INTERNATIONAL TELECOMMUNICATION UNION

CCITT

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

BLUE BOOK

VOLUME VIII – FASCICLE VIII.2

DATA COMMUNICATION NETWORKS: SERVICES AND FACILITIES, INTERFACES

RECOMMENDATIONS X.1-X.32

IXTH PLENARY ASSEMBLY
MELBOURNE, 14-25 NOVEMBER 1988

Geneva 1989

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Data communication networks
Services and facilities, interfaces

PRELIMINARY NOTES

1 The Questions entrusted to each Study Group for the Study Period 1989-1992 can be found in Contribution No. 1 to that Study Group.

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

3 The status of annexes and appendices attached to the Series X Recommendations should be interpreted as follows (except where specified):

- an *annex* to a Recommendation forms an integral part of the Recommendation;
- an *appendix* to a Recommendation does not form part of the Recommendation and only provides some complementary explanation or information specific to that Recommendation.

4 Recommendation X.15 (1984) has been deleted. The terms and definitions that it had contained are included in Fascicle I.3, *Terms and Definitions.*

FASCICLE VIII.2

Recommendations X.1 to X.32

DATA COMMUNICATION NETWORKS

SERVICES AND FACILITIES, INTERFACES

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PRINCIPLES GOVERNING THE COLLABORATION BETWEEN THE CCITT AND OTHER INTERNATIONAL ORGANIZATIONS IN THE STUDY OF DATA COMMUNICATIONS

Recommendation A.20 published in Volume I is reproduced below for the convenience of the reader of the Series X Recommendations.

Recommendation A.20

COLLABORATION WITH OTHER INTERNATIONAL ORGANIZATIONS OVER DATA TRANSMISSION

(Geneva, 1964; amended at Mar del Plata, 1968; Geneva, 1972, 1976 and 1980; Malaga-Torremolinos, 1984)

The CCITT,

considering

(a) that, according to Article 1 of the agreement between the United Nations and the International Telecommunication Union, the United Nations recognizes the International Telecommunication Union as the specialized agency responsible for taking such action as may be appropriate under its basic instrument for the accomplishment of the purposes set forth therein;

(b) that Article 4 of the *International Telecommunication Convention* (Nairobi, 1982) states that the purposes of the Union are:

"a) to maintain and extend international cooperation between all Members of the Union for the improvement and rational use of telecommunications of all kinds, as well as to promote and to offer technical assistance to developing countries in the field of telecommunications;

b) to promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them, so far as possible, generally available to the public;

c) to harmonize the actions of nations in the attainment of those ends;"

(c) that Article 40 of the Convention states that, in furtherance of complete international coordination on matters affecting telecommunication, the Union shall cooperate with international organizations having related interests and activities;

(d) that in the study of data transmission the CCITT has to collaborate with the organizations dealing with data processing and office equipment and particularly the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC);

(e) that this collaboration has to be organized in a manner that will avoid duplication of work and decisions that would be contrary to the principles set out above;

unanimously declares the view

that international standards for data transmission should be established with the following considerations in mind:

(1) Clearly it will be the responsibility of the CCITT to lay down standards for *transmission channels*, i.e. aspects of data transmission which require a knowledge of telecommunication networks or affect performance of these networks.

(2) The standardization of signal conversion terminal equipment (modems) is the province of the CCITT; the standardization of the junction (interface) between modem and the data terminal equipment is a matter of agreement between the CCITT and the ISO or the IEC.

(3) Devices designed to detect and (or) correct errors must take account of:

– the error rate tolerable to the user;

– the line transmission conditions;

– the code, which has to meet the exigencies of the data alphabet and the requirements of error control (this must be such as to give an output satisfactory to the user) together with the requisite signalling (synchronism, repetition signals, etc.).

Standardization here may not come wholly within the CCITT's province, but the CCITT has very considerable interests at stake.

(4) The alphabet (as defined in Fascicle XI.1 – Terms and Definitions) is a "table of correspondence between an agreed set of characters and the signals which represent them".

The CCITT and the ISO reached agreement on an alphabet for general (but not exclusive) use for data and message transmission and have standardized a common alphabet which is known as International Alphabet No. 5 (CCITT Recommendation T.50 and ISO Standard No. 646-1983; ISO 7-bit coded character set for information interchange).

Complementary study of some control characters of the alphabet should be effected cooperatively.

(5) Coding (as defined in Fascicle XI.1 – Terms and Definitions) is "a system of rules and conventions according to which the telegraph signals forming a message or the data signals forming a block should be formed, transmitted, received and processed". Hence, it consists of a transformation of the format of the signals in the alphabet for taking account of synchronous methods, and introduction of redundancy in accordance with the error control system. This is not a field in which the CCITT alone may be able to decide; however, no decision should be taken without reference to the Committee, because of the possible restrictions which transmission and switching peculiarities may impose on coding.

When the general switched network is used (telephone or telex) and when the error control devices are subject to restrictions (switching signals – reserved sequences), it is the CCITT which is in fact responsible for any necessary standardization in conjunction with other bodies.

