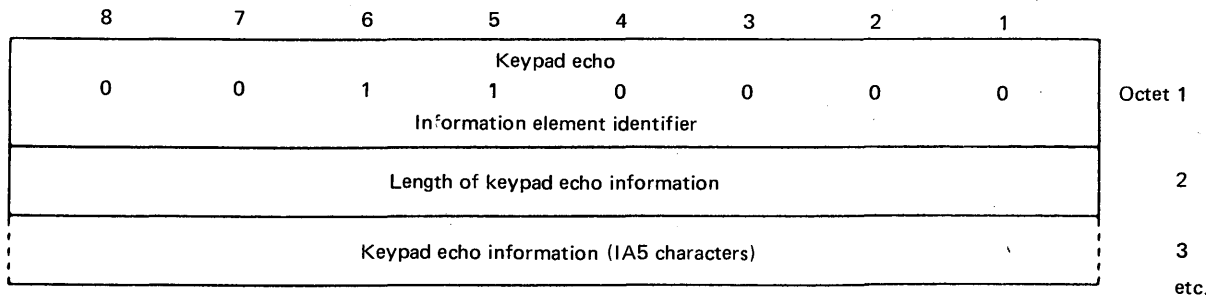


FIGURE 26/Q.931

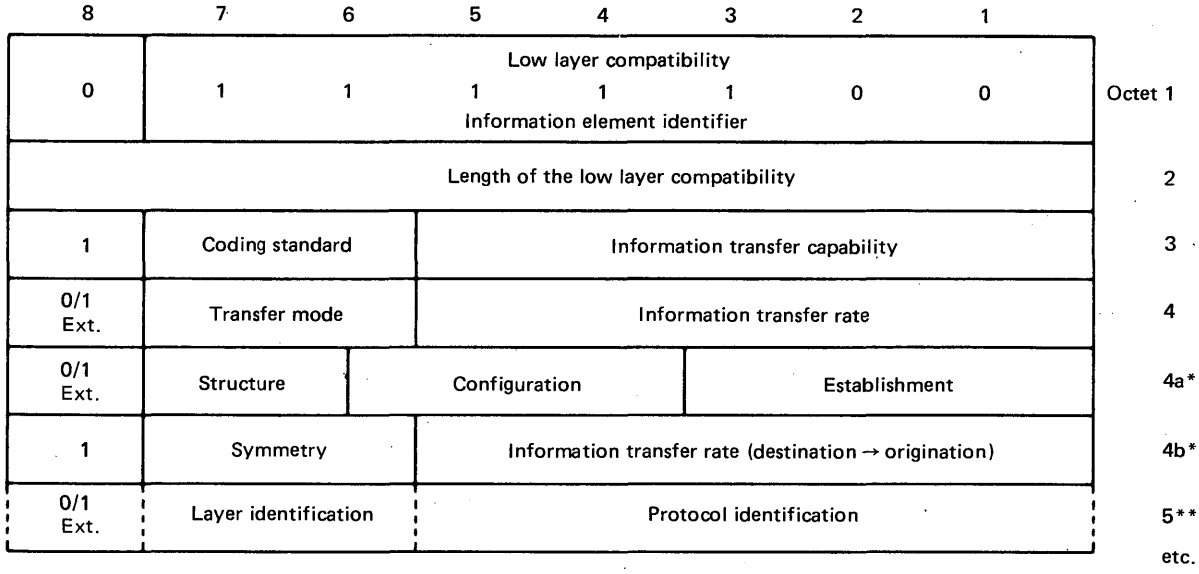
Keypad echo information element

4.5.18 *Low layer compatibility*

The purpose of the low layer compatibility information element is to provide a means which, in conjunction with the bearer capability and high layer compatibility information elements, may be used by the remote user for compatibility checking.

The low layer compatibility information element is coded as shown in Figure 27/Q.931.

Note – This information element is not interpreted by the network, but rather is carried transparently and delivered to the remote user(s).



Note — The contents of this information element are coded as shown in Figure 11/Q.931 and Tables 36a/Q.931 to 36d/Q.931.

* This octet may be omitted.
** This octet may be repeated.

FIGURE 27/Q.931

Low layer compatibility information element

4.5.19 *More data*

The more data information element is sent by the user to the network in a USER INFO message, and delivered by the network to the destination user(s) in the corresponding USER INFO message.

The use of the more data information element is not supervised by the network.

The more data information element is coded as shown in Figure 28/Q.931.

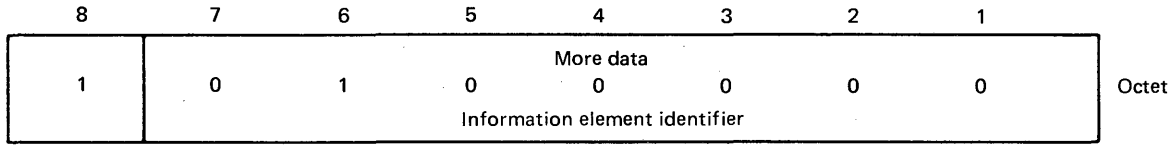


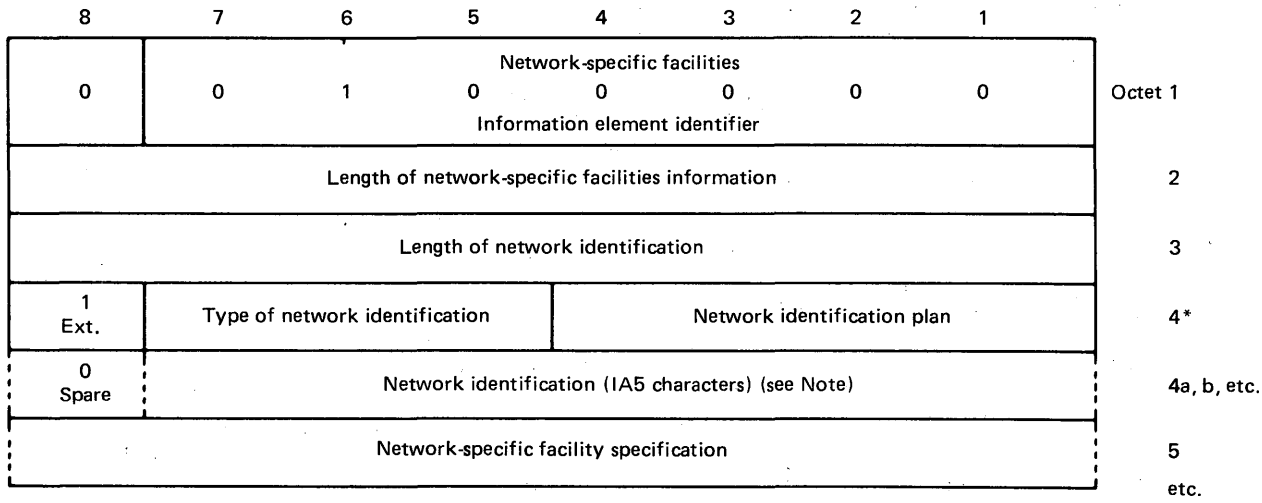
FIGURE 28/Q.931

More data information element

4.5.20 *Network-specific facilities*

The purpose of the network-specific facilities information element is to indicate which network facilities are being invoked at the specified network.

The network-specific facilities information element is coded as shown in Figure 29/Q.931.



Note — The network identification character in octet 4a precedes the character in octet 4b, etc.

* May be omitted.

FIGURE 29/Q.931

Network-specific facilities information element

Length of network identification (octet 3)

This field contains the length, in octets, of the network identification found in octets 4, 4a, etc. If the value is "0000 0000", then the local serving network is assumed, and octets 4, 4a, etc., are omitted.

Type of network identification (octet 4)

7 6 5	*meaning*
0 0 0	unknown
0 1 0	national network identification.

Network identification plan (octet 4)

bits 4 3 2 1	*Network identification code*
0 0 0 0	Unknown
0 0 1 1	Public data network identification code (DNIC – Recommendation X.121)
0 1 1 0	Public land mobile network identification code (MNIC – Recommendation E.212)

All other values are reserved.

Network identification (octets 4a, etc.)

These IA5 characters are organized according to the network identification plan specified in octet 4.

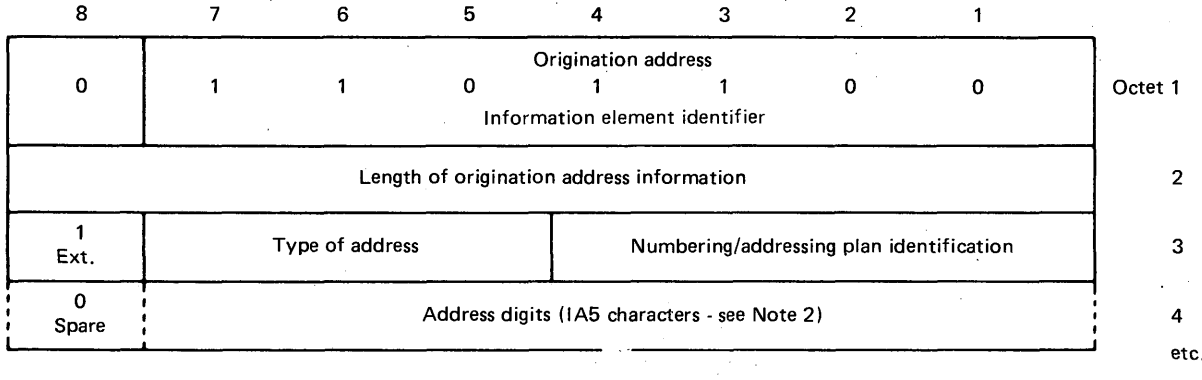
Network-specific facilities (octets 5, etc.)

This field is encoded according to the rules specified by the identified network.

4.5.21 *Origination address*

The purpose of the origination address information element is to identify the origin of a call.

The origin address information element is coded as shown in Figure 30/Q.931.



Note 1 — The contents of this information element are coded as shown in Figure 21/Q.931 and Table 42/Q.931.
Note 2 — The use of IA5 or BCD encoding for this field is for further study.

FIGURE 30/Q.931

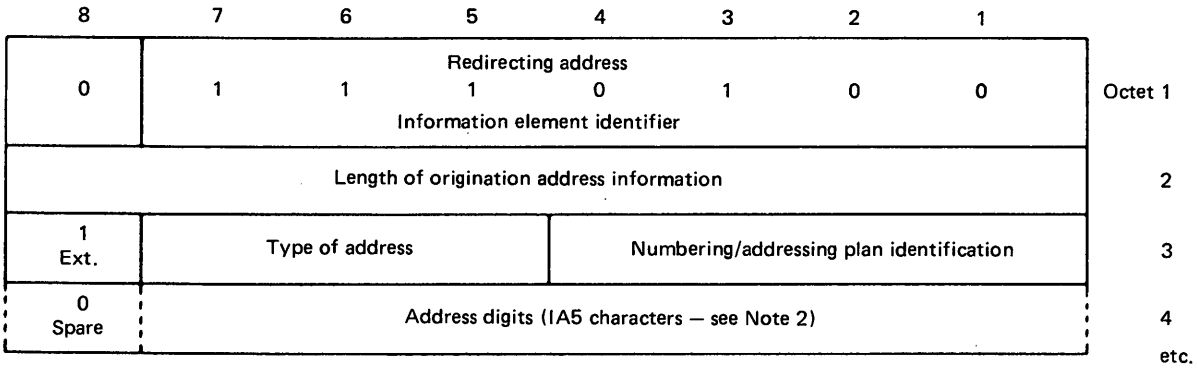
Origination address information element

4.5.22 *Redirecting address*

The purpose of the redirecting address information element is to identify the destination address from which call redirection/diversion/transfer was invoked.

The redirecting address information element is coded as shown in Figure 31/Q.931. The redirecting address information element may be repeated in a message in case of multiple redirections.

Note – The distinction between call redirection, call diversion and transfer, if any, is for further study.



Note 1 — The contents of this information element are coded as shown in Figure 21/Q.931 and Table 42/Q.931.
Note 2 — The use of IA5 or BCD encoding for this field is for further study.

FIGURE 31/Q.931

Redirecting address information element

4.5.23 *Signal*

The purpose of the signal information element is to convey indications causing a stimulus mode terminal to generate tones and alerting signals.

The signal information element is coded as shown in Figure 32/Q.931 and Table 43/Q.931.

The signal information element may be repeated in a message to convey multiple stimuli.

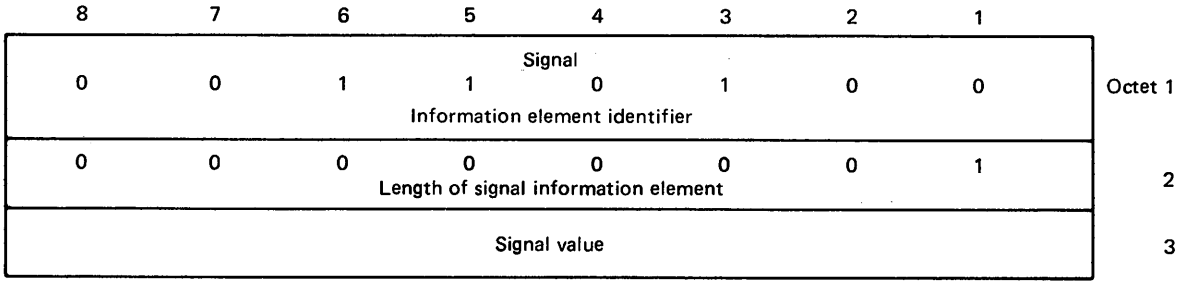


FIGURE 32/Q.931

Signal information elements

TABLE 43/Q.931

Signal information element

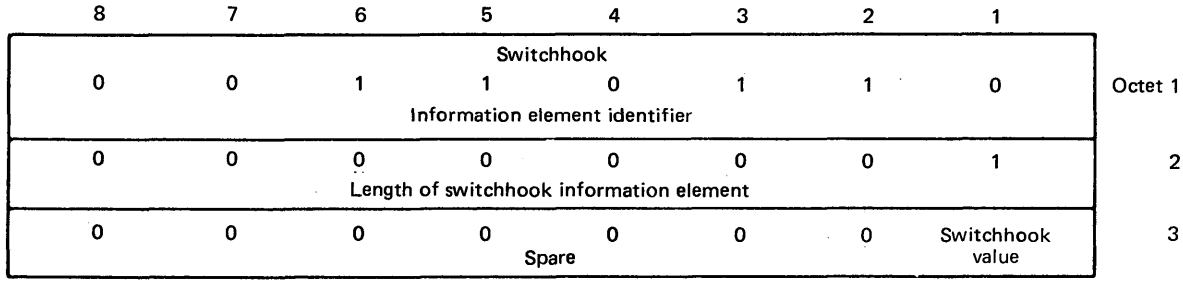
Signal value (octet 3)

0 0 0 0 0 0 0 0	dial tone on
0 0 0 0 0 0 0 1	ring back tone on
0 0 0 0 0 0 1 0	intercept tone on
0 0 0 0 0 0 1 1	network congestion tone on
0 0 0 0 0 1 0 0	busy tone on
0 0 0 0 0 1 0 1	confirm tone on
0 0 0 0 0 1 1 0	answer tone on
0 0 0 0 0 1 1 1	call waiting tone on
0 0 0 0 1 0 0 0	off-hook warning tone on
0 0 1 1 1 1 1 1	tones off
0 1 0 0 0 0 0 0	alerting on – pattern 0
0 1 0 0 0 0 0 1	alerting on – pattern 1
0 1 0 0 0 0 1 0	alerting on – pattern 2
0 1 0 0 0 0 1 1	alerting on – pattern 3
0 1 0 0 0 1 0 0	alerting on – pattern 4
0 1 0 0 0 1 0 1	alerting on – pattern 5
0 1 0 0 0 1 1 0	alerting on – pattern 6
0 1 0 0 0 1 1 1	alerting on – pattern 7
0 1 0 0 1 1 1 1	alerting off

4.5.24 *Switchhook*

The purpose of the switchhook information element is to indicate the state of the stimulus mode terminal switchhook to the network.

The switchhook information element is coded as shown in Figure 33/Q.931.



Switchhook value (octet 3, bit 1)

0 – on-hook
1 – off-hook

FIGURE 33/Q.931

Switchhook information element

4.5.25 *Terminal capabilities*

The terminal capabilities information element is used by stimulus mode terminals to indicate their capabilities to the network.

The terminal capabilities information element is coded as shown in Figure 34/Q.931 and Table 44/Q.931.

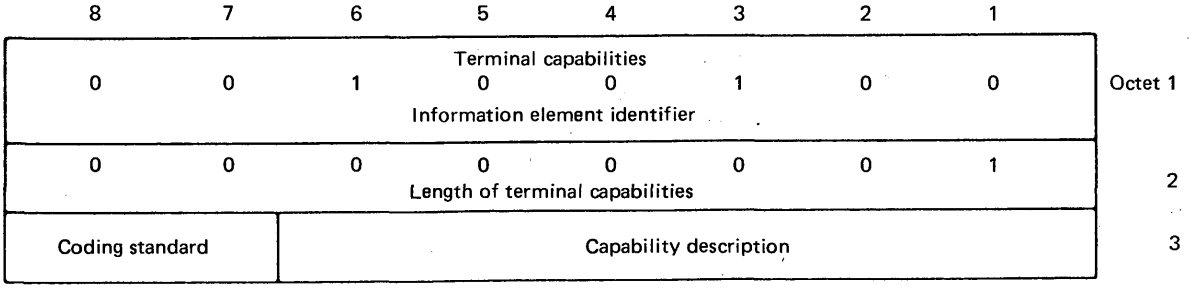


FIGURE 34/Q.931

Terminal capabilities information element

TABLE 44/Q.931

Terminal capabilities information element

Coding standard (octet 3)

8	7	
0	0	CCITT standard
0	1	reserved for other international standards
1	0	national standard
1	1	standard specific to network on network side of the interface

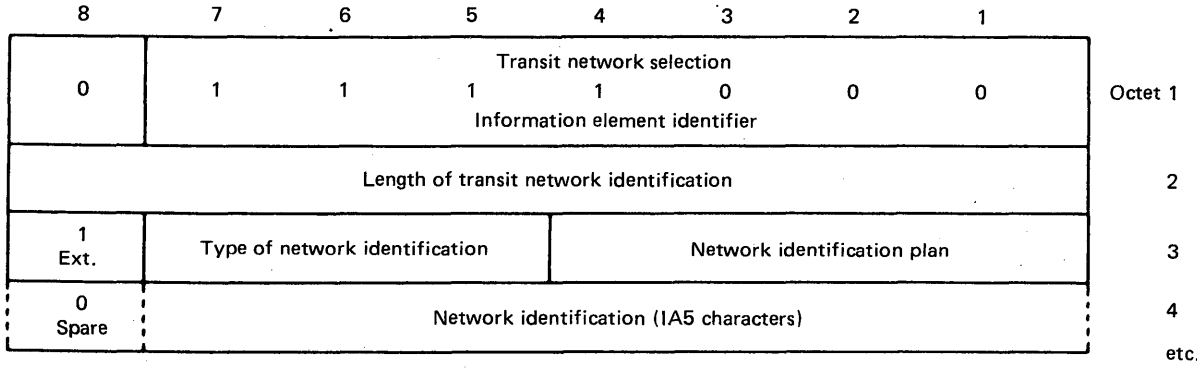
Capability description (octet 3)

6	5	4	3	2	1	
0	0	0	0	0	1	stimulus mode terminal – Type 1 (see § 6)
0	0	0	0	1	0	stimulus mode terminal – Type 2 (see § 6)

4.5.26 *Transit network selection*

The purpose of the transit network selection information element is to identify one requested transit network. The transit network selection information element may be repeated in a message to select a sequence of transit networks through which a call must pass.

The transit network selection information element is coded as shown in Figure 35/Q.931.



Note — The contents of this information element are coded as shown in Figure 29/Q.931, octets 3, 4, etc.

FIGURE 35/Q.931

Transit network selection information element

4.5.27 *User-user information*

The purpose of the user-user information element is to convey information between ISDN users. This information is not interpreted by the network, but rather is carried transparently and delivered to the remote user(s).

The user-user information element is coded as shown in Figure 36/Q.931. There are no restrictions on the content of the user information field.

In SETUP, ALERTing, CONNECT, DISConnect, DETach, and RELease messages, the user information field contained inside this information element has a network-dependent maximum size of 32 or 128 octets. The evolution to a single maximum value is the long-term objective, the exact maximum value is the subject of further study.

In USER INFO messages sent in association with a circuit-mode connection, the user information field contained inside this information element has a maximum size of 32 octets. For USER INFO messages sent in a temporary or permanent user-user signalling connection, the user information field contained inside this information element has a maximum size equal to the maximum size of messages defined in § 3 (excluding USER INFO).

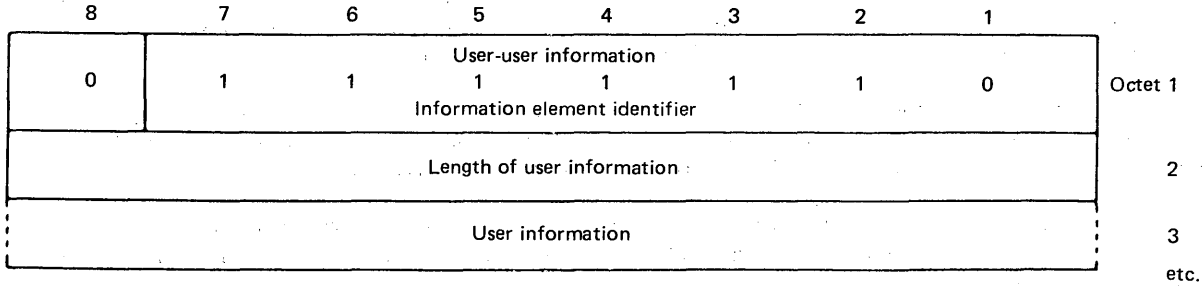


FIGURE 36/Q.931

User-user information element

5 Call control procedures

The call states referred to in this section cover the states perceived by the network, states perceived by the user and states which are common to both user and network. Unless specifically qualified, all states described in the following text should be understood as common (see §§ 2.1.1 and 2.1.2 for user and network call states respectively). An overview diagram of call states is given in §§ 2.1.3 and 2.1.4.

Provisional detailed specification and description language (SDL) diagrams and state transition tables for the procedures specified in this section are contained in Figures 38/Q.931 through 41/Q.931 and Tables 45a/Q.931 through 46d/Q.931. When there is an ambiguity in the narrative text, the SDL diagrams in Figures 37/Q.931 and 38/Q.931 should be used to resolve conflict. Where the text and the SDL are in disagreement, the text should be used as the prime source. Points requiring further study are indicated in both the text of this section and these SDL diagrams.

Note – Future enhancements to the following procedures are envisaged to allow for symmetric call control procedures (e.g., for PABX-to-PABX applications).

5.0 *General rules for message processing*

The following rules are listed in order of precedence:

a) when a message is received that is less than three octets long, that message shall be ignored;

b) when a message is received with a protocol discriminator not in accordance with § 4.2, that message shall be ignored;

c) if a message is received which has one or more mandatory information elements missing, no action should be taken on the message and no state change should occur. Then a STATUS message is returned with the cause "message type non-existent or not implemented";

d) when the user or network receives a message containing optional information elements that it does not know how to act upon, it shall act on the message and those information elements that it can action. Furthermore, it may return a STATUS message containing one cause information element for each of the unimplemented information elements received. In that case, each cause information element shall contain the cause "unimplemented information element" and the diagnostic field shall contain the unimplemented information element that was received, in its entirety. The precise conditions under which the STATUS message is returned are for further study.

5.1 *Procedures for circuit-switched calls*

Circuit-switched calls are controlled by a sequence of messages flowing across the user-network interface. This section describes the sequence.

All messages in this Recommendation may contain two types of information element, functional and/or stimulus. Functional information elements are characterized as requiring a degree of intelligent processing by the terminal in either their generation or analysis. Stimulus information elements, on the other hand, are either generated as a result of single event at the user/terminal interface (e.g. key depression) or contain a basic instruction from the network (e.g. display) to be executed by the terminal.

Functional information elements will always be used in a standardized way. Stimulus information elements mentioned in § 5 and § 6.1 to § 6.4 of this Recommendation will also be standardized. The precise meaning and application of additional stimulus information elements (see § 6.5) is for further study.

As a general principle, all the messages sent by the network to the terminals may contain a "Display" information element whose contents may be displayed by the terminal; the content of this information element shall be network dependent.

In addition to the messages exchanged as described in the following sections, INFORMATION messages for call control may be sent by a terminal or by the network at any time of the call (i.e. after the terminal has issued or received a SETUP message and before it has sent or received a disconnect message). Unless specified in the following text, the INFORMATION message may contain both stimulus and functional information elements. The stimulus type information elements "Keypad" and "Display" shall contain strings of IA5 characters arranged according to network dependent rules. Other stimulus information elements shall not be subject to the same coding restrictions.

Note – "Keypad" information elements shall only be conveyed in the direction user to network since their contents represent the depression of keypad buttons or an equivalent pre-programmed key at the user interface. "Display" information elements shall generally be conveyed in the direction network to user but may be generated by the user in some circumstances (see § 5.2).

5.1.1 *Call establishment at the originating exchange*

Before these procedures are invoked, a reliable data link connection must be established between the user (TE/NT2) and the network. The data link services described in Recommendations Q.920(I.440) [3] and Q.921 (I.441) [4] are assumed.

5.1.1.1 *Call request*

a) *General*

A user initiates call establishment by transferring a SETUP message across the user network interface. Following the transmission of the SETUP message, the call shall be considered by the user to be in the Call init state. The message shall always contain a call reference, selected according to the procedures given in § 4.3. In the case of a stimulus mode terminal which has a single B-channel connection per layer 2 end point capability with one call at a time, a dummy call reference value (i.e. all zero) shall be used (see § 6.1). At least, the bearer service information element is contained in the message even in the case of overlap sending.

