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PUBLIC DATA NETWORKS: INTERFACES

SUPPORT OF PACKET MODE TERMINAL EQUIPMENT BY AN ISDN

ITU-T Recommendation X.31

(Previously “CCITT Recommendation”)

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation X.31 was revised by the ITU-T Study Group VII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Recommendation X.31[1)]

SUPPPORT OF PACKET MODE TERMINAL EQUIPMENT BY AN ISDN

(Malaga Torremolinos, 1984; amended at Melbourne, 1988 and Helsinki, 1993)

The CCITT

considering:

(a) that DTEs conforming to Recommendation X.25 will be used, at least during the evolution of integrated services digital networks (ISDN) and possibly thereafter, in conjunction with packet switched data transmission services (PSDTS) provided on an ISDN or via an ISDN to PSPDNs;

(b) that packet-mode TE1s conforming to the I-Series Recommendations (1.430/1.431) at reference points S and T will be used in conjunction with PSDTS provided by an ISDN or via an ISDN to PSPDNS;

(c) that the functions and protocol defined by this Recommendation must allow the provision of the network service defined in Recommendation X.213;

(d) that the interworking function between an ISDN and a PSPDN is defined in Recommendation X.325;

(e) that the demand access to PSPDNs is defined in Recommendation X.32;

(f) that the dedicated access to PSPDNs is defined in Recommendation X.25.

unanimously declares

that the following should apply for the support of packet-mode terminal equipment by an ISDN.

This Recommendation addresses the following aspects:

1) definition of the aspects of the packet-mode services provided to the ISDN users in accordance with the bearer services defined in I-Series Recommendations;
2) definition of the procedures at the ISDN user-network interface for accessing packet-mode services in alignment with Recommendations I.430, I.431, Q.921 and Q.931;
3) definition of the TA's functions for adapting existing X.25 terminals.

PADs may be supported within the network, in which case existing Recommendations shall apply for asynchronous access (e.g. X.3, X.28, X.29, X.52). The support of asynchronous access by an ISDN or through an ISDN is not within the scope of this Recommendation.

1 General service aspects

Two main services for packet switched data transmission are defined for packet-mode terminals connected to the ISDN, namely:

Case A access to a PSPDN (PSPDN services);

Case B use of an ISDN virtual circuit service.

The provision of these services is defined in the I.230-Series Recommendations.

In Case A an ISDN transparent circuit connection, either permanent (i.e. non-switched) or demand (i.e. switched), is used. The corresponding ISDN bearer service is a 64 kbits service as described in Recommendation I.231. The service available to the user is that of the PSPDN described in X.25 (permanent access) and X.32 (demand access), as well as in other X-Series Recommendations (e.g. X.2, X.121).

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1) This Recommendation is also included in the I-Series Recommendations under number I.462

In Case B an ISDN virtual circuit service is used, as described in 3.2.1/I.232. The service available is described in I-Series Recommendations.

In Case A only B-channel can be used to access the packet switched service at the user-network interface, while in Case B both B- and D-channels can be used. The detailed service aspects for both cases are described in 3.

This Recommendation covers the following procedures at the S/T reference point:

- B- and D- channel access on both basic and primary rate interfaces. Application to H channel access is for further study.
- X.25 LAPB procedures on the B-channel and Q.921 LAPD procedures on the D-channel. X.25 LAP procedures are not considered here.
- X.25 packet layer procedures on both B- and D-channels.

In addition, this Recommendation defines the use of Q.921 and Q.931 procedures, when appropriate for the establishment and release of a physical path through the ISDN.

2 Reference configurations

The configurations given below are the basis on which the support of X.25 DTEs and TE1s. by the ISDN should be standardized. Interworking considerations are defined in 5.

These configurations are also the basis on which the support of packet mode TEs by an ISDN has been standardized, since an X.25 DTE and its Terminal Adaptor (TA) is always equivalent to a packet mode TE1 at the S/T interface. Therefore, every reference in this Recommendation to the combination of an X.25 DTE and its TA should always be considered as being applicable to a packet mode TE1. However, some TE1s may have more capability than that available from an X.25 DTE and its TA. Similarly, this Recommendation covers the support of NT2s operating in the packet-mode.

Multiple X.25 DTE + TAs or TE1s, or a combination thereof, may be supported at the customer premises. Multiple X.25 DTEs may be multiplexed at layer 3 by an NT2 onto a single B-channel. Multiple TAs or TE1s are able to use the B-channel, one at a time, on a per-call basis.

NOTE – Multiplexing at layer 2 within a B-channel is for further study.

This Recommendation only applies to packet mode operation carried out independently on a single ISDN network connection type (i.e. involving either a B- or D-channel).

2.1 Configuration when accessing PSPDN services (Case A)

This configuration (see Figure 2-1) refers to the service of Case A, thus implying a transparent handling of packet calls through an ISDN. Only access via the B-channels is possible. In this context, the only support that an ISDN gives to packet calls is a physical 64 kbit/s circuit-mode semi-permanent or demand transparent network connection type between the appropriate PSPDN port and the X.25 DTE + TA or TE1 at the customer premises.

In the case of semi-permanent access, the X.25 DTE + TA or TE1 is connected to the corresponding ISDN port at the PSPDN (AU). The TA, when present, performs only the necessary physical channel rate adaption between the user at the R reference point and the 64 kbit/s B-channel rate. Q.931 messages are not used in this case.

In the case of demand access to PSPDNS, which is illustrated in the upper portion of Figure 2-1, the X.25 DTE + TA or TE1 is connected to an ISDN port at the PSPDN (AU). The AU is also able to set up 64 kbit/s physical channels through the ISDN.

In this type of connection, originating calls will be set up over the B-channel towards the PSPDN port using the ISDN signalling procedure prior to starting X.25 layer 2 and layer 3 functions. This can be done by exploiting either hot-line (e.g., direct call) or complete selection methods. Moreover, the TA, when present, performs user rate adaption to

64 kbits. Depending on the data rate adaption technique employed, a complementary function may be needed at the AU of the PSPDN (see 7 on TA rate adaption).

In the complete selection case, two separate numbers are used for outgoing access to the PSPDN:

- the ISDN number of the access port of the PSPDN, indicated in the Q.931 SETUP message;
- the address of the called DTE indicated in the X.25 call request packet.

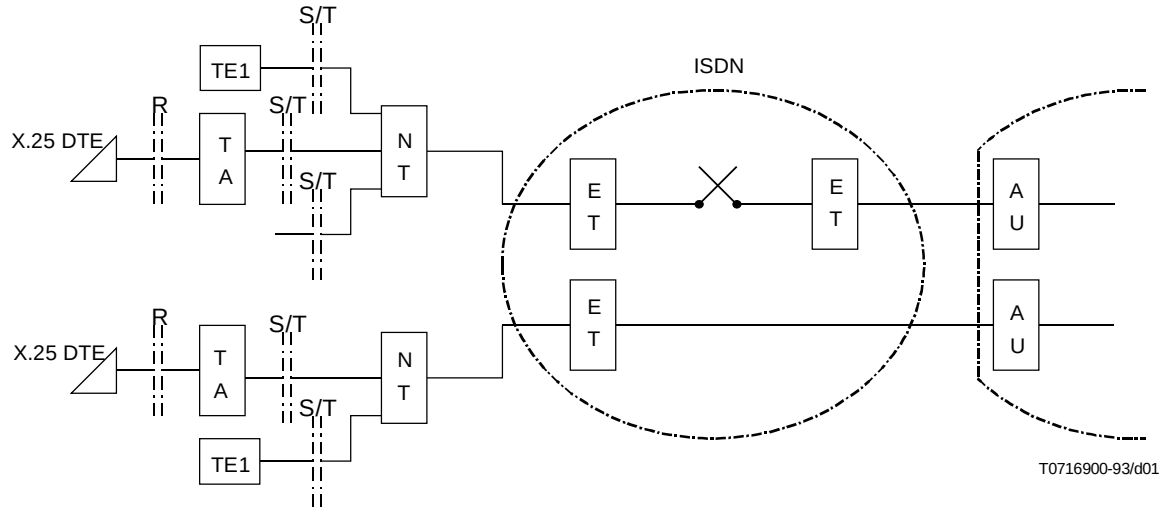
The corresponding service requested in the Q.931 SETUP message is ISDN circuit-mode bearer services.

For calls originated by the PSPDN, the same considerations as above apply. In fact, with reference to Figure 2-1, the ISDN port of the PSPDN includes both rate adaption (if required) and path setting-up functions.

When needed, DTE identification may be provided to the PSPDN by using the call establishment signalling protocols in Recommendation Q.931. Furthermore, DCE identification may be provided to the DTE, when needed, by using the same protocols.

For the demand access case, X.25 layer 2 and layer 3 operation in the B-channel as well as service definitions are given in Recommendation X.32.

Some PSPDNs may operate the additional DTE identification procedures defined in Recommendation X.32 to supplement the ISDN provided information in Case A.



B-channel is used

Reference points
(see Recommendation I.411)

AU ISDN access unit ports
TA Terminal adaptor
NT Network termination 2 and/or 1
ET Exchange termination
TE1 Terminal equipment 1

NOTES

1 This figure is only an example of many possible configurations and is included as an aid to the text describing the various interface functions.

2 See Recommendation X.325 for interworking guidelines.

FIGURE 2-1/X.31

Configuration when accessing PSPDN services

2.2 Configuration for the ISDN virtual circuit service (Case B)

This configuration refers to the case where a packet handling (PH) function is provided within the ISDN. The configuration in Figure 2-2 relates to the case of X.25 link and packet layer procedures conveyed through the B-channel. In this case, the packet call is routed, within an ISDN, to some PH function where the complete processing of the X.25 call can be carried out.

The PH function may be accessed in various ways depending on the related ISDN implementation alternatives. In any case a B-channel connection is set up to/from a PH port supporting the necessary processing for B-channel packet calls, standard X.25 functions for layer 2 and layer 3 as well as possible path setting-up functions for layer 1 and possible rate adaption.

The configuration in Figure 2-3 refers to the case of X.25 packet layer procedures conveyed through the D-channel. In this case a number of DTEs can operate simultaneously through a D-channel by using connection identifier discrimination at ISDN layer 2. The accessed port of PH is still able to support X.25 packet layer procedures.

It is also important to note that the procedures for accessing a PSDTS through an ISDN user-network interface over a B- or D-channel are independent of where the service provider chooses to locate packet handling functions, i.e.:

a) in a remote exchange or packet switching module in an ISDN;

b) in the local exchange.

However, the procedures for packet access through the B-channel or the D-channel are different (see 6).

In both cases of B- and D-channel accesses, in the service of Case B, the address of the called DTE is contained in the X.25 call request packet. The establishment of the physical connection from the TA/TE1 to the packet handling functions is done on the basis of the requested bearer service (ISDN virtual circuit service), therefore, the user does not provide any addressing information in the Q.931 procedures.

For demand access case, some ISDNs may operate the DTE identification procedures defined in Recommendation X.32.

3 Service aspects

3.1 Access to PSPDN services (Case A)

Interworking considerations are defined in 5.

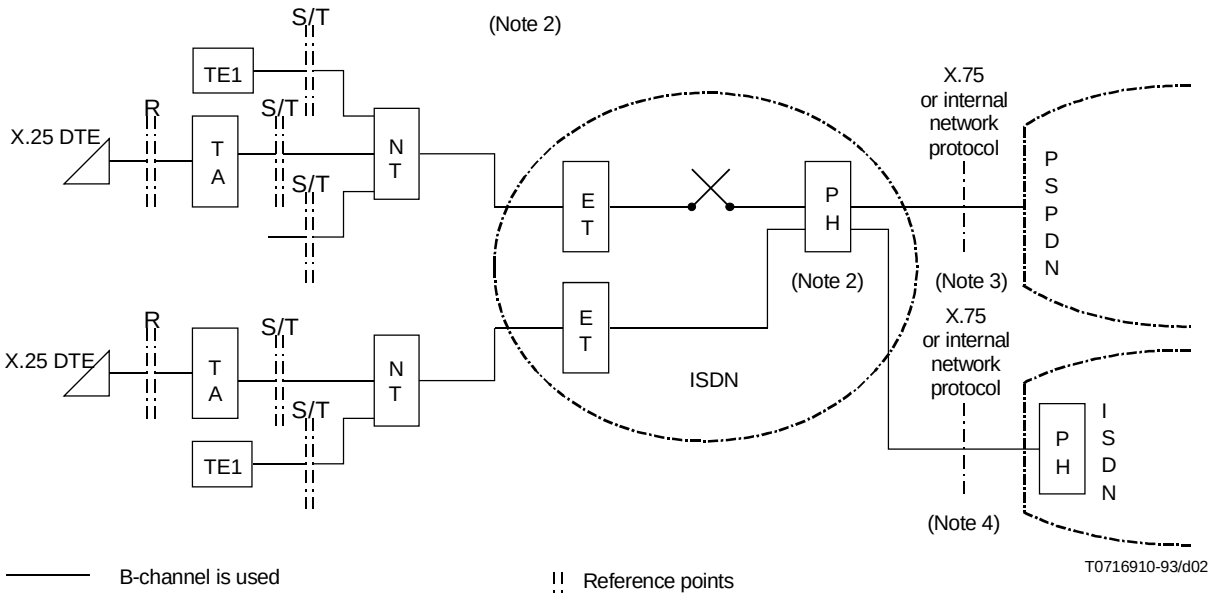
3.1.1 Service characteristics

In this case, the ISDN offers a 64 kbit/s circuit-switched or semi-permanent transparent network connection type between the TA/TE1 and the PSPDN port (AU). In the switched access case the AU must be selected by the called address in the D-channel signalling protocol when the TA/TE1 sets up the circuit-switched connection to the AU. In the non-switched access case, Q.931 call control messages are not used.

Since the packet switched service provider is a PSPDN, some DTEs are PSPDN terminals; they are handled by the PSPDN. Other DTEs may access the PSPDN without subscribing to the PSPDN permanently.

In the first case, the same services as PSPDN services are maintained, including facilities, quality of service (QOS) characteristics and DTE-DCE interfaces. In the case where a DTE is not subscribing to the PSPDN, it will be provided with a limited set of PSPDN facilities (see Recommendation X.32).

Every DTE will be associated with one or more ISDN (E.164) numbers. In addition, a DTE may be associated with one or more X.121 numbers assigned by the PSPDN(s) associated by the DTE. The method for X.25 packets to convey numbers from the ISDN numbering plan and the relationship with X.121 are described in Recommendation E.166.



TA Terminal adaptor
NT Network termination 2 and/or 1
ET Exchange termination
TE1 Terminal equipment 1
PH Packet handling function

NOTES

1 This figure is only an example of many possible configurations and is included as an aid to the text describing the various interface functions.

2 In some implementations the PH functions logically belonging to the ISDN may reside physically in a node of the PSPDN. The service provided is still the ISDN virtual circuit service.

3 See Recommendation X.325.

4 See Recommendation X.320.

FIGURE 2-2/X.31

Configuration for the ISDN virtual circuit service (access via B-channel)

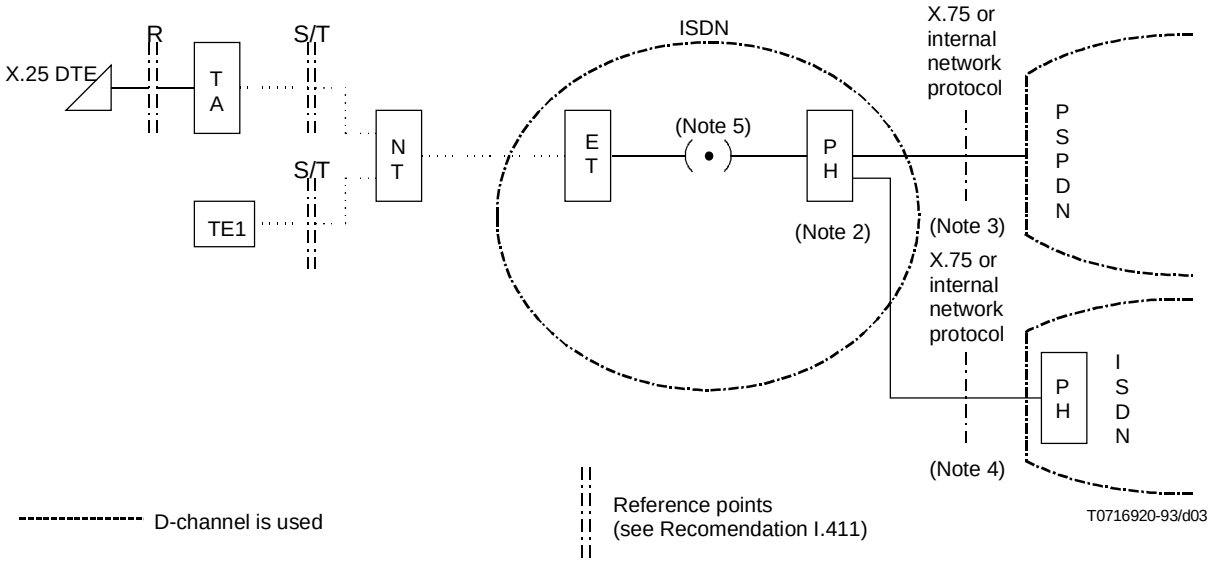
3.1.2 User access capabilites

In this case DTEs belonging to user classes of service 8 to 11 and 30 of Recommendation X.1 (categories of access Q1 to Q5) can be supported with no restrictions on the use of Recommendation X.25. The rate adaption mechanism for user classes of service 8 to 11 (categories of access Q1 to Q4) as well as the TA functionalities are described in clause 7.

3.1.3 Basic rules

Packet data communications, when using a switched B-channel, will be established by separating the establishment phase of the B-channel and the control phase of the X. 25 virtual circuits using the X.25 protocol (link layer and packet layer).

In general ISDN has no knowledge of the customer's terminal equipment or configuration. The incoming B-channel connection establishment will have to employ the D-channel signalling procedure (see Recommendation Q.931).



TA Terminal adaptor
NT Network termination 2 and/or 1
ET Exchange termination
TE1 Terminal equipment 1
PH Packet handling function

NOTES

1 This figure is only an example of many possible configurations and is included as an aid to the text describing the various interface functions.

2 In some implementations, the PH functions logically belonging to the ISDN may reside physically in a node of the PSPDN. The service provided is still the ISDN virtual circuit service.

3 See Recommendation X.325.

4 See Recommendation X.320.

5 This connection is either on demand or semi-permanent, but has no relevance with the user-network prodedures. Only internal procedures between the ET and the PH are required.

FIGURE 2-3/X.31

Configuration for the ISDN virtual circuit service (access via D-channel)

3.1.4 Notification classes

There is one class in terms of Q.931 procedures to notify the user of X.25 incoming calls. addition there is a notification class which does not use Q.931 procedures. These two classes may be provided on a subscription basis. Networks shall provide one or more of these classes. These classes are defined in 3.2.3.1 and 3.2.3.2 with the following exceptions:

- The terms used in 3.2.3.1 apply by replacing “PH” with “AU”.
- Only the B-channel access will be used in this case.
- Mapping of information in the conditional case is restricted to the information elements available for end-to-end transfer of information.

3.2 Access to the ISDN virtual circuit service (Case B)

Interworking considerations are defined in 5.

3.2.1 Service characteristics

The virtual circuit service provided within the ISDN is aligned with what is described in the X-Series Recommendations (e.g., in terms of facilities, quality of service, etc.).

The service and facilities provided as well as the quality of service characteristics are those of the ISDN. Existing features of the X-Series Recommendations may be enhanced and additional features may also be developed taking into account the new ISDN customer capabilities. A number from the ISDN numbering plan will be associated with one or more TA/TE1 (see Recommendation E.164).

