The drawings contained in this Recommendation have been done in Autocad

Recommendation X.31[1)]

SUPPORT OF PACKET MODE TERMINAL EQUIPMENT BY AN ISDN

(Malaga–Torremolinos, 1984; amended at Melbourne, 1988)

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 (I.430/I.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.

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1) This Recommendation is also included in the Recommendations of the I–series under the number I.462.

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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 Recommendation I.230 series.

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 kbit/s 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).

In Case B an ISDN virtual circuit service is used, as described in Recommendation I.231, § 3.2.1. 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.

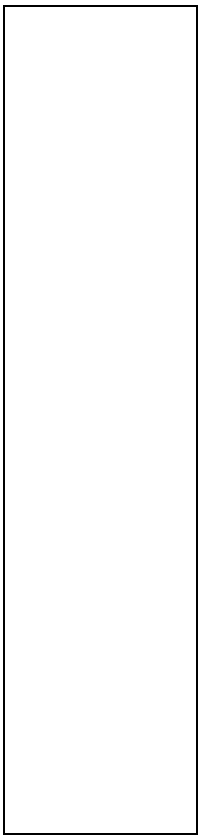
This Recommendation only applies to packet mode operation carried out independently on a single ISDN network connection type (i.e., involving either a B– or D–channel).

2.1 *Configuration when* accessing PSPDN services *(Case A)*

This configuration (Figure 2–1/X.31) refers to the service of Case A, thus implying a transparent handling of packet calls through an ISDN. Only access via the B–channel 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.

Fig. 2–1/X.31/T0700901-88 = 15 cm



In the case of demand access to PSPDNs, which is illustrated in the upper portion of Figure 2–1/X.31, 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 at 64 kbit/s. 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/X.31, 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.

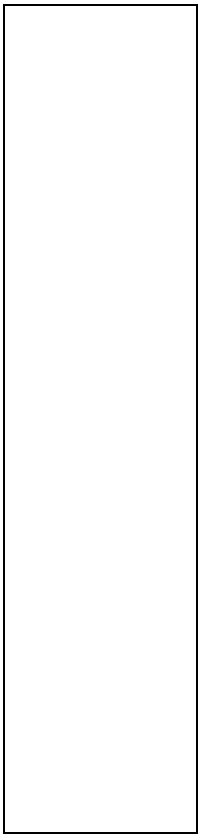
For the demand access case, layer 2 and layer 3 operation in the B–channel as well as service definitions are given in Recommendation X.32.

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

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/X.31 relates to the case of X.25 link and packet level 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.

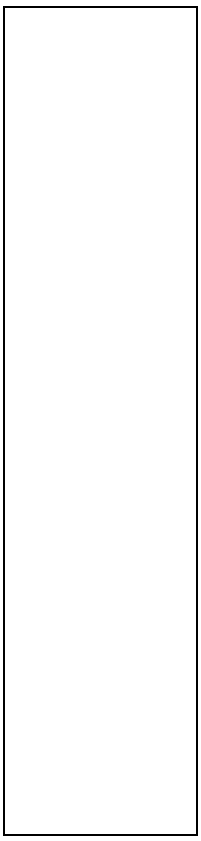
Fig. 2–2/X.31/T0700911-88 = 15 cm



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/X.31 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 layer 2. The accessed port of PH is still able to support X.25 packet layer procedures.

Fig. 2–3/X.31/T0700921-88 = 15 cm



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.

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.

3.1.2 *User access capabilities*

In this case DTEs belonging to user classes of service 8 to 11, 13 and 30 of Recommendation X.1 (categories of access Q1 to Q5 of Recommendation X.10) can be supported with no restrictions on the use of Recommendation X.25. The rate adaption mechanism for user classes of services 8 to 11 (categories of access Q1 to Q4) as well as the TA functionalities are described in § 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 virtual circuits using the X.25 protocol (link layer and packet layer).

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

3.1.4 *Notification classes*

There is one class in terms of Q.931 procedures to notify the user of incoming calls. In 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 Recommendation 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, 13 and 30 of Recommendation X.1 (categories of access T1 to T5 and Y1 to Y5 of Recommendation X.10) 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 (access categories T1 to T4 and Y1 to Y4) as well as the TA functionalities are described in § 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 § 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 of Recommendation X.10) and except on basic access user class of service 11 of Recommendation X.1 (categories of access U5 of Recommendation X.10) 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 limit for the size of each frame to be transferred on the D–channel shall be 260 octets.

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 Series X 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 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 layer 2. This results in the requirement that the network be able to support simultaneous layer 2 and 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 (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 logical channel, either two–way or incoming, on which the *incoming call* packet is sent.