Furthermore the SETUP message may also contain all or part of the call information (i.e. address and facility requests) necessary for call establishment depending on whether or not en-bloc or overlap procedures are being used respectively (see § 5.1.1 b)). This call information may be included within "keypad" information elements or in other functional information elements (e.g. destination address, CUG identity . . .). A mixture of keypad information and functional information for conveying call information is not precluded. However, a given element of the call information (e.g. addressing) must be sent in a unique way (i.e. keypad or functional).

b) *Call information sending*

If en-bloc sending is used, the SETUP message should contain all the information required from the user by the network to process the call. The network sends a CALL PROCEEDING message to the user to acknowledge the SETUP message and to indicate that the call is being processed. The CALL PROCEEDING message contains the B-channel allocated to the call and to which the user must be attached. At this point, the call enters the OUTGOING CALL PROCEEDING state.

If overlap sending is used, the SETUP message will contain only part of the information required by the network to process the call. On receipt of such a SETUP message, the network initializes timer T302 and sends a SETUP ACKNOWLEDGE message to the user. If the SETUP did not contain any element of call information, the network will also return dial tone, if appropriate. The precise conditions under which this applies are for further study (e.g. it might apply generally or based on the information contained in the SETUP).

The SETUP ACKNOWLEDGE message may contain the information element "signal – dial tone on"; when received by a user this information element may initiate a local indication that dialling can start (e.g. by an audible or visual indication). The SETUP ACKNOWLEDGE message also identifies the B-channel to be used.

If following the receipt of an en-bloc SETUP message or during overlap sending, the network determines that the call information received from the user is invalid (i.e. invalid facility request or address), then the network shall initiate clearing by sending a RELEASE COMPLETE or a DISCONNECT message to the user as defined in § 5.1.3.

After receiving the SETUP ACKNOWLEDGE message, the user sends the remainder of the call information in one or more INFORMATION messages. If dial tone has been returned, it will be terminated by the network on receipt of the first INFORMATION message. The call information in the message which completes the information sending may contain a "sending complete" indication, i.e. as part of the called address. The network shall reinitialize timer T302 on the receipt of every INFORMATION message not containing a sending complete indication and optionally generates an INFORMATION message containing a keypad echo information element.

Following the occurrence of one of the conditions described below, the network shall send a CALL PROCEEDING message to the user and cancel timer T302 where appropriate:

i) the expiration of timer T302 (the value of T302 is specified in § 7.1);

ii) the receipt by the network of a sending complete indication;

iii) analysis by the network that all call information necessary to effect call establishment has been received.

Note – With regard to case i), an alerting or connect indication can be received from the called party before timer T302 expires and in such cases an ALERTING or CONNECT message shall be sent to the calling user. No CALL PROCEEDING message shall be sent by the network and T302 shall be cancelled. Further study is required on the need of this procedure *in the full ISDN environment*, and on the procedure following this action which may be required to continue overlap sending, e.g., for sending a subaddress and for checking access to facilities.

c) *B-channel selection – originating*

In the SETUP message, the user will indicate one of the following:

i) a preferred channel with no acceptable alternative;

ii) a preferred channel, any alternative is acceptable;

iii) any channel is acceptable.

If no indication is included alternative iii) is assumed.

In cases i) and ii), if the preferred channel is available, the network reserves it for the call.

In case ii), if the network cannot grant the specified channel, it reserves any other available B-channel associated with the D-channel.

In case iii), the network reserves any available B-channel associated with the D-channel.

The reserved B-channel is indicated in the first message returned by the network in response to SETUP (i.e. SETUP ACKNOWLEDGE or CALL PROCEEDING). This message may also be used to activate the B-channel connection in the user's equipment.

In case i), if the specified channel is not available, and in cases ii) and iii), if no channel is available, a RELEASE COMPLETE message, indicating this condition, is sent by the network as described in § 5.1.3. However, if the network provides facilities in the "no channel available" condition (e.g. delayed call establishment), it may instead return a SETUP ACKNOWLEDGE or CALL PROCEEDING message as appropriate.

When the "no channel available" condition is indicated in the SETUP ACKNOWLEDGE or CALL PROCEEDING message, the user may clear the call by sending a DISCONNECT message as described in § 5.1.3.1 a), or initiate alternative procedures instead of clearing. Alternate procedures, for example, to request delayed call establishment by the exchange when a channel becomes available, are for further study.

A network timer T301 is initialized when the SETUP ACKNOWLEDGE or CALL PROCEEDING message is sent indicating that no channel is available, and the timer T301 is reset when the user initiates either clearing or some other procedure permitted to the user. If the timer expires, the network initiates clearing by sending a DISCONNECT message to the user as described in § 5.1.3.2 a). The value of T301 is specified in § 7.1.

5.1.1.2 *Call proceeding*

After completion of channel selection, and when the network has received sufficient call information, it determines whether the call can be established as requested. If access to any services and facilities requested is not authorized for the user, the network initiates clearing of the call with a cause indicated in the RELEASE COMPLETE or DISCONNECT message sent to the user (see § 5.1.3). Alternative procedures, for example, indicating call failure without initiating clearing, are for further study.

If access to requested services and facilities is authorized but not presently available, the network shall initiate clearing of the call by sending a RELEASE COMPLETE or DISCONNECT message as described in § 5.1.3. However, if the network provides call queueing facilities, it may place the call on a queue for the requested service or facility. The D-channel messages and in-band tones/announcement to be returned by the network in such circumstances and the network's subsequent treatment of the call require further study.

If access to the requested service and facilities is authorized and available, the network proceeds with call establishment.

If the user corresponding to the called address and the calling user are served by the same exchange, procedures given in § 5.1.2 are initiated.

If the user corresponding to the called address is served by another exchange, appropriate inter-exchange signalling and switching procedures are initiated.

5.1.1.3 *Call confirmation indication*

Upon receiving an indication that user alerting has been initiated at the called address, the network transfers an ALERTING message across the user-network interface of the calling address. This message may cause initiation of a user equipment generated alerting indication. At this time, the call enters the Call-delivered state.

5.1.1.4 *Call connected*

Upon receiving an indication that the call has been accepted, a CONNECT message is sent across the user-network interface to the calling user.

This message indicates to the calling user that a connection has been established through the network and stops a possible local indication of alerting. At this time, the call enters the Active state.

On receipt of the CONNECT message, the calling user may optionally generate a CONNECT ACKNOWLEDGE message. The network shall not take any action on receipt of this message when it perceives the call to be in the Active state.

5.1.1.5 *Call rejection*

Upon receiving an indication that the remote user (or network) is unable to accept the call, the network will initiate clearing as described in § 5.1.3.

5.1.2 *Call establishment at the destination exchange*

This procedure assumes that a data link connection providing services described in Recommendation Q.921 (I.441) may not exist before the first layer 3 message (SETUP) is transferred across the interface. However, reliable data link connections must be established by each of the users (terminals and/or NT2s) at the interface before they respond to the SETUP message. Permanent data link connections are not precluded, and may be recommended as a national option. The call reference contained in all messages exchanged across the user-network interface shall contain the call reference value specified in the SETUP message delivered by the network. However, in the case of a stimulus mode terminal which has only a single B-channel connection per layer 2 endpoint capability, it shall use a dummy value (all zero) for the call reference in all messages except the first response to the SETUP message. This response, being an ALERTING or CONNECT message must contain the terminal capabilities information element, indicating that the terminal is a stimulus mode terminal which can only support a single B-channel connection per layer 2 endpoint capability (see § 6.2).

5.1.2.1 *Incoming call*

The network will indicate the arrival of a call at the user-network interface by transferring a SETUP message across the interface. This message is sent if the network can select an idle B-channel. If the network provides facilities in "no B-channel condition" (e.g. call waiting), the message may also be sent when no B-channel is idle. The possible use of other messages for this purpose (e.g. INFORMATION) is for further study.

The SETUP message always includes the following information elements:

a) call reference;

b) bearer capability;

c) channel identification.

In addition, the SETUP message may include, as required, the information elements described in § 3.2.24 (e.g. display, low layer compatibility, signal (alerting-on)).

Since a multipoint terminal configuration may exist at the user-network interface, this message must be sent using a broadcast capability at the data link layer. In this case, the SETUP message should contain the DDI address where appropriate and sub-address if provided. However, if the network has knowledge that a single-point configuration exists at the interface, a point-to-point link may be used to carry the SETUP message. After sending the SETUP message, the call is in the Call-present state. The network initializes timer T303.

Note – In the case of overlap sending within the network, the DDI or sub-address may also be conveyed by means of INFORMATION messages to the called user in the point-to-point configuration. The detailed procedures to be used are for further study.

5.1.2.2 *B-channel negotiation*

i) *Basic interface structure*

When the network selects an idle B-channel for a call, terminals on a basic access can only accept the call on the channel indicated in the SETUP message. Further study is required on the need for channel negotiation when a single point configuration exists on a basic access. If the call cannot be accepted on the channel indicated, the user shall send a RELEASE COMPLETE message to the network and consider the call to be in the Null state.

ii) *Primary rate interface structure*

In point-to-point primary rate interface structures (e.g. PABX), negotiation between the network and user will be permitted on the selection of the B channel(s) for the call. Only B-channels which are controlled by the same D-channel will be the subject of the negotiation procedure. The negotiation procedure is as follows:

1) if the call can be accepted using the B-channel(s) indicated in the SETUP message, a CALL PROCEEDING, ALERTING or CONNECT message, which may also indicate the B-channel(s), is sent to the network;
2) if the call cannot be accepted using the B-channel(s) indicated in the SETUP message, a SETUP ACKNOWLEDGE message is sent to the network indicating alternative B-channel(s);
3) when the network receives a SETUP ACKNOWLEDGE message, it responds with an INFORMATION message indicating either:
   a) the B-channel indicated in the SETUP ACKNOWLEDGE message (negotiation successfully terminated);
   b) a second alternative B-channel;
   c) the same B-channel indicated in the SETUP message.

   After sending this information message, the network reinitializes timer T303. However, if the alternative channel indicated in the SETUP ACKNOWLEDGE is qualified as exclusive (i.e., no alternative is acceptable) and that channel is already allocated then the network does not send an INFORMATION message but instead initiates clearing by sending a RELEASE message as described in § 5.1.3.1 b);
4) the user response in case 3 a) above is a CALL PROCEEDING, ALERTING or CONNECT message;
5) in cases 3 b) and 3 c) above, if the call can be accepted on the B-channel selected by the network, an ALERTING, CALL PROCEEDING or CONNECT message, which may also indicate the B-channel, is sent;
6) in cases 3 b) and 3 c) above, if the call cannot be accepted on the B-channel selected by the network, a DISCONNECT message is sent to the network and the procedure of § 5.1.3.1 is followed;
7) if the timer T303 expires after reinitializing and the network has not received either an ALERTING, CALL PROCEEDING, CONNECT or DISCONNECT message, then the network initiates clearing. The procedure is for further study;
8) if the network receives a CALL PROCEEDING message, it cancels timer T303 and initializes timer T310. If an ALERTING, CONNECT or DISCONNECT message is not received by the network prior to expiration of T310, the network initiates clearing using the procedure in § 5.1.3.2.

5.1.2.3 *Call confirmation*

a) *Basic interface structure*

Idle user's equipment which satisfies the compatibility requirements indicated in the SETUP message responds with either an ALERTING, CALL PROCEEDING, CONNECT, FACILITY (e.g. for call forwarding, hold . . .), or INFORMATION message. After sending the CALL PROCEEDING message, the user proceeds by sending an ALERTING, CONNECT, FACILITY or INFORMATION message.

The CALL PROCEEDING message cancels timer T303 and initializes timer T310. The CALL PROCEEDING message facilitates symmetrical call control procedures. It may also be sent by users equipment which cannot respond to a SETUP message with an ALERTING, CONNECT or RELEASE COMPLETE message before expiration of T303.

The INFORMATION message contains the same request as the FACILITY message in specifically defined information elements, or KEYPAD information elements.

Busy user's equipment which satisfies the compatibility requirements indicated in the SETUP message shall normally respond with a RELEASE COMPLETE message. However, stimulus terminals may respond with an ALERTING message.

The possibility of alternative responses (e.g., in connection with supplementary services) is for further study.

If the compatibility requirements indicated in the SETUP message are not satisfied or the user wishes to refuse the call, a RELEASE COMPLETE message shall be sent with the cause "call rejected" and the user should then assume the call to be in a Null state.

Receipt of the CALL PROCEEDING message causes timer T303 to be cancelled and timer T310 to be initialized. Receipt of an ALERTING or CONNECT message in the case where a CALL PROCEEDING message has not been received cancels timer T303. Receipt of an ALERTING or CONNECT message subsequent to receipt of a CALL PROCEEDING message cancels timer T310.

Receipt of an ALERTING or CONNECT message causes a corresponding ALERTING or CONNECT message to be sent to the calling user. Where multiple ALERTING or CALL PROCEEDING messages are received in a multipoint access line, only the first is treated in this way. When the first CONNECT message is received, the network clears the non-selected terminals according to the procedures in § 5.1.2.6. In all the above cases, receipt of a valid FACILITY or INFORMATION message causes calling user treatment appropriate to the facility requested. Such treatment is for further study. The effect of the FACILITY message on timer T303 and T310 is also for further study.

The use of a SETUP message when no B-channel is available is for further study.

b) *Primary rate interface structure*

User equipment (intelligent NT2 type) can respond to the SETUP message with a SETUP ACKNOWLEDGE, ALERTING, CALL PROCEEDING, CONNECT, FACILITY/INFORMATION or RELEASE COMPLETE message. Receipt by the network of a CALL PROCEEDING message causes timer T303 to be cancelled and timer T310 to be initiated. Receipt by the network of an ALERTING or CONNECT message subsequent to receipt of a CALL PROCEEDING message causes a corresponding ALERTING or CONNECT message to be sent to the calling user, and timer T310 is cancelled.

Receipt by the network of an ALERTING or CONNECT message in the case where no CALL PROCEEDING message has been received causes a corresponding ALERTING or CONNECT message to be sent to the calling user and timer T303 to be cancelled. Some types of user equipment may respond as described for the basic access interface.

The use of a SETUP message when no B-channel is available is for further study.

c) *Call failure procedures*

If the network does not receive any response to the SETUP message within a time interval T303, the SETUP message is retransmitted. If no response is received during a further period T303, from the message retransmission, the network initiates clearing procedures. If the network receives a CALL PROCEEDING message in response to a SETUP message, timer T303 is cancelled and timer T310 is initialized. If the network subsequently does not receive an ALERTING, CONNECT or DISCONNECT message prior to expiration of timer T310, it will initiate clearing procedures. The value of T303 and T310 are specified in § 7.1. The clearing cause sent to the calling user is "no user responding".

If a RELEASE COMPLETE message is received whilst T303 or T310 is running, the message cause shall be retained by the network and returned in a DISCONNECT message to the calling user if T303 or T310 expires (i.e. if no valid ALERTING/CONNECT message has been received from the user).

Further study is required regarding the action to be taken by the network when multiple RELEASE COMPLETE messages are received with different causes.

5.1.2.4 *Call accept*

A user indicates acceptance of an incoming call by transferring a CONNECT message across the user-network interface towards the network. If an ALERTING message had previously been sent to the network, the CONNECT message may contain only the call reference. The CONNECT message may also contain the switchhook information element (Off-hook).

If a call can be accepted using the B-channel indicated in the SETUP message, and no user alerting is required, a CONNECT message may be sent without a previous ALERTING message. In this instance, the CONNECT message contains the call reference value specified in the SETUP message. It is presumed that the B-channel that has been negotiated earlier is being used for the call.

Note – Further study is required on the need for means to avoid service degradation or speech clipping on connections involving an NT2.

5.1.2.5 *Active indication*

On receipt of the first CONNECT message, the network completes the circuit switched path to the selected B-channel and subsequently sends a CONNECT ACKNOWLEDGE message to the user which first accepted the call. The CONNECT ACKNOWLEDGE message includes the call reference value specified. It is presumed that the B-channel that has negotiated earlier is being used for the call. It may contain the signal information element (alerting-off). The network also initiates procedures to send a CONNECT message towards the calling user.

The CONNECT ACKNOWLEDGE message indicates completion of the circuit switched connection. There may not be end-to-end communications until the CONNECT indication is received at the calling user. At this point, the call enters the Active state where it remains until clearing is initiated or until the call is suspended.

5.1.2.6 *Non selected user clearing*

In addition to sending the CONNECT ACKNOWLEDGE message to the terminal selected for the call, the network sends a RELEASE message (as described in § 5.1.3.1 b)) to all other terminals at the interface which had sent an ALERTING or CONNECT message in response to a SETUP message. This message is used to notify these terminals that the call is no longer offered to them. Each user receiving the message will return a RELEASE COMPLETE message and then consider the call to have returned to a Null state. The network shall maintain a timer T308 in accordance with § 5.1.3.1, and shall retransmit the RELEASE message if necessary.

5.1.3 *Call clearing*

Under normal conditions, call clearing is usually initiated by the user or the network sending a DISCONNECT message and following the procedures defined in §§ 5.1.3.1 and 5.1.3.2 respectively. The only exceptions to the above rule are as follows:

a) In response to a SETUP message, the user or network will clear a call which is rejected (e.g., because of the unavailability of a B channel) by responding with a RELEASE COMPLETE message provided no other response has previously been sent (e.g. the SETUP ACKNOWLEDGE in the case of overlap sending or B channel negotiation);

b) In the case of multipoint terminal configuration, the procedure described in § 5.1.2.6 above applies;

c) Clearing of temporary signalling connections will be initiated by sending a RELEASE message as described in § 5.1.3.1 b);

d) Termination of the B channel negotiation procedure by the network, when the desired channel is not available and the user indicates no alternative is acceptable (see § 5.1.2.2 ii) 6)), is accomplished by sending a RELEASE message as described in § 5.1.3.1 b).

The following terms are used in this Recommendation in the description of clearing procedures:

– A channel is "connected" when the channel is part of a circuit-switched ISDN connection established according to this Recommendation.

– A channel is "disconnected" when the channel is no longer part of a circuit-switched ISDN connection, but is not yet available for use in a new connection.

– A channel is "released" when the channel is not part of a circuit-switched ISDN connection, and is available for use in a new connection.

5.1.3.1 *Clearing by the user*

a) Apart from the exceptions identified in § 5.1.3 above, the user shall initiate clearing by transferring across the user-network interface a DISCONNECT message. Following the receipt of a DISCONNECT message, the network shall consider the call to be in the DISCONNECT REQUEST state and the procedures described below shall apply.

b) If the network immediately clears the call, the B-channel used in the call is disconnected and a RELEASE message shall be sent to the user. On receipt of the RELEASE message the user shall release the B-channel and the call reference and send in response a RELEASE COMPLETE message.

Following the transmission of the RELEASE message, the network shall start timer T308. Following the receipt of a RELEASE COMPLETE message from the user, the network shall cancel timer T308 and both the B-channel and the call reference shall be released for future use. If a RELEASE COMPLETE message is not received before timer T308 expires, the RELEASE message shall be retransmitted and timer T308 shall be reinitialized. If no RELEASE COMPLETE is received from the user before timer T308 expires a second time, the network shall release both the B-channel and the call reference for future use. The value of T308 is specified in § 7.1.

The RELEASE message has only local significance and does not imply an acknowledgement of clearing from the remote user.

c) In some cases, network facilities may require the network to retain the call reference for subsequent use after releasing the B-channel used for a call. The network shall inform the user of this condition by sending a DETACH message in response to the DISCONNECT message received from the user.

Following transmission of the DETACH message, the network shall start timer T311. On receipt of the DETACH message the user shall release the B channel and send in response a DETACH ACKNOWLEDGE message. Following the receipt of a DETACH ACKNOWLEDGE message from the user, the network shall cancel timer T311. The procedure if a DETACH ACKNOWLEDGE message is not received before timer T311 expires, is for further study.

Following the sending of the DETACH ACKNOWLEDGE message by the user and receipt of the DETACH ACKNOWLEDGE by the network the call shall be considered by the user and network respectively to be in a Detach state.

After the network has completed processing associated with the call, it shall send a DISCONNECT message with appropriate information to the user, and the procedures in a) § 5.1.3.2 below are followed with the exception of releasing the B-channel.

The network shall respond to all messages received from the user whilst the call is in the Detach state by sending a DETACH message.

d) Actions to be taken by the network if it wishes to retain the B-channel connection after it receives a DISCONNECT message (e.g. for emergency services) is for further study.

5.1.3.2 *Clearing by the network*

a) Apart from the exceptions identified in § 5.1.3 and § 5.1.3.4 the network shall initiate clearing by transferring a DISCONNECT message across the user-network interface and the procedures described below shall apply. At the instant, when the DISCONNECT message is sent by the network, the B-channel used in the call is disconnected but is not yet released and is not, therefore, available for further calls.

b) To clear the call the user will send a RELEASE message. This message indicates the deactivation of this particular transaction (by user) to the network. Upon receiving this message, the network releases the B-channel and the call reference for future use and returns a RELEASE COMPLETE message to the user. If no RELEASE or DETACH message (see case b)) is received from the user in a time interval T305 (specified in § 7.1) from the transmission of the DISCONNECT message, the network shall send a RELEASE message to the user. The network shall start timer T308 and continue as described in § 5.1.3.1 a).

In some networks, in-band tones and announcements will be provided as call progress information for calls in which the bearer service identification supplied, as part of the call information by the calling user, has indicated that this would be appropriate. When the network decides to initiate clearing for such calls, the appropriate in band tone shall be sent for a period T306 prior to the transmission by the network of a DISCONNECT message. If a DISCONNECT message is received from the user during a period covered by T306, the network shall remove the tone or announcement from the B-channel and shall send RELEASE message to the user. The value of T306 is specified in § 7.1.

c) In some cases, the user may wish to invoke facilities which may delay the release of the call reference whilst allowing the release of the B-channel. In these conditions the user will respond to the DISCONNECT message by sending a DETACH message.

On receipt of the DETACH message the network shall cancel timer T305, release the B-channel and send in response a DETACH ACKNOWLEDGE message. Following the sending of the DETACH ACKNOWLEDGE message by the network and receipt of the DETACH ACKNOWLEDGE by the user, the call shall be considered by the user and network respectively to be in a Detach state.

The procedures invoked by the network in response to user requested facilities and the procedures used to leave the Detach state are for further study.

d) In some cases the user may receive from the network a RELEASE message without having received a previous DISCONNECT message (e.g. if the DISCONNECT message was corrupted by undetected transmission errors). In these cases the user shall return a RELEASE COMPLETE message to the network and consider the call to be in the Null state.

5.1.3.3 *Clear collision*

Clear collision occurs when the user and the network simultaneously transfer a DISCONNECT message specifying the same call. Both the user and the network will regard the call as having entered the Disconnect request state. The procedures in § 5.1.3.1 will then apply.

5.1.3.4 *Handling of error conditions*

a) Whenever a message is received, at either side of the interface, specifying a call reference relating to a call which is considered to be in either the ACTIVE state or any of the states of call establishment, suspension or clearing, but for which a response is not prescribed by the procedures in § 5.1 or § 5.2, a STATUS message is returned indicating the call state of the receiver. The sending or receipt of a STATUS message in such a situation will not directly affect the call state of either the sender or the receiver. The side having received a STATUS message may, following analysis of the message contents, take appropriate action (e.g. by returning a DISCONNECT message in response to the STATUS). In particular, this could apply if the call state indicated in the STATUS message is different from the call state perceived by the side of the interface receiving the STATUS message. Alternative actions taken upon receipt of a STATUS message are for further study. The STATUS message and its contents are defined in § 3.2.26.

Note – In some abnormal conditions it may be appropriate to initiate forced clearing of the call by sending a RELEASE rather than a DISCONNECT message. This point is for further study.

b) Whenever the network receives any message except SETUP, RELEASE, RELEASE COMPLETE, DISCONNECT or RESUME specifying a call reference which it does not recognize as relating to an active call or a call in progress, it initiates clearing by sending a DISCONNECT message according to the procedure in § 5.1.3.2, specifying the call reference in the received message (see also the Note above).

c) Whenever the user receives any message except SETUP, RELEASE, RELEASE COMPLETE or DISCONNECT specifying a call reference which it does not recognize as relating to an active call or a call in progress, it initiates clearing by sending a DISCONNECT message according to the procedure in § 5.1.3.1, specifying the call reference in the received message (see also the Note above).

d) If the network or user receives a DISCONNECT message specifying a call reference which it does not recognize as relating to an active call or a call in progress it sends a RELEASE message, specifying the call reference in the received message.

e) If the network or user receives a RELEASE message specifying a call reference which it does not recognize as relating to an active call or a call in progress, a RELEASE COMPLETE is returned, specifying the call reference in the received message.

f) If the network or user receives a RELEASE COMPLETE message specifying a call reference which it does not recognize as relating to an active call or a call in progress, no action should be taken.

g) If layer 3 is notified by the data link layer entity that the underlying data link is disconnected, it should not immediately clear the calls supported by that data link but should attempt to re-establish a data link connection. Although messages in transit during the layer 2 failure may be lost or duplicated during recovery, as an objective, calls which were stable should not be lost if layer 2 can be reconnected within some brief interval (determined by timer T309, specified in § 7.1). Also as an objective the layer 3 procedures should provide as robust recovery procedures as possible even for those calls with lost or duplicated messages. The specific procedures to be invoked when there is a layer 2 disconnection are for further study.

5.1.4 *Call rearrangements*

The elements of procedure in this section provide for physical layer and/or data link layer rearrangements after a call has entered the ACTIVE state as defined in § 2.2.1.5. They are intended for application to the basic interface structure; their possible use for primary rate interface structures is for further study.

The activation of this procedure at a user-network interface may correspond to a number of possible events such as the following:

- physical disconnection of user equipment and reconnection at a different connection point in the same user-installation (e.g. comprising a number of logically associated basic interface structures);
- physical replacement of one user equipment by another at the same connection point;
- the human user moves from one equipment to another;
- suspension of call and its subsequent reactivation at the same user equipment and connection point.

The procedures in this section are described in terms of functional messages and information elements. These procedures may also be realized by stimulus information elements within INFORMATION messages, see § 6.

If the procedures for call suspension in this section are not followed prior to the physical disconnection of the terminal from the interface, then the integrity of the call cannot be guaranteed by the network.

The present text may not completely describe the procedures applicable to calls other than a point-to-point call between two users (e.g. a conference call).