3.2.2 User access capabilities

In this case both B- and D-channels can be used for accessing the ISDN virtual circuit service.

3.2.2.1 Access through the B-channel

3.2.2.1.1 Service limitations

In this case DTEs belonging to user classes of service 8 to 11 and 30 of Recommendation X.1 (categories of access T1 to T5 and Y1 to Y5) can be supported with no restrictions on the use of Recommendation X.25. The rate adaption mechanisms for user classes of service 8 to 11 (categories of access T1 to T4 and Y1 to Y4) as well as the TA functionalities are described in clause 7.

3.2.2.1.2 Basic rules

Packet data communications, when using a switched B-channel, will be established by separating the establishment phase of the B-channel and the control phase of the virtual circuits using the X.25 protocol (link layer and packet layer).

In general an ISDN has no knowledge of the customer's terminal equipment or configuration. In the demand access case the incoming B-channel connection establishment will have to employ the signalling procedures of clause 6 (see Recommendation Q.931).

3.2.2.2 Access through the D-channel

3.2.2.2.1 Service limitations

In this case DTEs belonging to user classes of service 8 to 10 of Recommendation X.1 (categories of access U1 to U4) and except on basic access user class of service 11 of Recommendation X.1 (categories of access U5) can be supported subject to the limitation imposed by LAPD as regards the maximum I-field length of the information frames (parameter N201 as defined in Recommendation Q.921). In any case, the maximum number of octets in the information field of each frame transferred on the D-channel shall be 260.

3.2.2.2.2 Basic rules

The following principles must always be respected in order to offer TE access to the PSDTS, as it is defined in the X-Series Recommendations, particularly X.25.

A single SAPI = 16 LAPD link, as viewed by both the network and the user, must support multiplexing of logical channels at X.25 layer 3. Additionally, because the user may have a multipoint access, and because a single TA or TE1 is allowed to operate with more than one TEI, the network must support the presence of multiple SAPI = 16 LAPD logical links simultaneously operating at ISDN layer 2. This results in the requirement that the network be able to support simultaneous layer 2 and X.25 layer 3 multiplexing for D-channel packet mode connections.

All X.25 packets, including *call request and incoming call packets*, must be transported to and from the TE in numbered information frames (I-frames) in a SAPI = 16 LAPD link.

An *incoming call* packet will be transmitted to a TE only after the public networks check at least the following:

- compatibility of user facilities contained in the incoming call packet with the called subscriber profile when present,
- availability of the X.25 logical channel, either two-way or incoming, on which the incoming call packet is sent.

3.2.3 Notification classes for X.25 incoming calls

There are three classes in terms of Q.931 procedures to notify the user of incoming calls. These classes may be provided on a subscription basis. Networks shall provide one or more of these classes.

3.2.3.1 No notification class

The network shall allocate incoming calls to a channel (D/B) using a network implemented algorithm. No Q.931 procedures are used to notify the user of incoming calls. Two subclasses are recognized:

a) Semi-permanent (nailed-up) connections to the PH

   An *incoming call* packet will be directly delivered over the semi-permanent connection.

b) User initiated demand connections (at the called side)

   The user is responsible for initiating channels to the PH using Q.931 procedures. If the user has not initiated channels to the PH, the network shall clear incoming calls.

3.2.3.2 Conditional notification class

Q.931 procedures are only used by the network to activate a channel for delivery of an incoming call when there is no available channel in the active state as defined in Recommendation Q.931. Subsequent incoming calls to the same ISDN number will be delivered over this channel without using Q.931 procedures.

Some networks may have the ability to maintain information related to the state of the user's packet access channel. The network may apply an algorithm to determine that no additional X.25 calls should be added to the active packet access channel. The network may then reject the X.25 call immediately or use Q.931 procedures in an attempt to activate another channel for the purpose of delivering additional X.25 calls.

NOTE – Some networks may also compare the subaddress and use Q.931 procedures in an attempt to activate another channel for the purpose of delivering additional calls when the ISDN address differs from the ISDN address of the terminal with active packet access channel.

3.2.3.3 Unconditional notification class

Q.931 procedures are used by the network to notify the user of each X.25 incoming call.

In this Case, the user may select a B-channel which has either a demand or semi-permanent connection between the terminal and the PH (see Table 6-3). In case a B-channel with semi-permanent connection may be selected, the network needs to identify the terminal connected to that B-channel. The use of the non-automatic assignment of TE1 may be applicable as a network option for this purpose. Other methods for terminal identification are for further study.

As Table 3-1 notes, all of the information that is in the X.25 incoming call packet is mapped to the Q.931 SETUP message. Table 6-4 contains the X.25/Q.931 corresponding information elements. Mapping may be restricted by length limitations of the SETUP message in Q.931. In the case of mandatory mapping, this restriction may result in the clearing of the call. The X.25 call will not be cleared if the Q.931 message segmentation is used. In case of optional mapping for conditional notification class; or length limitation violation in case of mandatory mapping when Q.931 message segmentation is not used, individual information elements will be selected by the network to be mapped in order not to exceed Q.931 SETUP message length limit, and will not result in clearing of the X.25 call. The exact criteria for selection of Information Element to be mapped is network-dependent. Note that in this case the incoming X.25 call packet will include facilities which are not present in the Q.931 SETUP message.

3.2.3.4 Information mapping from the X.25 incoming call packet to the Q.931 message

In case of the conditional notification and unconditional notification classes, some of the information present in the X.25 incoming call packet should be mapped into the Q.931 SETUP message as indicated in Table 3-1.

TABLE 3-1/X.31

Information mapping requirements for notification classes

Notification class	Information mapping	
Conditional notification	Called DTE address	M
	Called subaddress	M (Note 1)
	Any others	O
Unconditional notification	All (Note 2)	M

M Mandatory

O Network option

NOTES

1 For networks which support the ISDN supplementary services Multiple Subscriber Number and/or Direct Dialling In, mapping of the X.25 called extension facility parameter field to the called sub-address field in DSS 1 SETUP message is optional.

2 "All" means as many as possible using available information elements shown in Table 6-4.

3.3 Compatibility checking

This subclause is relevant for both Case A and Case B services.

Information subject to compatibility checking in the public network(s), in the terminal systems, or in both the public network(s) and the terminal systems when establishing a communication between two systems can be divided into two basic capabilities.

- The transmission capability may include ISDN network connection types, bearer service identification information in relation to layers 1 to 3 in the terminals, and facilities defined in Recommendation X.2.

- The communication capability involves higher layer functions for standardized applications in relation to telecommunication services. Other information, which is passed transparently between the terminal systems, may also form part of the communication capability. The coding of the information elements for compatibility checking and their relation to the open systems interconnection (OSI) reference model is in Recommendations Q.931 and X.300. Communication capability checking at the ISDN network connection level is limited to those parameters conveyable by the X.25 packet layer protocols, i.e. higher layer compatibility parameters cannot be passed from the calling user to the called user.

The network provides the transmission capability and furnishes the associated Bearer capability information element to the user in the Q.931 SETUP message when the incoming call is notified to the user. This element and possibly others are used by the user equipment for compatibility checking purposes as described in Annex B/Q.931.

The network does not transmit any communication capability (i.e. the associated High layer compatibility information element) to the user since an X.25 packet layer protocol cannot transfer such an information element from the calling to the called user.

4 Addressing and routing aspects

4.1 Terminal interface selection

This subclause describes the information necessary to select a compatible TA/TE1 for the completion of an X.25 incoming call since users may operate several packet terminals in their multiservice arrangements.

For data transmission, it is envisaged that an ISDN would identify, by means of an ISDN address, a specific interface within the subscriber premises. The transmission capability information may be used by the called TA/TE1 for compatibility checking purposes.

In Case B, the non-automatic assignment of TE1 may be used for terminal identification for PVC services. Other methods are for further study.

In general, an ISDN number identifies one or more ISDN user-network interfaces. However, some networks may allow an ISDN user-network interface to be allocated more than one ISDN number, thus allowing the identification of a given terminal within an ISDN user-network interface.

There are two ways of selecting a specific terminal in the ISDN. One is by means of the ISDN supplementary services Multiple Subscriber Number (MSN) or Direct Dialling In (DDI), the second is by means of ISDN sub-addressing.

4.1.1 Terminal interface selection by means of MSN/DDI

In a point to multipoint configuration, the ISDN supplementary service MSN may be used to select a specific terminal.

In a point to point configuration, the ISDN supplementary service DDI may be used to select a specific terminal.

4.1.2 Terminal interface selection by means of ISDN subaddressing

A subaddress from the X.25 address extension facility may be used to identity a pacific terminal within a user installation in a point to point or point to multipoint configuration.

4.2 Access to PSPDN services (Case A)

4.2.1 Channel type selection

Packet calls using this bearer service (i.e. circuit-mode) will always use the B-channel.

4.2.2 Addressing scheme for outgoing calls

The Q.931 SETUP message, when used, contains the request for a circuit-mode bearer service. The SETUP message also contains the ISDN address of the AU of the PSPDN.

The X.25 *call request* packet contains the address of the called terminal.

4.3 Access to the ISDN virtual circuit service (Case B)

4.3.1 Channel type selection

Two procedures are available regarding the manner in which channel type selection (i.e. selecting between the B- and D-channel type) can be performed:

i) the terminal which is to accept the X.25 call will indicate the channel type to be used;

ii) the ISDN has information on which channel type will indicate the channel type will be used for the X.25 incoming call. The various sorts of information that the ISDN may use to determine the channel may include, but are not limited to:

   a) subscription time agreements;

   b) occupancy level on established channels.

Channel negotiation procedures may be found in clause 6.

4.3.2 Addressing scheme for outgoing calls

The Q.931 SETUP message, when used, contains the request for the ISDN virtual circuit service. The SETUP message does not contain an address.

The X.25 *call request* packet contains the address of the called terminal.

5. Interworking with dedicated networks

5.1 Circuit-mode access to PSPDN services (Case A)

Interworking by port access (see Recommendation X.300) applies, i.e. the packet mode terminal accesses the PSPDN access port (AU) by use of a 64 kbit/s connection through the ISDN. The AU belongs to the PSPDN and is functionally equal to the interworking function (IWF) (see Recommendation X.325).

5.2 Access to PSPDNs via virtual circuit service (Case B)

Interworking by call control mapping (see Recommendation X.300) applies, i.e. interworking between the ISDN and PSPDN is effected using X.75 or a functionally equivalent internal network protocol. In some implementations, the PH functions logically belonging to the ISDN may reside physically in a node of the PSPDN. The service provided is still the ISDN virtual circuit service. In any case, interworking between network providers is effected through use of X.75 (See also Recommendation X.325).

6 Packet communications at the S/T reference point

This clause describes the information flows necessary to support packet communication over

a) circuit mode (Case A) operation on B- channels; and

b) packet mode (Case B) operation on B- and D-channels of an ISDN access line.

The ISDN TA/TE1 presents an S/T-reference point towards the network and therefore the TA/TE1 implementation should embody the procedures described in Recommendations Q.921 and Q.931 for B- and D-channel connection establishment and control. The protocol and the text of 6.1-6.5/Q.931 and Appendix II/Q.931, and 6.1-6.5 and Appendix III to this Recommendation are identical.

For demand access connections, 6.1 through 6.4 apply. Example message flows for demand access connections are shown in Appendix III.

Two types of semi-permanent connections on Band D-channels are covered in this clause.

1) physical layer semi-permanently established between the terminal and the PH/AU, i.e. the I.430/I.431 physical layer remains activated and the physical path through the ISDN is connected semi-permanently;

2) X.25 data link and physical layers semi-permanently established between the terminal and the PH/AU (in this type, both the user and the network shall keep the X.25 data link layer in the established state).

When a PVC is used, there must exist a type 2) semi-permanent connection.

In semi-permanent connection type 1), the procedures of 6.3 are followed for X.25 call establishment and release.

In semi-permanent connection type 2), only the procedures of 6.3.2 are followed for X.25 call establishment and release.

When semi-permanent connection type 2) is used for PVCS, none of the following procedures apply.

Semi-permanent connections are established via a provisioning process without Q.931 procedures.

6.1 Outgoing access

If the user selects an already established channel for the outgoing X.25 virtual call, then the procedures described in 6.3 apply. If the selected channel is not established to the AU/PH, then the procedures for activating a channel described in the following subclauses are to be used before establishing the virtual call using the procedures of 6.3.

For outgoing X.25 data calls, the user first must decide whether circuit-switched (Case A) or packet switched services (Case B) are desired from the network. For outgoing circuit calls, the user follows the procedures of 6.1.1. For outgoing packet calls, a user decides whether B-channel or D-channel is to be used for the packet call. If the user decides to use the B-channel, then the procedures described in 6.1.2.1 are used. If the user decides to use the D-channel, then the procedures described in 6.1.2.2 are used.

NOTE – Some networks may not support every type of access. In the case of B-channel access, the network will clear a request for unsupported services by sending a RELEASE COMPLETE message with cause #65, "*bearer service not implemented*". In the case of a request for D-channel access (an SABME with SAPI = 16), on a network port which does not support the service, no response is required of the network.

6.1.1 Circuit-switched access to PSPDN services (Case A)

The B-channel connection between the user and the AU shall be controlled using the D-channel signalling procedures for call establishment described in 5.1/Q.931. The specific B-channel to be used as a switched connection is selected using the channel negotiation procedures described in 5.1.2/Q.931 and summarized in Table 6-1.

On the basis of the call set-up information (e.g. called party number identifying AU, transit network selection, etc.) and/or a subscription time agreement, the network provides a connection to the appropriate AU. The bearer capability information element included in the SETUP message shall be coded with:

- information transfer capability set to either
  a) "unrestricted digital information"; or
  b) "restricted digital information";
- transfer mode set to "circuit mode";
- information rate set to "64 kbit/s".

The user may also specify the layer 1 (e.g. rate adoption), layer 2 (i.e. LAPB), and layer 3 (i.e. X.25) information transfer protocols in the low layer compatibility information element in the SETUP message (see Annex L/Q.931 entiled "Low layer information coding principles").

TABLE 6-1/X.31

User requested channel and network response
Outgoing access to either an AU or PH

Channel indicated in the SETUP message user to network direction			Allowable network response network-user
Information channel selection	Preferred or Exclusive	D-channel indicator (Note 3)	
Bi	Exclusive	No	Bi
	Preferred	No	Bi, Bi′
Any	(Ignore)	No	Bi′
(Absent)			Bi′

Bi The indicated (idle) B-channel

Bi′ Any (other) idle B-channel

NOTES

1 All other encodings are invalid.

2 All columns under the heading "Channel indicated in the SETUP message" indicate possible user codings of the Channel identification information element contained in the SETUP message sent by the user to the network requesting a connection to an AU or PH (see 4.5.13/Q.931). The column under "Allowable network response" refers to the allowable responses by the network to the user.

3 D-channel indicator shall been coded "0" to indicate No and "1" to indicate Yes.

6.1.2 Access to the ISDN virtual circuit service (Case B)

6.1.2.1 B-CHANNEL

Demand access B-channel connections are controlled using the D-channel signalling procedures for call establishment described in 5.1/Q.931 using the messages defined in 3.2/Q.931 with the following exceptions:

a) The procedures for overlap sending specified in 5.l.3/Q.931 do not apply.

b) The procedures for call proceeding and overlap sending specified in 5.1.5.2/Q.931 do not apply.

c) The procedures for notification of interworking at the origination interface specified in 5.1.6/Q.931 do not apply.

d) The procedures for call confirmation indication specified in 5.1.7/Q.931 do not apply.

e) The procedures for call connected specified in 5.1.8/Q.931 apply as follows:

   1) Upon accepting the access connection, the network shall send a CONNECT message across the user-network interface to the calling user and enter the Active state.

   2) This message indicates to the calling user that an access connection to the packet handler has been established.

   3) On receipt of the CONNECT message, the calling user shall stop timer T310, (see Recommendation Q.931) may optionally send a CONNECT ACKNOWLEDGE message, and shall enter the active state.

f) The procedures for call rejection specified in 5.1.9/Q.931 apply as follows:

   1) When unable to accept the access connection, the network shall initiate ISDN access connection clearing at the originating user-network interface as described in 5.3/Q.931.

g) The procedures for transit network selection specified in 5.1.10/Q.931 do not apply.

The specific B-channel to be used as a demand connection is selected using the channel selection procedures described in 5.1.2/Q.931 and summarized in Table 6-1.

For a demand connection to an ISDN PH, the Bearer capability information element included in the SETUP message shall be coded with:

– information transfer capability set to “unrestricted digital information”.

– transfer mode set to “packet mode”.

– information transfer rate set to 00000.

– user information layer 2 protocol set to “Recommendation X.25, link layer”.

– user information layer 3 protocol set to “Recommendation X.25, packet layer”.

NOTE – Octets 5a, 5b, 5c and 5d shall not be included.

The demand access connection can then be used to support packet communications according to X.25 link layer and X.25 packet layer procedures as specified in 6.3.

Some ISDNs may require the Calling party number and Calling party sub-address information elements to be included in the SETUP message to select a specific user profile.

6.1.2.2 D-Channel

The D-channel provides a connection which enables the ISDN user terminal to access a PH function within the ISDN by establishing a link layer connection (SAPI = 16) to that function which can then be used to support packet communications according to X.25 layer 3 procedures as defined in 6.3. The X.25 packet layer uses the acknowledged information transfer service (i.e. I-frames) provided by LAPD (see Recommendation Q.920). Consequently, Q.931 procedures are not required to provide D-channel access.

A number of packet mode user equipment can operate simultaneously over the D-channel, each using a separate ISDN layer 2 data link identified by an appropriate address (see Recommendation Q.921) in frames transferred between the user and PH.

6.2 Incoming access

6.2.1 Access from PSPDN services (Case A)

The ISDN signals the establishment of the circuit-mode connection using the procedures described in 5.2/Q.931. The X.25 virtual calls are signalled between the user and the AU using the procedures described in 6.3.

6.2.1.1 General

The general procedures performed by the AU are those defined in Recommendation X.32.

6.2.1.2 Channel selection

If the ISDN physical circuit desired by the AU does not exist between the terminal and the AU, the procedures for physical channel establishment described in the following clauses apply.

The format of the SETUP message sent by the network to the user is in accordance with 3.1.16/Q.931.

The bearer capability information element included in SETUP message shall be coded with:

- information transfer capability set to either:
  a) "unrestricted digital information"; or
  b) "restricted digital information".
- transfer mode set to "circuit mode".
- information rate set to "64 kbit/s".

The channel identification information element shall be coded according to Table 6-2.

TABLE 6-2/X.31

Network requested channel and user response
Incoming access from an AU

Channel indicated in the SETUP message user to network direction			Allowable user response user-network
Information channel selection	Preferred or Exclusive	D-channel indicator (Note 3)	
Bi	Exclusive	No	Bi
Bi	Preferred	No	Bi, Bi′ (Note 1)

Bi Indicated (idle) B-channel

Bi′ Any other idle B-channel (not permitted for broadcast call offering)

NOTES

1 This encoding is not used for broadcast call offering.

2 All other encodings are invalid.

3 D-channel indicator shall been coded "0" to indicate No and "1" to indicate Yes.

The B-channel connection to the called user shall be established by the network using the signalling procedures described in 5.2/Q.931. The call is offered by ending the SETUP message on a point-to-point data link or on the broadcast data link.

The user responds to the SETUP as specified in 5/Q.931.

6.2.2 Access from the ISDN virtual circuit service (Case B)

To offer an incoming X.25 call, the network must perform the following steps in sequence:

1) Channel selection – the physical channel / logical link to be used for the incoming call must be identified. The network may use customer profile information, network resources, etc., to choose the channel, or the procedures in Step 2) below.