3.2.3 *Notification classes for 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 calls should be added to the active packet access channel. The network may then reject the call immediately or use Q.931 procedures in an attempt to activate another channel for the purpose of delivering additional calls.

Note – Some network may also compare the subaddress and use Q.931 procedure when the ISDN address differs from the ISDN address of the terminal with the 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. As Table 3–1/X.31 notes, all of the information that is able to be copied from the X.25 *incoming call* packet to the Q.931 SETUP message is copied. This service is provided in order to aid the terminal equipment in the management of the interface (e.g., compatibility checking, channel selection).

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/X.31.

3.3 *Compatibility checking*

This paragraph 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.

TABLE 3–1/X.31

Information mapping requirements for notification classes

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

M Mandatory

O Network option

Note 1 – "All" means as many as possible using available information elements shown in Table 6.4/X.31.

Note 2 – Mapping may be restricted by length limitations of the SETUP message in Recommendation Q.931. In case of a mandatory mapping, this restriction will result in clearing of the call. In case of an optional mapping, or length limitation violation, the selection of individual information elements to be mapped is network dependent, and will not result in clearing of the call.

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 Recommendation Q.931, Annex B.

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 section describes the information necessary to select a compatible TA/TE1 for the completion of an 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.

Note – The terminal identification for PVC services is 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. Furthermore, a subaddress, derived from the X.25 address extension facility may be used to identify a specific terminal within a user installation.

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 call will indicate the channel type to be used;

ii) the ISDN has information on which channel type will be used for the 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 § 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 section 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 and Appendix II of Recommendation Q.931, and §§ 6.1–6.5 and Appendix III of Recommendation X.31 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 B– and D–channels are covered in this Section:

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; and

2) data link and physical layers semi–permanently established between the terminal and the PH/AU (in this type, the network shall keep the 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 call establishment and release.

In semi–permanent connection type 2), only the procedures of § 6.3.2 are followed for 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 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 subsections are to be used before establishing the virtual call using the procedures of § 6.3.

For outgoing 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 of Recommendation Q.931. The specific B–channel to be used as a switched connection is selected using the channel selection procedures described in § 5.1.2 of Recommendation Q.931 and summarized in Table 6–1/X.31.

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
Channel indication	Preferred or exclusive	D–channel indication	
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

Note 1 – All other encodings are invalid.

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

On the basis of the call set–up information (e.g., called party number identifying an 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".

Note – Bearer capability information element octets 4a and 4b shall not be included.

The user may also specify the layer 1 (e.g., rate adaption), 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 to Q.931 entitled "Low layer information coding principles").

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 of Recommendation Q.931 using the messages defined in § 3.2 of Recommendation Q.931 with the following exceptions:

- The procedures for overlap sending specified in § 5.1.3 of Recommendation Q.931 do not apply.
- The procedures for call proceeding and overlap sending specified in § 5.1.5.2 of Recommendation Q.931 do not apply.
- The procedures for notification of interworking at the origination interface specified in § 5.1.6 of Recommendation Q.931 do not apply.
- The procedures for call confirmation indication specified in § 5.1.7 of Recommendation Q.931 do not apply.
- The procedures for call connected specified in § 5.1.8 of Recommendation Q.931 apply as follows:
  - 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;
  - this message indicates to the calling user that an access connection to the packet handler has been established;
  - 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.
- The procedures for call rejection specified in § 5.1.9 of Recommendation Q.931 apply as follows:
  - when unable to accept the access connection, the network shall initiate call clearing at the originating user–network interface as described in § 5.3 of Recommendation Q.931.
- The procedures for transit network selection specified in § 5.1.10 of Recommendation 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 of Recommendation Q.931 and summarized in Table 6–1/X.31.

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 4a, 4b and 5a, 5b, 5c, 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.

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 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 of Recommendation Q.931. The 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 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 sections apply.

The format of the SETUP message sent by the network to the user is in accordance with § 3.1 of Recommendation 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".

Note – Bearer capability information element octets 4a and 4b shall not be included. The channel identification information element shall be coded according to Table 6–2/X.31.

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 network response network–user
Channel indication	Preferred or exclusive	D–channel indication	
Bi	Exclusive	No	Bi
Bi	Preferred	No	Bi, Bi` (Note 1)

Bi indicated (idle) B–channel

Bi` any another idle B–channel (not permitted for broadcast call offering)

Note 1 – This encoding is not used for broadcast call offering.

Note 2 – All other encodings are invalid.

The B–channel connection to the called user shall be established by the network using the signalling procedures described in § 5.2 of Recommendation Q.931. The call is offered by sending 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 of Recommendation Q.931.

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

To offer an incoming 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) 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 of Recommendation X.31).