5.1.4.1 *Call suspension*

The procedure is initiated by the user by sending a SUSPEND message, containing the current call reference, to the network. The user may optionally include in this message a bit sequence (e.g. IA5 characters) to be known as the call identity for subsequent reconnection. Where no call identity is included by the user, the network allocates a null-value.

5.1.4.2 *Call suspended state*

Following the receipt of a SUSPEND message a SUSPEND ACKNOWLEDGE message shall be sent from the network to the user initiating the action, and a network timer T307 shall be initiated. (The value of T307 is specified in § 7.1.)

At this time, the network will consider the call reference to be released. The B-channel involved in the connection will be reserved until reconnection of the call (or until a clearing cause occurs, e.g. expiry of timer T307). A STATUS message with cause "remote user suspended" is sent to the other address(es) involved in the call with the address of the user which initiated the action.

When the user receives the SUSPEND ACKNOWLEDGE message, it may disconnect the underlying data link connection, if the terminal has to be physically disconnected from the interface.

5.1.4.3 *Call suspend error*

On receipt of a SUSPEND message, the network will respond by sending a SUSPEND REJECT message if the information contained in the SUSPEND message is not sufficient to avoid ambiguities on subsequent call re-establishment. This will apply, in particular, when at a given user-network interface, a SUSPEND message is received with a call identity sequence already in use, or when the SUSPEND message does not contain any call identity sequence and another call with a null-value is in the Local suspend state at that interface.

In this case the state of the call is not altered with the network (i.e. it remains in the Active state).

5.1.4.4 *Call re-establishment*

At the connection end where suspension was initiated, the user may request re-establishment of a call after physical reconnection of a terminal by sending a RESUME message containing the call identity used at the time of call suspension. The call reference included in the RESUME message may be the one relating to the suspended call or a new one chosen by the user. B-channel information may be included in the RESUME message, but the "any B-channel available" option specified in § 5.1.1.1 c) shall be used.

If the terminal was physically disconnected from the interface, a data link connection must be re-established by the user before sending the RESUME message.

On receipt of the RESUME message, the network shall re-establish the call in the Active state, provided that the call was not cleared due to other reasons. The network shall then send a RESUME ACKNOWLEDGE message to the user and it shall cancel timer T307. The RESUME ACKNOWLEDGE will specify the B-channel allocated to the call by the network according to the procedures specified in § 5.1.1.1 c).

If the call is reconnected at the same user-network interface where it was suspended, then the previously reserved B-channel will be used. Otherwise, any channel may be selected by the network. If the call is reconnected at a different user-network interface, then the reserved B-channel will be released by the network at the time of reconnection.

The network will also send a STATUS message with cause "remote user resumed" to the other address(es) involved in the call.

No memory of a previously received call identity sequence is kept by the network after sending the RESUME ACKNOWLEDGE message.

If the call had been cleared by the network, the network shall respond to the RESUME message by initiating call clearing in accordance with § 5.1.3.2.

5.1.4.5 *Call resume error*

If a received RESUME message cannot be actioned by the network (e.g. as a result of the B-channel selection procedure), a RESUME REJECT message should be returned to the requesting user. The call returns to the Local suspend state.

If timer T307 expires before a valid RESUME message is received from the user, the network shall initiate clearing of the call. Moreover, if the associated data link connection was not disconnected, the network shall initiate clearing procedures towards the concerned user as described in § 5.1.3.2.

5.1.5 *Call collisions*

Call collision occurs when a user's request to establish a call encounters an attempt by the network to establish a call at the same interface. Such a situation could occur if both the network and the user will send a SETUP message at approximately the same time. If the user can support simultaneous calls and sufficient B-channels are available, the collision is resolved by the channel selection procedures in §§ 5.1.1.2 and 5.1.2.2.

If only one B-channel is available, the network shall give an incoming call preference over a call request received from the user.

If only one B-channel is available, the user shall generally give preference to the network for call establishment. However, some terminal adaptors supporting existing non-voice terminals (e.g. X.21) may need to resolve call collision by clearing the incoming call and reattempting the outgoing call set-up in order to satisfy the requirements of the "R" interface.

5.1.6 *Control of user facilities*

5.1.6.1 *General*

Two procedures for the control of user facilities are defined as follows:

i) control of call related facilities, in connection with a call control procedure, and;

ii) registration/cancellation of facilities, independently from call control procedures and from any particular call.

The application of such procedures to the various user facilities is described in the specification of the procedure relating to the user facilities themselves. Detailed application of these procedures to specific user facilities is for further study.

User facilities may be controlled using either functional information elements carried by FACILITY messages in accordance with internationally standardized procedures or by stimulus information elements conveyed in INFORMATION messages in accordance with network dependent procedures.

5.1.6.2 *Control of call related facilities*

Requests for call related facilities may be included in call control messages. Additionally the following messages may be used to control call related facilities: FACILITY, FACILITY ACKNOWLEDGE and FACILITY REJECT. Facility control may also be performed by using INFORMATION messages containing KEYPAD, DISPLAY and other stimulus information elements.

The FACILITY message or the INFORMATION message is sent by a user (calling or called) to initiate the procedure to request the concerned facility. It may also be sent by the network to the remote user if the control procedure of the facility requires this user to be involved.

If the control procedure only involves the initiating user, the network responds to the FACILITY message with either a FACILITY ACKNOWLEDGE or FACILITY REJECT message, to respectively indicate completion or rejection of the procedure.

If the facility is activated by using an INFORMATION message, the network responds with an INFORMATION message containing DISPLAY information.

If the control procedure involves the remote user, this user responds to the FACILITY message with either a FACILITY ACKNOWLEDGE or FACILITY REJECT message.

Alternatively where the network informs the remote user of the facility via an INFORMATION message that user shall respond with an INFORMATION message containing Keypad information elements.

The decision to use functional or stimulus signalling shall be taken locally by the network on the basis of user characteristics determined by the network at call establishment or when the user resumes after call suspension.

Following the receipt of such a message from the remote user, the network will send the appropriate message to the initiating user.

The above indicating messages may be sent in the active state of the call. Sending of a message does not in itself change the state of the call; however, this state may be changed as a result of the facility invoked.

All the above indicated messages contain the call reference appropriate to the call.

5.1.6.3 *Registration and cancellation of facilities*

The following messages are used to control registration and cancellation of user facilities: REGISTER, REGISTER ACKNOWLEDGE, REGISTER REJECT, CANCEL, CANCEL ACKNOWLEDGE, CANCEL REJECT.

Facility registration and cancellation may also be controlled by using stimulus information elements (e.g. Keypad) within INFORMATION messages. In this case, the network may respond using DISPLAY and/or other stimulus information elements conveyed in INFORMATION messages.

A REGISTER or CANCEL message is sent by a user to initiate a registration or cancellation procedure of a user facility. It may also be sent by the network to a remote user if the control procedure of the facility requires this user to be involved.

If the control procedure only involves the initiating user, the network responds to such a message with the appropriate ACKNOWLEDGE or REJECT message to indicate completion or rejection of the procedure.

If the facility requested involves the agreement of a remote user, this user responds to the message with the appropriate ACKNOWLEDGE or REJECT message. The network transfers the message to the initiating user.

The above indicated messages do not relate to a call, however, they contain a call reference, which is the same in the REGISTER or CANCEL and ACKNOWLEDGE or REJECT messages of the same procedure. The REGISTER and CANCEL messages may contain the address of the user to which they are destined.

5.1.7 *Charging indication*

5.1.7.1 *General*

Charging indication is a feature allowing a user to be informed about the charging of a call. It is for further study if it is to be provided as a standard service feature or as a user facility assigned to the user for an agreed contractual period.

5.1.7.2 *Procedures*

Charging indication information may be sent by the network to the appropriate user (calling or called) on the following occasions:

i) at the beginning of the call, to indicate the charging rate plus, when applicable, charging units on answer;

ii) during the call, to indicate a change in the charging rate;

iii) during the call, to indicate that N (value for further study) charging units have been charged;

iv) at the end of the call, to indicate the overall charge.

Note – It is for further study how items i)-iv) apply, e.g. if they have to be considered as separate features or if they have to be combined as part of the same feature.

Charging indication information may be sent to the calling user in any of the following messages: SETUP ACKNOWLEDGE, ALERTING, CONNECT, DISCONNECT, RELEASE and INFORMATION. To the called user, it may be sent in the following messages: SETUP, CONNECT ACKNOWLEDGE, INFORMATION, DISCONNECT and RELEASE. The INFORMATION message shall be used during the Active state of the call. No charging indication information shall be sent when the call is in the Local suspend state.

5.1.8 *Closed user group (CUG)*

The closed user group (CUG) facility is assigned to a user for an agreed contractual period. Principles and procedures to be used are in accordance with Recommendations I.330 [5], Q.764 [6] and X.300 [7].

The SETUP message format allows the inclusion of a CUG facility request by a calling user.

Incoming calls associated with a closed user group shall include a CUG facility request in the SETUP message delivered to the called user.

In both cases the facility request may contain an index referring to the particular CUG to which the call is associated. The CUG index shall only have local significance at each user-network interface. If no CUG facility request is included by the calling user in a SETUP message, then the preferential CUG for that customer will be assumed by the network (see Recommendation X.300 [7]).

An ISDN user may be registered as a member of several closed user groups, as specified in relevant CCITT Recommendations.

5.1.9 *Calling line identification*

Calling line identification is a user facility assigned to a user for an agreed contractual period. It applies to all incoming calls to that user. Principles and procedures to be used are in accordance with Recommendations I.330 [5], Q.764 [6] and X.300 [7].

In this case, the SETUP message sent to the called user includes the calling line identity provided by the network, encoded as the origination address information element; the calling line identity may additionally be provided in the "Display" information element. If an ALERTING or CONNECT message is received containing an indication that the called terminal cannot handle such a specific information element (stimulus mode terminal, see § 7), then the network will send a second time the calling line identity by "Display" information in an INFORMATION message.

Some networks may provide calling line identity within the CONNECT ACKNOWLEDGE message.

Note – Delivery of calling line identity to the called user may be subject to agreement by the calling user. The definition of a possible new user facility to allow a calling user to prevent such a delivery is for further study.

5.1.10 *Called line identification*

Called line identification is a user facility assigned to a user for an agreed contractual period. It applies to all outgoing calls from that user. Principles and procedures to be used are in accordance with Recommendations I.330, Q.764 and X.87.

In this case, the CONNECT message sent to the calling user includes the called line identity. Depending on the capabilities of the calling terminal (i.e. if it is a stimulus mode terminal or not), this identity will be sent as "Display" information or as a specific information element.

Note – Delivery of called line identity to the calling user may be subject to agreement by the called user. The definition of a possible new user facility to allow a called user to prevent such a delivery is for further study.

5.1.11 *Charging method selection*

The charging method selection facility is assigned to a user for an agreed contractual period.

The SETUP message format allows the inclusion of a charging method selection/indication at the calling user interface and called user interface respectively.

This facility shall allow the following charging methods to be selected/indicated:

a) normal charging (in this case normal charging shall be assumed in the absence of a facility request);

b) reverse charging (further study is required regarding the exact method of negotiating this facility with the called user);

c) other charging methods (e.g. credit card) require further study.

5.1.12 *Call redirection*

The call redirection facility is assigned to a user for an agreed contractual period and causes incoming calls to be redirected to an address previously specified by the called user at the time of facility registration.

The user may register a request for call redirection by using the procedures described in § 5.1.3, i.e. either with a FACILITY REGISTER message or with stimulus information in an INFORMATION message.

The principles and procedures by which the network implements this facility shall be in accordance with Recommendations I.330 [5], Q.764 [6] and X.300 [7].

Additional procedures to allow e.g. selective redirection of calls are for further study.

5.2 *Procedures for user-to-user signalling*

5.2.1 *General*

User-to-user signalling provides a means of communication between two customers by using as a basis the layer 3 protocol defined in § 5.1.

User-to-user signalling is used to exchange information between two users to provide, for example, additional facilities that are not described in this Recommendation.

The exchange of user-to-user signalling is limited by flow control procedures provided by the network.

Three possibilities of user-to-user signalling are provided by the network to the users, as follows:

a) user-to-user signalling in association with a circuit-switched connection on the B-channel(s);

b) user-to-user signalling (not associated with a circuit-switched connection) via an end-to-end signalling connection which is dynamically established;

c) user-to-user signalling (not associated with a circuit-switched connection) via an end-to-end signalling connection which is permanently established.

It is for further study how these facilities are provided; for example, as a standard service feature to all users, as a user facility assigned for an agreed contractual period or on a per call basis. Service characteristics including tariff arrangements are for further study by the relevant Study Groups.

Note – Both functional and stimulus modes of conveying user-to-user information may be employed. The use of a combination of modes is not precluded.

5.2.2 *User-to-user signalling in association with a B-channel connection*

a) *Call establishment*

A "*User-to-user information" information element* of variable length as specified in § 4.5.27 may be included in the SETUP message transferred across the user-network interface at the calling side as described in § 5.1.1.1. The content of this information element is transferred in the network and delivered in the same information element included in the SETUP message transferred across the user-network interface at the called side as described in § 5.1.2.1.

"Keypad" information element(s) may also be used to convey user-to-user information in the SETUP message provided that the remaining elements of call information are also conveyed in this manner. User-to-user information received by the network within "Keypad" information elements shall be delivered to the called user via a "Display" information element within the SETUP message.

The character sequences used to delimit the user-to-user information with "Keypad/Display" information elements in a SETUP message whilst maintaining code transparency may be a network dependent matter. However, the user-to-user information shall be included as the last element within a "Keypad/Display" information element.

The maximum amount of user-to-user information which may be conveyed in the SETUP message via "Keypad/Display" information elements is for further study.

A "User-user information" information element with the same characteristics may be included in the ALERTING and/or CONNECT messages transferred across the user-network interface at the called side as described in §§ 5.1.2.2, 5.1.2.3 and 5.1.2.4. The content of this information element is transferred in the network and delivered in the corresponding message(s) transferred across the user-network interface at the calling side as described in §§ 5.1.1.5 and 5.1.1.6.

Note – Where user-to-user information is conveyed in the SETUP message via "Keypad/Display" information elements, any user-to-user information returned in the ALERTING and/or CONNECT messages shall be contained in "Display" information elements.

If a multipoint terminal configuration exists at the user-network interface at the called side, inclusion of the "User-user information" information element in the ALERTING message is for further study; moreover if in such a case more than one CONNECT message is received, the content of the "User-user information" information element delivered to the calling user is the one in the message received from the terminal to which a CONNECT ACKNOWLEDGE message is sent as described in § 5.1.2.7.

A user facility request/indication may be included in SETUP, ALERTING or CONNECT messages to indicate that either:

i) User-to-user signalling is present in the message (Note – no user-to-user signalling is allowed in the ALERTING message for point-to-multipoint operation) or

ii) the originator of the message has the capability to receive user-to-user signalling information.

The precise definition of the facility request requires further study. However, it should indicate the type of information element to be used for the conveyance of user-to-user information (i.e. functional or stimulus).

b) *Transfer of USER INFO messages*

Once the call is established, both the involved users can transfer information between themselves by transferring USER INFO messages across the user-network interface. The network provides for the transfer of such messages from the calling to the called side and vice versa.

The USER INFO message includes as information element the call reference, the user-to-user information as defined in § 3.2.30 and the more data indication. The more data indication is set by the source user to indicate to the remote user that another USER INFO message will follow, containing information belonging to the same block. The use of the more data indication is not supervised by the network.

If the user-to-user signalling facility is provided, the transfer of USER INFO messages across the calling and called user-network interfaces may be performed in the following states (see §§ 2.2.1 and 2.2.2): CALL-DELIVERED/CALL RECEIVED and ACTIVE. No more than two messages (provisional value) may be transferred in the CALL DELIVERED/CALL RECEIVED states in each direction; transfer of message in such a state in case of a multipoint terminal configuration is for further study. USER INFO messages received from the user in any other state of the call are discarded by the network and the user notified with a STATUS message with a cause "USER INFO local discard".

In any case, sending of USER INFO messages does not change the state of the call.

As described in § 3.2.30, USER INFO messages may contain a "User-to-user information" information element or a "Display" information element. The choice of information element should be made according to the user-to-user facility request in the SETUP message.

Note – Stimulus mode terminals may transmit user-to-user information via "Keypad" information elements contained in INFORMATION messages at any phase of a call following the generation of a SETUP message. Such user-to-user information shall be delivered to the remote user via a "Display" information element contained within a USER INFO message. The ability for the user to send a USER INFO message with the "Display" information element (to be conveyed transparently by the network) is for further study.

c) *Flow control of USER INFO messages*

The network will flow-control, when needed, the transfer of USER INFO messages from a user by means of a CONGESTION CONTROL message containing a "Congestion level" information element. Two indications of "Congestion level" are specified: "receive not ready" and "receive ready". On receipt of the former, the user should suspend sending USER INFO messages; on receipt of the latter, sending may recommence. After having sent a receive not ready indication, the network may discard USER INFO messages which are subsequently received. The network will send a congestion control message with a receive not ready indication whenever a USER INFO message is locally discarded. The CONGESTION CONTROL message shall also include a cause "USER INFO discarded locally". The possible inclusion of additional indications in the CONGESTION CONTROL message to signify intermediate congestion levels between "receive not ready" and "receive ready" is for further study.

The receipt of the receive ready indication by the user shall be interpreted by the user as an indication that no more than "n" USER INFO messages may be sent before another receive ready indication is received from the network. The value of "n" requires further study.

Note – Where user-to-user information has been conveyed within "Keypad" or "Display" information elements, CONGESTION CONTROL message may also contain "Display" information elements. The character sequences contained in the "Display" information elements shall be network dependent.

d) *Call clearing*

A "user-to-user information" information element with the characteristics above described may be included in the DISCONNECT, DETACH and RELEASE messages. The information contained in such an information element is transferred to the remote user in the corresponding clearing message. Such a transfer is only performed if the information is received at the local exchange of the remote user before sending a clearing message to that user; otherwise, the information is discarded.

Note – Application of flow-control procedures by the user is for further study.

e) *Call suspension*

When user-to-user information is received from the remote user during the call suspended state, this information is discarded by the network.

5.2.3 *User-to-user signalling via a temporary signalling connection*

a) *General characteristics*

This feature allows the users to communicate by means of user-to-user signalling without setting up a circuit-switched connection. A temporary signalling connection is setup and cleared in a similar way to the control of a circuit-switched connection, as detailed in the following.

b) *Call establishment*

Procedures for call establishment are as described in §§ 5.1.1 and 5.1.2 with the following modifications.

On call request, the SETUP message sent by the calling user will indicate "Recommendation I.451 user-to-user signalling" in the bearer service identification information element, thereby indicating to the network that the establishment of a B-channel connection is not required. Moreover no B-channel preference is indicated, as described in § 5.1.1.2. Similar rules apply to the SETUP message sent at the called side. Sending of call information is always performed en-bloc.

Procedures as described in § 5.2.2 apply for the inclusion of the "User-to-user information" information element in call establishment messages and for the handling of ALERTING and CONNECT messages.

c) *Transfer of USER INFO messages*

The procedures described in § 5.2.2 b) apply, where the call reference applies to the signalling connection.

d) *Flow control*

The procedures described in § 5.2.2 c) apply.

e) *Call clearing*

The clearing of a temporary signalling connection will be initiated by the user or the network sending a RELEASE message as described in §§ 5.1.3.2 b) or 5.1.3.1 b) respectively. In addition, a "user-to-user information" information element (having the characteristics described in § 5.2.2 may be included in the RELEASE message sent by the clearing user and sent to the remote user before the signalling connection is cleared.

5.2.4 *User-to-user signalling via a permanent signalling connection*

This feature allows the users to communicate by means of user-to-user signalling without setting up a circuit-switched connection; moreover, the communication is permanently in the Active state. Thus, the only messages transferred by the users across the user-network interface are the USER INFO messages.

Procedures for transfer of USER INFO messages are as described in § 5.2.2 b).

Procedures for flow control are as specified in § 5.2.2.

5.3 *Procedures for packet communications*

This section is intended to explain the role of the D-channel signalling procedures in the support of packet communications in an ISDN. A complete description of terminal adaptor (TA) functions necessary for Recommendation X.25 terminals support can be found in Recommendation X.31(I.462) [8] together with a description of ISDN-based packet handling functions.

According to the scenarios defined in Recommendation X.31(I.462) [8], packet communications may be accessed, using either:

a) the maximum integration scenario. In this case a packet-handling function (PH) is included within an ISDN. In this case any channel may be used for access;

b) the minimum integration scenario. In this case only a B-channel is used for access.

The procedure in §§ 5.3.2 and 5.3.3 apply to the maximum integration scenario.

5.3.1 *Packet switching service via B-channel*

In this context, the ISDN provides a physical 64 kbit/s semi-permanent or switched channel between the appropriate PH/PSPDN port and the user terminal (TE1/TA) at the customer premises. The user terminal shall communicate with the PH/PSPDN over the B-channel using full Recommendation X.25 procedures (layers 2 and 3).

In the case of semi-permanent access, the user terminal shall be dedicated to the corresponding PH function or ISDN interworking unit port (IP) at the PSPDN.

In the case of switched access, the user terminal shall first set up, via the ISDN signalling procedure, the path towards the PH/PSPDN port (layer 1 set up) before starting Recommendation X.25 layer 2 and layer 3 functions.

For calls originated by the PH/PSPDN, the same considerations as above shall apply.

5.3.1.1 *Elements of procedure*

5.3.1.1.1 *Outgoing call*

1) *Establishment of the circuit-mode connection (B-channel) to PH/PSPDN*

a) *Leased connection*

The method of establishment of leased circuits is for further study.

b) *Switched connection*

Switched connections to a PSPDN or PH shall be established using the D-channel signalling procedures for outgoing call establishment described in § 5.1.1.

2) *Packet-mode operation*

Following the establishment of the connection, the user terminal shall communicate with the PSPDN or PH using full Recommendation X.25 procedures (layers 2 and 3).

3) *Clearing of the circuit-switched connection to the PH/PSPDN*

a) *Leased connection*

The method of clearing of leased circuits is for further study.

b) *Switched connection*

The clearing of the switched connection shall be effected by using the D-channel signalling procedures for call termination described in § 5.1.3. Thus the B-channel may be cleared at any time by the user though, in general, it will be cleared following the clearing of the last virtual call over that B-channel. The circumstances in which the network shall clear the connection require further study.

5.3.1.1.2 *Incoming calls*

1) *Establishment of the circuit-switched connection (B-channel) to TA/TE1*

The B-channel to the called user shall be established by the network using the D-channel signalling procedures for incoming call establishment described in § 5.1.2. The call will be either offered to all packet-mode user equipment at the user interface or to a single user equipment identified by the TEI value of the TA/TE1 (see § 5.2.3) or by means of the ISDN sub-address.

2) *Packet-mode operation*

Following the establishment of the connection, the PH/PSPDN shall use Recommendation X.25 procedures (layers 2 and 3) to communicate over the B-channel to the called user.

3) *Clearing of the B-channel connection*

See § 5.3.1.1.1 3).

5.3.1.2 *Overview diagrams of signalling flow*

Figures 40/Q.931 and 41/Q.931 describe the signalling message flows on the D-channel and the Recommendation X.25 transmissions on the B-channel necessary to effect Recommendation X.25 packet communications over the B-channel.

Note – These figures are included for explanatory purposes and do not show all Recommendation X.25 frames which may be sent across the user-network interface within the B-channel (e.g. layer 2 acknowledgements of I frames and the possible use of the restart procedure).

5.3.2 *Packet switching service via the D-channel*

The D-channel enables ISDN user terminals to access a PH function within the ISDN by establishing a data link connection to that function which can then be used to support packet communication according to Recommendation X.25 layer 3 procedures. The address of the ISDN interface over which such access is being made will be known either directly or indirectly by the PH function. The specific address of the terminal making this access shall be supplied by the layer 2 service of the D-channel access link.

The layer 2 procedures shall be in accordance with Recommendation Q.921(I.441) [4]. The D-channel provides a semi-permanent connection for packet access since all layer 2 frames containing a packet-mode Service Access Point Identifier (SAPI) will be routed automatically between the user and PH function.

The PH function may similarly effect the establishment of data link connection over the D-channel of an ISDN interface to a user equipment capable of operating in the packet mode in order to deliver an incoming packet call. In this case, the call will be either offered to all packet-mode user equipment at the user interface or to a single user equipment specified by the TEI value in accordance with the channel selection procedures described in § 5.3.3.

A number of packet-mode user equipments can operate simultaneously over the D-channel, each using a separate layer 2 link identified by an appropriate address (see Recommendation Q.921(I.441)) in frames transferred between the user and PH function.

5.3.2.1 *Overview diagrams of message flows*

Figures 42/Q.931 and 43/Q.931 describe the message flows for packet communications over the D-channel.

Note in § 5.3.1.2 applies.

5.3.3 *Packet-switching service with channel selection*

The choice of which channel to use for the delivery of a new incoming packet call shall be made by the PH according to certain criteria (see Recommendation X.31(I.462) [8], § 3.2.2). In the most general case, new incoming packet calls may be indicated to the ISDN customer via the point-to-multipoint call offering procedures. The call offering procedure is performed using the layer 3 messages and procedures of § 5.1.2 and these layer 3 messages may be carried in data link layer frames with the SAPI indicating either packet data (p) or signalling (s) information (see Recommendation Q.921(I.441) [4]). Further study is required on the support of the following procedures. The operation of these procedures is as follows:

a) *Networks using SAPI = "s" at data link layer*

In this case the call offering procedure is integrated into the circuit-switched call control procedures with the channel selection being accomplished by means of the channel negotiation procedures if offered as a network option (see § 5.1.2.2). However, in the case where the TA/TE1 requests the new incoming packet call on either a B-channel already established for packet-mode calls or on the D-channel, the network will terminate the layer 3 procedures after the channel negotiation phase by sending a RELEASE message as described in § 5.1.3.1 b).

b) *Networks using SAPI = "p" at data link layer*

In this case, the call offering procedure takes the form of an enquiry/response interaction at layer 3 which precedes any procedures for circuit or packet-switched call control. The call offering procedure uses identical messages to the SET-UP and SET-UP ACK messages, and optionally identical messages to RELEASE and RELEASE COMPLETE (Note) messages described in § 5. The channel selection functions is performed using the

layer 3 channel negotiation procedures of § 5.1.2.2 if offered as a network option. The four messages of the call offering procedure are conveyed using the Unacknowledged Information Transfer Service at data link layer. If the TA requests the use of a free B-channel then following the call offering procedure, the network shall initiate the establishment of a B-channel to the selected TA/TE1 by using the procedures described in § 5.1.2. In this case, the called TA/TE1 shall be identified by means of the TEI value of the TA/TE1 which is returned with the SETUP ACKNOWLEDGE response to the SETUP message during the call offering sequence. Alternatively, the TA/TE1 may be identified by a sub-address in which case the establishment of a B-channel to the selected TA/TE1 may be achieved using the point-to-multipoint incoming circuit-switched call procedures. If the TA/TE1 requests the incoming packet call on either a B-channel already established for packet-mode calls or on the D-channel, then no further D-channel signalling (following the call offering procedure) is required before the Recommendation X.25 procedures begin.