2) Physical channel / logical link establishment – if the physical B-channel or the logical link of the D-channel have not been determined by Step 1, the network may use the procedures in 6.2.2.3. The network may then proceed with Step 3).

3) X.25 virtual call establishment – the network establishes the virtual call using the procedures described in 6.3.

In the configuration for the ISDN virtual circuit service, the choice of channel type to be used for the delivery of a new incoming call packet shall be made by the network as described below.

1) A new *incoming call* packet may be indicated to the ISDN customer by a call offering procedure between the network and all user packet mode terminals (see 3.2.3.2 and 3.2.3.3).

2) An incoming virtual call directed to a terminal with an established connection to the PH may be offered directly to the terminal over the established access connection without the use of Q.931 call offering procedures (see 3.2.3.1 and 3.2.3.2).

6.2.2.1 B-Channel

When X.25 calls are to be offered on the B-channels without channel negotiation, the procedures described in 5.2/Q.931 using the messages of 3.2/Q.931 apply with the following exceptions:

- The procedures for overlap receiving specified in 5.2.4/Q.931 do not apply.
- The procedures for receipt of CALL PROCEEDING and ALERTING specified in 5.2.5.2/Q.931 apply with the following exception:
  - The receipt of an ALERTING message shall not cause the network to send a corresponding ALERTING message to the calling user.
- The procedures for call failure specified in 5.2.5.3/Q.931 apply with the following note:
  - The network clears the incoming X.25 virtual call towards the calling X.25 DTE using the appropriate cause from Table 6-5.
- The procedures for notification of interworking at the terminating interface specified in 5.2.6/Q.931 apply with the following exceptions:
  - The case of the call entering an ISDN environment during call establishment is not applicable.
  - In the case of a call leaving the ISDN environment within the called user's premises, no notification is sent to the calling party.
  - The case of in-band information/patterns is not applicable.
- The procedures for active indication specified in 5.2.8/Q.931 apply with the following exception:
  - The network shall not initiate procedures to send a CONNECT message towards the calling user.
- The procedures for user notification specified in 5.9/Q.931 do not apply.

Where an established B-channel connection is to be used, the incoming call packet will be delivered in accordance with 6.3.

Where a new B-channel connection is to be established, the identity of the selected user will be associated with the Connection Endpoint Suffix (CES) from which the first CONNECT message has been received.

6.2.2.2 D-Channel

The D-channel provides a connection which enables the ISDN PH to access an ISDN user terminal or vice versa. This access is accomplished by establishing an ISDN link layer connection (SAPI = 16) to the terminal or network which can then be used to support packet communications according to X.25 layer 3 procedures as defined in 6.3.

The layer 2 procedures shall be in accordance with Recommendation Q.921. The D-channel provides a semi-permanent connection for packet access since all D-channel layer 2 frames containing a packet mode SAPI (16) are routed automatically between the user and the PH function.

When an incoming call is offered to packet mode user equipment at the user interface, the channel selection procedures described in 6.2.2.3 shall be used.

A number of packet mode terminals can operate simultaneously over the D-channel, each using a separate layer 2 link identified by an appropriate TE1 (see Recommendation Q.921) in frames transferred between the terminal and the network.

6.2.2.3 Call offering

6.2.2.3.1 Channel selection through call offering

The call offering procedure is performed using the layer 3 messages and procedures of 5/Q.931. The call offering procedure is integrated into the circuit-switched call control procedures, signalled on the D-channel, with the channel selection being accomplished by means of the channel selection procedure if offered as a network option.

As described in 5/Q.931, the network selects the first user which responds to the call offering with a CONNECT message. When the selected user has requested that the X.25 call be set up over a new B-channel, the network will indicate that the channel is acceptable by returning a CONNECT ACKNOWLEDGE message to the user. If multiple terminals have responded positively to the SETUP message, the network shall clear each of the non-selected terminals with a RELEASE message containing cause #26, "*non-selected user clearing*".

When the selected user has requested that the X.25 call be set up over an established B-channel or the D-channel, the network shall respond to the CONNECT message with a RELEASE message containing cause #7, "*call awarded and being delivered in an established channel*". The network shall also return a RELEASE message containing cause #26, "*non-selected user clearing*" to any other positively responding terminals. The network will then deliver the X.25 call over the selected channel.

NOTES

1 There is no time significance between the delivery of the RELEASE message and the incoming call packet, i.e. either may occur first.

2 The network shall send the RELEASE message(s) and the user(s) shall respond with RELEASE COMPLETE.

If the channel indicated by the first positively responding user is not available, the network will use Q.931 call clearing procedures to clear the call with cause #6, "*channel unacceptable*". If the channel indicated in the SETUP message is not acceptable to the user, the user will clear the call with a RELEASE COMPLETE message containing cause #34, "no *circuit/channel available*" or cause #44, "*requested circuit/channel not available*".

On the basis of a network option or subscription agreement, the network may choose the access channel or access channel type (e.g., B or D) for a particular incoming packet call.

When the Channel indication information element indicates *Channel indication = No channel, Exclusive,* and *D-channel indication =Yes*, then the Bearer capability information element should be encoded as follows:

- Information transfer capability set to: *Unrestricted digital information*;
- Transfer mode set to: *Packet mode*;
- Information rate set to: *packet mode (00000)*;
- Layer 2 protocol set to: *Recommendation Q.921*;
- Layer 3 protocol set to: *Recommendation X.25, packet layer*;

In all other cases, the Bearer capability information element should be encoded as follows:

– Information transfer capability set to either:

Unrestricted digital information or *restricted digital information*;

– Transfer mode set to: *Packet mode*;

– Information rate set to: *packet mode (00000)*;

– Layer 2 protocol set to: *Recommendation X.25, link layer*;

– Layer 3 protocol set to: *Recommendation X. 25, packet layer*.

There exists an understanding that if the terminal responds with D-channel indication set (see Table 6-3), the Layer 2 protocol to be used is Recommendation Q.921 (LAPD)

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, provided the user rates and available bandwidth are compatible.

The channel selection principle to be used in the procedure is shown in Table 6-3.

NOTES

3 When the incoming SETUP message is sent on a broadcast data link with a Channel identification information element which indicates an idle B-channel and 'Preferred", the called user is not permitted to respond with a different idle B-channel in the response. The option to respond with a different idle channel is restricted to point-to-point call offerings.

4 Networks providing packet mode call offering shall provide Q.931 signalling procedures for packet mode calls on SAPI = 0. For an interim period, some networks, by subscription agreement, may offer SAPI = 16 broadcast call offering procedures for providing Q.931 signalling. This option shall use all Q.931 procedures for packet mode calls with the following restriction: All calls will be offered as "D-channel exclusive" and will not provide channel negotiation procedures. Terminals implementing SAPI = 16 procedures shall also implement SAPI = 0 procedures for portability.

6.2.2.3.2 Information element mapping

Some networks may choose to provide a service of mapping some or all of the information from the incoming call packet into the SETUP message (see 3.2.3). Table 6-4 shows the mapping of the X.25 incoming call elements to Q.931 information elements. The incoming call packet will still contain these fields when it is delivered. See 3.2.3 for mapping requirements.

TABLE 6-3/X.31

Network requested channel and user response
Incoming access for packet mode

Channel indicated in the SETUP message network to user direction			Allowable network response user-network
Information channel selection	Preferred or Exclusive	D-channnel indicator (Note 2)	
Bi	Exclusive	No	Bi
		Yes	Bi, D
Bi	Preferred	No	Bi, Bi′, Bj,
		Yes	Bi, Bi′, Bj, D
No channel	Preferred	No	Bj
		Yes	Bj, D
	Exclusive	Yes	D

Bi Indicated (idle) B-channel

Bi′ Any other idle B-channel (not permitted in response to broadcast call offering)

Bj An established B-channel under the user's control (A semi-permanent B-channel which is allocated to the user may be indicated if the user subscribes to the unconditional notification class)

D The D-channel

NOTES

1 All other encodings are invalid.

2 D-channel indicator shall be encoded "0" to indicate No and "1" to indicate Yes.

TABLE 6-4/X.31

Mapping of X.25 information elements to corresponding Q.931 SETUP message information elements in packet-mode incoming call

	Information elements in X.25 *incoming call* packet	Corresponding information element in Q.931 SETUP message
	Calling DTE address	Calling party number (Note 7)
	Called DTE address	Called party number
	User data (UD)	User-user information (Note 2)
	A-bit (Note 3)	For further study
	D-Bit	Packet layer binary parameters
	Modulus	Packet layer binary parameters
X.25 User facility	Flow control parameter negotiation	Packet size Packet layer window size
	Throughput class negotiation	Information rate (Note 5)
	Fast select	Packet layer binary parameters
	Reverse charging	Reverse charging information
	Closed user group selection	Closed user group
	Closed user group with outgoing access selection	Closed user group
	Bilateral closed user group	For further study
	Transit delay selection and indication	Transit delay selection and indication
	Call redirection and deflection notification	Redirecting number
DTE facility	Calling address extension	Calling party sub-address
	Called address extension	Called party sub-address (Note 6)
	End-to-end transit delay	End-to-end transit delay
	Minimum throughput class	Information rate (Note 4)
	Expedited data negotiation	Packet layer binary parameters
	Priority	For further study
	Protection	For further study

NOTES

1 Mapping is optional or required as indicated in 3.2.3.

2 The maximum length of the user data within the user-user information element is network dependent and is either 32 or 128 octets.

3 The need and procedures for A-bit mapping is for further study.

4 This information is not always present even when the “Information rate” is provided in the Q.931 SETUP message.

5 When the “Throughput class negotiation” is not set in the X.25 Incoming call packet, this information shall be provided as the default throughput values applying to the virtual call.

6 The network will map bits 8 and 7 of the first octet of the called address extension facility parameter field in X.25 incoming call packet to “Type of subaddress” field in octet 3 of called party subaddress information element in Q.931 SETUP message, assuming that the X.25 incoming call packet is coded based on 1988 version of X.25. Therefore, the called user should notice that the received “Type of subaddress” may not be correct when the X.25 incoming call packet is coded based on 1984 version of X.25.

7 This mapping is mandatory and octet 3a shall be set with Presentation indicator set to “presentation allowed” and Screening indicator set to “network provided”.

6.2.2.3.3 Channel selection without call offering

Where the network and user have agreed beforehand, the network may route an incoming call to the called user over an established B-channel connection or D-channel link without the need for any signalling for channel selection.

6.3 X.25 Virtual call establishment and release

In all cases, once the physical channel has been selected and, if necessary, connected to the PH or AU, the virtual call is established according to-the procedures below. Some networks may require some of the terminal identification procedures of Recommendation X.32 as well.

6.3.1 Link layer establishment and release

Link layer (LAPB on the B-channel or LAPD on the D-channel) establishment shall be initiated by:

- the calling terminal in the case of outgoing calls;
- the AU in the case of incoming calls in Case A; or
- the PH in the case of incoming calls in Case B.

Link layer release may be initiated by:

- the terminal;
- the AU in Case A; or
- the PH in Case B.

6.3.2 Packet layer virtual call setup and release

The packet layer procedures of X.25 will be used for layer 3 call set-up and release. The packet layer procedures will additionally be able to control and monitor the established or released state of the link layer.

In Case B, the PH may maintain a timer T320 (defined in Recommendation Q.931). T320, if implemented, is started:

a) upon clearance of the last virtual call; or

b) upon transmission of a CONNECT message by the network in case of an outgoing B-channel access connection; or

c) upon transmission of a CONNECT ACKNOWLEDGE message by the network in case of an incoming B-channel access connection; or

d) upon: establishment of the link layer for D-channel access connections.

T320 is cancelled upon:

a) establishment of the first (next) virtual call; or

b) receipt of a Q.931 clearing message from the user; or

c) disconnection of the SAPI = 16 link on the D-channel.

Upon expiry of T320, the PH will release the link layer and, in the case of B-channel access, initiate clearing of the B-channel.

X.25 logical channels are associated with their underlying logical link. Specifically, in case of the use of the B-channel for packet communication' there is an association between the logical channels and the LAPB logical link below them. Thus' the same logical channel number may be used simultaneously on each different B-channel.

6.4 Call clearing

6.4.1 B-Channel

The clearing of the switched connection shall be effected by using the D-channel signalling procedures for call clearing as specified in 5.3/Q.931. For access to PSPDN services, no exceptions apply. For the ISDN virtual circuit service, the messages of Section 3.2 of Recommendation Q.931 are used, and the following exceptions apply:

- The terms defined in 5.3.1/Q.931 "Terminology" apply by replacing "circuit-switched ISDN connection" with "demand packet mode access connection".

- The exception condition (f) specified in 5.3.2/Q.931 does not apply.

- The procedures for clearing with tones and announcements provided in 5.3.4.1/Q.931 do not apply.

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. In the ISDN virtual circuit service, In case B, if the user clears the B-channel access connection using a Q.931 clearing message while X.25 virtual calls still exist on the B-channel, the network shall clear the X.25 virtual call(s) with cause #17, "*remote procedure error*", and diagnostic #64, "*call setup, call clearing, or registration problem*".

In case B, if a Q.931 RESTART message is received by the PH during the X.25 data transfer phase, the X.25 virtual calls shall be treated as follows:

- For switched virtual circuits, an X.25 clear indication packet shall be sent with cause #9, "*out of order*" and diagnostic #0, "*no additional information*".

- For permanent virtual circuits, an X.25 reset packet shall be sent containing cause #9, "*out of order*" and diagnostic #0, "*no additional information*".

At the expiration of timer T320, the network may disconnect the X.25 link layer and the access connection. B-channel clearing is as described in 5.3/Q.931 with the exceptions above, with cause #102, "*recovery on timer expiry*".

6.4.2 D-Channel

D-channel access connections are cleared using the disconnect procedures as defined in 6.3.

6.4.3 Additional error handling information

When an ISDN access connection failure occurs, or the X.25 virtual call is cleared prematurely, the rules of 5.8/Q.931 shall apply. In addition, the following rules for determining the appropriate cause to be used shall apply in order of priority decreasing:

1) If a Q.931 clearing message or RESTART message is received by the PH during the X.25 data transfer phase, 6.4.1 applies.

2) In general, if an ISDN access connection is rejected by the destination user using Q.931 messages, the X.25 virtual call shall be cleared using a clear indication packet and cause #0, "*DTE originated*" with diagnostic #0, "*no additional information*". Some networks may map some Q.931 causes to the corresponding X.25 causes according to Table 6-5.

3) If a condition exists that prevents the Q.931 SETUP message from being delivered at the user-network interface, the X.25 virtual call shall be cleared using a *clear indication* packet and a cause shall be selected appropriate to the condition. Table 6-5 shall serve as a guide to selecting an appropriate cause, i.e. the X.25 mapping of the Q.931 cause describing the interface condition shall be used.

4) If the Q.931 SETUP message is sent across the user-network interface, but no response is received prior to the second expiry of timer T303 (defined in Recommendation Q.931), rule #3 applies.

5) If the Q.931 SETUP message is sent across the user-network interface, and a response other than a call rejection is received from a user which results in the clearing of the ISDN access connection at the user-network interface, the X.25 virtual call shall be cleared using a clear indication packet containing cause #17, "*remote procedure error*" with diagnostic #64, "*call setup, call clearing, or registration problem*".

6) If an X.25 *clear request packet* is received from the originating user prior to the delivery of the X.25 *incoming call* packet to the called user (premature clearing), the PH shall sent a *clear confirmation* packet to the calling user and the access connection shall be treated as follows:

   – If the Q.931 SETUP message was associated with the Unconditional notification class of service (see 3.2.3), the access connection, when and if established, shall be cleared. The Q.931 clearing message shall contain the appropriate cause as described in Table 6-6.

   – If the Q.931 SETUP message was associated with the Conditional notification class of service (see 3.2.3) and there exists at least one terminal which responds positively to the Q.931 SETUP message, then two options are allowed:

      a) the access connection is cleared as described for the Unconditional notification class of service; or

      b) the access connection is established and timer T320 is started. Upon expiry of timer T320, the access connection is cleared with cause #102, "*recovery on timer expiry*" and diagnostic indicating timer T320.

6.4.4 Cause mappings

6.4.4.1 Access to/from PSPDN services (Case A)

The AU may choose to follow the procedures in 6.4.4.2 when mapping between causes delivered by the ISDN or the PSPDN.

6.4.4.2 Access to/from the ISDN virtual circuit service (Case B)

There are several cases where it is necessary to map causes between Q.931 and X.25. ISDN networks shall use Table 6-5 and Table 6-6 to map the causes between Q.931 and X.25 messages. The figures in Appendix III describe some example situations.

6.5 Access collision

When the network offers a packet mode call at the interface simultaneously with the user requesting a packet mode call, the network shall give priority to the completion of the incoming call. If the user determines that accepting the incoming call would meet the needs of its own outgoing call request, the user may clear the call request and accept the incoming call.

7. Terminal adaptor functionalities

7.1 General

Terminal Adaptor (TA) functions are needed to support the access of X.25 DTEs at the S/T reference point (see Figure 7.1).

Main functionalities which are provided by the TA are the following:

– Rate adaption.

– Mapping of signalling information and procedures between the S/T and the R reference point.

– Synchronization.

– Maintenance.

TABLE 6-5/X.31

Mapping of Q.931 cause fields to X.25 cause field

Item	Q.931 cause	Code	Q.931 Diagnostic	X.25 Cause	Code	X.25 Diagnostic	Code
1	Unassigned or unallocated number	1	Condition: unknown, transient, permanent	Not obtainable	13	Invalid called address	67
2	No route to destination	3	Condition: unknown, transient, permanent	Not obtainable	13	Invalid called address	67
3	Channel unacceptable	6	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
4	Normal clearing	16	Condition: unknown, transient, permanent	DTE originated	0	No additional information	0
5	User busy	17	(None)	Number busy	1	No logical channel available	71
6	No user responding	18	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
7	User alerting, no answer	19	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
8	Call rejected	21	Condition: unknown, transient, permanent + user applied diagnostics	DTE originated	0	No additional information	0
9	Number changed	22	New destination address	Not obtainable	13	Invalid called address	67
10	Destination out of service	27	(None)	Out of order	9	No additional information	0
11	Invalid number format (Incomplete number)	28	(None)	Local procedure error	19	Invalid called address	67
12	Normal, unspecified	31	(None)	DTE originated	0	No additional information	0
13	No circuit/channel available	34	(None)	Number busy	1	No logical channel available	71
14	Network out of order	38	(None)	Out of order	9	No additional information	0
15	Temporary failure	41	Network identity	Out of order	9	No additional information	0
16	Switching equipment congestion	42	Network identity	Network congestion	5	No additional information	0

TABLE 6-5/X.31 *(continued)*

Mapping of Q.931 cause fields to X.25 cause field

Item	Q.931 cause	Code	Q.931 Diagnostic	X.25 Cause	Code	X.25 Diagnostic	Code
17	Requested circuit or channel not available	44	(None)	Number busy	1	No logical channel available	71
18	Resources unavailable unspecified	47	(None)	Network congestion	5	No additional information	0
19	Quality of service unavailable	49	Condition: unknown, transient, permanent	Network congestion	5	No additional information	0
20	Bearer capability not authorized	57	Bearer capability information element identifier	Incompatible destination	33	No additional information	0
21	Bearer capability not presently available	58	Bearer capability information element identifier	Remote procedure error	17	Call setup, call clearing or registration problem	64
22	Service or option not available, unspecified	63	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
23	Bearer service not implemented	65	Attribute numbers	Incompatible destination	33	No additional information	0
24	Channel type not implemented	66	Channel type	Remote procedure error	17	Call setup, call clearing or registration problem	64
25	Service or option not implemented, unspecified	79	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
26	Invalid call reference value	81	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
27	Identified channel does not exist	82	Channel identity	Remote procedure error	17	Call setup, call clearing or registration problem	64
28	Incompatible destination	88	Incompatible parameter	Incompatible destination	33	No additional information	0
29	Invalid message	95	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64

TABLE 6-5/X.31 *(concluded)*

Mapping of Q.931 cause fields to X.25 cause field

Item	Q.931 cause	Code	Q.931 Diagnostic	X.25 Cause	Code	X.25 Diagnostic	Code
30	Mandatory information element is missing	96	Information element	Remote identifier(s) procedure error	17	Call setup, call clearing or registration problem	64
31	Message type non-existent or not implemented	97	Message type	Remote procedure error	17	Call setup, call clearing or registration problem	64
32	Message not compatible with call state or message type non-existent or not implemented	98	Message type	Remote procedure error	17	Call setup, call clearing or registration problem	64
33	Information element non-existent or not implemented	99	Information element identifier(s)	Remote procedure error	17	Call setup, call clearing or registration problem	64
34	Invalid information element contents	100	Information element identifier(s)	Remote procedure error	17	Call setup, call clearing or registration problem	64
35	Message not compatible with call state	101	Message type	Remote procedure error	17	Call setup, call clearing or registration problem	64
36	Recovery on timer expiry	102	Timer number	Remote procedure error	17	Call setup, call clearing or registration problem	64
37	Protocol error unspecified	111	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
38	Interworking unspecified	127	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64

NOTES

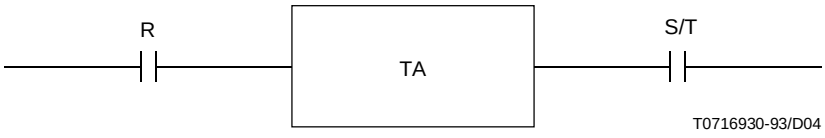
1 When clearing occurs during the X.25 data transfer phase, the procedure described in 6.4.1 should be used.