(6) The limits to be observed for transmission performance on the transmission path (modem included) fall within the competence of the CCITT; the limits for the transmission performance of the sending equipment and the margin of terminal data equipment (depending on the terminal apparatus and the transmission path limits) should be fixed by agreement between the ISO and the CCITT.

(7) In all instances, the CCITT alone can lay down manual and automatic operating procedures for the setting-up, holding and clearing of calls for data communications when the general switched networks are used, including type and form of signals to be interchanged at the interface between data terminal equipment and data circuit terminating equipment.

(8) When a public data network is involved, the CCITT has the responsibility to provide the Recommendations which apply. Where these Recommendations have an impact on the basic design and features of data processing systems and office equipment [normally the Data Terminal Equipment (DTE)], they shall be the subject of consultation between CCITT and ISO and in some cases a mutual agreement may be desirable. Likewise when the ISO is developing or changing standards that may affect compatibility with the public data network there shall be consultation with the CCITT.

SECTION 1

SERVICES AND FACILITIES

Recommendation X.1

INTERNATIONAL USER CLASSES OF SERVICE IN PUBLIC DATA NETWORKS AND INTEGRATED SERVICES DIGITAL NETWORKS (ISDNs)

(Geneva, 1972; amended at Geneva, 1976 and 1980; Malaga-Torremolinos, 1984 and Melbourne, 1988)

Preface

The establishment in various countries of public networks for data transmission and ISDNs for integrated services creates a need to standardize user classes of service. An international user class of service is a category of data transmission service in which the data signalling rate, call control signalling rates and data terminal equipment operation modes are standardized.

Recommendations in the V Series already standardize data signalling rates for data transmission in the general telephone network and modulation rates for modems. These rates are, however, not necessarily the most suitable for public networks devoted entirely to data transmissions.

There are three public data transmission services, namely circuit-switched, packet-switched and leased circuit.

There are several methods by which data terminal equipment (DTE) may gain access to the public data transmission services. These methods are direct connections and a variety of switched connections via other public networks. To enable the method of access to be identified in addition to the user class of service, categories of access are defined in Recommendation X.10.

It is not mandatory for Administrations to provide all the user classes of service contained in this Recommendation.

The CCITT,

considering

(a) the desirability of providing sufficient data signalling rates to meet users' needs;

(b) the requirement to optimize data terminal equipment (DTE), transmission and switching costs to provide an overall economic service to the user;

(c) the particular operating modes of users' data terminal equipment (DTE);

(d) the users' need to transfer information consisting of any bit sequence and of any number of bits up to a certain amount;

(e) the interaction between users' requirements, technical limitations and tariff structure;

(f) that Recommendation X.10 defines the categories of access for data terminal equipment (DTE) to public data transmission services,

unanimously declares the view

that users' data transmission requirements via public data networks and ISDNs may best be served by defined international user classes of service.

These international user classes of service are shown in the following tables.

TABLE 1/X.1

International user classes of service in public data networks and ISDNs

a) Circuit switched and leased circuit data transmission services for data terminal equipment operating in start-stop mode, using X.20 or X.20 bis interfaces (see Note 1)

User class of service	Data signalling rate and code structure in the data transfer phase (see Notes 2 and 3)	Call control signals in the call control phase (see Note 4)
1	300 bit/s, 11* units/character start-stop (see Note 5)	300 bit/s, International Alphabet No. 5 (11 units/character) start-stop
2	50 to 200 bit/s, 7,5 to 11* units/character start-stop (see Notes 6 and 7)	200 bit/s, International Alphabet No. 5 (11 units/character) start-stop (see Note 8)

* Usage in accordance with Recommendation X.4.

b) Circuit switched and leased circuit data transmission services for data terminal equipment operating in synchronous mode, using X.21 or X.21 bis interfaces

User class of service	Data signalling rate in the data transfer phase (see Notes 3, 9 and 10)	Call control signals in the call control phase (see Note 11)
3	600 bit/s	600 bit/s, International Alphabet No. 5
4	2 400 bit/s	2 400 bit/s, International Alphabet No. 5
5	4 800 bit/s	4 800 bit/s, International Alphabet No. 5
6	9 600 bit/s	9 600 bit/s, International Alphabet No. 5
7	48 000 bit/s	48 000 bit/s, International Alphabet No. 5
19	64 000 bit/s	64 000 bit/s, International Alphabet No. 5

c) Packet switched data transmission service for data terminal equipment operating in synchronous mode, using X.25 or X.32 interface (see Note 12)

User class of service	Data signalling rate (see Note 13)
8	2 400 bit/s
9	4 800 bit/s
10	9 600 bit/s
11	48 000 bit/s
12	1 200 bit/s (see Note 14)
13	64 000 bit/s

d) Packet switched data transmission service for data terminal equipment operating in start-stop mode, using X.28 interface (see Notes 12 and 15)

User class of service	Data signalling rate and code structure (see Note 3)
20	50-300 bit/s, 10 or 11 units/character
21	75/1200 bit/s, 10 units/character (see Note 16)
22	1200 bit/s, 10 units/character
23	2400 bit/s, 10 units/character

TABLE 2/X.1

International user classes of service specific to ISDN

(see Notes 17 and 18)

User class of service	Data signalling rate	DTE/DCE interface requirements and call control signals
30	64 kbit/s	The call control signals used will be in accordance with those defined for ISDN at reference point S/T. For interface at reference point R, see Table 1/X.1 a) (user class of service 19) and b) (user class of service 13) Reference points S, T and R are defined in Recommendation I.411.