Note – RELEASE COMPLETE is named as RELEASE ACK in Recommendation X.31(I.462). The discrepancy shall be resolved in the next study period.

According to the extent of addressing, sub-addressing and bearer service indication information provided by the calling terminal, these procedures will allow the call to be offered to a subset of the terminal population at the ISDN address or to a specific interface at reference point S or T.

Apart from this general approach to incoming call offering, in some circumstances (for a period for which the facility is subscribed), the service characteristics for a particular ISDN address may be registered at the PH such that the network may choose the access channel for a particular incoming call packet. Furthermore, in such cases, it shall also be possible to route an incoming call packet to the called terminal over an established B-channel connection or D-channel link without the need for any preceding D-channel signalling. Also some networks may not provide an option for channel negotiation. In this manner the particular approach to incoming call routing may be tailored to meet the particular requirements of the network and the user.

Where a number of ISDN lines form a "Hunt Group", successive incoming packet calls may be routed on different lines in accordance with the line selection algorithm associated with that group. Each call will be offered on the chosen line using either the general call offering procedure or specific incoming call routing as appropriate.

The channel selection procedure for incoming calls is independent of the type of channel selected at the calling end. In this respect, any combination of channel type used at each end is possible.

The procedures for channel selection are shown in Figures 44/Q.931 and 45/Q.931.

Key to the Figures 40/Q.931 through 45/Q.931

D-channel signalling messages

[ ] Layer 3

C – CONNECT

CA – CONNECT ACKNOWLEDGE

CC – CALL CONNECTED

D – DISCONNECT

R – RELEASE

IC – INCOMING CALL

S – SETUP

SA – SETUP ACKNOWLEDGE

CP – CALL PROCEEDING (Note)

RC – RELEASE COMPLETE (Note)

Recommendation X.25 level 3 messages

Any layer 3 message preceded by Recommendation X.25 indicates a Recommendation X.25 layer 3 packet e.g. [Recommendation X.25 CR] = Recommendation X.25 Call Request packet.

CA – CALL ACCEPTED

CC – CALL CONNECTED

CLC – CLEAR CONFIRMATION

CLI – CLEAR INDICATION

CLR – CLEAR REQUEST

CR – CALL REQUEST

IC – INCOMING CALL

Layer 2 frames

( ) – Layer 2

GTEI – Group TEI

A, B – X.25 layer 2 addresses (includes command and response)

Layer 2 addresses marked (X, p) indicates that the SAPI element of the frame address is coded as for packet type information as described in Recommendation Q.921(I.441). Layer 2 addresses marked (X, s) refer to signalling type information

SABM – Set Asynchronous Balance Mode frame

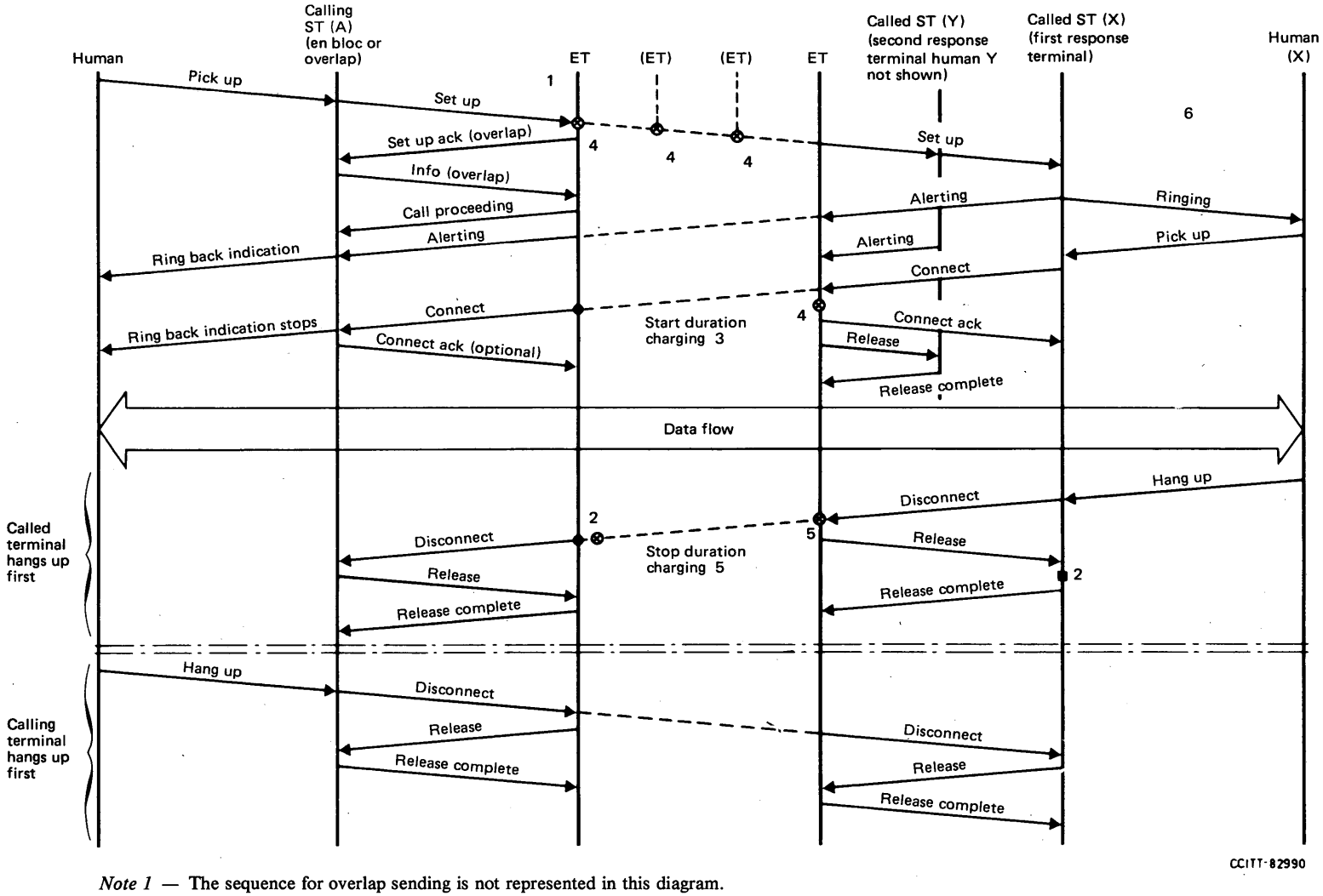
UA – Unnumbered Acknowledgement frame

UI – Unnumbered Information frame (i.e. using unacknowledged information transfer service at data link layer)

I – Information frame

DISC – Disconnect frame

Note – CALL PROCEEDING and RELEASE COMPLETE are named, in Recommendation X.31(I.462), as CALL SENT and RELEASE ACK, respectively. The discrepancy shall be resolved in the next study period.



Note 1 — The sequence for overlap sending is not represented in this diagram.

Note 2 — A terminal should not release the D-channel connection and power until after this point.

Note 3 — A proposal for further study (it may be a national matter).

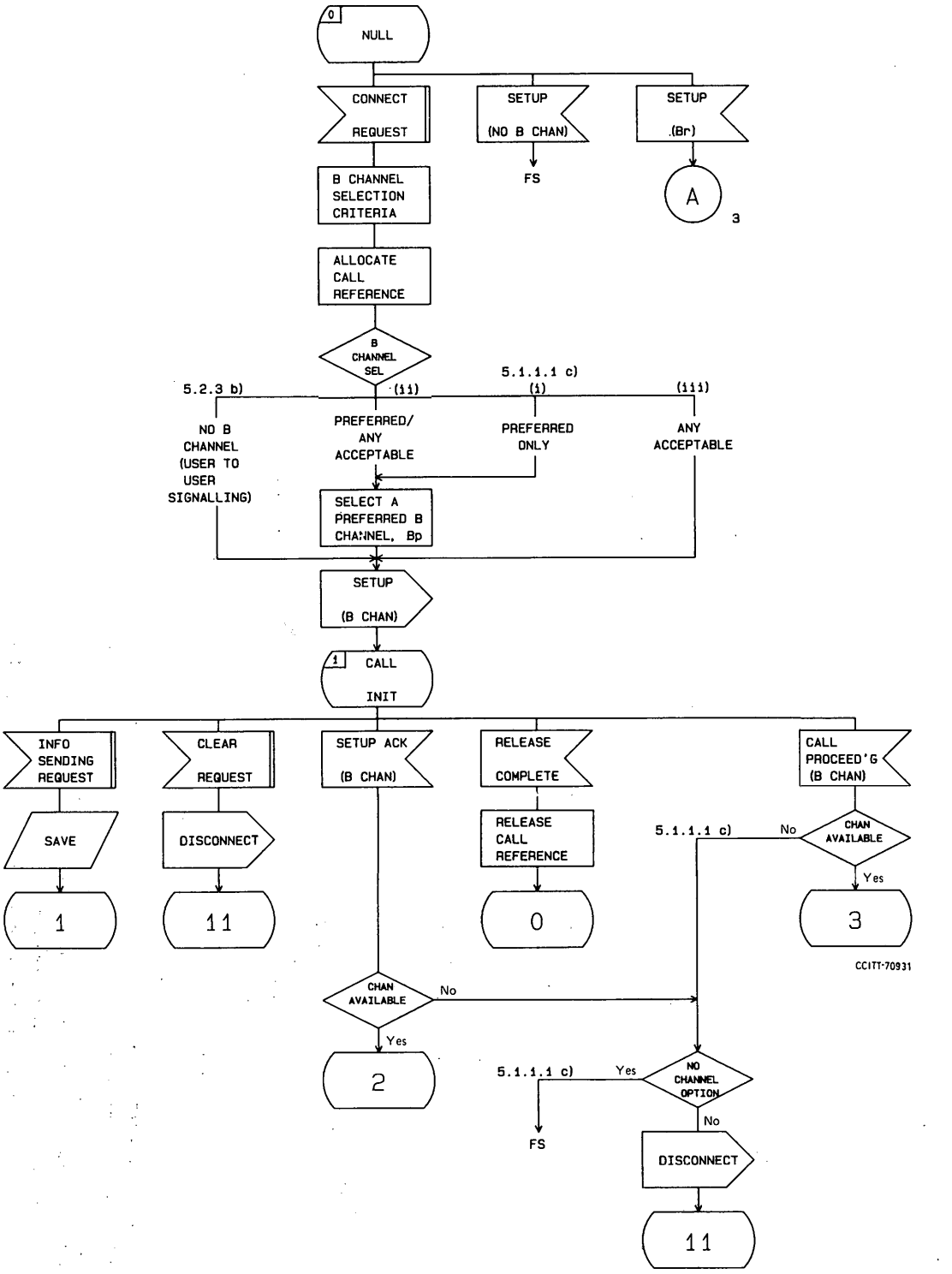
Note 4 — Proposed switch-through points and the sequence in which they occur.

Note 5 — Proposed network release points and sequence.

Note 6 — The interactions between the human and the terminal are shown for illustration only.

FIGURE 37/Q.931

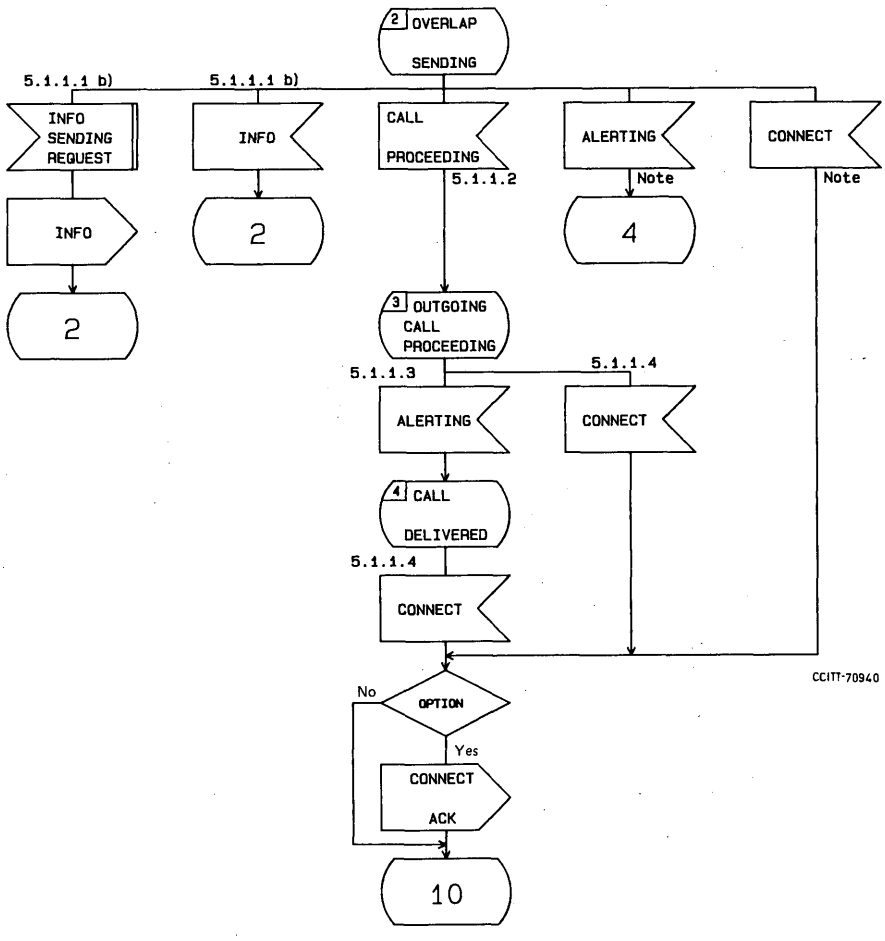
Procedure for a simple circuit switched call (example)



Note 1 — FS indicates further study required.
Note 2 — In the event of conflict between these diagrams and the text of Section 5, the text should be the prime source.
Note 3 — These diagrams show call control for circuit switched calls.

FIGURE 38/Q.931 (1 of 5)

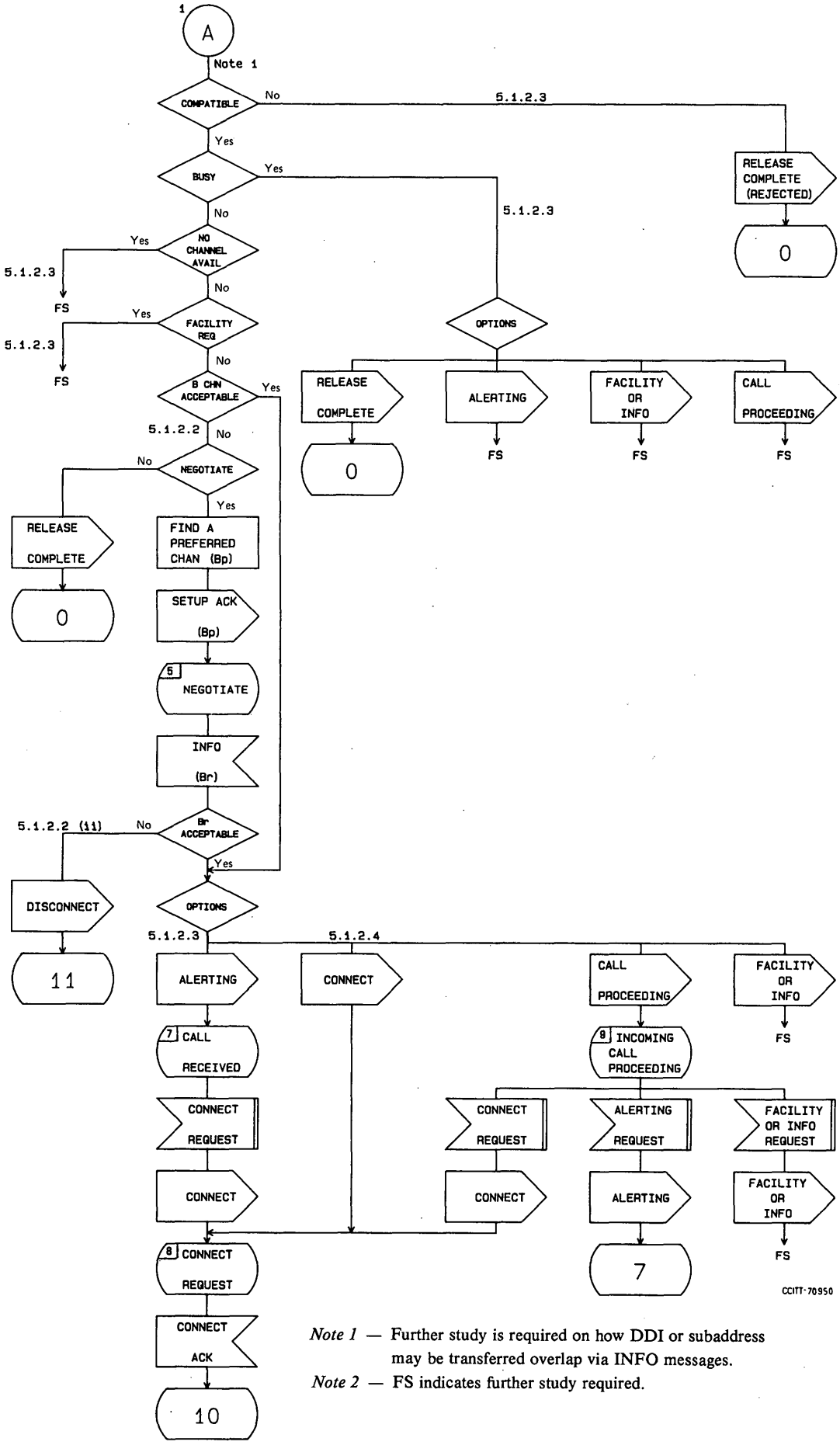
Call control detailed SDL diagram (user side)



Note — Further study is required on the procedures following this transition.

FIGURE 38/Q.931 (2 of 5)

Call control detailed SDL diagram (user side)

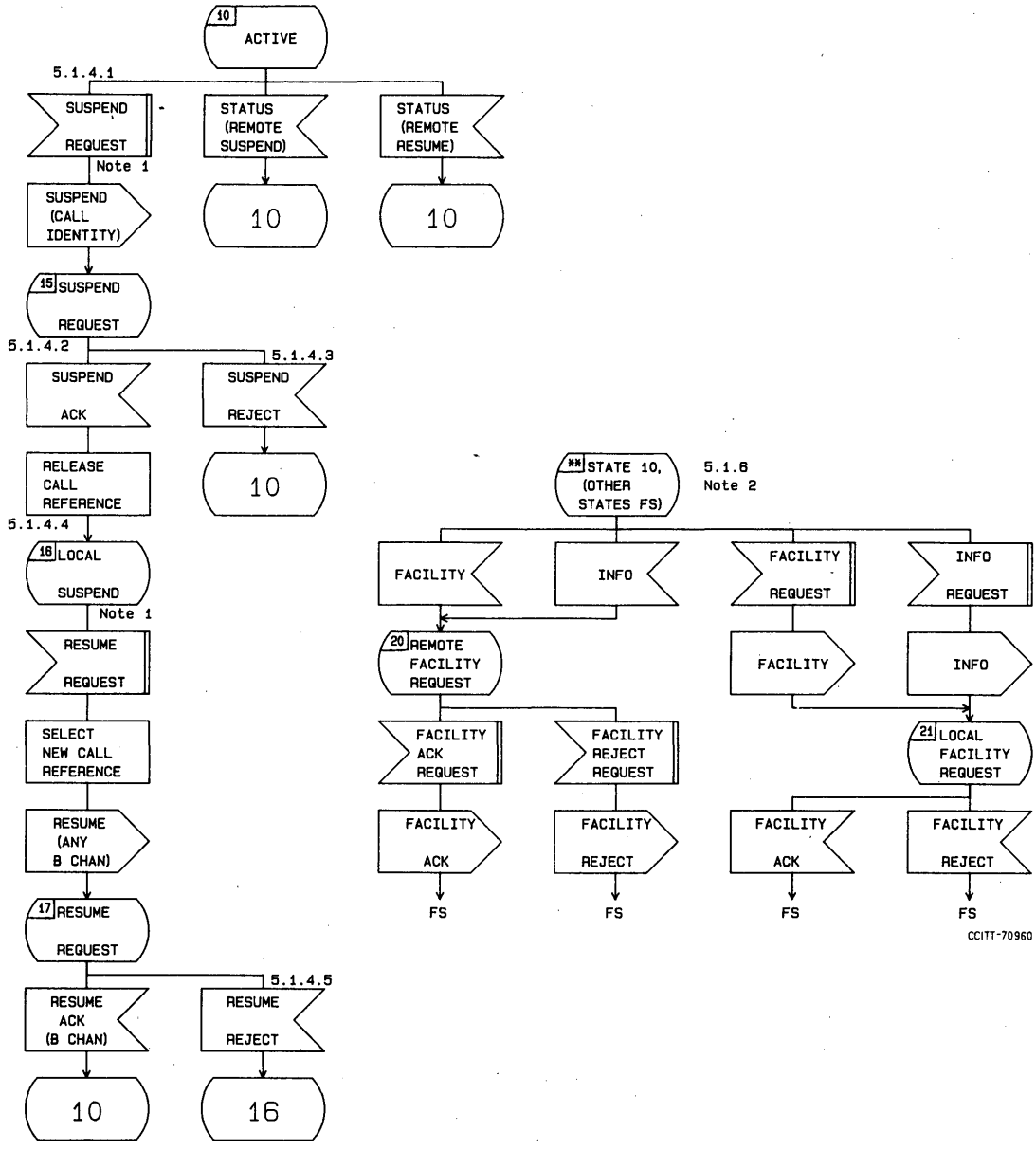


Note 1 — Further study is required on how DDI or subaddress may be transferred overlap via INFO messages.

Note 2 — FS indicates further study required.

FIGURE 38/Q.931 (3 of 5)

Call control detailed SDL diagram (user side)



Note 1 — SUSPEND/RESUME procedure defined for basic interface structure only. Application to primary rate interface is for further study.

Note 2 — The procedures and SDL diagram for facility procedures require further study.

Note 3 — FS indicates further study required.