2 When a Q.931 RESTART message is received during the X.25 data transfer phase, switched virtual circuits shall be cleared with a clear indication packet containing cause # 9, *Out of order*, with diagnostic # 0, *no additional information*. Permanent virtual circuits shall have an X.25, *reset* packet sent with the same cause and diagnostic.

TABLE 6-6/X.31

Mapping of X.25 cause to Q.931 cause for premature clearing of the incoming call

	X.25 cause in clear indication packet				Q.931 Error condition		
Item	X.25/X.96 cause	Code	Diagnostic	Code	Q.931 cause	Code	Diagnostic
1	DTE originated	0	No additional information	0	Normal clearing	16	(None)
		1XX	DTE specified	XX			
2	Network congestion	5	No additional information	0	Switching equipment congestion	42	(None)
3	Out of order	9	No additional information	0	Destination out of order	27	(None)
4	Remote procedure error	17	(Any allowed)		Protocol error unspecified	111	(None)
NOTE – Instead of providing the above mapping of X.25 to Q.931, the PH, as a network option, may code the Q.931 Cause information element to indicate "CCITT Coding Standard" in octet 3, "X.25" in octet 3a, and code octets 4 and 5 according to Recommendation X.25, copying the cause from the X.25 *clear indication* packet rather than mapping it to a Q.931 cause.							



NOTE – A TA function supports only one X.25 DTE (simple or complex, e.g. LAN-gateway) at reference point R but more than one TA function may simultaneously share the D-channel, each TA using a separate LAPD link.

FIGURE 7-1/X.31

Reference configuration of TA

In the following, these main functionalities are described depending on the access types (B-channel and/or D-channel access), highlighting the differences between the two services defined in this Recommendation (Case A and Case B).

The procedures at the S/T reference point are described in 6.

7.2 Physical interfaces

The physical interfaces supported at the R reference point are those defined in 1/X.25 and in Recommendation X.32.

7.3 Access through the B-channel

7.3.1 General

This part defines the functionalities to be supported by the TA when the access through the-B-channel is used. Both service Cases A and B are covered and differences, if any, are shown in the appropriate subclauses.

7.3.2 Rate adaption

Rate adaption can be performed in two ways:

1) Packet mode of operation (Case B) by using HDLC interframe flag stuffing

   In this case, packet mode terminals operating at data signalling rates lower than 64 Kbits at the R reference point can no longer be distinguished by the network from packet mode terminals operating at a data rate of 64 kbit/s at the R interface.

   Therefore, the D-channel signalling procedures will indicate the data signalling rate of 64 kbit/s rather than the user data signalling rate at the R reference point. In addition, a throughput class may be indicated in the D-channel incoming call signalling procedures.

   It should be noted that the packet handling in the ISDN will be optimized for DTEs generating HDLC structured traffic at 64 kbit/s. In such an ISDN, flag stuffing is the preferred method for rate adaption.

   In order to avoid unnecessary retransmission on the B-channel, the TA implementation could have a buffer capacity which is related to the layer 2 window size and maximum frame length or may have flow control at layer 2.

2) Circuit mode of operation (Case A) by using the method indicated in Recommendation X.30/I.461

   In this case, the D-channel signalling procedures shall indicate the data signalling rate being used by the DTE connected to the R reference point (this will be lower than 64 kbit/s).

   As an alternative to HDLC interframe flag stuffing, this bit rate adaption method may be supported by some network in case of access to PSPDN services.

   NOTE - The use of V-Series specification is for further study.

7.3.3 Signalling

This part defines the functionalities to be supported by the TA to establish, maintain and release a B-channel connection to the PH/AU. These functionalities require a different degree of capabilities by the TA on the basis of the different implementation of X.25 procedures in the DTE. Two cases can be identified, namely:

Case 1: TA acts only on level I;

Case 2: TA acts also on level 2 and/or 3.

The first case applies to X.25 DTEs which can disconnect at the physical level, when no VCs are in progress.

For X.25 DTEs which are not able to disconnect at the physical level or even require an active link, the consequence of the first case may be the automatic allocation of the B-channel immediately after power on. To avoid this situation with a permanent allocated B-channel, an alternative configuration is presented in Appendix I.

This subclause refers to signalling mapping of the first case.

7.3.3.1 Outgoing call

To provide a physical connection by means of a B-channel to the PH or PSPDN AU, the TA shall provide

- a method to indicate that the TA should start the B-channel establishment procedure at the S/T reference point. The options available are described in 7.3.3.1.1.
- a method to transfer ISDN address information to the TA which is needed by the B-channel establishment procedure. The options available are described in 7.3.3.1.2.

7.3.3.1.1 Conditions for initiating B-channel establishment

Two situations can be identified to categorize the conditions which may cause the TA to attempt to establish a B-channel connection.

a) *(semi-)permanent B-channel*

In this case, the B-channel is always available. No TA functionality is required to initiate the establishment of the B-channel connection.

b) *B-channel establishment is initiated by actions at the R reference point (DTE/TA interface)*

Two conditions are possible (see Table 7-1).

TABLE 7-1/X.31

DTE/TA Layer 1 specifications and procedures to initiate B-channel establishment

Condition	DTE/TA layer 1 specification		Events at the R reference point	Procedures according to:
Hot-line access	X.25	X.21 leased circuit	DTE sets C = ON	1.1/X.25
		X.21 *bis*	DTE sets circuit 108 = ON	1.2/X.25
		V-Series interfaces	DTE sets circuit 108 = ON	1.3/X.25
	X.21 circuit-switched		DTE signals direct call	4.4/X.21
	X.21 *bis* direct call		DTE signals direct call	2.3.1/X.21 *bis*
	V.25 *bis* direct call		DTE uses direct call mode (Note 1)	5/V.25 *bis*
Full circuit switched access	X.21 addressed call		DTE enters call control phase	4/X.21
	Rec. X.21 *bis*, addressed call		DTE performs automatic address call	2.3.2 iii)/X.21 *bis*
	V.25 *bis* addressed call		DTE uses address call mode	4/V.25 *bis*
NOTE – The difference between the V. 25 *bis* direct call mode and operation according to 1.3 (V-Series interfaces) is for further study.				

b1) Hot-line access at the R reference point

In case of hot-line access at the R reference point the detection of the following appropriate interface conditions shall cause the TA to establish the B-channel with the PH/PSPDN.

i) For X.25 level 1 interfaces – a transition from OFF to ON on the control lead (in case of X.21 leased circuit procedures) or circuit 108 (in case of X.21 *bis* or V-Series interface procedures).

ii) For X.21 interfaces – direct call signal (C = ON).

The DTE will wait for I = ON before starting transmission.

iii) For the X.21 *bis* interface – direct call signal (108 = ON).

The DTE will wait for 107 = ON before starting transmission

iv) For the V.25 *bis* interface – direct call signal (108 = ON).

The DTE will wait for 107 = ON before starting transmission.

b2) Full circuit-switched selection access

Full circuit-switched selection procedure (X.21, X.21 *bis* or V.25 *bis*) may be used at the DTE/TA interface to request the establishment of the B-channel connection to a PSPDN or PH. The TA will establish the B-channel connection to a PSPDN or PH. The TA will establish the B-channel in accordance with the procedures described in 6. The ISDN address provided may be used to identify the PSPDN port and full X.25 procedures must be used following the establishment of the B-channel connection to identify the called packet mode DTE.

In case of full circuit-switched selection, the following operating modes of Recommendation X.21, X.21 *bis* and V.25 *bis* at the DTE/TA interface shall cause the TA to establish the B-channel with the PH/PSPDN.

i) For X.21 circuit-switched interfaces – X.21 call control phase.

ii) For X.21 *bis* circuit-switched interfaces – use of X.21 *bis* automatic address call facility.

iii) For V.25 *bis* circuit-switched interfaces – V.25 *bis* addressed call mode.

NOTE – The user may cause the TA to attempt to establish a B-channel connection by manual actions (e.g. by pressing a button) at the human/machine interface of the TA. Subsequently the TA may emulate the incoming call towards the DTE.

7.3.3.1.2 Options for transferring the ISDN address of the PSPDN port to the TA

Four options exist to handle address information of the PSPDN port at the TA:

a) (Semi-) permanent B-channel at the S/T reference point

In this case the TA has no need for address information, i.e. no functionality is required in the TA to obtain an address.

b) The address is conveyed across the R reference point

In this case the circuit-switched procedures described in 7.3.3.1.1 b2) are required.

c) The address is conveyed across the human/machine interface of the TA

Manual procedures are used (e.g. by means of a keypad) at the human/machine interface of the TA. The address may be input each time the B-channel is requested. Alternatively the address may be stored at the TA (e.g. in the case of hot line operation at the R reference point).

d) The address is downloaded by the network via the S/T reference point

The need for this option is for further study.

NOTE – The address information may be for example a full ISDN address and abbreviated ISDN address, which is used by hot-line access procedures at the S/T reference point, or an abbreviated address which is interpreted by the TA and expanded to an (abbreviated) ISDN address using pre-recorded information in the TA.

7.3.3.1.3 Mapping of procedures

The list of supported combinations and the appropriate procedures are given in Table 7.2/X.31.

The list of supported combinations and the appropriate procedures are given in Table 7-2.

7.3.3.1.4 Mapping of the Q.931 messages

The procedures between the TA and the network are the same as described in 6. The choice of the requested service will be made by the appropriate coding of the bearer capability.

In Case A the ISDN address of the PSPDN port will be introduced as the destination in the Q.931 message while in Case B no address is contained.

TABLE 7-2/X.31

TA functionality to control B-channel establishment

	TA functions		Description of procedures
	Conditions for initiation of B-channel establishment (7.3.3.1.1)	Transfer of address information to the TA (7.3.3.1.2)	
1	Condition a	Option a	(Semi-) permanent B-channel. No signalling functions for layer 1 are needed in the TA.
2	Condition b1 i	Option c	The DTE sets C = ON or circuit 108 = ON. When C (or circuit 108) becomes ON, and the manual selection has been made at the TA, the TA then initiates, using the D-channel procedures, the establishment of an ISDN B-channel to provide a connection to the PSPDN. When the B-channel is completely established at the S/T reference point, the TA sets I = ON (or circuit 107 = ON).
3	Any of conditions b1 ii, iii, iv ..... See Note in Section 7.3.3. 1. 1	Option c ..... Option c	When the manual selection has been made at the TA, the TA may emulate an incoming call at the R reference point, If the DTE accepts this incoming call, the TA places the R reference point in the DCE waiting state at layer 1 and then initiates, using the D-channel procedures, the establishment of an ISDN B-channel to provide a connection to the PSPDN. When the B-channel is completely established at the S/T reference point, the TA signals ready for data at the R reference point.
4	Any of condition b2	Option b	When the DTE has requested the layer 1 connection and provided ISDN address information to the TA, the TA initiates, using the D-channel procedures, the establishment of an ISDN B-channel. When the B-channel is completely established at the S/T reference point the TA signals ready for data, using the appropriate procedure at the R reference point.
5	Condition b1	Option a	In this case hot-line access is applied at the R reference point as well as the S/T reference point. No ISDN address information is therefore required by the TA. When the DTE presents the call request, the TA attempts to establish a B-channel. When the B-channel is completely set-up, the TA signals ready for data at the R reference point.

7.3.3.1.5 X.25 procedures

In the data transfer phase, the TA may be transparent to layer 2 and layer 3 of the X.25 procedures. However, some realizations of X.25 terminals may require full or partial termination of layer 2 within the TA to accommodate existing LAPB establishment procedures (see Appendices I and IV).

7.3.3.2 Incoming call

7.3.3.2.1 Q.931 call offering

The X.25 incoming call, in both Cases A and B, is first offered using Q.931 procedures for setting up the B-channel connection.

7.3.3.2.2 Actions at the R reference point

The TA shall not accept an X.25 incoming call from the network unless the R reference point is in one of the following states:

- the ready state for an R reference point conforming to X.21 circuit-switched procedures;
- the ready or send data state for an R reference point conforming to X.21 leased circuit procedures;
- circuits 125 and 108 ON with 107 OFF for an R reference point conforming to X.21 *bis* procedures.

If the R reference point is in, or can be placed in, the appropriate state defined above, the TA shall respond to the SETUP message (when compatibility checking has been successful) by returning a CONNECT message in accordance with the procedures of 6 and shall then wait for either a CONNECT ACKNOWLEDGE or RELEASE signalling message from the network. (The TA may also reject the SETUP message by responding with a RELEASE COMPLETE message.)

NOTE – Recommendation Q.931 does not oblige the TA to return an ALERTING message prior to the return of a CONNECT.

If the R reference point is not and can not be placed in the appropriate states defined above, then the TA shall respond to the SETUP message in accordance with the negative response to the incoming call procedures defined in 6.

The receipt of a CONNECT ACKNOWLEDGE message causes the TA to initiate the appropriate procedures described in Recommendation X.30/I.461 leading to the placing of the R reference point into the appropriate condition for data transfer, and to begin transmission of information in the B-channel.

NOTE – The DTE/TA interface shall not be placed in the data transfer state before the B-channel is completely set up at the S/T reference point (see 7.3.4).

7.3.3.2.3 X.25 Procedures

In the data transfer phase, the TA may be transparent to layer 2 and layer 3 of the X.25 procedures. However, some realizations of X.25 terminals may require full or partial termination of layer 2 within the TA to accommodate existing LAPB establishment procedures (see Appendix 1).

7.3.3.3 Call clearing

To initiate the clearing of the B-channel it is necessary to detect the clearing of the last virtual call on the B-channel. Three parties can detect the clearing of the B-channel:

1) the DTE; initiating clearing via the R reference point,
2) the network (PH or AU); initiating clearing via the S/T reference point,
3) the user; initiating clearing manually via the human/machine interface.

Before clearing of the B-channel is initiated, the layer 2 connection between the network and the DTE should be cleared.

7.3.3.3.1 Initiation of call clearing by the DTE

The conditions of the R reference point which cause the TA to attempt to disconnect the B-channel connection are:

- for X.21 circuit-switched interface – DTE clear request signal;
- for X.21 leased circuit interface – a transition from ON to OFF on the control lead;
- for X.21 *bis* interface – DTE clear request signal (circuit 108 from ON to OFF).

When one of this conditions occurs, the TA will disconnect the internal rate adapting connection between the R and the S/T reference point (see 7.3.2) and will try to disconnect the B-channel applying the procedures of 6.4.

7.3.3.3.2 Initiation of call clearing by the network

For the clearing of the B-channel the network applies the procedures of 6.4. The receipt of a DISCONNECT or RELEASE message shall cause the TA to disconnect the internal rate adapting connection between the R and the S/T reference point and to take on the R reference point interface the appropriate action as described below:

- for X.21 circuit-switched interface – signal a DCE clear indication;
- for X.21 leased circuit interface – signal a DCE ready condition;
- for X.21 *bis* interface – set circuit 107 OFF.

For further details, see Recommendation X.30.

NOTE – RELEASE may be a common response to a CONNECT message in the case where more than one packet mode terminal is present at the customer premises and the X.25 incoming call has been globally offered using the point to multipoint procedures of Recommendation Q.921.

7.3.3.3.3 Initiation of call clearing by the user

After the manual notification of the clearing of the last virtual call by the user, the TA disconnects the internal connection between the R and S/T reference point and applies the procedures of 6.4 for the clearing of the B-channel. On the R reference point it takes the appropriate action as described below:

- for X.21 circuit-switched interface – signal a DCE clear indication,
- for X.21 leased circuit interface – signal a DCE ready condition,
- for X.21 *bis* interface – set circuit 107 OFF.

See Recommendation X.30 for further details.

7.3.4 Synchronization

The TA should effect synchronization between the D (Q.931 activities) and the B (X.25 activities) channel activities.

Synchronization between TA and PH/AU is provided by the exchange of synchronization pattern. Continuous flag transmission shall be used when flag stuffing rate adaption is used. For class 30, synchronization will be between the DTE and the PH/AU. The X.30 scheme will be used when the X.30 rate adaption is used.

7.4 Access through the D-channel

7.4.1 General

This part defines the functionalities to be supported by a TA when access through a D-channel is used. This applies only to Case B (access to the ISDN virtual circuit service).

7.4.2 LAPB-LAPD mapping

The rate adaption is inherent to the contention mechanism for accessing the D-channel. In particular, the contiguous flag transmission perceived at the R reference point shall not be repeated at the S/T reference point.

7.4.2.1 Mapping by full link layer termination

Figure 7.2 shows the mapping architecture between the LAPB link at the R and the LAPD logical link at the S/T reference point, based on full termination of both link layer protocols in the TA. This figure is intended to describe the functionality to be provided by the TA. However, this figure should not constrain any specific implementation.

The supervisory and unnumbered frames of the LAPB and LAPD procedures have local significance (i.e. only relevant for that link) and need therefore not to be mapped to the other link. However, it is possible that the receipt of a supervisory or unnumbered frame should result in the transmission of such a frame on the other link; for instance a SABM(E) frame (when both links are in the disconnected state) or an RR frame may result in the transmission of an equivalent frame on the other link.

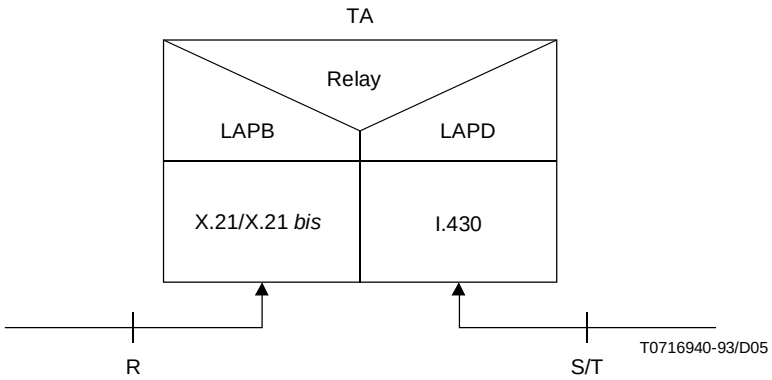


FIGURE 7-2/X.31

Architecture of the mapping function

The information transfer frames have to be mapped if both links are in the transfer phase. The following mapping functions for these frames can be distinguished:

– address field mapping;

– control field mapping;

– frame check sequence recalculation.