6.2.2.1 *B–channel*

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

- The procedures for overlap receiving specified in § 5.2.4 of Recommendation Q.931 do not apply.
- The procedures for receipt of CALL PROCEEDING and ALERTING specified in § 5.2.5.2 of Recommendation 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 of Recommendation 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/X.31.
- The procedures for notification of interworking at the terminating interface specified in § 5.2.6 of Recommendation 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 of Recommendation 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 § 5.2.10 of Recommendation 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 a 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 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 appropiate 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 of Recommendation 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 of Recommendation 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.

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

Note 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 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 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 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/X.31), 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/X.31.

Note 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.

Note 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 selection procedures. Terminals implementing SAPI = 16 procedures shall also implement SAPI = 0 procedures for portability.

TABLE 6–3/X.31

Network requested channel and user response
Incoming access for packet mode

Channel indicated in the SETUP message user to network direction			Allowable network response network–user
Channel indication	Preferred or exclusive	D–channel indication	
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

D the D–channel

Note – All other encodings are invalid.

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/X.31 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.

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 *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 of Recommendation Q.931. For access to PSPDN services, no exceptions apply. For the ISDN virtual circuit service, the messages of § 3.2 of Recommendation Q.931 are used, and the following exceptions apply:

– the terms defined in § 5.3.1 of Recommendation 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 of Recommendation Q.931 does not apply;

– the procedures for clearing with tones and announcements provided in § 5.3.4.1 of Recommendation 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, 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*".

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 elements in Q.931 SETUP message
	Calling address	Calling party number
	Called 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
	Fast select	Packet layer binary parameters
	Reverse charging	For further study
	Closed user group selection	For further study
	Closed user group with outgoing access selection	For further study
	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
	End–to–end transit delay	End–to–end transit delay
	Minimum throughput class	Information rate
	Expedited data negotiation	Packet layer binary parameters

Note 1 – Mapping is optional or required as indicated in § 3.2.3.

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

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

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 of Recommendation Q.931 with the exceptions above, with cause ## 102, "*recovery on time 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 call failure occurs, or the X.25 virtual call is cleared permanently, the rules of § 5.8 of Recommendation Q.931 shall apply. In addition, the following rules for determining the appropriate cause to be used shall apply in order of decreasing priority:

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) If a call is rejected by the destination user using Q.931 messages, the X.25 virtual call shall be cleared using a *clear indication* packet and the appropriate cause from Table 6–5/X.31.

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/X.31 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 iterface, 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 is received from a user which results in the clearing of the call at the user–network interface, the X.25 virtual call shall be cleared using a *clear indication* packet containing the appropriate cause from Table 6–5/X.31 relative to the cause received/sent in the Q.931 clearing message.

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 send a *clear configuration* 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/X.31;

   – 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 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. Networks shall use Table 6–5/X.31 and Table 6–6/X.31 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.

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	Unallocated (unassigned) 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 call clearing	16	Condition: unknwon, 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 order	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

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
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
17	Requested circuit/channel not available	44	(None)	Number busy	1	No logical channel available	71
18	Resources unvailable, unspecified	47	(None)	Nework congestion	5	No additional information	0
19	Quality of service unvailable	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 unavailable, unspecified	63	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
23	Bearer service not implemented	65	Attribute numbers	Incompatible destintion	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

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
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, unspecified	95	(None)	Remote procedure error	17	Call setup, call clearing or registration problem	64
30	Mandatory information element is missing	96	Information element identifier(s)	Remote 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

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
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

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

Note 2 – When a Q.931 RESTART message is received during the X.25 data tranfer 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 call 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 addtional information	0	Destination out of order	27	(None)
4	Remote procedure error	17	(Any allowed)		Protocol error, unspecified	111	(None)

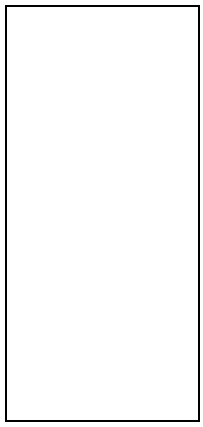
Note – Instead of providing the above mapping of X.25 to Q.931, the PH, as a network option, may code the Q.931 Cause information element to indicate "CCITT Coding Standard" in octet 3, "X.25" in octet 3a, and code octets 4 and 5 according to Recommendation X.25, copying the cause from the X.25 *clear indication* packet rather than mapping it to a Q.931 cause.

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/X.31).

Fig. 7–1/X.31/T0702840-87 = 7 cm



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 reference point;

– synchronization;

– maintenance.

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 Recommendation X.25 Section 1, and 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 subparagraphs.

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 kbit/s 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 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 1

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 section 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 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/X.31.

1) 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.

2) 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 Section 6. The 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 b) 2) 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 1 – 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.

Following the establishment of the connection, the TA should place the R reference point in the appropriate condition for data transfer at layer 1.

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.

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).