FIGURE 38/Q.931 (4 of 5)

Call control detailed SDL diagram (user side)

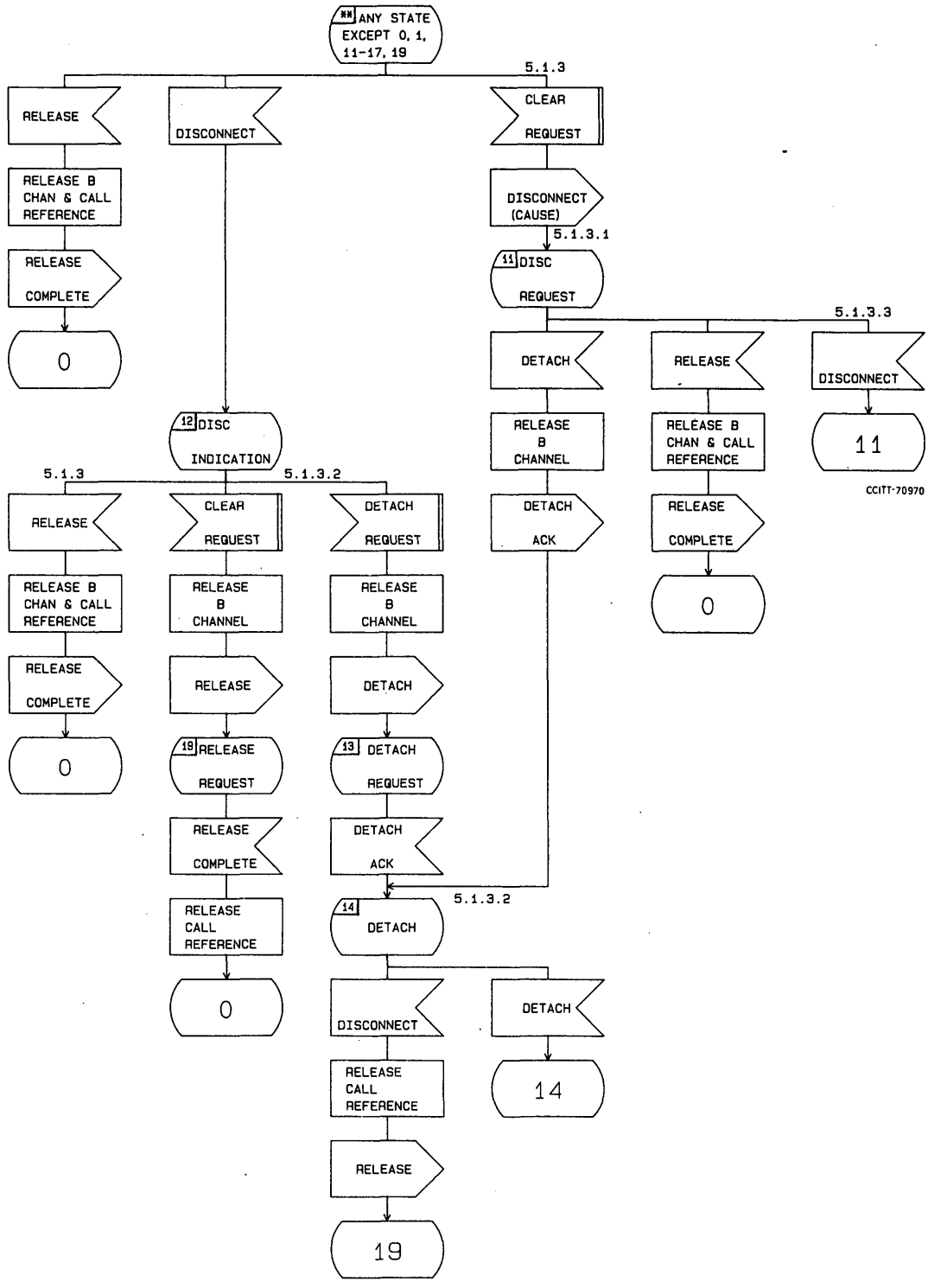
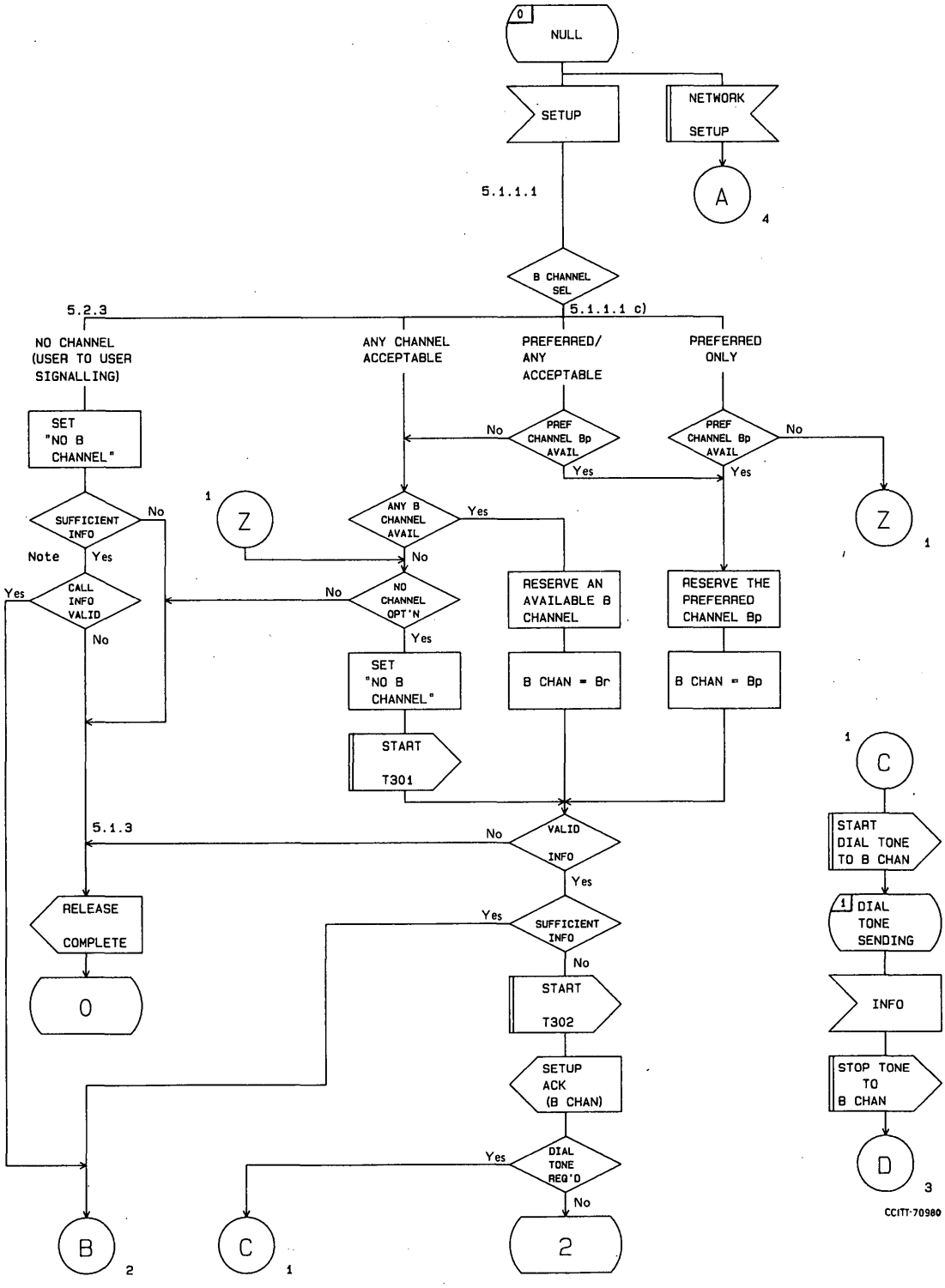


FIGURE 38/Q.931 (5 of 5)

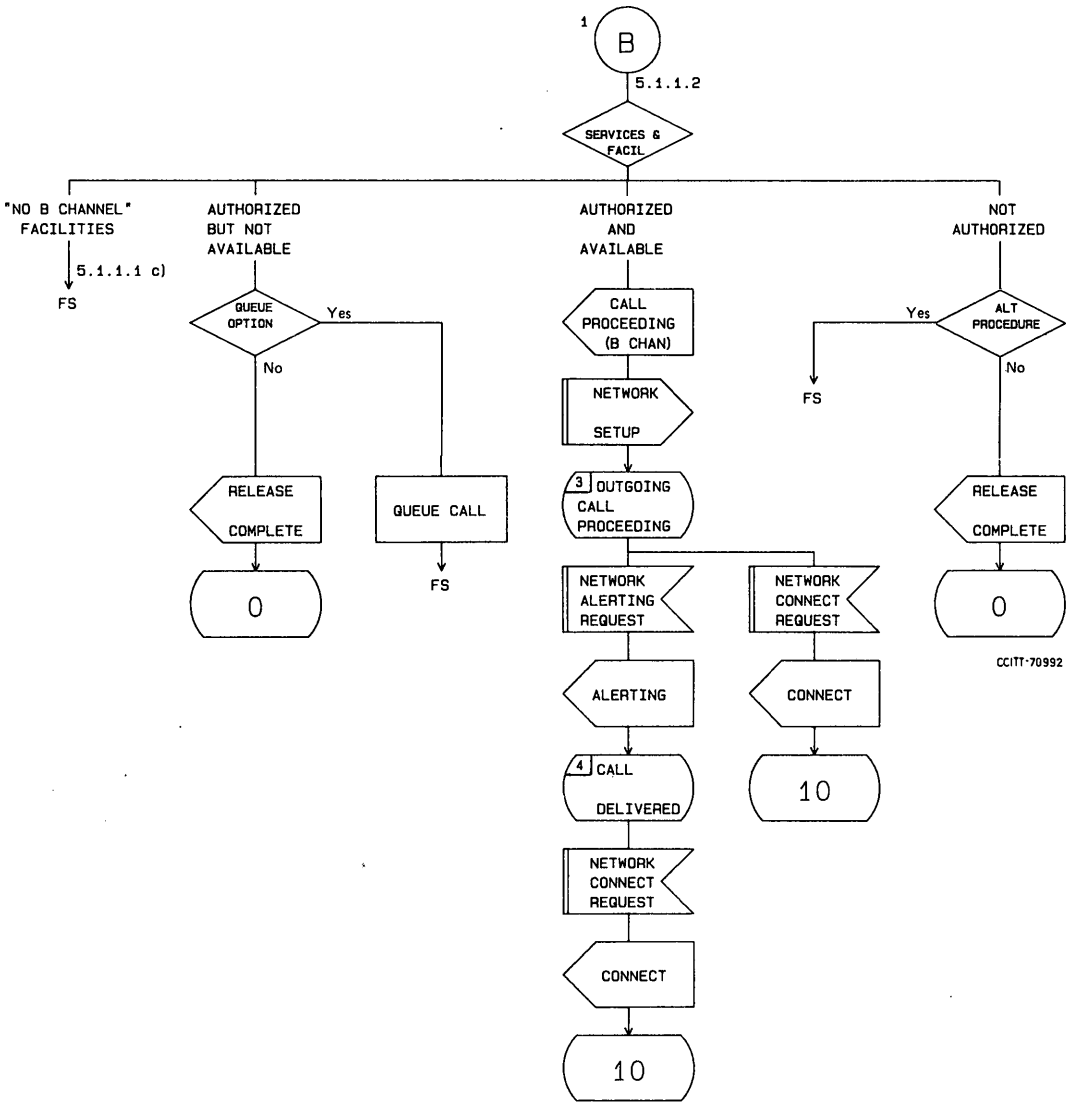
Call control detailed SDL diagram (user side)



Note — User-user signalling with no B channel is EN BLOC only.

FIGURE 39/Q.931 (1 of 7)

Call control detailed SDL diagram (network side)



Note — FS indicates further study required.

FIGURE 39/Q.931 (2 of 7)

Call control detailed SDL diagram (network side)

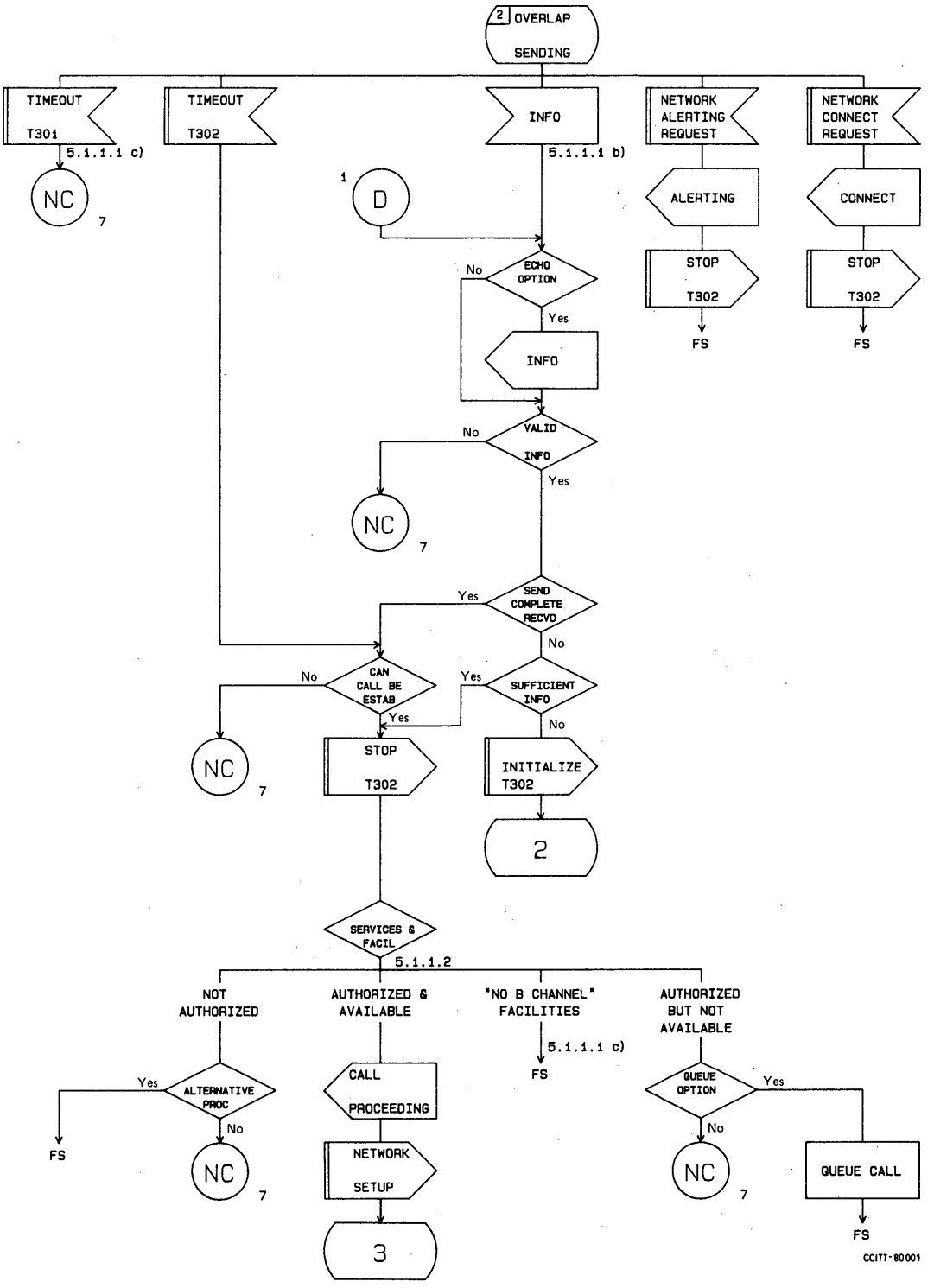
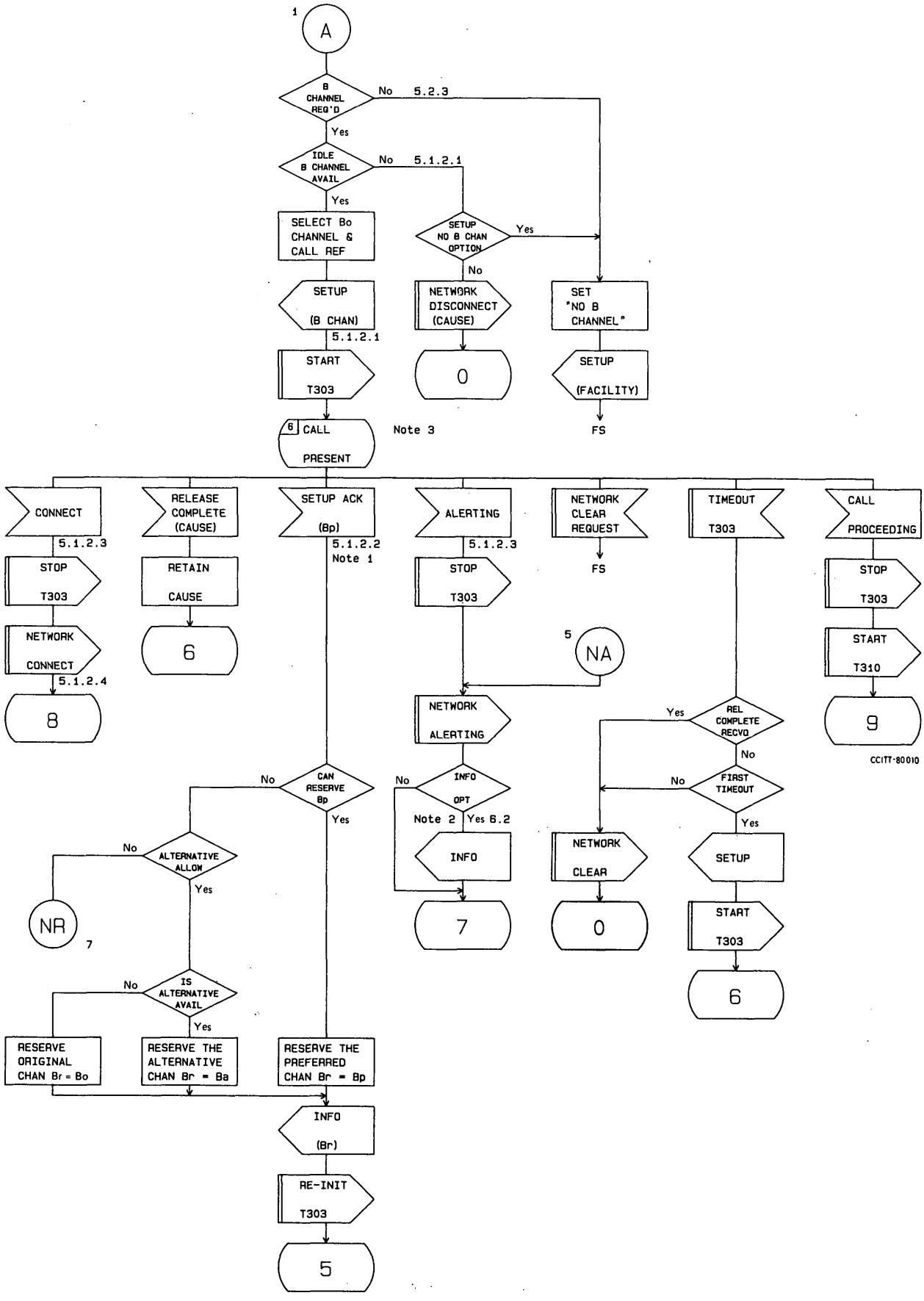


FIGURE 39/Q.931 (3 of 7)

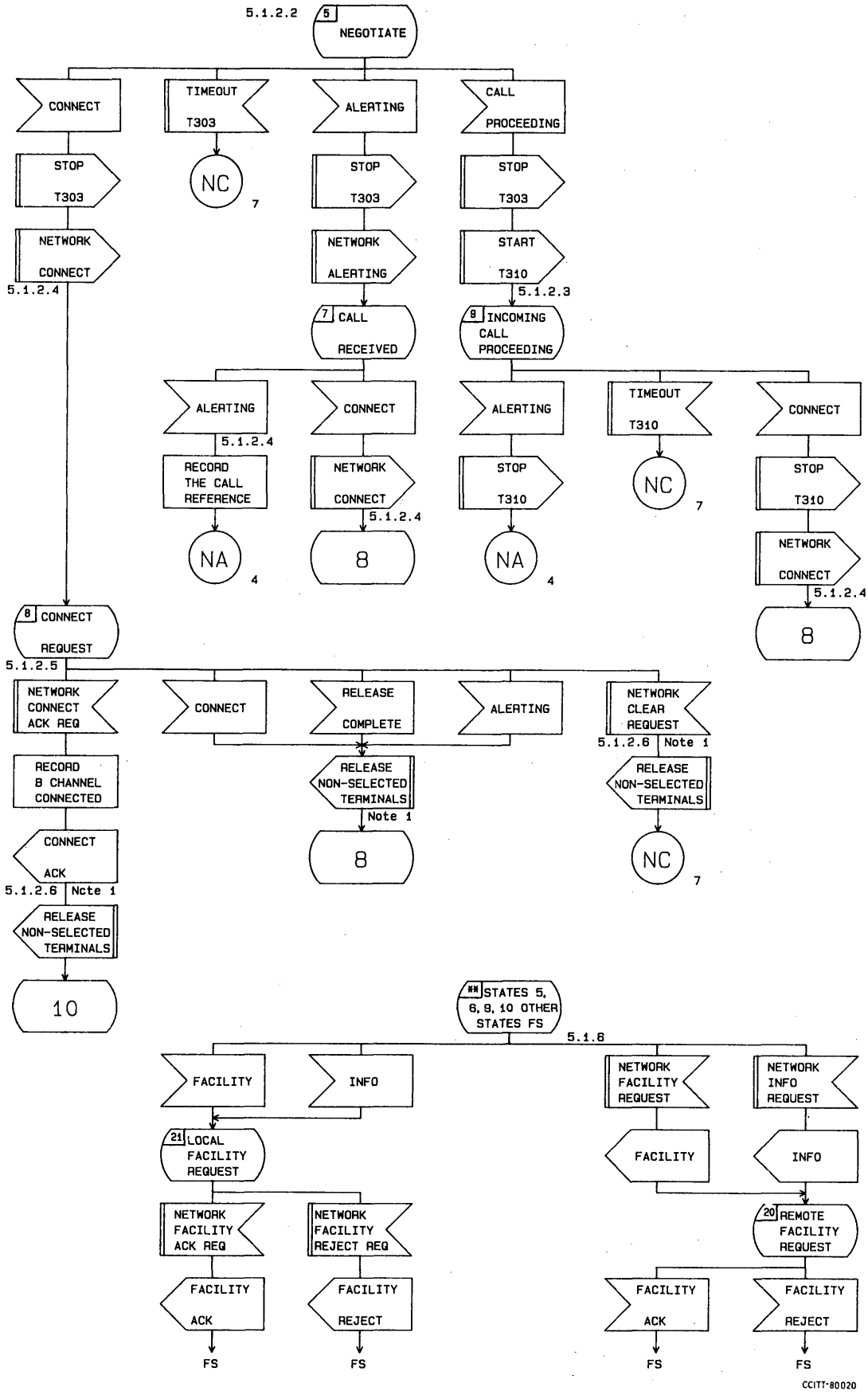
Call control detailed SDL diagram (network side)



Note 1 — Channel negotiation only recommended for primary rate interface structure — basic interface structure requires further study.
Note 2 — For some (stimulus) terminals the network may respond to ALERTING with INFO (see § 6.2).
Note 3 — DDI or subaddress can be conveyed by INFO messages. Detailed procedure requires further study.

FIGURE 39/Q.931 (4 of 7)

Call control detailed SDL diagram (network side)

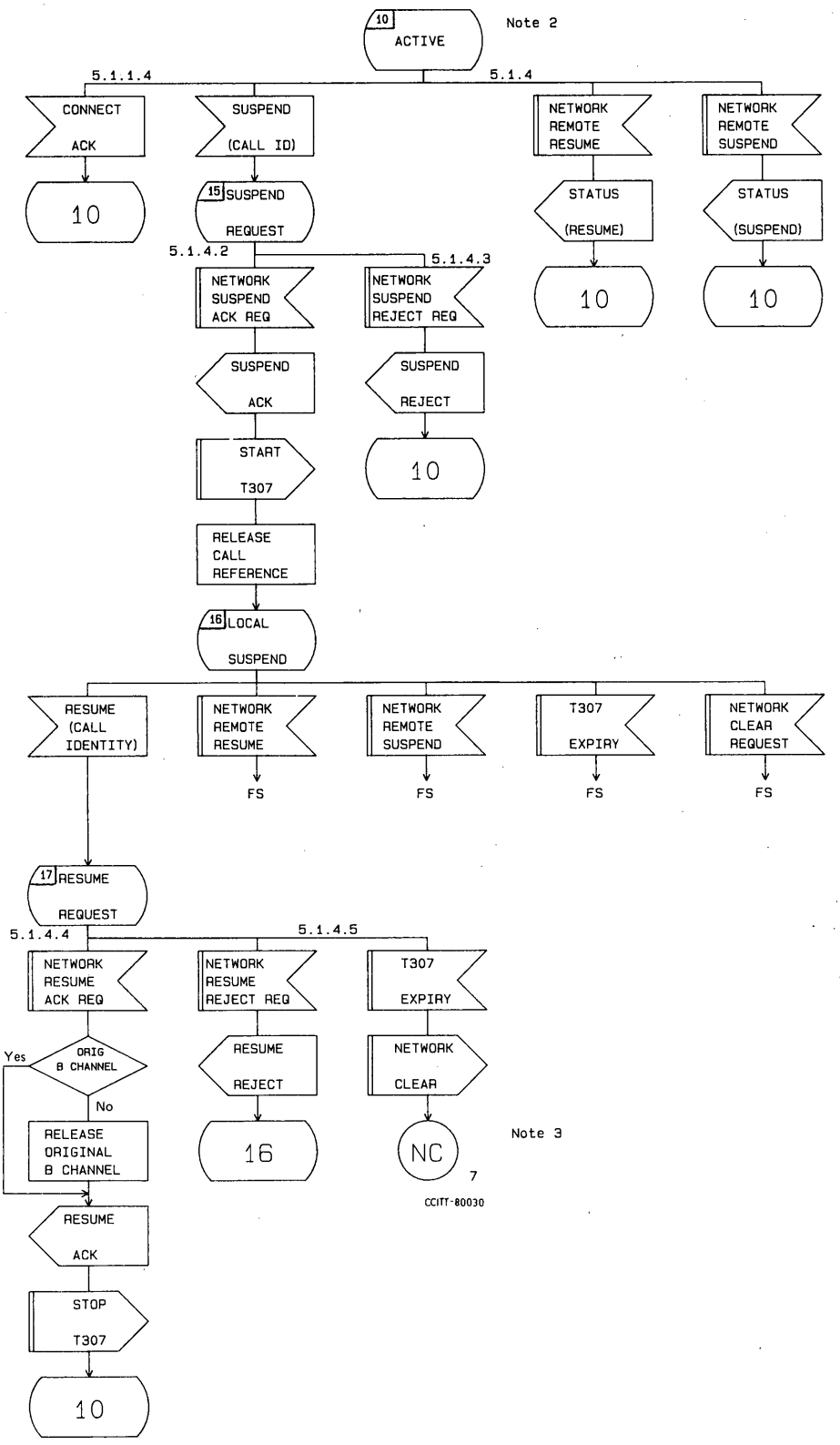


Note 1 — Details for the clearing procedure for non-selected terminals are not shown on this diagram, but clearing of the selected terminal is shown.

Note 2 — Procedures and SDL diagrams for facility procedures need further study.