These functions are discussed in following subclauses.

7.4.2.1.1 Information frame address field mapping

The LAPB address length is 1 octet.

The LAPD address length is 2 octets.

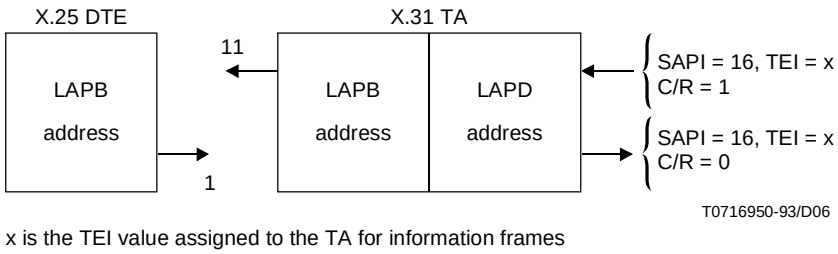


FIGURE 7-3/X.31

Mapping of LAPB/LAPD addresses by a TA for information frames

7.4.2.1.2 Information frame control field mapping

LAPB sequence numbering of the I-frames is in general modulo 8, though it might be modulo 128.

LAPD sequence numbering of the I-frame is modulo 128.

The sequence numbers N(S) and N(R) on the LAPB and LAPD link are independent.

In the case where the LAPD window size of 8 would fulfill (e.g. the throughput requirements), the maximum number of I-frames to be buffered in the TA's relay function is 7 in each direction.

The use of the P/F-bit in the LAPB link is independent of the use of that bit in the LAPD link.

7.4.2.1.3 Information frame check sequence recalculation

The FCS values on the LAPB and LAPD link are independent. For every frame the FCS values need to be calculated.

7.4.2.2 Mapping by minimum link layer termination

In addition a simpler implementation of the LAPB-LAPD mapping is possible, without implementing the flow control and error recovery procedures. Such a TA has as a minimum to implement the following mapping functions:

- frame type recognition;
- mapping of address field;
- mapping of control field;
- administration of the state variables (V(S) and V(R) at both interfaces);
- FCS handling.

7.4.3 Signalling

This part defines the functionalities to be supported by the TA to establish, maintain and release a LAPD, SAPI = 16, logical link to the PH at the S/T reference point and a LAPB link at the R reference point. These functionalities require a different degree of capabilities by the TA on the bases of the different implementation of X.25 procedures in the DTE.

Several types may be identified, depending on the criteria at the R reference point to initiate call set-up:

Type 1 Establishment of a logical, SAPI = 16, link in the D-channel upon recognition of the receipt of a SABM frame.

Type 2 Idem on receipt of an I frame.

Type 3 Idem on receipt of a call request packet.

NOTE – Alternatively, initiation of call set-up can be carried out by manual means, for example a push button on the TA.

Type 1 is the most simple one because a minimum mapping between LAPB and LAPD is implemented in the TA. This type will be described in 7.4.3.1, 7.4.3.2 and 7.4.3.3. Types 2 and 3 which require full protocol termination in the TA (as described in 7.4.2) are more complicated, but application of these types may be necessary depending on the needs of existing X.25 DTES. More details about these types are given in Appendix IV.

7.4.3.1 X.25 outgoing call

At the outgoing call the TA initiates the establishment of a D-channel SAPI = 16 link to the PH.

The several conditions which force the TA to initiate this establishment are described in Section 7.4.3.1.1. The establishment of the D-channel link is in accordance with the procedures described in Section 6.1.2.2.

7.4.3.1.1 Conditions for the establishment of a logical link between the DTE and the PH

Two situations can be identified to categorize the condition which may cause the TA to attempt to establish a D-channel SAPI = 16 logical link:

a) *(semi-)permanent logical link*

In this case the logical link is always available. No TA functionality is required to initiate the establishment of a logical link.

b) *Logical link establishment is initiated by actions at the R reference point*

The layer 1 interface at the R reference point is in accordance with X.21, X.21*bis* or V.25*bis* interface procedures. Subsequently the DTE will establish the LAPB link at the R reference point and as a consequence the TA will activate the LAPD link (SAPI = 16) at the S/T reference point.

NOTE – In principle it is also possible to activate the link between DTE and PH as a result of a manual action at the TA.

7.4.3.1.2 Mapping of link procedures

The mapping between the LAPD logical link at the S reference point and the LAPB link at the R reference point is described in 7.4.2.

7.4.3.1.3 X.25 Procedures

After the establishment of a LAPD link at the S/T, and a LAPB link at the R reference point and the concatenation of both links via a mapping function in the TA, X.25 layer 3 procedures are possible between the DTE and the PH. The TA is transparent for these X.25 layer 3 procedures.

7.4.3.2 X.25 Incoming call

7.4.3.2.1 Q.931 call offering

When notification of the incoming call applies (see 3.2.3), the incoming call is first offered using the Q.931 procedures described in 6.2.2.3.1 (channel selection through call offering).

The TA accepts the incoming call when the R reference point is or can be placed in one of the following states:

– the ready or send data state for an R reference point conforming to X.21 procedures

– circuits 125 and 108 ON with 107 OFF for an R reference point conforming to X.21 *bis* and V.25 *bis* procedures

The TA shall respond to the offered call according to the same 6.2.2.3.1.

After a successful incoming call procedure, the PH will initiate the establishment of a LAPD SAPI = 16 link between the PH and the TA. The LAPB link at the R reference point will be established at the same time via the mapping procedures described in 7.4.2.

The link layers are now in the data transfer phase.

7.4.3.2.2 X.25 Procedures

After the establishment of a LAPD link at the S/T, and a LAPB link at the R reference point and the concatenation of both links via a mapping function in the TA, X.25 layer 3 procedures are possible between the DTE and the PH. The TA is transparent for these X.25 layer 3 procedures.

7.4.3.3 Data link disconnection

To initiate the clearing of a D-channel, SAPI = 16 logical link, it is necessary to detect the clearing of the last virtual call on that logical link. This detection can be done by two parties:

a) the PH; clearing of the LAPD logical link is initiated by the PH;

b) the DTE; clearing is initiated by actions at the R reference point.

NOTE – In principle it is possible to clear the link between the DTE and the PH as a result of a manual action at the TA.

7.4.3.3.1 Disconnection by the PH

The PH clears the LAPD logical link in accordance with the procedures described in 6.4.2. Via the mapping function between that LAPD logical link and a LAPB link at the R reference point, clearing of the format will be followed by clearing of the latter, applying the appropriate LAPD procedures. After having cleared the LAPB link, the TA will disconnect the layer 1 interface at the R reference point by either

- a transition from ON to OFF on the I-lead in case of an X.21 interface; the DTE has to respond with an ON to OFF transition of the C-lead. After that the interface is in the ready state; or
- a transition from ON to OFF on circuit 107 in case of an X.21*bis* or a V.25*bis* interface; the DTE has to respond with an ON to OFF transition on circuit 108.

7.4.3.3.2 Disconnection by the DTE

The DTE indicates to the TA that the logical link between the TA and the PH has to be cleared, by clearing the LAPB link at the R reference point between the DTE and the TA.

The appropriate LAPB procedures apply. Following that DTE action, the TA will clear the logical link between the TA and the PH.

After having completed the disconnection procedure of the LAPB link, the DTE disconnects the layer 1 interface at the R reference point, by either

- a transition from ON to OFF on the C-lead in case of an X.21 interface; the TA has to respond with an ON to OFF transition on the I-lead. After that the interface is in the ready state; or
- A transition from ON to OFF on circuit 108 in case of an X.21 *bis* or a V.25 bis is interface; the TA has to respond with an ON to OFF transition on circuit 107.

7.5 Access through the B and D channels

7.5.1 General

This part defines the functionalities to be supported by a TA when the access through both B and D channels is used. This applies only to Case B (access to the ISDN virtual circuit service). Everything described in 7.3 and 7.4 is applicable except the following.

7.5.2 X.25 outgoing call

When the PH can be accessed by either the B- or the D-channel, the call request will be sent by a Q.931 message with the request for packet mode bearer service.

The TA may express its preference for a particular channel based on preselected criteria such as X.25 packet size (limited in the D-channel to 256 bytes) or throughput requirements (limited to less than 16 kbit/s on the basic access D-channel).

If the “any channel” option is retained by the TA, the network will allocate a B-channel based on X.25 quality of service requirements that are assumed *a priori*.

7.5.3 X.25 Incoming call

The network will issue a call offering on the D-channel according to Q.931 procedures. The TA will proceed according to the procedures defined in previous subclauses (see 6.2).

7.6 Test loops

The maintenance concept of the TA shall comply with the maintenance concept of the ISDN subscriber access and subscriber installation as defined in the I.600-Series Recommendation and in Recommendation I.430 on ISDN subscriber access and installation maintenance. The test loops are specified in these Recommendations. The ISDN communication architecture enables communication of maintenance information over bearer connections between network service access points (NSAPs). Accordingly, bearer service may be used on either a B- or the D-channel to transport the protocol.

Maintenance entities can choose to communicate information about performance management, fault management, configuration and naming management, etc., using an application layer protocol using OSI. The specification of these management capabilities to be supported by TAs is for further study.

7.6.1 Test loops for TA with access through the B-channel

7.6.1.1 Test loop reference configuration

Figure 7-4 shows the location of test loops within the TA.

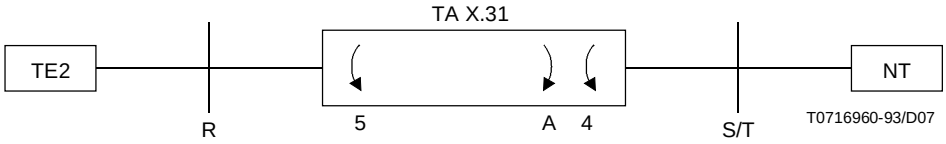


FIGURE 7-4/X.31

Location of test loops

Loop 4 shall be allocated close to the S/T reference point. Loop 5 shall be allocated close to the R reference point. Loop A shall be allocated close to the S/T reference point.

7.6.1.2 Test loop characteristics

The test loop characteristics for loops 4, 5, and A are defined in the I.430- and I.600-Series Recommendations.

7.6.1.3 Loop activation/deactivation mechanism

i) Test loop 4

Test loop 4 being controlled from the network side of the TA is activated either via an application layer protocol on the B/D-channel or via a layer I message on the selected B-channel after a connection has been established from the control point to the TA. Selection of the B-channel to be looped is part of the call set-up procedure. During the loop is established the following states shall apply at the R reference point (X.21):

towards the terminal R = 0/l . . ., I = OFF (DCE controlled not ready) shall apply.

ii) Test loop 5

For activation/deactivation of test loop 5, the definitions as under (i) apply. Since the test loop 5 is close to the R reference point, the loop point is located within the R reference point circuitry and not within the B-channel. Due to the rate adaption mechanism the composition of the bit-stream received at the TA and the composition of the bit-stream which is looped and sent back on the B-channel may not be identical at the S/T reference point. At the loop point, however, the incoming and outgoing (looped) bit-streams are identical.

During the loop is established the states as defined in X.21 for loop 2b shall apply.

NOTE – The possible use of logical loops by means of layer 2 frames in the B-channel requires further study.

iii) Test loop A

Test loop A is activated/deactivated by procedures defined in Recommendations X.21 / X.21 *bis*.

NOTES

1 Since selection of a specific B-channel is not part of X.21/X.21*bis*, the subject of B-channel selection within test loop A, if required, remains for further study.

2 Loop activation/deactivation for the above 3 test loops can optionally as an alternative also be provided manually.

7.6.1.4 Coding of activation/deactivation control messages

– loop 4 control via B- or D-channel application layer protocol: for further study;

– loop 4 control via B-channel layer 1 message: for further study;

– loop 5 control via B- or D-channel application layer protocol: for further study;

– loop 5 control via B-channel layer 1 message: as in X.21/X.21 *bis*;

– loop A: as in X. 21 / X. 21 *bis*.

7.6.2 Test loops for TA with access through the D-channel

For further study.

Appendix I

(to Recommendation X.31)

B-channel TA acting on layer 2 and 3 of X.25

(This appendix does not form an integral part of this Recommendation)

I.1 Introduction

On the basis of the different implementation of X.25 procedures in existing DTEs, two types of terminal adaptors can be identified, namely:

a) TA acts only on layer 1 at the R reference point;

b) TA acts also on layer 2 and 3 at the R reference point.

The first type applies to DTEs which can disconnect at the physical layer of the R reference point, when no virtual calls are in progress.

For X.25 DTEs which are not able to disconnect at the physical layer, the consequence in that case may be the automatic allocation of the B-channel, immediately after power-on. Therefore, for such DTEs, alternatively the second type may be used.

The first case is described in 7.3.

This appendix presents some possible approaches for the functionalities and signalling mapping procedures of terminal adaptors of the second type.

These examples should not constrain implementations and do not cover all possible types.

This type of TA covers Case A access, as well as Case B access.

I.2 Call control

In this appendix the following call phases are specified:

- idle phase;
- establishment phase;
- data transfer phase;
- clearing phase.

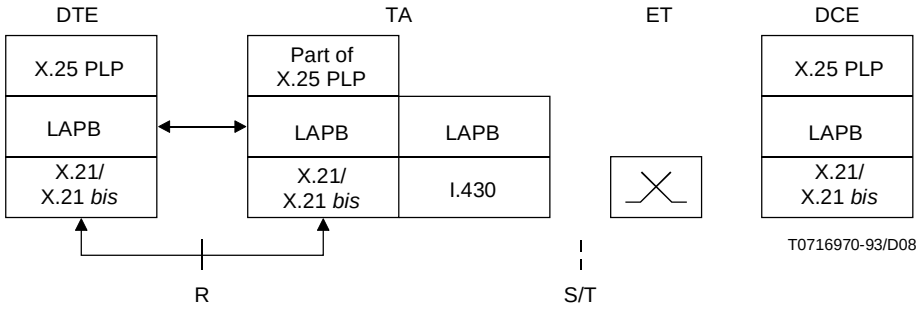
When no virtual calls are in progress, the TA is in the idle phase. Incoming or outgoing calls force transition to the data transfer phase, via the establishment phase. After the clearing of the last virtual call the TA transits from the data transfer phase via the clearing phase to the idle phase.

I.2.1 Idle phase

In the idle phase no virtual calls are in progress.

In the idle phase, the TA acts on the R reference point as X.25 DCE (Figure I.1). All X.25 layer 2 procedures are supported X.25 layer 3 restart procedures must be supported, whereas other X.25 layer 3 procedures may be supported.

When the beginning of a call establishment phase is indicated by manual methods (e.g. a push button on the TA), there is in principle no need for the TA to support layer 3 procedures (see Figure I.2).



NOTE – Events and protocols on the D-channel are not shown in this figure.

FIGURE I.1/X.31

Example configuration in the idle phase, non-transparent at layer 3

I.2.1.1 Transferring to the establishment phase

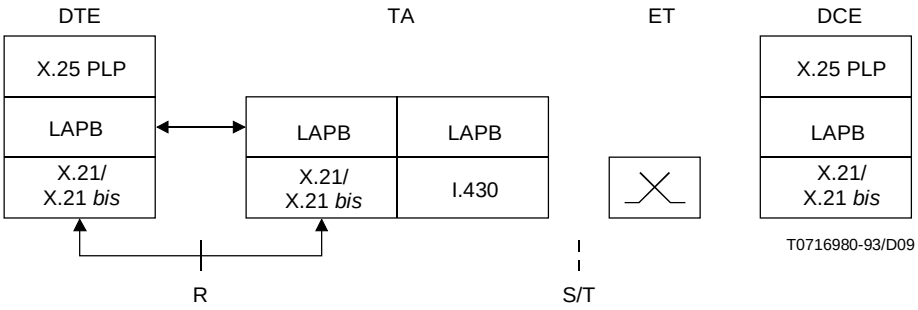
The TA transits to the establishment phase at:

- The detection of an outgoing call

  Outgoing calls are detected by the reception of a *call request* packet.

- The detection of an incoming call

  The TA applies the procedures of 6.2 for the detection and acceptance of incoming calls.



NOTE – Events and protocols on the D-channel are not shown in this figure.

FIGURE I.2/X.31

Example configuration in the idle phase, transparent at layer 3

I.2.2 Establishment phase

For call establishment, the following functions are defined;

1) establishment of a B-channel;

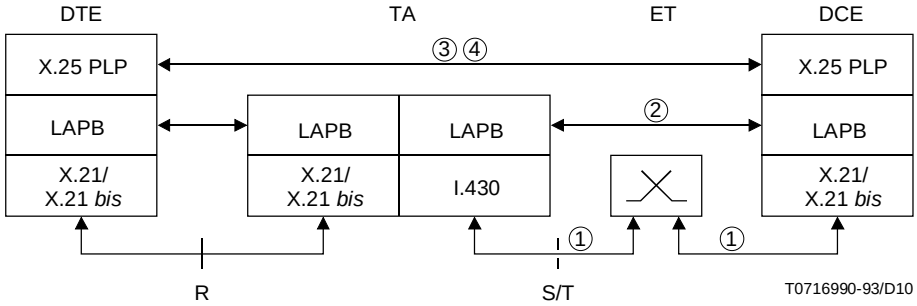
2) establishment of a layer 2 connection between the TA and the X.25 DCE in the PH/AU;

3) synchronization of the layers 3 of the X.25 DTE and the X.25 DCE in the PH/AU;

4) changing to the data transfer phase configuration.

For the establishment phase also a layer 2 implementation is needed on the S/T reference point side of the TA (Figure 1.3). Only layer 3 dedicated procedures apply.

Figure I.4 gives an example of the message sequence for the establishment phase.



NOTES

1 The numbers ①②③ and ④, refer to the same numbers, used in I.2.2.

2 Events and protocols on the D-channel are not shown in this figure.

FIGURE I.3/X.31

Active layers in the establishment phase

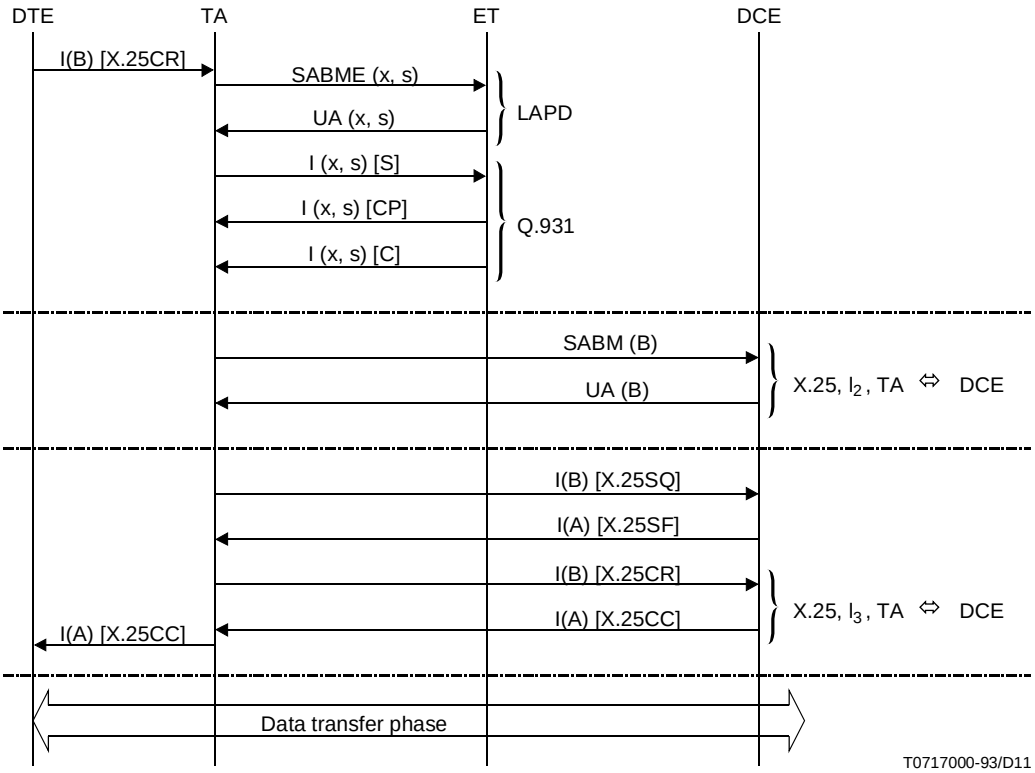


FIGURE I.4/X.31

Example Q.931 and X.25 message sequences for the establishment phase

I.2.2.1 X.25 outgoing call

The *call request* packet received from the X.25 DTE is buffered in the TA. For the allocation of a B-channel the procedures of 6.1 apply. After allocation of a B-channel a link is established between the DCE in the PH/AU and the TA, following the layer 2 procedures of Recommendation X.25. Layer 3 of the DCE in the PH/AU must be initiated by means of a restart procedure. The buffered *call request* packet is sent to the DCE in the PH/AU. At the acknowledgment of the correct reception of the *call connected* packet, the TA changes to the data transfer phase following the procedures of I.2.2.3.