FIGURE 39/Q.931 (5 of 7)

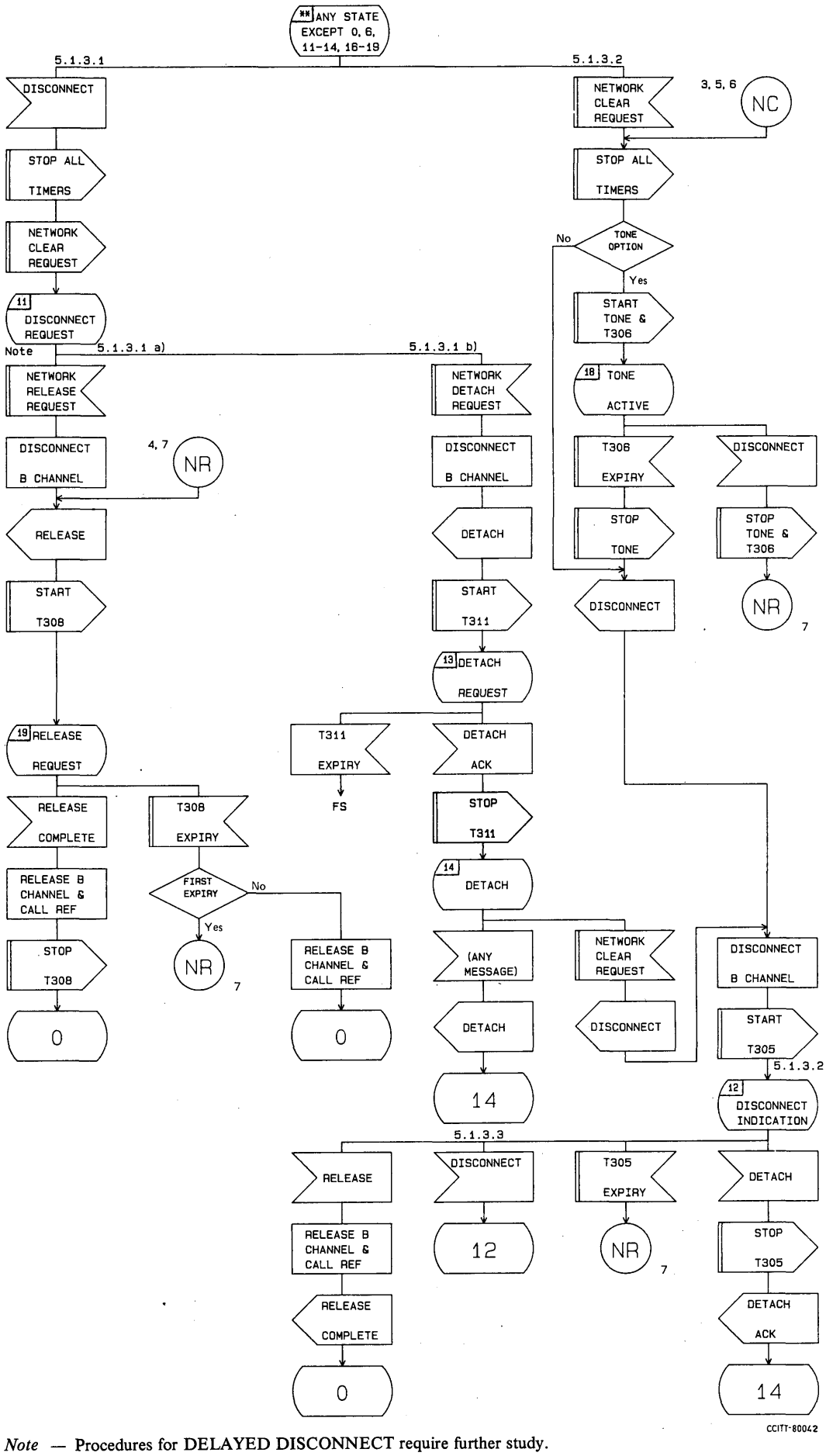
Call control detailed SDL diagram (network side)



Note 1 — FS indicates further study required.
Note 2 — Procedures for non-selected terminals are not shown.
Note 3 — Clearing is not possible in all cases. Further study is required.

FIGURE 39/Q.931 (6 of 7)

Call control detailed SDL diagram (network side)



Note — Procedures for DELAYED DISCONNECT require further study.

FIGURE 39/Q.931 (7 of 7)

Call control detailed SDL diagram (network side)

TABLE 45a/Q.931

State transition table – user side: outgoing call reference

Current state / Event received	Null U0	Call initialization U1	Overlap sending U2	Outgoing call proceeding U3	Call delivered U4	Active U10	Disconnect request U11	Disconnect indication U12	Detach request U13	Detach U14	Suspend request U15	Local suspend U16	Resume request U17	Release request U19	Remote facility request U20	Local facility request U21
ALERT			4	4												
CALL PROC		NOTE 12	3													
CANC																
CANC ACK																
CANC REJ																
CONG CONT																
CONN			NOTE 10	NOTE 10	NOTE 10											
CONN ACK																
DET							det ack 14			14						
DET ACK									14							
DISC			12	12	12	12	11			rel 12					12	12
FAC						20										
FAC ACK																FS
FAC REJ																FS
INFO			2			20										
REG																
REG ACK																
REG REJ																
REL			rel comp0	rel comp0	rel comp0	rel comp0	rel comp0	rel comp0							rel comp0	rel comp0
REL COMP																
RES																
RES ACK													10			
RES REJ													16			
SETUP																
SETUP ACK		NOTE10 2														
STAT	◄							See table 45b/Q.931								►
SUSP																
SUSP ACK											16					
SUSP REJ											10					
Alerting request																
Clear request			rel comp0	disc 11	disc 11	disc 11	disc 11	disc 11	disc 11	rel 19					DISC 11	DISC 11
Connect request	SETUP 1					FAC 21										
Connect response																
Detach request								det 13								
Facility request																
Facility ACK request																fac. ack. fs
Facility REJ request																fac. rej. fs
Info request						INFO 21										
Info sending request		1	INFO 2													
Resume request												res 17				
Suspend request																

TABLE 45b/Q.931

State transition table – user side: outgoing call reference – receipt of status message

State reported by status \ Current state		Null U0	Call initialization U1	Overlap sending U2	Call sent U3	Call delivered U4	Active U10	Disconnect request U11	Disconnect indication U12	Detach request U13	Detach U14	Suspend request U15	Local suspend U16	Resume request U17	Release request U19	Remote facility request U20	Local facility request U21
Null	N0																
Dial tone sending	N1																
Overlap	N2																
Outgoing call proceeding	N3																
Call delivered	N4																
Negotiate	N5																
Call present	N6																
Call received	N7																
Connect request	N8																
Incoming call proceeding	N9																
Active	N10						10										
Disconnect request	N11																
Disconnect indication	N12																
Detach request	N13																
Detach	N14																
Suspend request	N15																
Local suspend	N16																
Resume request	N17																
Tone active	N18																
Release request	N19																
Remote facility request	N20																
Local facility request	N21																
Any other state																	

TABLE 45c/Q.931

State transition table – user side: incoming call reference

Current state / Event received	Null U0	Negotiate U5	Call received U7	Connect request U8	Incoming call proceeding U9
ALERT					
CALL PROC					
CANC					
CANC ACK					
CANC REJ					
CONG CONT					
CONN					
CONN ACK				10	
DET					
DET ACK					
DISC		12	12	12	12
FAC					
FAC ACK					
FAC REJ					
INFO		Note 5			
REG					
REG ACK					
REG REJ					
REL		rel comp0	rel comp0	rel comp0	rel comp0
REL COMP					
RES					
RES ACK					
RES REJ					
SETUP	Note 4				
SETUP ACK					
STAT	◄		See table 45d/Q.931		►
SUSP					
SUSP ACK					
SUSP REJ					
USER INFO					
Alerting request					
Clear request					
Connect request			conn 8		conn 8
Connect response					
Detach request		disc 11	disc 11	disc 11	disc 11
Facility request					fac fs
Facility ACK request					
Facility REJ request					
Info request					info fs
Info sending request					
Release request					
Resume request					
Suspend request					

Note – Remaining state transitions are shown in Table 45a/Q.931.

TABLE 45d/Q.931

State transition table – user side:
incoming call reference – receipt of status message

Current state / State reported by status		Null U0	Negotiate U5	Call received U7	Connect request U8	Incoming call proceeding U9	
Null	N0						
Dial tone sending	N1						
Overlap	N2						
Outgoing call proceeding	N3						
Call delivered	N4						
Negotiate	N5						
Call present	N6						
Call received	N7						
Connect request	N8						
Incoming call proceeding	N9						
Active	N10						
Disconnect request	N11						
Disconnect indication	N12						
Detach request	N13						
Detach	N14						
Suspend request	N15						
Local suspend	N16						
Resume request	N17						
Tone active	N18						
Release request	N19						
Remote facility request	N20						
Local facility request	N21						
Any other state							

Note – Remaining state transitions are as shown in Table 45b/Q.931.

Note 1 — A CONN ACK message may be sent as a user option.

Note 2 — The contents of this table reflect the SDL diagrams. Blank entries are for further study.

Note 4 — The following transitions are allowed from the Null state, for incoming calls, upon receiving a SETUP message:

	Null (U0)							
	REL COMP	SETUP ACK	ALERT	CONN	FAC	INFO	N 11	CALL PROC
SETUP	0	5	7 or FS	8	FS	FS	FS	FS or 9

Note 5 — The following transitions are allowed from the Negotiate state, for incoming calls upon receiving an INFO message:

	Negotiate (U5)					
INFO:	ALERT	CONN	FAC	INFO	DISC	CALL PROC
	7	8	FS	FS	11	9

Note 6 — States applicable to § 5.1.3.4 a), c), d), e) and f) are for further study.

Note 7 — Depiction of USER INFO message transfer and flow control as per § 5.2 is for further study.

Note 8 — Inclusion of s-type packet call offering as per § 5.3 is for further study.

Note 9 — Inclusion of facility registration/cancellation as per § 5.1.7.3 is for further study.

Note 10 — If information has been saved, transmit an INFO message.

Note 11 — If no B-channel is available this transition is for further study.

Note 12 — If channel is available, go to state 3. If no channel is available, and the "no channel option" is not provided, send REL COMP and go to state 0. Other transitions are for further study.

Note 13 — For basic access, send SUSP and go to state 15. The use of the suspend procedure is for further study on a primary rate access.

TABLE 46a/Q.931

State transition table – network side: outgoing call reference

Event \ Current state	Null N0	Dial tone sending N1	Overlap sending N2	Outgoing call proceeding N3	Call delivered N4	Active N10	Disconnect request N11	Disconnect indication N12	Detach request N13	Detach N14	Suspend request N15	Local suspend N16	Resume request N17	Tone active N18	Release request N19	Remote facility request N20	Local facility request N21
ALERT										det 14							
CALL PROC										det 14							
CANC										det 14							
CANC ACK										det 14							
CANC REJ										det 14							
CONG CONT										det 14							
CONN										det 14							
CONN ACK						10				det 14							
DET										det 14							
DET ACK								det ack 14	14	det 14							
DISC		clear req 11	clear req 11	clear req 11	clear req 11	clear req 11		12		det 14	clear req 11			rel 19		clear req 11	clear req 11
FAC						21				det 14							
FAC ACK										det 14						FS	
FAC REJ										det 14						FS	
INFO			Note6							det 14							
REG										det 14							
REG ACK										det 14							
REG REJ										det 14							
REL								rel comp0		det 14							
REL COMP										det 14					0		
RES										det 14		17					
RES ACK										det 14							
RES REJ										det 14							
SETUP	Note 2									det 14							
SETUP ACK										det 14							
STAT	←						See Table 46b/Q.931										→
SUSP						15				det 14							
SUSP ACK										det 14							
SUSP REJ										det 14							
USER INFO										det 14							
Alerting req			alert FS	alert 4													
Connect req			alert FS	conn 10	conn 10												
Connect ack req																	
Detach req							det 13										
Clear req		Note 5	Note 5	Note5	Note 5	Note 5				disc 12	Note 5	FS				Note5	Note 5
Facility req							fac 20										
Facility ack req																	fac ack fs
Facility rej req																	fac rej fs
Information req							info. 20										
Release req								rel 19									
Remote resume							stat 10										
Resume ack req																	
Resume rej req																	
Network setup																	
Remote suspend							stat 10				Note4						
Suspend ack req												res ack 16					
Suspend rej req												res rej 10					
No chan T301 exp			Note5														
Call orig T302 exp			Note1								Note3						
Call offd T303 exp										susp ack 10							
T304 exp										susp rej 16							
Disc ind T305 exp							rel 19	rel 19									
Clear tone T306 exp																	
Local susp T307 exp																	
Rel req T308 exp														disc 12			
Call proc T310 exp												NOTE 10	fs				
Detach req T311 exp															NOTE 15		

TABLE 46b/Q.931

State transition table – network side:
outgoing call reference – receipt of status message

State reported by status \ Current state		Null N0	Dial tone sending N1	Overlap sending N2	Outgoing call proceeding N3	Call delivered N4	Active N10	Disconnect request N11	Disconnect indication N12	Detach request N13	Detach N14	Suspend request N15	Local suspend N16	Resume request N17	Tone active N18	Release request N19	Remote facility request N20	Local facility request N21
Null	U0																	
Call initialization	U1																	
Overlap sending	U2																	
Call sent	U3																	
Call delivered	U4																	
Negotiate	U5																	
Call received	U7																	
Connect request	U8																	
Incoming call proceeding	U9																	
Active	U10																	
Disconnect request	U11																	
Disconnect indication	U12																	
Detach request	U13																	
Detach	U14																	
Suspend request	U15																	
Local suspend	U16																	
Resume request	U17																	
Release request	U19																	
Remote fac. req.	U20																	
Local fac. req.	U21																	
Any other state																		

TABLE 46c/Q.931

State transition table – network side: incoming call reference

Event \ Current state	Null N0	Negociate N5	Call present N6	Call received N7	Connect request N8	Incoming call proceeding N9
ALERT		network alerting 7	Note 16	Note 16	8	Note 16
CALL PROC		9	9			
CANC						
CANC ACK						
CANC REJ						
CONG CONT						
CONN		network connect 8	network connect 8	network connect 8	8	network connect 8
CONN ACK						
DET						
DET ACK						
DISC		clear request 11	network disc 10	clear request 11	clear request 11	network clear 11
FAC		21	21			21
FAC ACK						
FAC CANC						
FAC REJ						
INFO						
FAC REG						
FAC ACK						
REG REJ						
REL						
REL COMP				6		8
RES						
RES ACK						
RES REJ						
SETUP						
SETUP ACK			Info 5			
STAT						
SUSP						
SUSP ACK						
SUSP REJ						
USER INFO						
Alerting request						
Connect request						
Connect ack request					Note 7	
Detach request						
Clear request		Note 5	FS	Note 5	Note 5	Note 5
Facility request						Fac 20
Facility acknowledge request						
Facility reject request						
Information request		Info 20	Info 20			Info 20
Release request						
Remote resume						
Resume acknowledge						
Resume reject request						
Network setup	Note 14					
Remote suspend						
Suspend acknowledge request						
Suspend reject request						
No channel T301 expires						
Call orig T302 expires						
Call offered T303 expires		Note 5				
T304 expires						
Disc ind T305 expires						
Clear tone T306 expires						
Local susp T307 expires						
Release request T308 expires						
Call proceeding T310 expires						

Note – For other status, see Table 46a/Q.931.

TABLE 46d/Q.931

State transition table – network side:
incoming call reference – receipt of status message

Current state / State reported by status		Null N0	Negotiate N5	Call present N6	Call received N7	Connect request N8	Incoming call proceeding N9
Null	U0						
Call initialization	U1						
Overlap sending	U2						
Call sent	U3						
Call delivered	U4						
Negotiate	U5						
Call received	U7						
Connect request	U8						
Incoming call proceeding	U9						
Active	U10						
Disconnect request	U11						
Disconnect indication	U12						
Detach request	U13						
Detach	U14						
Suspend request	U15						
Local suspend	U16						
Resume request	U17						
Release request	U19						
Remote facility request	U20						
Local facility request	U21						
Any other state							

Note – For remaining status, see Table 46b/Q.931.

Notes to Tables 46a/Q.931 to 46d/Q.931

Note 1 — The following transitions are allowed from the Overlap Sending state, for outgoing calls, when T302 expires:

	Overlap sending N2			
	DISC	CALL PROC	FS	(disc tone)
T302 expires	12	3		18

Note 2 — The following transitions are allowed from the Null state, for outgoing calls, upon receiving a SETUP message:

	Null				
	CALL PROC	SETUP ACK	(dial tone)	REL COMP	
SETUP:	3	2	1	11	FS

Note 3 — § 5.1.4.2 indicates the remote user is notified when the local user has suspended. It is not clear how this is done if the remote user is also suspended.

Note 4 — § 5.1.4.4 indicates the remote user is notified when the local user resumes a call. It is not clear how this is done if the remote user is suspended.

Note 5 — If B-channel is still allocated, a disconnect tone may be sent and the transition to the Tone Active State (N18) is allowed. Otherwise, send DISC and go to state 12.

Note 6 — The following transitions are allowed from the Dial Tone Sending and Overlap Sending state, for outgoing calls, upon receiving an INFO message:

	N1 or N2								
	–	CALL PROC	DISC	INFO	INFO DISC	INFO CALL PROC		(disc tone)	INFO (disc tone)
INFO	2	3	12	2	12	3	FS	18	18

Note 7 — REL is sent to users not awarded the call. CONN ACK is sent to user who is awarded the call. Go to state 10.

Note 8 — The contents of this table reflect the SDL diagrams. Blank entries are for further study.

Note 9 — States applicable to § 5.1.3.4 a), b), d), e) and f) are unclear.

Note 10 — § 5.1.4.5 says the network "initiates clearing". Since the call reference is released in the local suspend state, it does not seem possible to send a DISC message as per § 5.1.3.2.

Note 11 — Depiction of USER INFO message transfer and flow control as per § 5.2 is for further study.

Note 12 — Inclusion of s-type packet call offering as per § 5.3 is for further study.

Note 13 — Inclusion of facility registration/cancellation as per § 5.1.7.3 is for further study.

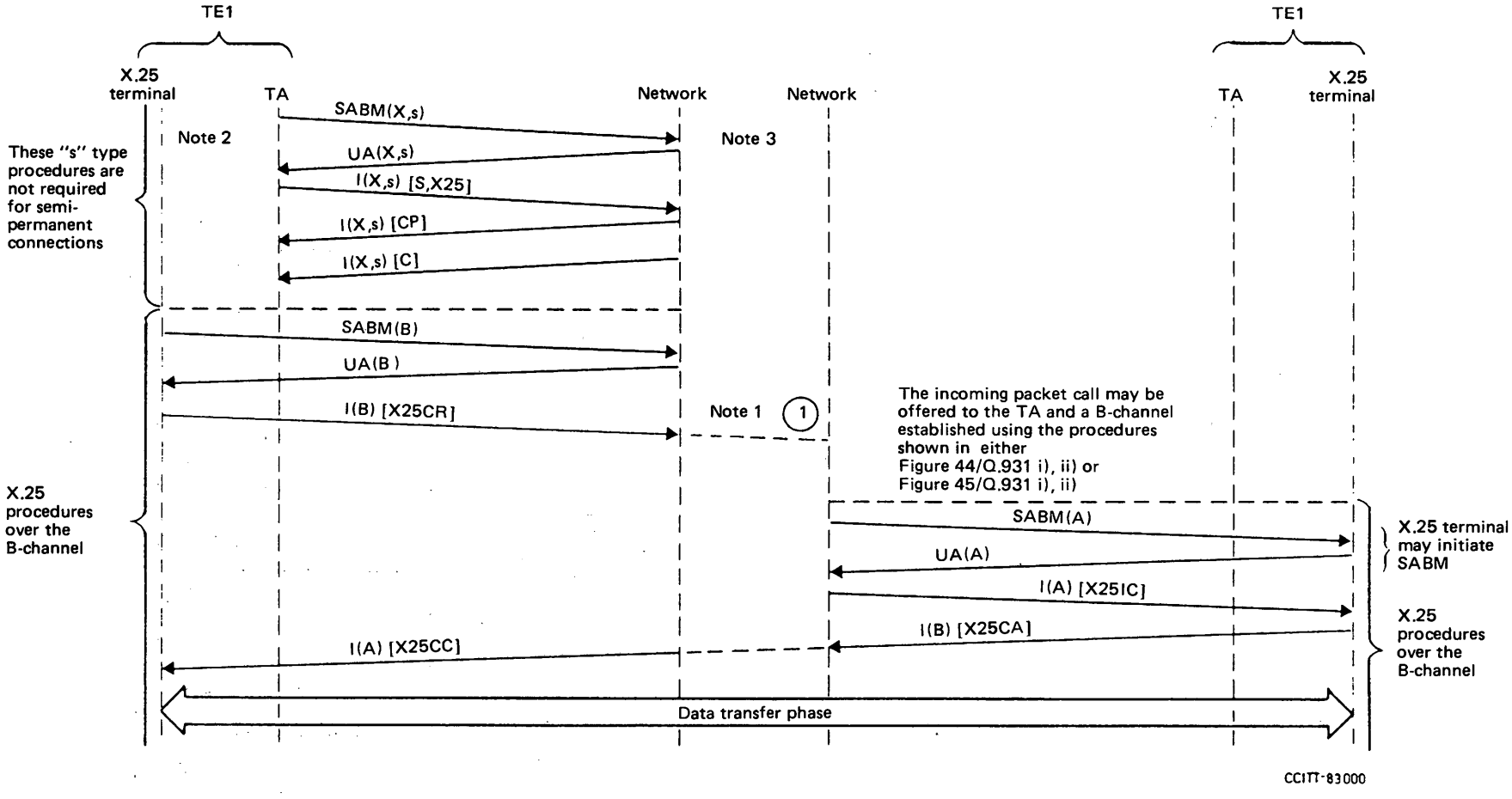
Note 14 — The following transitions are allowed from the Null state, for incoming calls, when the Network Setup internal signal is received:

	Null N0	
SETUP	SETUP	
6	FS	0

Note 15 — On first expiration, send REL and remain in state 19. On second expiration, go to state 0.

Note 16 — Send internal signal "network alerting". INFO may optionally be sent. Go to state 7.

Note 17 — REL is sent to "non-selected" terminals. Disconnect tone may be sent to users which have sent CONN, and go to state 18; otherwise, send DISC to these users and go to state 12.



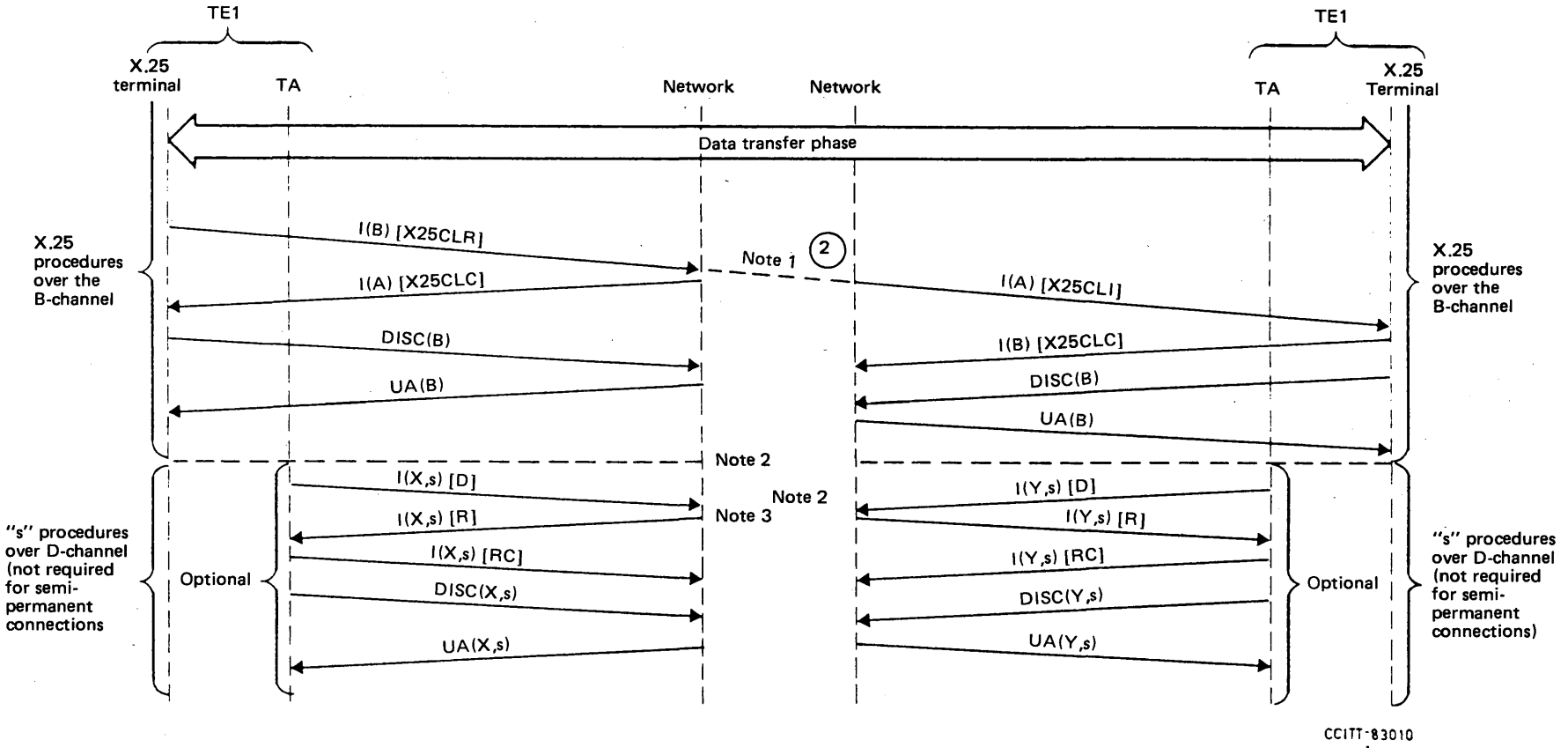
○ *Note 1* — When the called side establishes the call using D-channel access, the message sequence will continue as from point 3 in Figure 42/Q.931.

Note 2 — When the calling side establishes the call using D-channel access, the message sequence on the calling side will be in accordance with the calling side of Figure 42/Q.931.

Note 3 — If "s" link is not already established.