I.2.2.2 X.25 incoming call

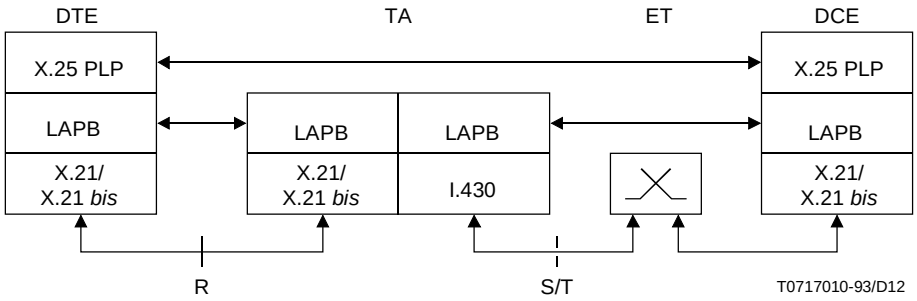
At the reception of an incoming call the procedures of 6.2 apply for the allocation of a B-channel. After allocation of a B-channel a link is established between the DCE in the PH/AU and the TA according to the layer 2 procedures of Recommendation X.25. Layer 3 of the X.25 DTE must be initiated by means of a restart procedure. The TA can change to the data transfer phase following the procedures of I.2.2.3.

I.2.2.3 Changing to the data transfer phase

After sending the *call request* to the network the TA becomes layer 2 relay by terminating the layer 2 protocols on both sides. Detailed procedure specifications of layer 2 relaying are for further study.

I.2.3 Data transfer phase

In the data transfer phase the TA acts as layer 2 relay (Figure I.5).



NOTE – Events and protocols on the D-channel are not shown in this figure.

FIGURE I.5/X.31

Example configuration in the data transfer phase

I.2.3.1 Transferring to the clearing phase

The clearing phase is entered at the detection that no virtual calls are in progress any more.

This detection can be done by;

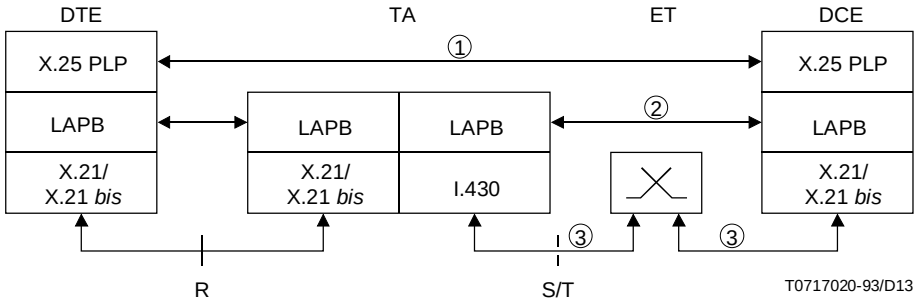
- the PH/AU;
- the user (manually).

I.2.4 Clearing phase

For call clearing the following functions are defined:

1) Clearing of the layer 3 connection;
2) Clearing of the layer 2 connection;
3) Release of the B-channel;
4) Changing to the idle phase.

The active layers in the DTE, the TA and the DCE in the clearing phase are shown in Figure I.6.



NOTES

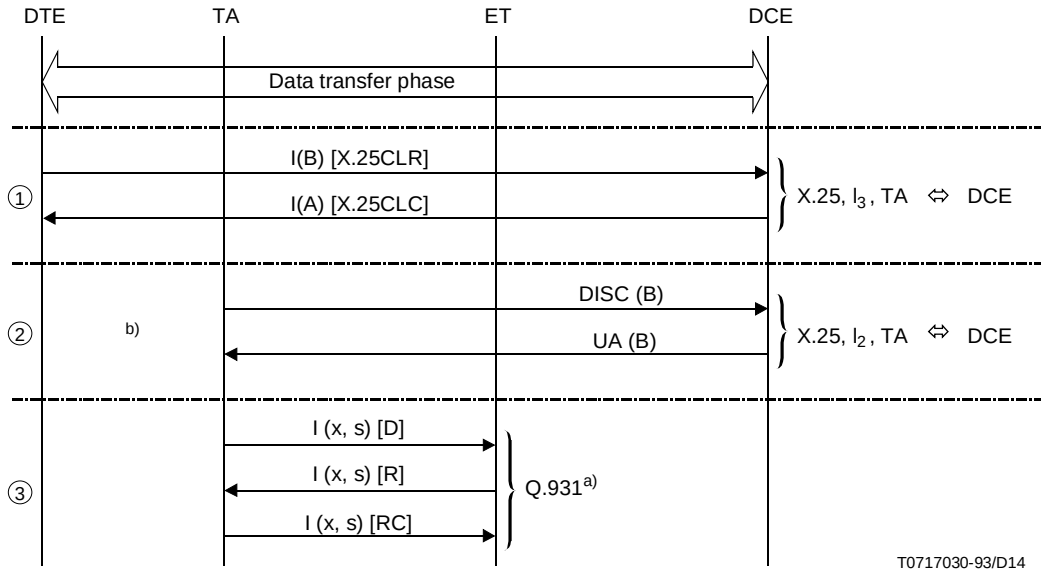
1 The numbers ①② and ③, refer to the same numbers, used in I.2.4.

2 Events and protocols on the D-channel are not shown in this figure.

FIGURE I.6/X.31

Active layers in the clearing phase

Figure I.7 gives an example of the message sequence for the clearing phase.



a) The B-channel is cleared, only if the cleared virtual call was the last one via that B-channel.

b) Layer 2 between DTE and TA is always established.

FIGURE I.7/X.31

Example Q.931 and X.25 message sequence for the clearing phase

1.2.4.1 Detection by the user

After the notification by the user, DISC frame is sent to the PH/AU which is answered with a UA frame. After reception of the UA frame by the TA, the procedures of 6.4 apply. After these procedures the TA enters the idle phase.

I.2.4.2 Detection by the network

The DISC frame sent by the network is answered by the TA with a UA frame. The procedures of 6.4 apply to clear the B-channel. After these procedures the TA enters the idle phase.

Appendix II
(to Recommendation X.31)

Interconnection of packet mode TE2s which use the circuit-mode bearer service of the ISDN

(This appendix does not form an integral part of this Recommendation)

When two packet mode TE2s are interconnected by an ISDN circuit-mode connection they will make use of TAs as shown in Figure II.l.

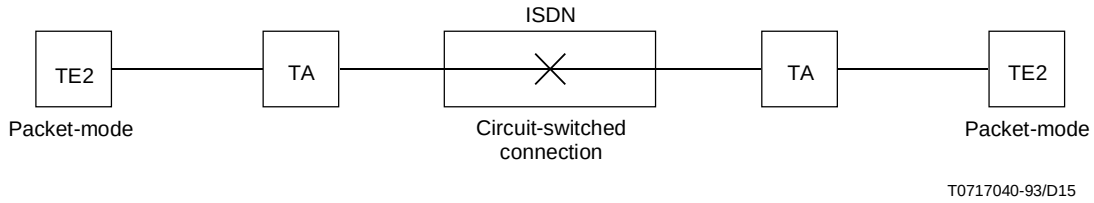


FIGURE II.1/X.31

Use of circuit-switched connection for communications between packet mode TE2s

For such connections the Q.931 end-to-end parameter exchange procedures will be used to exchange the characteristics of the protocols that will be used over the circuit-switched connection by the. DTEs. The TAs may examine the frames and packets of the B-channel in order to perform the necessary functions to support packet mode DTE to DTE communication.

Appendix III
(to Recommendation X.31)

Example message flow diagrams and example conditions for cause mapping

(This appendix does not form an integral part of this Recommendation)

III.1 Example message flow diagrams

Examples of the procedures for the use of the B- and D-channel network connection types and the selection of the appropriate channel types are summarized in Figures III.1 to III.7. These figures are intended to complement the description in the preceding text and do not illustrate all possible situations.

NOTE – Not all frames that may be sent across the TA interface may be represented in the following figures.

III.1.1 Key to the figures

Q.931 messages

[ ]	Layer 3
C	CONNECT
CA	CONNECT ACKNOWLEDGE
CP	CALL PROCEEDING
D	DISCONNECT
R	RELEASE
RC	RELEASE COMPLETE
S	SETUP

X.25 layer 3 messages

Any layer 3 message preceded by X.25 indicates an X.25 layer 3 packet. (e.g. X.25 CR means X.25 *call request*)

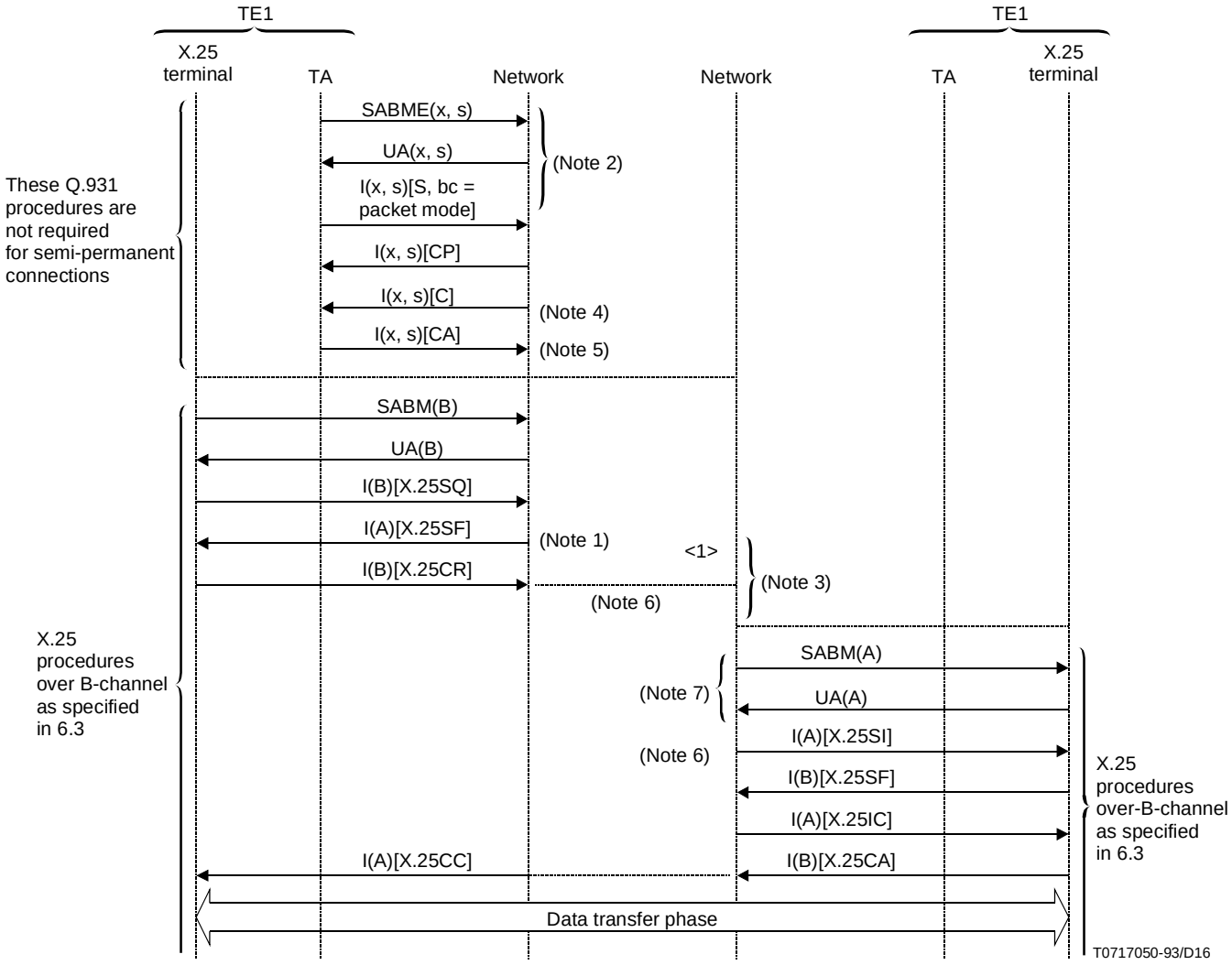
CA	Call accepted
CC	Call connected
CLC	Clear confirmation
CLI	Clear indication
CLR	Clear request
CR	Call request
IC	Incoming call
SQ	Restart request
SF	Restart confirmation
SI	Restart indication

Layer 2 frames

( )	Layer 2
GTE1	Group TE1 (1 27)
A. B	X.26 layer 2 addresses (includes command and response)
SABM	Set asynchronous balance mode
SABME	Set asynchronous balance mode extended
UA	Unnumbered acknowledgement frame
UI	Unnumbered information frame (i.e. using unacknowledged information transfer at layer 2)
I	Information frame
DISC	Disconnect frame

Layer 2 addresses marked (x, p) indicates that the SAPI element of the frame address is coded for packet type (SAPI = 16) information as described in Recommendation Q.921. Layer 2 addresses marked (x, s) refer to signalling type (SAPI = 0) information.

III.1.2 Example message flow diagrams



NOTES

1 When the called side establishes the call using D-channel access, the message sequence will continue as from point < 3 > in Figure III.3.

2 If signalling link is not already established.

3 For packet call offering, the incoming call may be offered to the TA and a B-channel established using the procedure shown in Figures III.5 and III.7.

4 The network starts timer T320, if implemented.

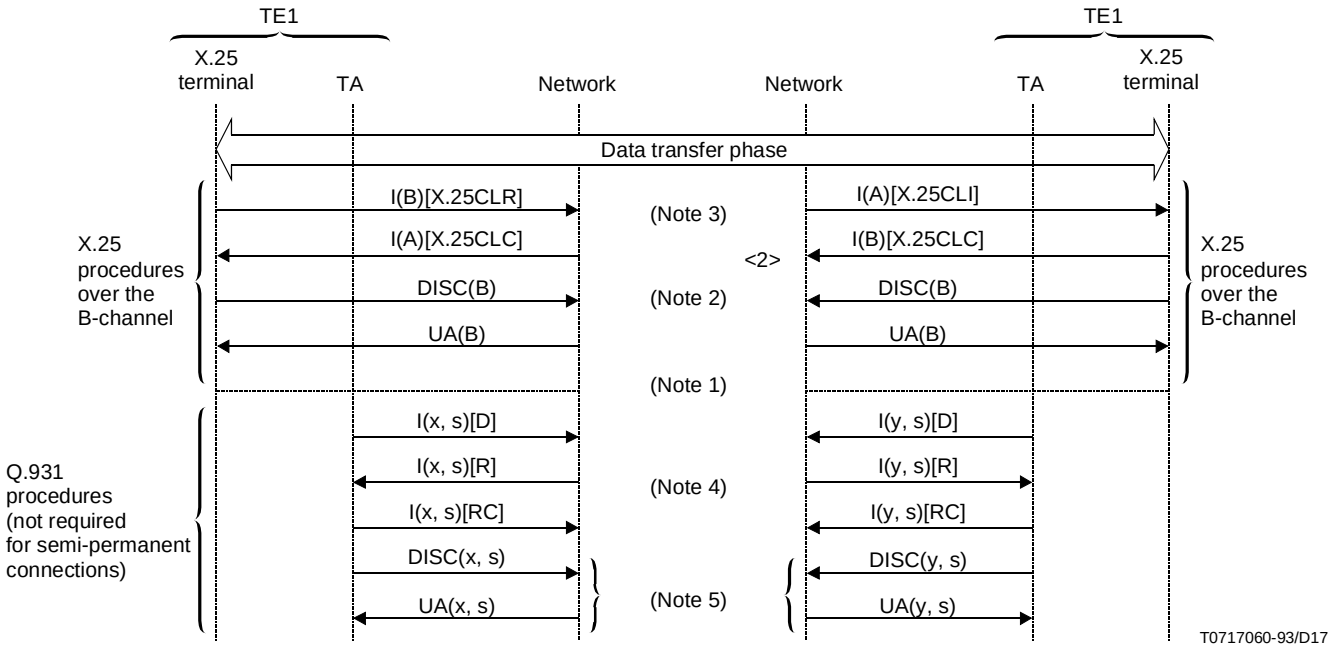
5 This message is optional.

6 The network cancels timer T320, if implemented and running.

7 The network establishes the link layer on the B-channel, if it is not already established as specified in 6.3.

FIGURE III.1/X.31

Example message sequence for the ISDN virtual circuit service B-channel access, first virtual call set-up in this channel



NOTES

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 III.4.

2 Clearing of the B-channel may be initiated by the network upon expiry of timer T320, if implemented. See 6.4.

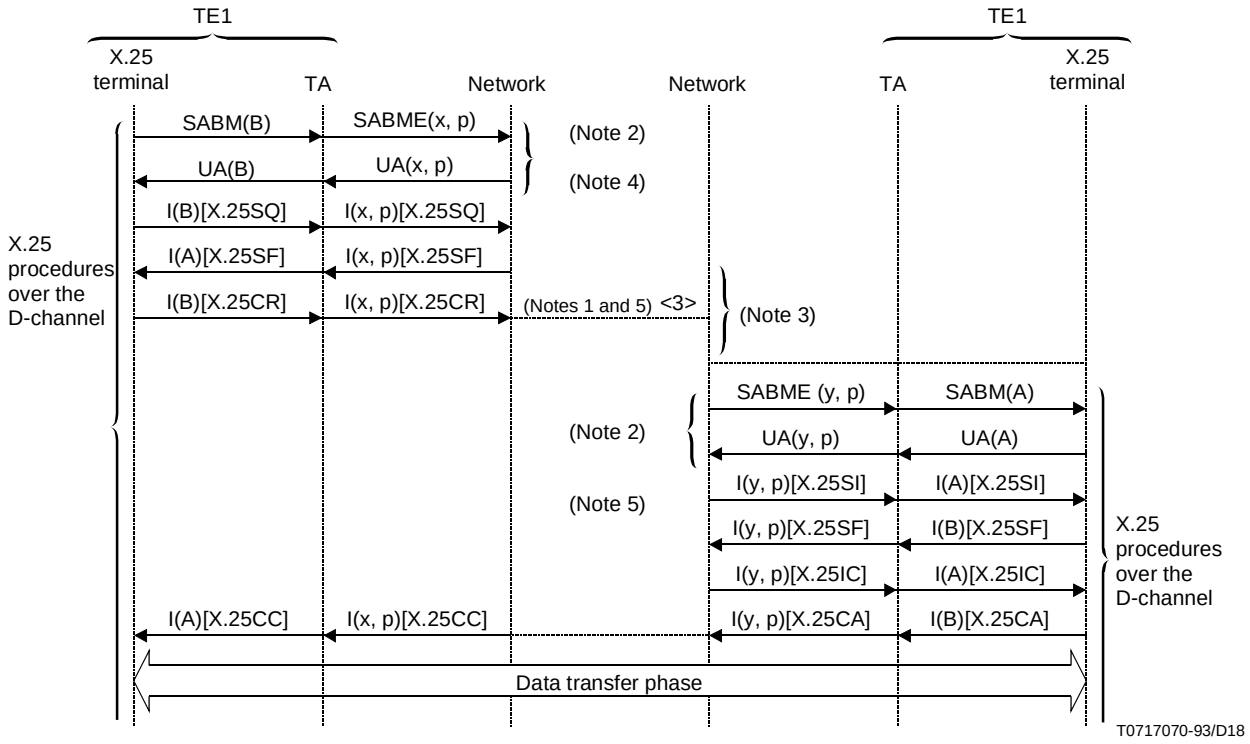
3 The network starts timer T320, if implemented.