FIGURE 40/Q.931

Message sequence for the B-channel access, first virtual call set-up in the maximum integration scenario



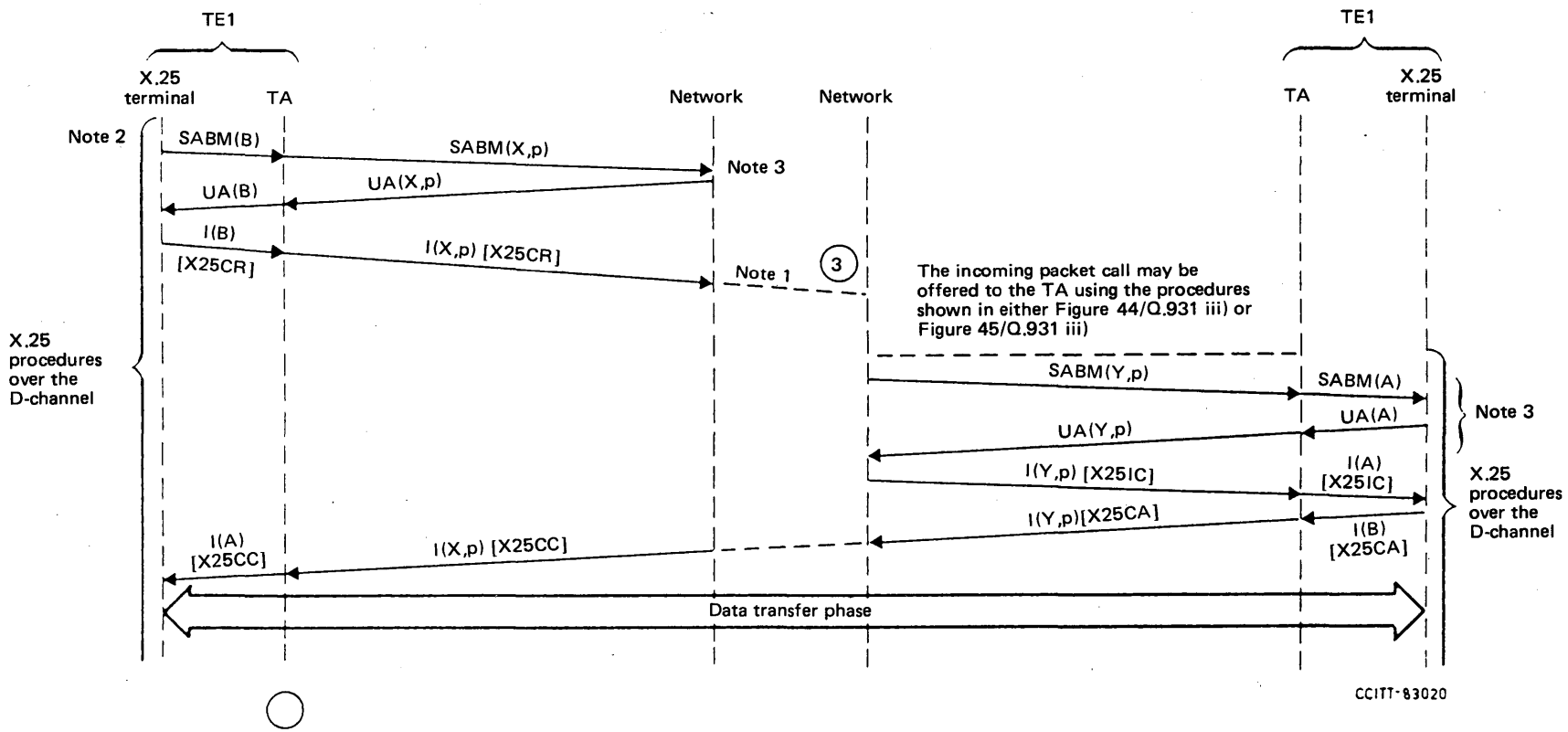
○ *Note 1* — When the cleared side has set-up the call using D-channel access, the message sequence at the cleared side will be as from point 4 in Figure 43/Q.931.

Note 2 — Clearing of the B-channel may be initiated by the network.

Note 3 — The full circuit-switched clearing procedures in § 5.1.3 shall apply.

FIGURE 41/Q.931

Message sequence for the B-channel access, last virtual call clearing



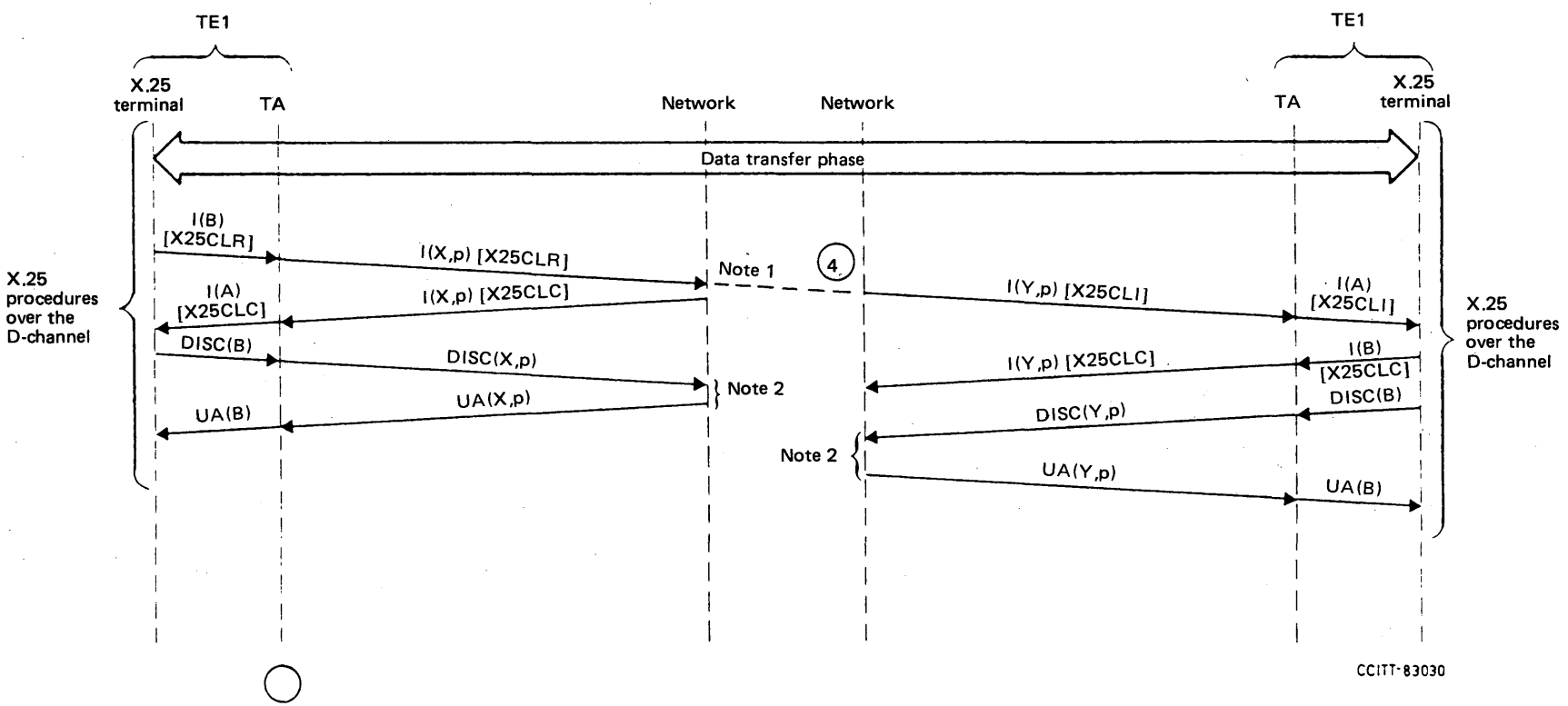
Note 1 — When the called side establishes the call using B-channel access, the message sequence will continue as from point 1 in Figure 40/Q.931.

Note 2 — When the calling side establishes the call using B-channel access, the message sequence at the calling side will be in accordance with the calling side of Figure 40/Q.931.

Note 3 — If "p" link is not already established.

FIGURE 42/Q.931

Message sequence for D-channel access — virtual call set-up



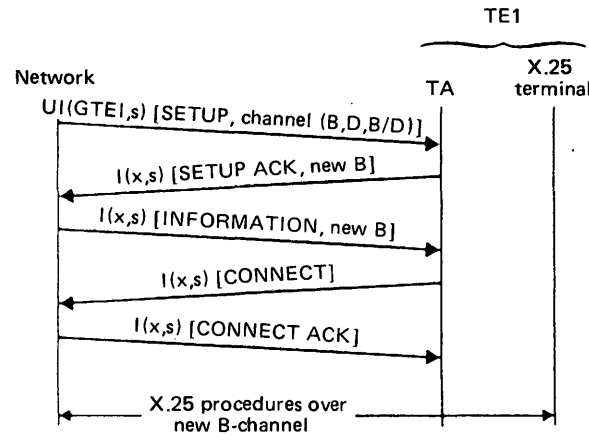
Note 1 — When the cleared side has set-up the call using B-channel access, the message sequence at the cleared side will be as from point 2 in Figure 41/Q.931.

Note 2 — This sequence is only required if the X.25 DTE does not wish to continue with further packet communications.

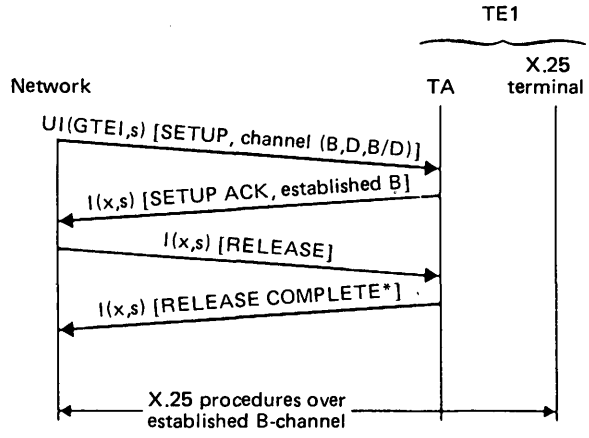
FIGURE 43/Q.931

Message sequence for D-channel access — last virtual call clearing

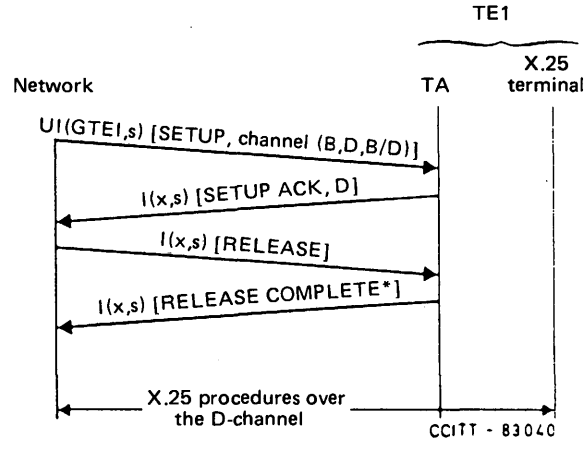
(i) Terminal requests call on a new B-channel



(ii) Terminal requests call on an established B-channel



(iii) Terminal requests call on the D-channel

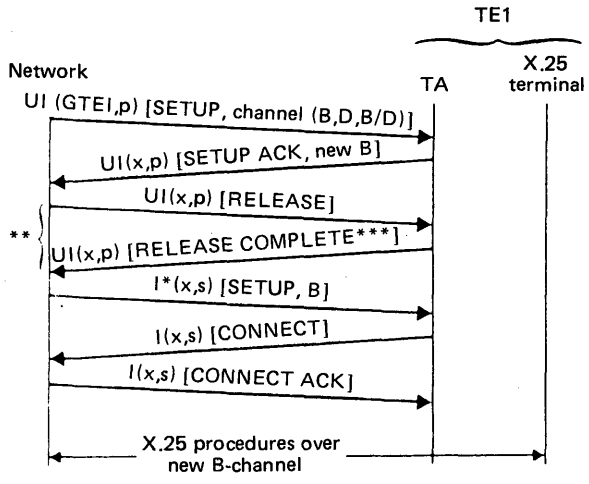


* RELEASE COMPLETE is named as RELEASE ACK in Recommendation X.31 (I.462). The discrepancy shall be resolved in the next study period.

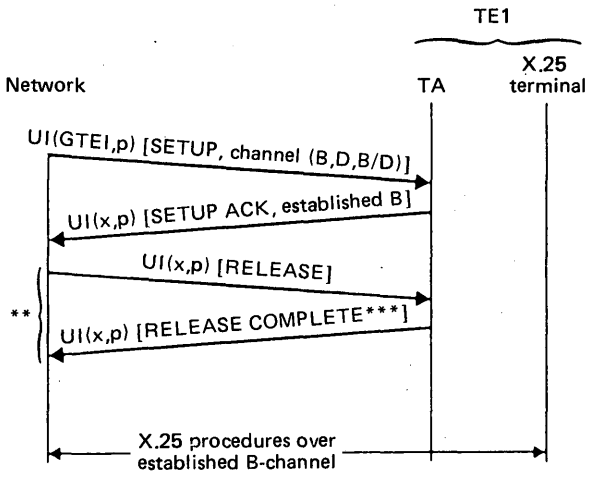
FIGURE 44/Q.931

Incoming packet call offering procedure using "s" type signalling

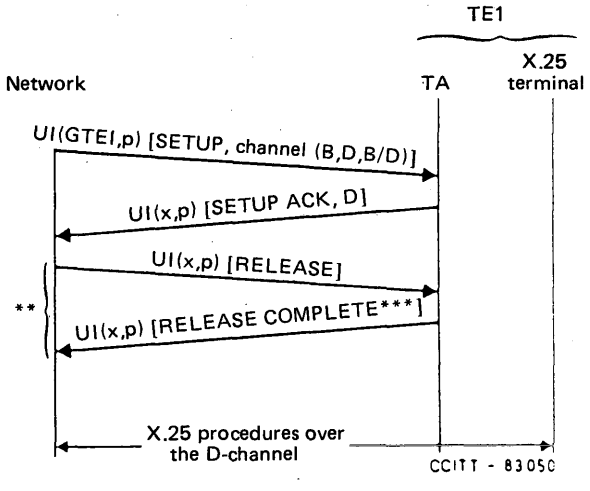
(i) Terminal requests call on a new B-channel



(ii) Terminal requests call on an established B-channel



(iii) Terminal requests call on the D-channel



* The SETUP message may be sent in a globally addressed UI frame. In this case the TA allocated the incoming packet call might, if required, be identified by its sub-address.

** Some networks may not implement this RELEASE-RELEASE COMPLETE message sequence. (See § 5.3.3b).)

*** RELEASE COMPLETE is named as RELEASE ACK in Recommendation X.31 (I.462). The discrepancy shall be resolved in the next study period.

FIGURE 45/Q.931

Incoming packet call offering procedure using "p" type signalling

6 Application of circuit-switched call control procedures to terminals operating in a stimulus mode

This section describes how the circuit-switched call control procedures of § 5 may be used by an ISDN terminal operating in stimulus mode to establish a simple call.

For explanatory purposes, stimulus mode terminals have been classified in this section into the following types:

- Type 1 terminals for which each layer 3 endpoint has a unique data link layer address (i.e. only one B-channel may be connected at a time per data link layer address);
- Type 2 terminals for which multiple layer 3 endpoints may be associated with a single data link layer address (i.e. multiple B-channels may be connected per data link address).

Thus the procedures of § 5 may be simplified for Type 1 terminals with respect to the use of the call reference. In this respect, the data link layer address provides a unique call identity and Type 1 terminals shall only include a dummy call reference in all signalling messages other than in the first response to a SETUP message (see § 6.2). Type 2 terminals are required to generate a call reference in accordance with the procedures of § 5.

Signalling messages sent by stimulus mode terminals to the network are usually generated as a direct result of actions by the terminal user (e.g. handset lifted) and in general do little more than describe the event which has taken place at the man-machine interface. Similarly, signalling messages sent by the network to terminals operating in the stimulus mode contain explicit instructions regarding the operations to be performed by the terminal (e.g. connect B-channel, start alerting, etc.).

Stimulus mode terminals are not expected to maintain a record of the state of any call which is currently supported since they have a master-slave relationship with the network. However, stimulus mode terminals are expected to retain the following information:

1) Whether or not the terminal is currently alerting (*Note* – this information is required to determine the correct message to be generated when the handset is lifted, i.e. SETUP or CONNECT).
2) The current condition of the switchhook, i.e. on or off (*Note* – this information is required to determine how to respond to a SETUP message).

The possible enhancement of these procedures to support additional capabilities such as multi-line or switchhookless operation (see Appendix I) is for further study.

The following sections describe the detailed application of the circuit-switched call control procedures to Type 1 stimulus mode terminals. For Type 2 terminals, the procedures are identical except that call reference is generated in accordance with the procedures of § 5. Table 47/Q.931 summarizes the principle operations whilst Figures 46/Q.931, 47/Q.931 and 48/Q.931 show the information flows for a simple call.

6.1 *Procedures for call establishment at the originating exchange*

6.1.1 *Call request*

The call is initiated by activating the switchhook of the originating terminal, which then generates a SETUP message with a dummy call reference. This message must contain a Bearer capability information element to inform the network of the type of call being requested, a terminal capabilities element, and may contain a Switchhook information element. The network sends back to the user either a SETUP ACKNOWLEDGE or a CALL PROCEEDING message indicating which B-channel is to be used for the call (§ 5.1.1.1).

TABLE 47/Q.931

Stimulus mode terminal operation

User action	Message generated by terminal operating in the stimulus mode
*"Lift handset" when terminal is not ringing	SETUP [Call reference, BC] (Switchhook ‹off-hook›) *Notes* 1. For simple terminals only capable of terminating one B-channel at a time, a dummy call reference (i.e. all zero) shall be used. 2. If the terminal can only make/accept calls on a single B-channel, then that B-channel identity will be included in the SETUP message. 3. Information keyed in by the user while the handset is on-hook may also be sent in the SETUP message as Keypad information when the handset is lifted (for further study).
*"Lift handset" when terminal is alerting	CONNECT [Call reference] (Switchhook ‹off-hook›) *Notes* 1. See Note 1 above on call reference. 2. The terminal is assumed to be aware that it is alerting prior to the off-hook condition.
*"Handset replaced"	DISCONNECT [Call reference] *Notes* 1. See Note 1 above on call reference.
Key depressed	INFORMATION [Call reference] (Keypad information) *Notes* 1. See Note 1 above on call reference. 2. The Keypad information element contains the corresponding IA5 character of the key depressed.
Special keys/pre-programmed keys (for supplementary services)	These keys generate the INFORMATION message containing: a) appropriate supplementary service stimulus information element, see § 6.5; b) Keypad information element. *Notes* 1. Both messages will have a call reference set according to the rules described above. 2. In the case of b), the Keypad information element will contain the sequence of IA5 characters which the user would have had to key-in to request the supplementary facility if the special key had not been implemented.

Message received	Terminal action
SETUP	Perform simple compatibility checking using the bearer capability and channel identification information elements. If the compatibility check is positive, the terminal will return an ALERTING message using the call reference contained in the SETUP message.
SETUP ACKNOWLEDGE, CALL PROCEEDING, CONNECT ACKNOWLEDGE	The terminal attaches to the B-channel indicated in the message.
INFORMATION (Display)	The IA5 information contained in the Display information element is displayed by the terminal.
ALERTING	May be used to provide an audible or visual indication that far end alerting has begun.
CONNECT	May be used to provide audible or visual indication that far end connect has occurred.
DISCONNECT	No action taken. DISCONNECT may be used to provide an indication of call cleared.
RELEASE	Disconnect from B-channel and send RELEASE ACKNOWLEDGE.
Any message	The terminal will take the appropriate action to Display and Signal information elements which may be contained in any message type.
INFORMATION (Stimulus information elements)	The terminal will take the specific action indicated in the stimulus information element. See § 6.5.

* Or equivalent action.
[x] Mandatory information element.
(y) Optional information element.
BC Bearer capability.

6.1.2 *Call information sending*

If there is no Keypad information element in the SETUP message, the network assumes that overlap procedure is used for sending the call information. The SETUP ACKNOWLEDGE message will contain an information element which may cause the terminal to initiate the proper prompt (e.g. dial tone, screen message) indicating that dialling can start. The dial digits are sent as Keypad information element in INFORMATION messages. When the network receives the first INFORMATION message containing keypad information element, it sends an INFORMATION message to the terminal instructing it to stop the local prompt. The network may optionally acknowledge each message by sending an INFORMATION message with a Keypad echo information element. The Network determines that dialling has finished either by analysis of the digits or by receipt of an end of dialling indication as defined by the local network procedures (e.g. a # character).

An INFORMATION message may also contain the called party address *en bloc*, as Keypad information element; this is mainly applicable when the user invokes a dialling facility (e.g. abbreviated address stored in the terminal, last dialled number).

If the SETUP message contains sufficient Keypad information for call establishment, then *en bloc* procedure should be assumed. The network then sends a CALL PROCEEDING message to the terminal, containing the B-channel to be used.

6.1.3 *Call confirmation*

When the terminal has received the CALL PROCEEDING message, it may give a local call progress indication (tone, screen message). When the originating exchange receives an indication that user alerting has been initiated at the called address, it sends an ALERTING message to the calling terminal (see § 5.1.1.3). The ALERTING message may contain network-dependent optional stimulus elements. The terminal then stops the possibly locally-generated call progress indication (tone or other user indication), and may turn on a local indication of the alerting condition at the far end.

6.1.4 *Call connected*

The originating exchange sends a CONNECT message to the calling terminal when it gets an indication that the call is accepted and answered at the remote end. This message may also contain Display information element provided by the network (e.g. charging rate, address of the connected terminal). Upon receipt of this message, the terminal must turn off its possible local indication of the alerting condition at the far end.

6.2 *Procedures for call establishment at the destination exchange*

The network will send a SETUP message containing at least the call reference, a bearer capability information element and the B-channel specification. The message may also contain optionally the signal information element Alerting-on.

The terminal checks the bearer capability information and, if not compatible, responds by a RELEASE COMPLETE message as described in § 5.1.3 a).

If the SETUP-message contains a Display information element, the associated IA5 characters shall be displayed to the user. Any Signal information element(s) will also be acted upon in the normal manner.

If the terminal is able to provide the service indicated, it should return an ALERTING message, a CALL PROCEEDING message or directly a CONNECT message. This message will include the call reference chosen by the network and the Terminal capabilities information element. It may display any Display information contained in the SETUP message and may start alerting in response to the Signal information element (Alerting-on).

All other information elements are to be ignored. There will be no negotiation of B-channels.

On an optional basis, the network may choose not to instruct the terminal to alert until after it has been informed of the terminal's capabilities. In this case, the information element signal (Alerting-on) is not contained in the SETUP message. Specific alerting instructions are sent in an INFORMATION message after receipt of the ALERTING message.

When the terminal goes "off hook" a CONNECT message is sent to the network. This message must contain the dummy value of the call reference and may contain the Switchhook information element.

If the terminal responds to a SETUP message with a CONNECT message, it shall include the original call reference (as chosen by the network) and the Terminal capabilities information element.

The network sends a CONNECT ACKNOWLEDGE message including the original call reference (the one in SETUP), the B-channel specification and the Signal information element (Alerting-off). The terminal then connects to the B-channel indicated.

6.3 *Procedures for user-to-user signalling*

The procedures described in § 5.2 should be applied to stimulus mode terminal operation in the following manner:

a) SETUP messages originated by a terminal should contain a user-to-user facility request indicating that stimulus mode operation is required;

b) for calls in which the above facility is requested, user-to-user information should be conveyed in the following manner:

   1) via Keypad information elements in the SETUP message generated by a stimulus mode terminal,

   2) via Display information elements in the SETUP message sent to the called terminal,

   3) via Keypad information elements in INFORMATION messages generated by a terminal (*Note* – this information will be delivered to the remote terminal via Display elements within USER INFO messages),

   4) via Display information elements in ALERTING, CONNECT, USER INFO, DISCONNECT or RELEASE messages.

6.4 *Procedures for call clearing*

Call clearing procedures have been simplified for the stimulus mode terminals. Clearing procedures are described in §§ 6.4.1 and 6.4.2 and shown in Figure 48/Q.931.

6.4.1 *Call clearing by the terminal*

The user initiates call clearing by replacing the switchhook (or equivalent). The user equipment generates a DISCONNECT message. The network responds to the DISCONNECT message by sending a RELEASE message to the user. Upon receipt of the RELEASE message, the terminal detaches from the B-channel and generates a RELEASE COMPLETE in accordance with the procedures in § 5.1.3.

6.4.2 *Call clearing by the network*

The network initiates clearing by sending a DISCONNECT message to the user. When the user replaces the switchhook (or equivalent), a DISCONNECT message is sent to the network. After the terminal generates the DISCONNECT message, the procedures are as described in § 6.4.1. If, after receipt of a DISCONNECT message, the user does not replace the switchhook within the prescribed period (T305), the procedures in § 5.1.3.2 are invoked.

6.5 *Stimulus information elements*

A provisional list of information elements and their definitions is contained in this section. These information elements may be used for stimulus mode signalling. The precise meaning and application of those elements which are not described in §§ 5 and 6.1 through 6.4 of this Recommendation is for further study.

Coding space for additional stimulus information elements has been reserved in § 4. Possible assignment of the reserved codes to the stimulus information elements in this section which do not appear in §§ 5 or 6.1 through 6.4 is for further study. The information elements which have been coded in § 4 are marked with *.

6.5.1 *Information elements from terminal to network*

6.5.1.1 *Charging method selection information element*

This information element from the terminal to the network indicates the billing method (reverse charging, third number, etc.) to be used for a given call.

6.5.1.2 *Bearer capability information element* *

This information element from the terminal to the network specifies that the call is requesting a service specified by the information contained in this information element.

6.5.1.3 *Bearer service acknowledge information element*

This information element from the terminal to the network reports whether the terminal's capabilities match the bearer capability in the SETUP message. This indication can take one of three forms:

1) terminal's capabilities match the bearer capability;
2) terminal's capabilities do not match the bearer capability;
3) terminal's capabilities match the bearer capability and terminal can accept the call.

The third response is optional for intelligent terminals. The network must be capable of interfacing with terminals which do not provide information on whether they can accept the present call.

6.5.1.4 *Call waiting accepted information element*

This information element is sent from the terminal to the network to indicate that the user wishes to place his current call on hold, and accept the incoming call which generated the signal information element (Call waiting tone on).

6.5.1.5 *Charge advice information element*

This information element from the terminal to the network requests charge information at the completion of a given call.

6.5.1.6 *Conference information element*

This information element from the terminal to the network requests a conference call. After a receipt of the conference information element, the network should expect to receive a Keypad information element containing the address of the connection to be added.

6.5.1.7 *Closed user group selection information element*

This information element is sent from the terminal to the network to indicate that a call is to be placed to a closed user group. This information element will be followed by a Keypad information element, containing the identity of the closed user group.

6.5.1.8 *Feature activation information element*

This information element from the terminal to the network is used to convey requests for features that are not included in the fixed function signal set. A feature activation information element is assignable to any function, allowing flexibility in offering features for stimulus mode terminals. The Feature activation information element can be used to provide supplementary features on a system specific or national option basis.

6.5.1.9 *Hold information element*

This information element from the terminal to the network is a request to place the current call on hold. Recovery from Hold is for further study.

6.5.1.10 *Keypad information element* *

This information element from the terminal to the network is used to convey information from the terminal's keypad.

6.5.1.11 *Resume information element*

The use of this information element is as defined in § 5.1.4.