4 The network cancels timer T320, if implemented and running.

5 This sequence is only required if the terminal does not wish to continue with further communication.

FIGURE III.2/X.31

Example message sequence for the ISDN virtual circuit service B-channel access, last virtual call cleared in this channel



NOTES

1 When the called side establishes the call using B-channel access, the message sequence will continue as from point < 1 > in Figure III.1.

2 If SAPI = 16 link is not already established.

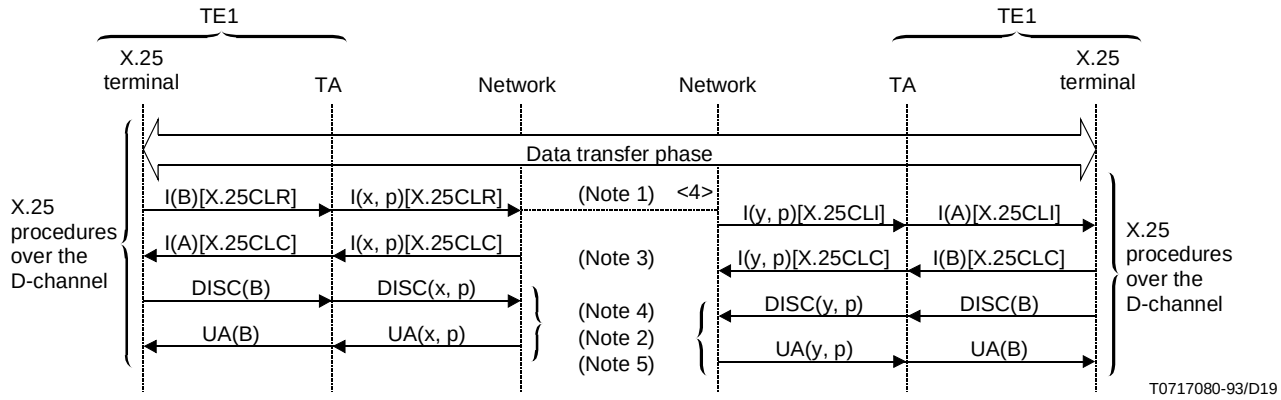
3 The incoming call may be offered to the TA using the procedures shown in Figure III.7.

4 The network starts timer T.320, if implemented.

5 The network cancels timer T320, if implemented and running.

FIGURE III.3/X.31

Example message sequence for the ISDN virtual circuit service D-channel access, first virtual call set-up in this SAPI = 16 link



NOTES

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 III.2.

2 This sequence is only required if the X.25 DTE does not wish to continue with further communications.

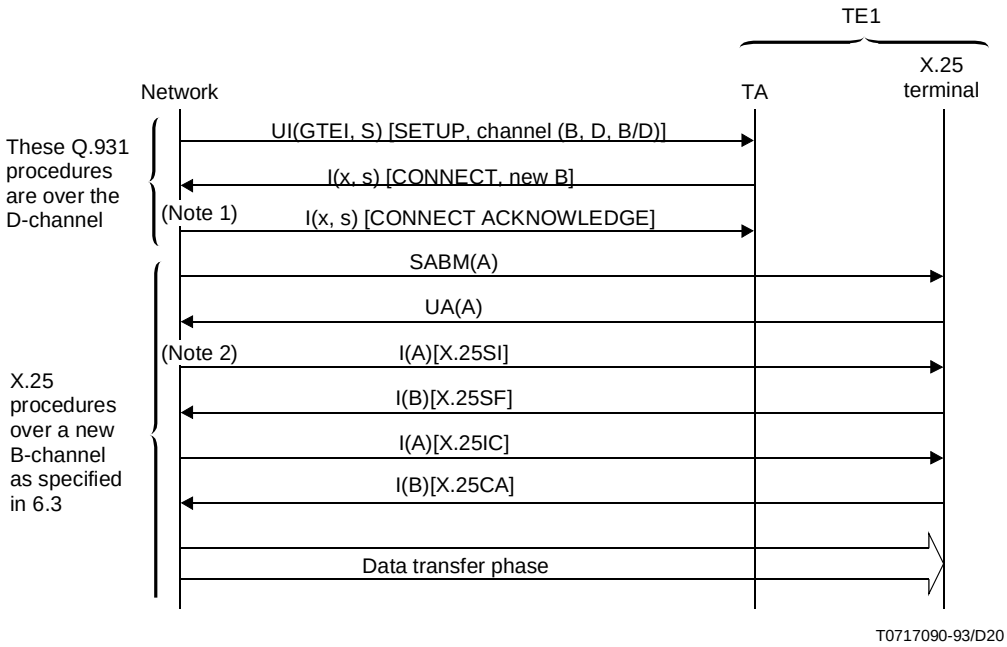
3 The network starts timer T320, if implemented.

4 The network cancels timer T320, if implemented and running.

5 Link layer release may be initiated by the network upon expiry of timer T320, if implemented. See 6.4.

FIGURE III.4/X.31

Example message sequence for the ISDN virtual circuit service D-channel access, last virtual call cleared in this SAPI = 16 link



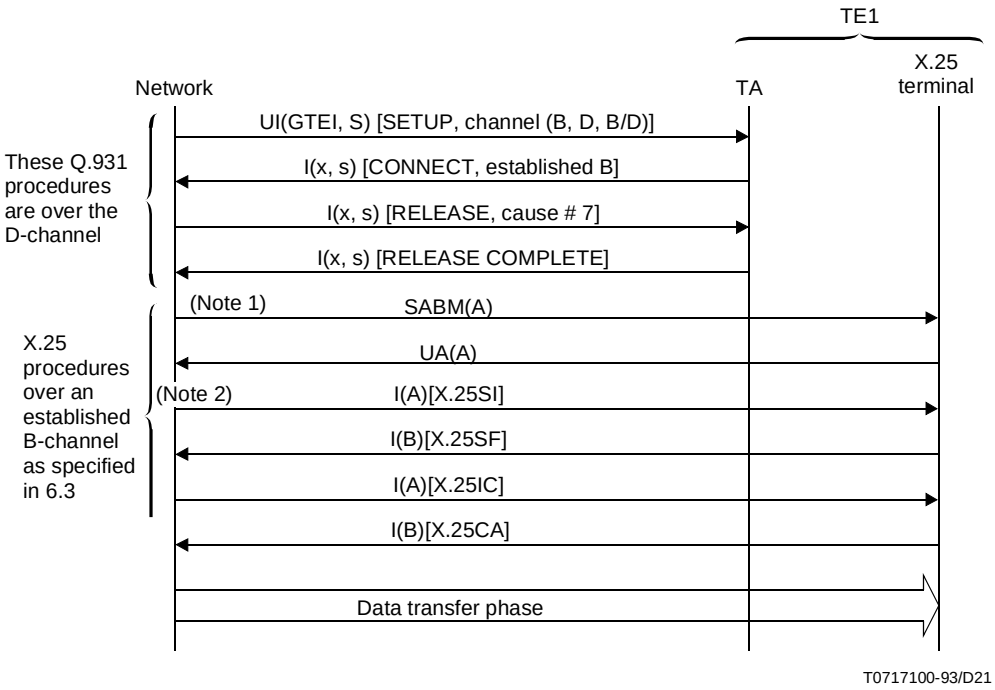
NOTES

1 The network starts timer T320, if implemented.

2 The network cancels timer T320, if implemented and running.

FIGURE III.5/X.31

Example of incoming call offering procedures using signalling on SAPI = 0 link: Terminal accepts call on a new B-channel



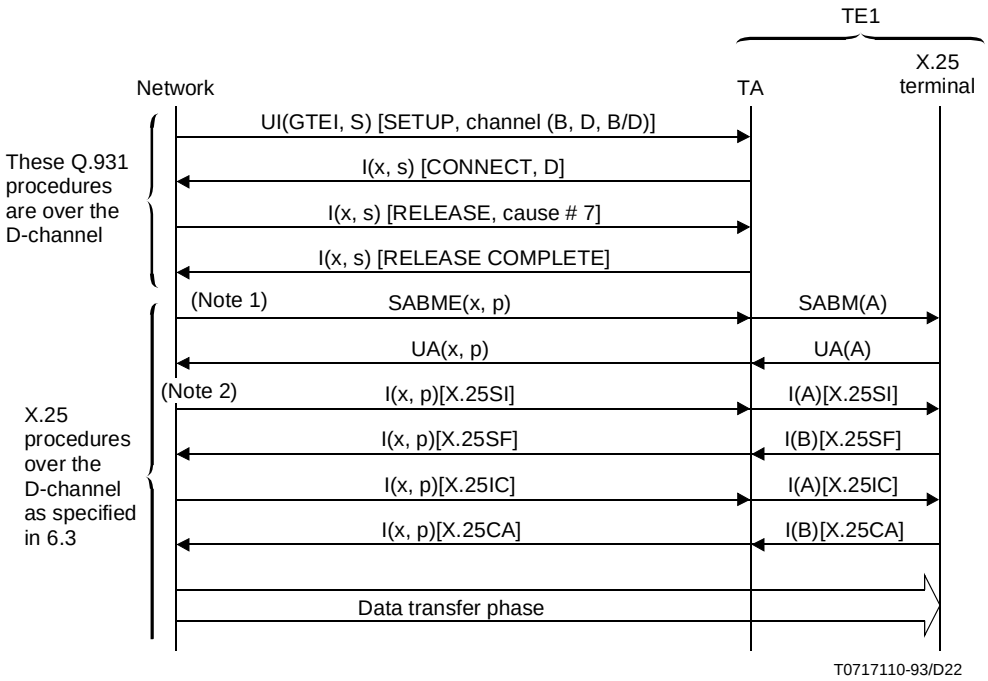
NOTES

1 The network establishes the link layer in the B-channel if it is not already established. See 6.3.

2 The network cancels timer T320, if implemented and running.

FIGURE III.6/X.31

Example of incoming call offering procedures using signalling on SAPI = 0 link: Terminal accepts call on an established B-channel



NOTES

1 The network establishes the link layer in the D-channel if it is not already established. See 6.3. The network starts timer T320, if implemented.

2 The network cancels timer T320, if implemented and running.

FIGURE III.7/X.31

Example of incoming call offering procedures using signalling on SAPI = 0 link: Terminal accepts call on the D-channel

III.2 Example conditions for cause mapping

Figures III.8 through III.16 show example conditions when cause mappings would be utilized between Q.931 and X.25 messages and utilize the specific mappings of Table 6-5 and Table 6-6 as shown below:

Figure	*Reference Table*	*Note*
*****	Q.931 failures during call establishment *****	
III.8		
III.9		
III.10	Table 6-5	
III.11		
III.12		
*****	User side failures during X.25 data transfer phase *****	
III.13	Table 6-5	1
III.14	Table 6-5	2
*****	Network side premature clearing *****	
III.15	Table 6-6	
III.16	Table 6-6	

NOTES

1 This mapping is only needed in the case of the Q.931 message arriving prior to the clearing of the last virtual call..

2 This situation always results in either an X.25 clear indication packet with cause #9, “out of order” for switched virtual calls, or an X.25 reset packet with cause #9, “out of order” for permanent virtual circuits.

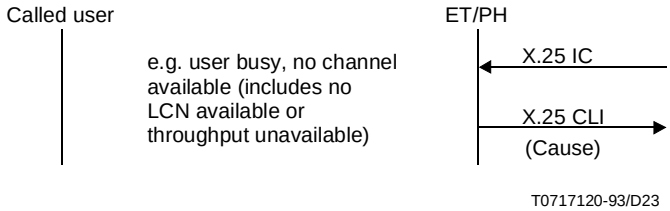
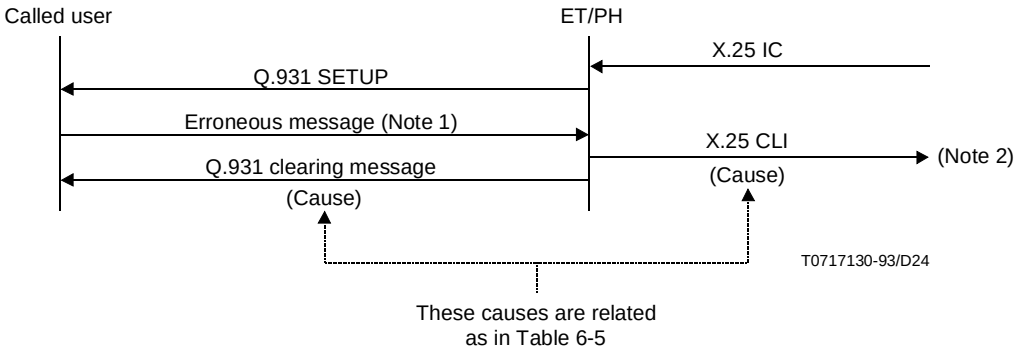


FIGURE III.8/X.31

Undeliverable call



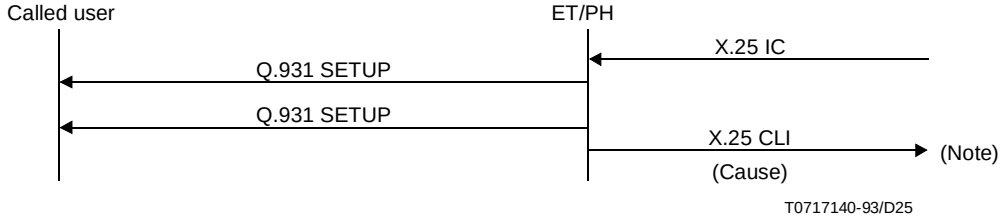
NOTES

1 This figure only applies to the case where the erroneous message results in a Q.931 clearing message. See 6.4.3 for more information.

2 This message would be sent after the expiry of timer T303 on a multipoint interface.

FIGURE III.9/X.31

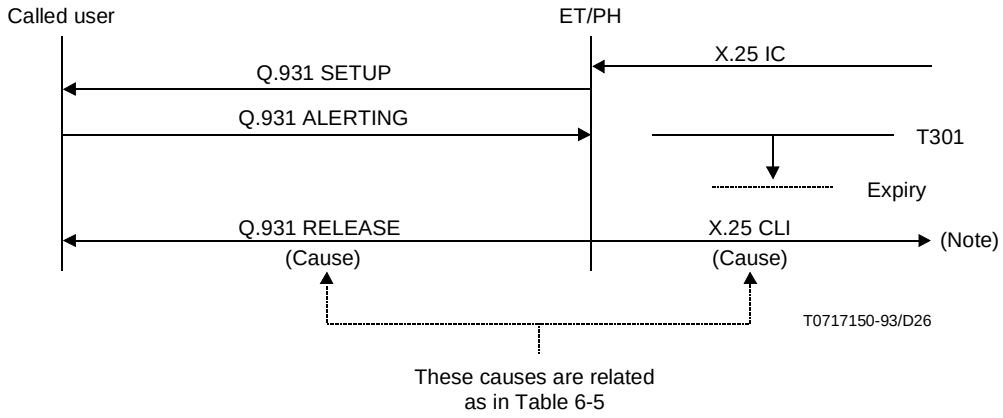
Erroneous message (e.g. format error)



NOTE – This message is sent after the second expiry of timer T303 (defined in Recommendation Q.931).

FIGURE III.10/X.31

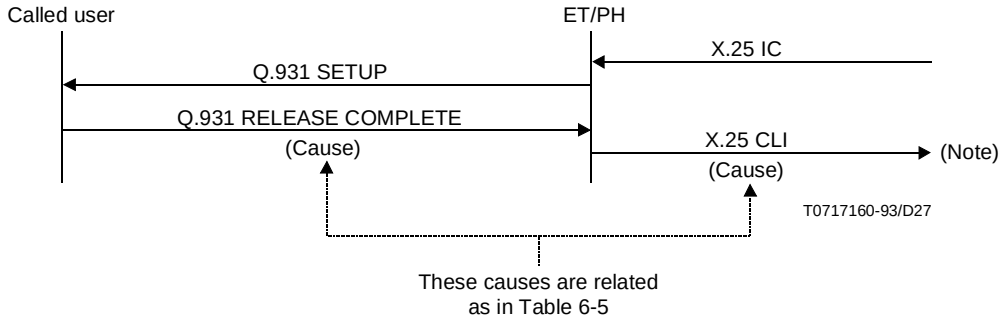
No responding user



NOTE – This message is sent after the expiry of timer T301 (defined in Recommendation Q.931).

FIGURE III.11/X.31

Expiry of timer T301



NOTE – This message would be sent after the expiry of T303 when on a multipoint interface.

FIGURE III.12/X.31

Call rejection by called party

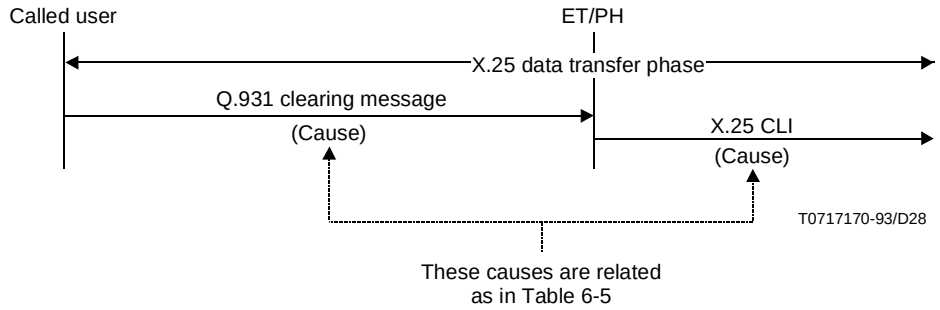
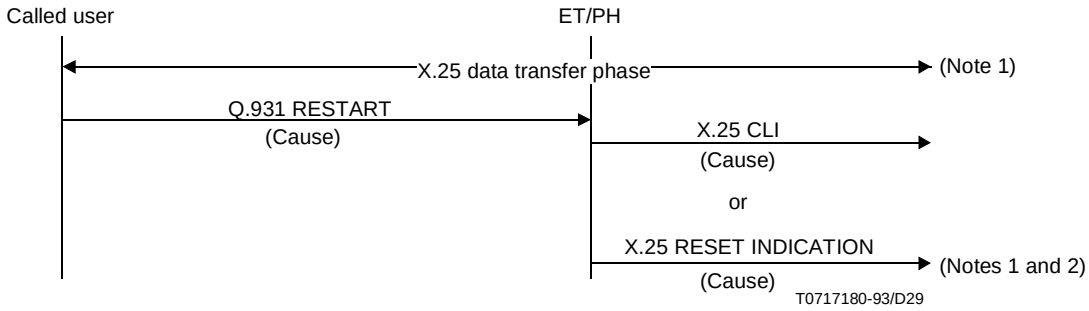


FIGURE III.13/X.31

Q.931 clearing during X.25 data transfer phase



NOTES

1 The cause parameter in the X.25 CLI packet will indicate “out of order” with diagnostic value 0.

2 For permanent virtual circuits only.

FIGURE III.14/X.31

Q.931 RESTART during X.25 data transfer phase

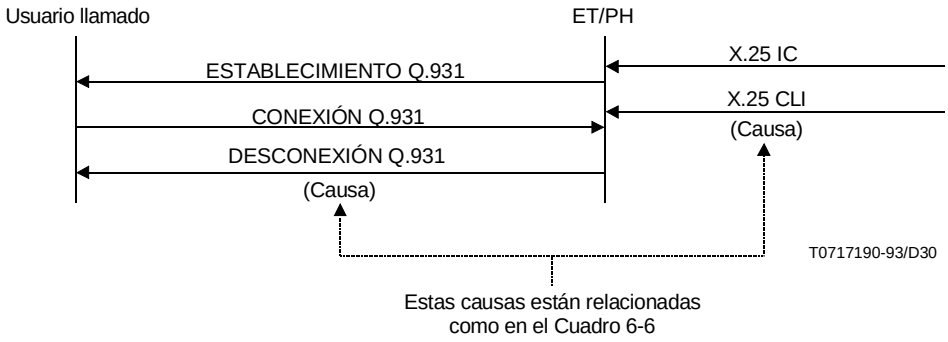
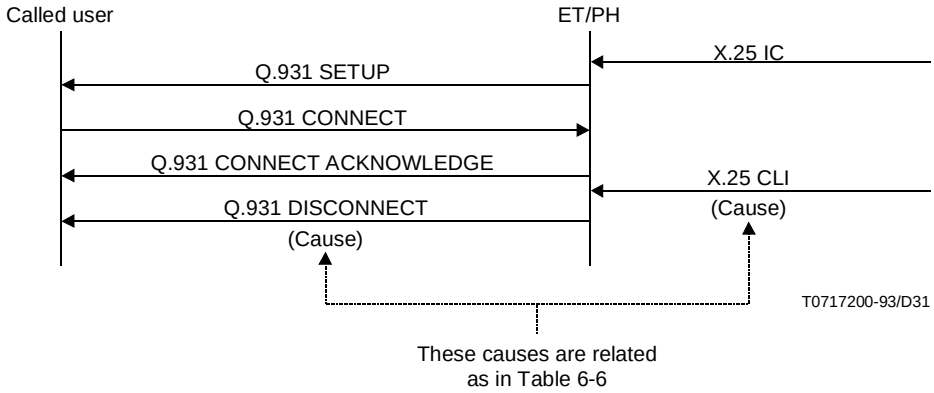


FIGURA III.15/X.31

Liberación prematura de la llamada virtual (por ejemplo, por expiración del temporizador T21 de la Recomendación X.25)



NOTE – This is the case when X.25 *incoming call* packet has NOT been delivered.

FIGURE III.16/X.31

Premature clearing of the virtual call

Appendix IV

(to Recommendation X. 3 1)

D-channel TAs requiring full protocol termination in the TA

(This appendix does not form an integral part of this Recommendation)

IV.1 Introduction

On the basis of different implementations of X.25 procedures in existing DTEs, several types of terminal adaptors can be identified, namely:

- type 1: establishment of a logical, SAPI=16, link in the D-channel upon recognition of the receipt of a SABM frame;
- type 2: idem, on receipt of an I frame;
- type 3: idem, on receipt of a CR packet.

NOTE – Alternatively, initiation of call set-up can be carried out by manual means, for example a push button on the TA.

The first type applies to DTEs which disconnect the link at the R reference point, when no virtual calls are in progress, and is described in 7.4.

However, there are also DTEs which are not able to disconnect the link at the R reference point. Therefore, this appendix presents possible approaches for the functionalities and the signalling mapping procedures of terminal adaptors, applicable to DTEs of this type.

These examples should not constrain implementations and do not cover all possible cases.

IV.2 Call control

In this appendix the following call phases are specified:

- idle phase;
- establishment phase;
- data transfer phase;
- clearing phase.

When no virtual calls are in progress, the TA is in the idle phase.

Incoming or outgoing calls force transition to the data transfer phase, via the establishment phase.

After the clearing of the last virtual call the TA transits from the data transfer phase via the clearing phase to the idle phase.

IV.2.1 Idle phase

In the idle phase no virtual calls are in progress.

In the idle phase the layers 1 and 2 on the R reference point are established, see Figure IV.1. All X.25 layer 2 procedures are supported by the TA. X.25 layer 3 restart procedures must be supported, whereas other X.25 layer 3 procedures may be supported.

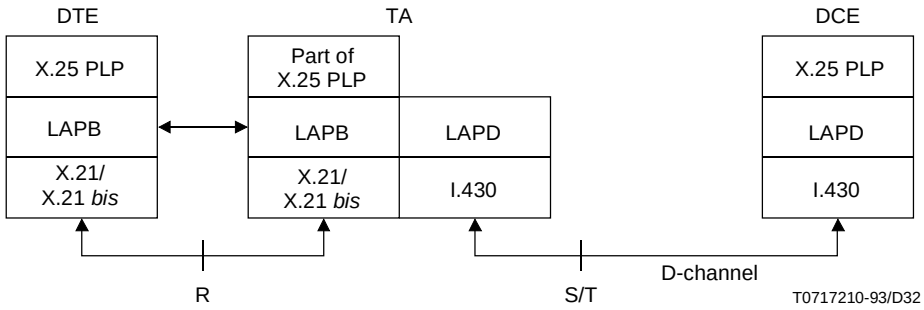


FIGURE IV.1/X.31

Example configuration in the idle phase, non-transparent at layer 3

There is no need to support layer 3 procedures, when an outgoing call is initiated by the DTE by sending an I frame to the TA. Receipt of that I frame is followed by setting up a D-channel, SAPI = 16, logical link by the TA; as soon as that link is established, the TA will transmit the packet contained in the received I frame to the DCE; that packet has to be an X.25 CR packet.

Figure IV.2 depicts this situation.

NOTE – When only incoming calls are to be supported or the beginning of an outgoing call is initiated via the human/machine interface of the TA (e.g. a push button on the TA), there is in principle no need for the TA to support layer 3 procedures.

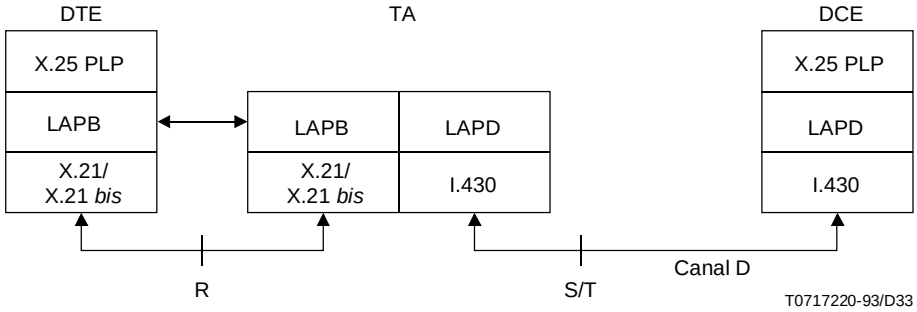


FIGURA IV.2/X.31

Ejemplo de configuración en la fase de reposo, transparente en la capa 3

IV.2.1.1 Transferring to the establishment phase

The TA transmits to the establishment phase at:

– the detection of an outgoing call. Outgoing calls are detected by the receipt of an X.25 *call request* packet , or via the human/machine interface of the TA , or by the receipt of an I frame (see IV.2.2.1).

– the detection of an incoming call. The TA applies the procedures of 6.2 for the detection and acceptance of incoming calls (see also IV.2.2.2).

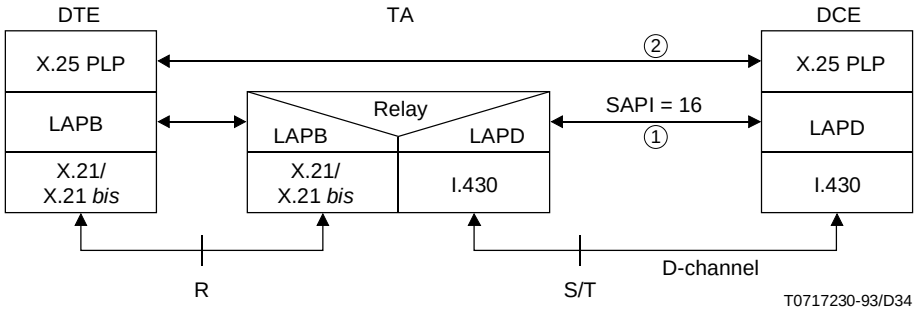
IV.2.2 Establishment phase

For call establishment, the following subsequent actions can be distinguished (see Figure IV.3):

1) establishment of a SAPI = 16, logical link via the D-channel;

2) establishment of layer 3 between the X.25 DTE and the X.25 DCE in the PH;

3) proceeding to the data transfer phase, during which the TA is always transparent at layer 3.



NOTE – The numbers ① and ② refer to the numbered actions in this subclause.

FIGURE IV.3/X.31

Example configuration in the establishment phase

IV.2.2.1 Outgoing call initiated via a call request packet or an I frame

NOTE – Reference to an I frame throughout this appendix means that the TA has no knowledge about the type of X.25 packet, contained in that I frame.

The *call request* packet received from the X.25 DTE is buffered in the TA. A D-channel logical link, SAPI = 16 is established between the DCE in the PH and the TA, following the procedures of Q.921. Layer 3 of the DCE in the PH must be initiated by means of the restart procedure. The buffered *call request* packet is sent to the DCE in the PH.

After that the TA proceeds to the data transfer phase.

Figure IV.4 gives an example of the message sequence for establishment phase.

NOTE – After initiation via the human/machine interface of the TA, a D-channel logical link, SAPI = 16, is established between the PH and the TA, following the procedures of Q.921. Layer 3 of the DCE of the PH must be initiated by means of the restart procedure.

The TA then proceeds to the data transfer phase.

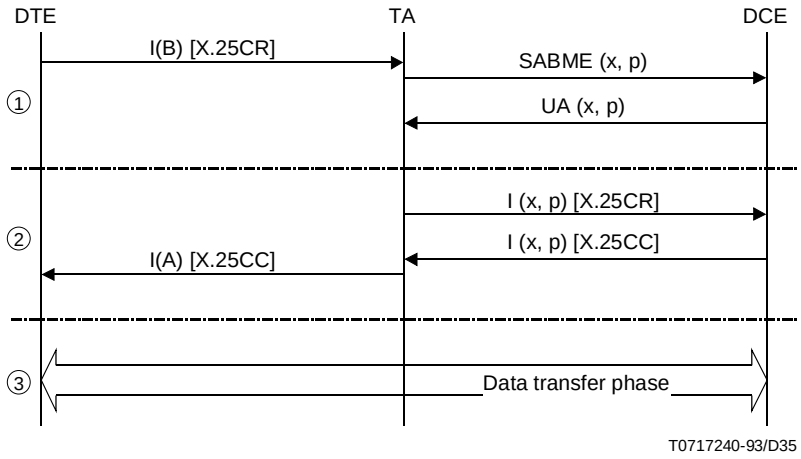


FIGURE IV.4/X.31

Example Q.921 and X.25 message sequence for an outgoing call initiated by the DTE

IV.2.2.2 Incoming call

At the reception of an incoming call, the procedures of 6.2.2 of apply for the allocation of a D-channel SAPI = 16 link between the TA and the PH.

The TA proceeds to the data transfer phase after the sending of a UA frame, acknowledging the received SABME frame from the PH.

IV.2.3 Data transfer phase

In the data transfer phase the TA acts as a layer 2 relay by terminating the layer 2 links at both sides and performing a mapping function between them, see Figure IV.5. The mapping is described in 7.4.2.

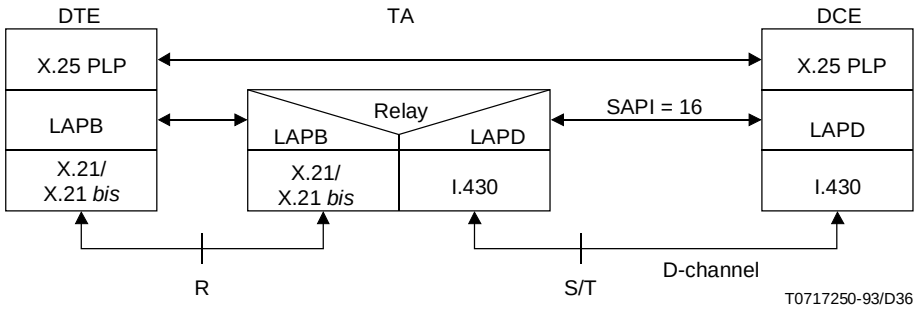


FIGURE IV.5/X.31

Example configuration in the the data transfer phase

IV.2.3.1 Transferring to the clearing phase

The clearing phase is entered at the detection that no virtual calls over the D-channel link are in progress anymore. This detection will be done by the PH (see IV.2.4)

NOTES

1 Alternatively, this detection is done by the user, e.g. notification via a push button on the TA.

2 Detection by the DTE is not relevant because there are no means to notify the detection of the clearing of the last virtual call to the TA (layers 1 and 2 are always established here).

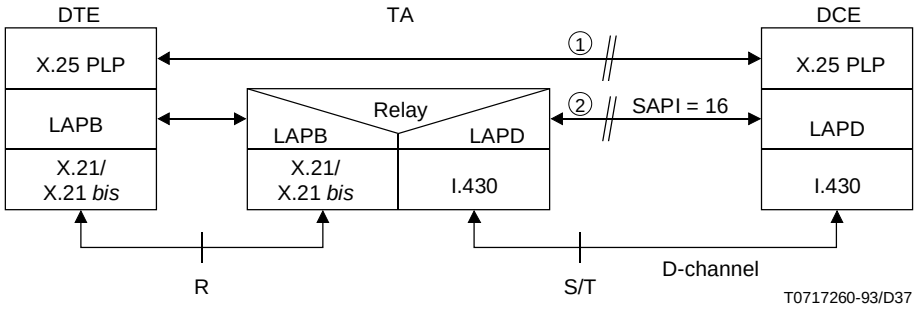
IV.2.4 Clearing phase

For call clearing the following actions can be distinguished (see Figure IV.6).

1) clearing of the layer 3 connection;

2) clearing of the SAPI = 16, logical link via the D-channel;

3) transferring to the idle phase.



NOTE – The numbers ① and ② refer to the numbered actions in this subclause.

FIGURE IV.6/X.31

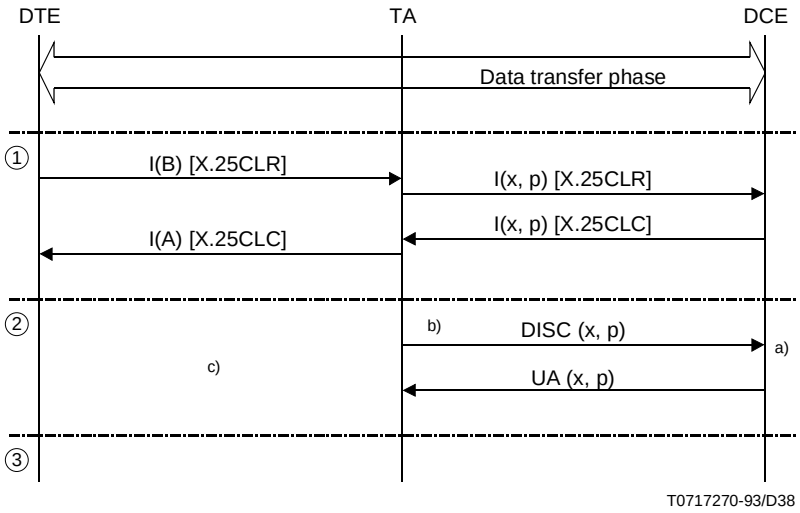
Example configuration in the clearing phase

IV.2.4.1 Detection by the PH

After the clearing of the last virtual call via a certain logical link the PH sends a DISC frame to the TA, initiating the disconnection of the D-channel, SAPI = 16 logical link. The TA enters the idle phase, after acknowledging this disconnection by sending a UA frame.

Figure IV.7 gives an example of the message sequence for the clearing phase.

NOTE – After the manual notification by the user via the human/machine interface of the TA, the TA sends a DISC frame to the PH, requesting for disconnection of the D-channel, SAPI = 16 logical link. After reception of the UA frame by the TA (acknowledging this disconnection), the TA enters the idle phase.



[a] The D-channel logical link is disconnected, only if the cleared virtual call was the last one via that link.

[b] Manual notification by the user is supposed.

[c] Layer 2 between DTE and TA is always established.

FIGURE IV.7/X.31

Example Q.921 and X.25 message sequence for the clearing phase (detection by the user)

Appendix V

(to Recommendation X.31)

References

(This appendix does not form an integral part of this Recommendation)

X.1 *International user classes of service and categories of access to public data networks and integrated services digital networks (ISDNs).*

X.2 *International data transmission services and optional user facilities in public data networks.*

X.3 *Packet assembly/disassembly facility (PAD) in a public data networks.*

X.21 *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for synchronous operation on public data networks.*

X.21 *bis Use on public data networks of data terminal equipment (DTE) which is designed for interfacing to synchronous V-series modems.*

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.*

X.28 *DTE/DCE interface for a start-stop mode data terminal equipment accessing the packet assembly/disassembly facility (PAD) in a public data network situated in the same country.*

X.29 *Procedures for the exchange of control information and user data between a packet assembly/disassembly (PAD) facility and a packet mode DTE or another PAD.*

X.30 (I.461) *Support of X.21, X.21 bis and X.20 bis based data terminal equipments (DTEs) by an integrated services digital network (ISDN).*

X.32 *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and accessing a packet switched public data network through a public switched telephone network or an integrated services digital network or a circuit switched public data network.*

X.52 *Method of encoding anisochronous signals into a synchronous user bearer.*

X.75 *Packet switched signalling system between public networks providing data transmission services.*

X.96 *Call progress signals in public data networks.*

X.121 *International numbering plan for public data networks.*

X.213 *Network service definition for Open Systems Interconnection (OSI) for CCITT Applications.*

X.300 *General principles for interworking between public networks and other networks for the provision of data transmission services.*

X.320 *General arrangements for interworking between integrated services digital networks (ISDNs) for the provision of data transmission services.*

X.325 (I.550) *General arrangements for interworking between packet switched public data networks (PSPDNs) and integrated services digital networks (ISDNs) for the provision of data transmission services.*

I.230 *Definition of bearer service categories.*

I.231 *Circuit mode bearer service categories.*

I.232 *Packet mode bearer service categories.*

I.331 (E.164) *Numbering plan for the ISDN era.*

I.411 *ISDN user-network interface – Reference configurations.*

I.430 *Basic user-network interface – Layer 1 specification.*

I.431 *Primary rate user-network interface – Layer 1 specification.*

I.441 (Q.921) *ISDN user-network interface data link layer specification.*

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

I.461 See X.30.

Q.920 *ISDN user-network interface data link layer – General aspects.*

Q.921 See I.441.

Q.931 See I.451.

V.25 *bis* *Automatic calling and/or answering equipment on the general switched telephone network (GSTN) using the 100-series interchange circuits.*

V.110 *Support of data terminal equipments (DTEs) with V-series type interfaces by an integrated services digital network (ISDN).*

E.166 *Numbering plan interworking in the ISDN era.*

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