6.5.1.12 *Transit network selection information element* *

This information element from the terminal to the network indicates the transit network chosen by the user to provide transmission facilities for use with a given call.

6.5.1.13 *Self-test response information element*

This information element from the terminal to the network is in response to the Self-test inquiry signal. It enables the terminal to report the results of its self-test to the network. The nature of the terminal self-test, if provided, is for further study. If no self-testing capability is provided by the terminal, it will so indicate via this information element.

6.5.1.14 *Terminal capabilities information element* *

This information element is sent to the network as part of the ALERTING or CONNECT message in response to the functional SETUP message. It indicates to the network that it is a stimulus mode terminal.

6.5.1.15 *Suspend information element*

The use of this information element is defined in § 5.1.4.

6.5.1.16 *Switchhook information element*

This information element from the terminal to the network indicates a change in the switchhook state.

6.5.1.17 *Switchhook response information element*

This information element from the terminal to the network reports the switchhook status as requested by a Switchhook inquiry information element from the network.

6.5.1.18 *Terminal capabilities response element*

This information element from the terminal to the network is a response to the Terminal capabilities inquiry information element. It contains a list of the bearer services the terminal is capable of handling.

6.5.1.19 *Transfer information element*

This information element from the terminal to the network is a request to transfer the current call. After receiving this information element, the network should expect to receive a Keypad information element containing the address where the call is to be transferred.

6.5.2 *Information elements from network to terminal*

6.5.2.1 *Bearer capability information element* *

This information from the network to the terminal informs the terminal of the bearer service associated with an incoming call.

6.5.2.2 *Display information element*

This information element from the network to the terminal contains information to be displayed on the terminal's display. The message contains IA5 characters. Escape sequences for screen controls (cursor, clearing screen, etc.) are for further study.

6.5.2.3 *Feature indication information element*

This information element from the network to the terminal causes the terminal to activate an indicator associated with the feature activation function. An example of a Feature indication is the lighting of a lamp in response to the pressing of a feature button.

6.5.2.4 *Keypad echo information element* *

This information element from the network to the terminal acknowledges receipt of a Keypad information element. This information element is used to provide visual or audible feedback to the terminal user to indicate that address digits or feature codes have been received by the network. It does not need to be interpreted by the terminal.

6.5.2.5 *Reset information element*

This information element from the network to the terminal causes the terminal to be reinitialized. The terminal resets layer three signal processing and deactivates all indicators.

6.5.2.6 *Self-test inquiry information element*

This information element from the network to the terminal causes the terminal to perform a self-test.

6.5.2.7 *Signal information element* *

This information element from the network to the terminal tells the terminal to generate alerting signals, call progress tones or other indications informing the user of an incoming call or about the current status of a call. The data field of this information element provides for distinctive alerting signals allowing, for example, use of different ringing patterns to indicate an on-premises versus an off-premises call. Call progress indications are:

- dial tone,
- ringing,
- busy,
- reorder,
- confirmation of a request,
- call answered,
- call waiting, and
- off-hook warning.

6.5.2.8 *Switchhook inquiry information element*

This information element from the network to the terminal requests the status of the terminal's switchhook.

6.5.2.9 *Terminal capability inquiry information element*

This information element from the network to the terminal inquires as to the capabilities of the terminal. The terminal responds with the Terminal capability response information element which reports the bearer services that the terminal can handle.

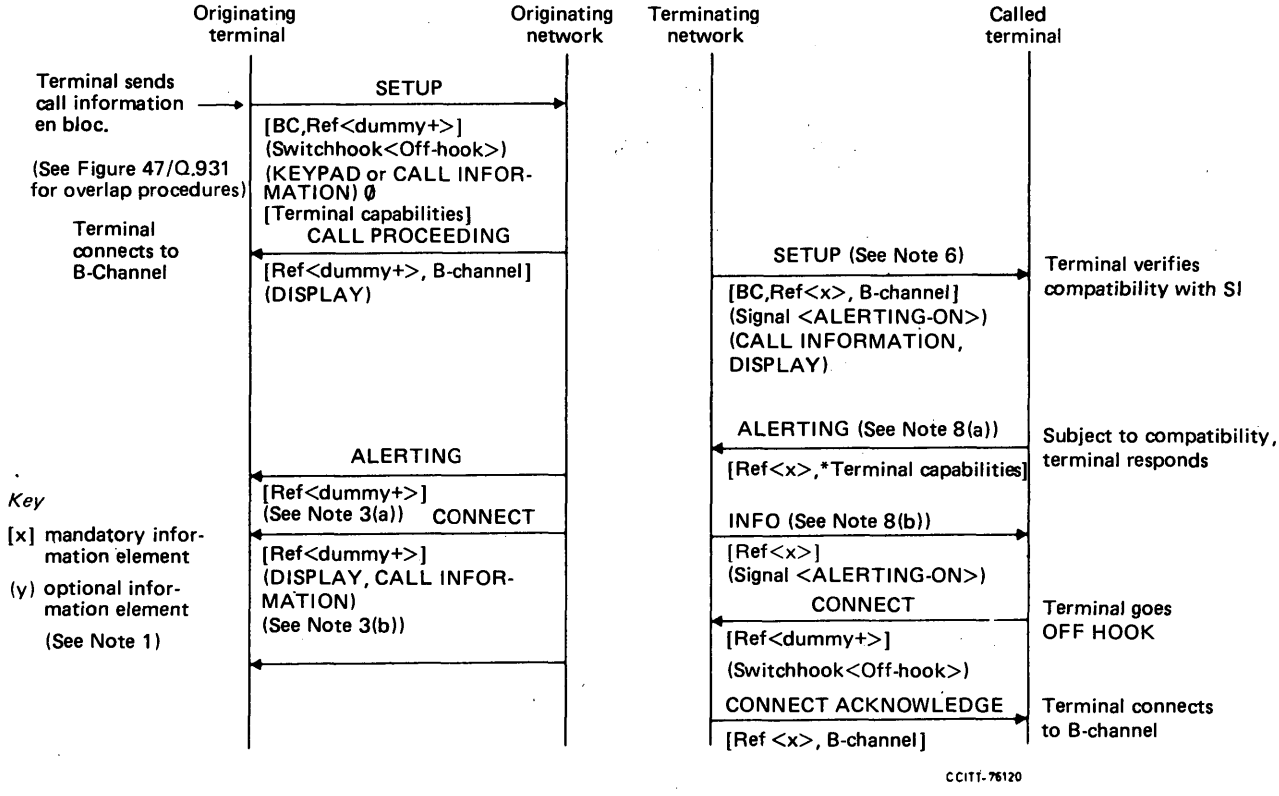
7 List of system parameters

7.1 *Timers in the network side*

The timers specified in Table 48/Q.931 are maintained in the network side of the interface.

7.2 *Timers in the user side*

For further study.



\+ See Note 1(b).

* Included in the first response to SETUP.

Ø CALL INFORMATION is taken to mean addressing and facility information necessary for call establishment. If the network determines that insufficient information is present in SETUP, the overlap procedures would be assured.

BC Bearer capability.

FIGURE 46/Q.931

Functional procedures with stimulus information elements for basic call establishment

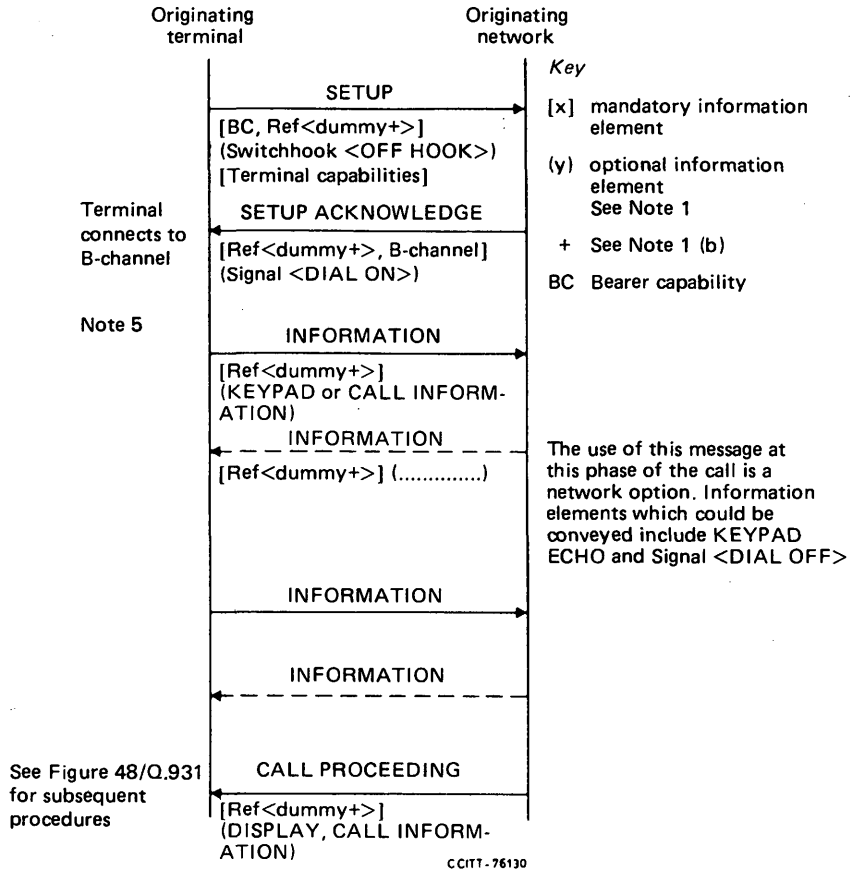
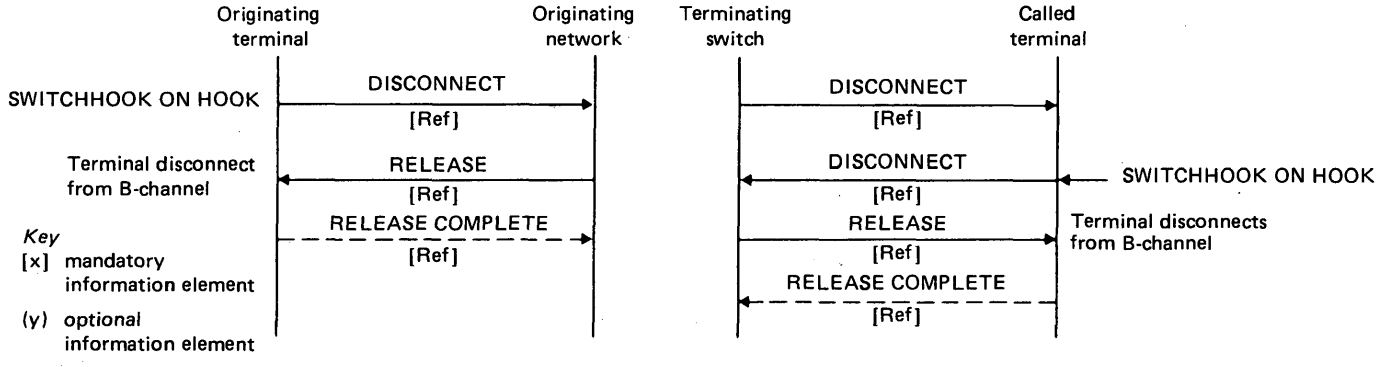
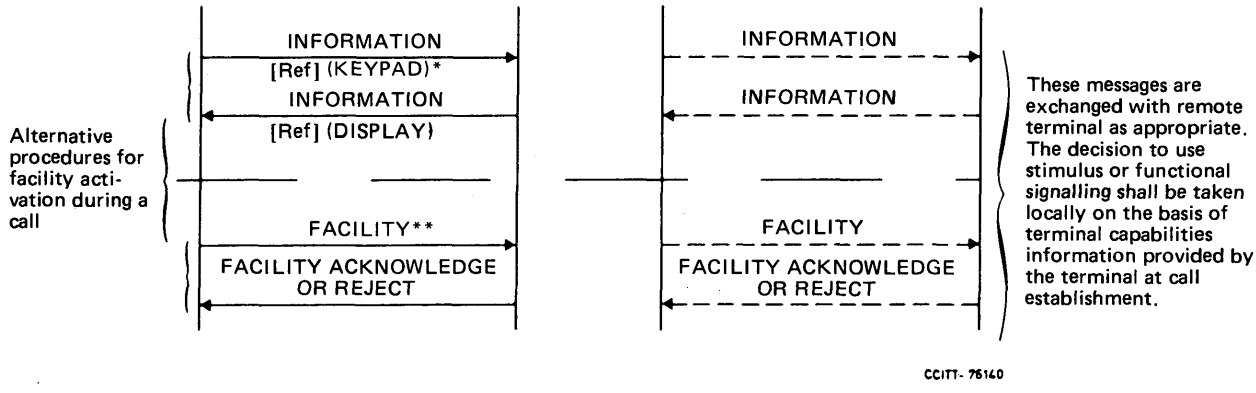


FIGURE 47/Q.931

Overlap procedures for basic call establishment



Application of Q.931 clearing procedures to simple terminals (Note 7)



* Other stimulus information elements may also be used.

** If the FACILITY message contains a dummy call reference, the network may send an INFORMATION message to supplement the FACILITY ACKNOWLEDGE/REJECT message.

FIGURE 48/Q.931

Clearing and facility activation/deactivation during a call

Notes to Figures 46, 47 and 48/Q.931

Note 1a) — The mandatory and optional elements shown in each message are those necessary for simple terminals. Other information elements would also be included in accordance with Recommendation Q.931 (I.451) but could be ignored by the simple terminal.

Note 1b) — The "dummy" call reference is used for Type 1 terminals only. Type 2 terminals use the call reference in the usual Recommendation Q.931 (I.451) manner.

Note 2 — It is intended that the message elements which are essential for simple terminal operation should be included at the beginning of each message.

Note 3a) — The information element "Signal <Ringing-on>" may be optionally included in this message. It is envisaged that this information element would not be used for Public Network access but could be employed for terminal to PBX signalling.

Note 3b) — If the information element "Signal <Ringing-on>" was sent in the ALERTING message, then "Signal<Ringing-off>" should be included in the CONNECT message.

Note 4 — A Display information element may be included in any message sent by the network to the terminal. The nature of the information to be displayed is a network-dependent matter.

Note 5 — INFORMATION messages may be sent by the network or terminal at any time in a call. This message may be used to convey information elements such as Keypad (terminal to network), Signal, Display (network to terminal).

Note 6 — The information element "Signal <Alerting-on>" may be included in the SETUP message to indicate a particular alerting pattern. The alerting action is autonomously terminated by the terminal when it goes off-hook and sends a CONNECT message.

Note 7 — In clearing procedures in Figure 48/Q.931, the sending of a DETACH message is not precluded.

Note 8a) — If the SETUP message included the information element "Signal <Alerting-on>", then the terminal will generate a local alerting signal in conjunction with returning the ALERTING message.

Note 8b) — If the SETUP message did not include the information element "Signal <Alerting-on>", then the terminal will simply return the ALERTING message with the information element "Terminal capabilities" to inform the network that it is a simple terminal. The network may instruct the terminal to begin alerting by sending the information element "Signal <Alerting-on>" in the INFORMATION message.

TABLE 48/Q.931

Timers in the network side

TIMER NUMBER	TIME-OUT VALUE	STATE OF CALL	CAUSE FOR INITIATION	NORMAL TERMINATION	AT THE FIRST EXPIRY	AT TE SECOND EXPIRY
T301	FS	N0	SETUP ACK or CALL PROCEEDING to user with no-channel-available condition	When a Channel becomes available; INFO or DISCONNECT from the user	Network clears the call by DISCONNECT	Timer is not reinitialized
T302	FS	N2	Call is in overlap sending mode	At the receipt of INFO message from the user or network alert or connect request	Network sends CALL PROCEEDING if it has received sufficient information. Otherwise clear the call	Timer is not reinitialized
T303	FS	N6	SETUP is transmitted to the user	ALERTING, CONNECT, CALL PROCEEDING or SETUP ACK from the user. If it is RELEASE reinitiate T303 with saving the cause	Retransmit SETUP and reinitialize T303	Network clears the call by DISCONNECT
T304	FS	N5	Network has responded to SETUP ACK with INFO	ALERTING, CONNECT, CALL PROCEEDING or DISCONNECT from the user	Network clears the call by DISCONNECT	Timer is not reinitialized
T305	FS	N12	Network sends DISCONNECT to clear the call	RELEASE, DISCONNECT or DETACH from the user	Network sends RELEASE to the user	Timer is not reinitialized
T306	FS	N18	Timing for "clearing tones" to be sent in-band before sending DISCONNECT to the user	DISCONNECT from the user	Stop the tone and send DISCONNECT to the user	Timer is not reinitialized
T307	FS	N16	Network sends SUSPEND ACK to the user	RESUME from the user	Network "clears" the call	Timer is not reinitialized
T308	FS	N19	Network sends RELEASE to the user	RELEASE COMPLETE from the user	Retransmits RELEASE and reinitialize T308	Network releases the B-Channel and call reference value
T309	FS	Any stable state	Data link layer disconnection. Calls in stable states are not lost	When data link layer is reconnected	FS	FS
T310	FS	N9	Network has received CALL PROCEEDING message from user	ALERTING, CONNECT or DISCONNECT from user. If DISCONNECT, retain cause and continue timing	Send DISCONNECT to the user	Timer is not reinitialized
T311	FS	N13	Network sends DETACH to the user	DETACH ACKNOWLEDGE from the user	FS	FS

APPENDIX I

(to Recommendation Q.931)

This Appendix is provided only for information. It shows only one possibility of solving the problem hereunder mentioned. Further study is required to evaluate all the implications.

An example modification to simulus mode call control procedures to simplify terminal requirements and provide for enhanced capabilities such as multi-line operation[1] is provided.

The simplified call control procedures in § 6 require the stimulus terminal to generate messages based on knowledge of the status of its switchhook and of its alerting mechanism. This requirement may limit the design flexibility for certain terminal types such as multi-line terminals. This Appendix shows example modifications to the procedures which will permit multiple line operation without requiring the terminal to keep track of terminal states.

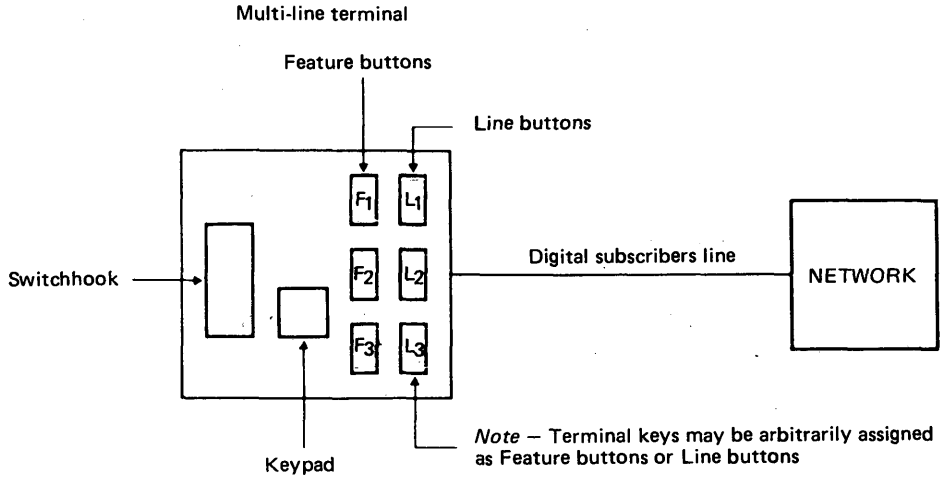
I.1 *Call establishment at originating exchange*

Procedures as described in § 6.1 apply.

I.2 *Call establishment at the destination exchange*

The procedures of § 6.2 apply with the following exception: the network interprets the CONNECT message based on its knowledge of current terminal status. In cases in which the "line" selected by the user is different than the line the network has instructed the terminal to alert, the CONNECT message is interpreted as a request for service (SETUP) and the originating call procedures are followed. An example case in which these procedures apply is shown in Figure I-1/Q.931.

[1] A multi-line terminal is a terminal which terminates on a single access facility but which has the ability to originate or terminate calls from or to multiple ISDN addresses which may also appear at other access facilities.



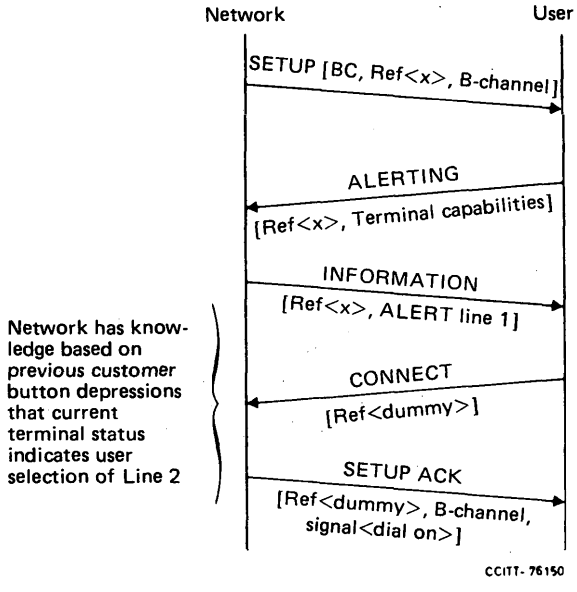


FIGURE I-1/Q.931

Example procedure for multi-line terminal

References

[1] CCITT Recommendation I.412 *ISDN user-network interfaces – Interface structures and access capabilities.*

[2] CCITT Recommendation Q.930(I.450) *ISDN user-network interface layer 3 – General aspects.*

[3] CCITT Recommendation Q.920(I.440) *ISDN user-network interface data link layer – General aspects.*

[4] CCITT Recommendation Q.921(I.441) *ISDN user-network interface data link layer specification.*

[5] CCITT Recommendation I.330 *Addressing and numbering principles in ISDN.*

[6] CCITT Recommendation Q.764 *Signalling procedures.*

[7] CCITT Recommendation X.300 *General principles and arrangements for interworking between public data networks, and between public data networks and other public networks.*

[8] CCITT Recommendation X.31(I.462) *Support of packet-mode terminal equipments on an ISDN.*

[9] CCITT Recommendation X.25 *Interface between data terminal equipment (DTE) and data circuit terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

[10] CCITT Recommendation T.61 *Character repertoire and coded character sets for the international teletex service.*

[11] CCITT Recommendation T.62 *Control procedures for the teletex and group 4 facsimile services.*

[12] CCITT Recommendation T.5 *General aspects of group 4 facsimile apparatus.*

[13] CCITT Recommendation T.6 *Facsimile coding schemes and coding control functions for group 4 facsimile apparatus.*

[14] CCITT Recommendation T.100 *International information exchange for interactive videotex.*

Abbreviation			*Meaning*
English	*French*	*Spanish*	
ACK	AR	AR	ACKNOWLEDGE
ADPCM	MICDA	MICDA	Adaptive Differential Pulse Code Modulation
BC	MFS	CP	Bearer Capability
BCD	DCB	DCB	Binary Coded Decimal
C	C	C	CONNECT
CA	ARC	AC	CONNECT ACKNOWLEDGE
CA	AA	LLA	CALL ACCEPTED
call ref.	réf. appel	RLL	call reference
CC	CC	LLC	CALL CONNECTED
chan	voie	canal	channel
CLC	CL	CL	CLEAR CONFIRMATION
CLI	IL	IL	CLEAR INDICATION
CLR	DL	PL	CLEAR REQUEST
Configur.	Configur.	Config.	Configuration
CP	AC	LLC	CALL PROCEEDING
CR	DA	PLL	CALL REQUEST
CUG	GFU	GCU	Closed User Group
D	D	D	DISCONNECT
DCE	ETCD	ETCD	Data Circuit-terminating Equipment
D-ch	voie D	canal D	D-channel
DDI	SDPS	SDE	Direct Dialling In
dest.	dest.	dest.	destination
DISC	DISC	DISC	Disconnect
DTE	ETTD	ETD	Data Terminal Equipment
Excl	Excl	Excl.	Exclusive
Ext.	PS	Ext.	Extension
FS	EU	UE	Further Study
GTEI	ITPEG	IETG	Group Terminal Endpoint Identifier
I	I	I	Information
IA5	AI nº 5	AI N.º 5	International Alphabet No. 5
IC	AE	LLEN	INCOMING CALL
ID/id	ID/id	ID/id	IDentification
id	id	id	identifier
ind	ind	ind	indicator
info.	info.	info.	information
INFORM.	INFORM.	INFORM.	INFORMATION
INIT	INIT	INIC	INITiate
Int	Int	Int.	Interface
IP	BI	PU	ISDN interworking unit port
ISDN	RNIS	RDSI	Integrated Services Digital Network

Abbreviation			*Meaning*
English	*French*	*Spanish*	
M	O	O	Mandatory
max.	max.	máx.	maximum
min.	min	mín	minimum
n	n	n	network
NT2	TR2	TR2	Network Termination 2
O	O	F	Optional
Op	Op	Mf	Operation Mode
orig.	orig.	orig.	Origination
OSI	ISO	ISA	Open Systems Interconnection
p	p	p	packet data
PABX	PABX	CAP	Private Automatic Branch Exchange
PAD	ADP	EDD	Packet Assembly/Disassembly facility
PBX	PBX	PBX	Private Branch Exchange
PH	TP	TP	Packet Handler
Pref	Préf.	Pref.	Preferred
PSPDN	RPDCP	RPDCP	Packet Switched Public Data Network
R	L	L	RELEASE
RC	FL	LC	RELEASE COMPLETE
Ref	Réf.	Ref	Call Reference
S	E	ES	SETUP
s	s	s	signalling
SA	ARE	AES	SETUP ACKNOWLEDGE
SABM	EMEA	SABM	Set Asynchronous Balanced Mode
SAPI	IPAS	IPAS	Service Access Point Identifier
SDL	LDS	LED	Specification and Description Language
TA	AT	AT	Terminal Adaptor
TE	ET	ET	Terminal Equipment
TE1	ET1	ET1	Terminal Equipment type 1
TEI	ITPE	IET	Terminal Endpoint Identifier
Transp.	Transp.	Transp.	Transparency
u	u	u	user
UA	ARSN	UA	Unnumbered Acknowledgement
UI	INN	UI	Unnumbered Information

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