Note 1 – There is no user class of service for the data signalling rate of 50 bit/s, the transmission mode of 7.5 units/character start-stop and address selection and call progress signals at 50 bit/s, International Telegraph Alphabet No. 2. However, several Administrations have indicated that their telex service (50-baud, International Telegraph Alphabet No. 2) will be provided as one of the many services carried by their public data network.

Note 2 – The need to provide user classes 1 and 2 in ISDN is for further study.

Note 3 – Some Administrations are offering a circuit-switched asynchronous services for terminal operating at the data signalling rate of: 600 bit/s, 1200 bit/s, 2400 bit/s, 4800 bit/s, 9600 bit/s. 10 units/character, start-stop in the data transfer phase and respectively 600 bit/s, 1200 bit/s, 2400 bit/s, 4800 bit/s, 9600 bit/s, International Alphabet No. 5, 10 units/character, start-stop in the call control phase. These services are supported by the synchronous network bearer channels with asynchronous to synchronous coding according to Recommendation X.52 for the user classes of service 1 and 2, and for 1200 bit/s. For the data signalling rates 600, 2400, 4800 and 9600 bit/s, the asynchronous to synchronous coding of Recommendation V.14 is used.

Note 4 – Only applicable for the circuit-switched data transmission service.

Note 5 – Taking account of the existence of data terminal equipments operating in the start-stop mode at a data signalling rate of 300 bit/s and with a 10 unit/character code structure, some Administrations have indicated that their public data networks will accommodate such terminals. Other Administrations, however, have indicated that they cannot guarantee acceptable transmission if such terminals are connected to their networks.

Note 6 – Class 2 will provide, in the data transfer phase, for operation at the following data signalling rates and code structures:

50 bit/s (7.5 units/character)
100 bit/s (7.5 units/character)
110 bit/s (11 units/character)
134.5 bit/s (9 units/character)
200 bit/s (11 units/character)

Call control signals would be at 200 bit/s, International Alphabet No. 5 (11 units/character) as indicated in a) of Table 1/X.1.

Note 7 – For international user class of service 2, it should be noted that some public data networks may not be able to prevent two terminals working at different data signalling rates and code structures from being connected together by means of a circuit-switched connection.

Note 8 – Some Administrations have indicated that, for certain of the data signalling rates listed in Note 6 above, they will permit users in class 2 to operate the same signalling rate and code structure for both data transfer and address selection and to receive call progress signals at these signalling rates and code structures. Where International Alphabet No. 5 is used for the call control signals, the appropriate parts of Recommendation X.20 shall apply.

Note 9 – The support of user classes of service 3 to 7 and 19 in the ISDN may be provided by means of a terminal adaptor (in accordance with Recommendation X.30). The concept of terminal adaptor functional grouping is defined in Recommendation I.411.

Note 10 – Some Administrations may offer higher speeds.

Note 11 – Only applicable for the circuit-switched data transmission service, using the Recommendation X.21 interface.

Note 12 – The packet-switched data transmission service allows for communication between Recommendations X.25 and/or X.28 data terminal equipments operating at different data signalling rates.

Note 13 – The support of user classes of service 8 to 11 and 13 in the ISDN may be provided by means of a terminal adaptor (in accordance with Recommendation X.31). The concept of terminal adaptor functional grouping is defined in Recommendation I.411.

Note 14 – The user class of service 12 is only provided via PSTN access. It might also be offered in the maritime satellite data transmission system.

Note 15 – The support of user classes of service 20 to 23 in the ISDN may be provided by means of a terminal adaptor providing PAD functions. Other means to support these user classes of service in the ISDN are for further study.

Note 16 – 75 bit/s from DTE to DCE, 1200 bit/s from DCE to DTE.

Note 17 – Class 30 is valid for both circuit switching and packet switching.

Note 18 – The packet-switched data transmission service allows for communication between ISDN packet mode terminal equipments operating at 64 kbit/s (Terminal Equipment 1 according to Recommendation I.411) and Recommendation X.25 or X.28 data terminal equipments operating at different data signalling rates.

INTERNATIONAL DATA TRANSMISSION SERVICES AND OPTIONAL USER FACILITIES IN PUBLIC DATA NETWORKS AND ISDNs

(Geneva, 1972; amended at Geneva, 1976, 1980; Malaga-Torremolinos, 1984 and Melbourne, 1988)

The CCITT,

considering

(a) the international user classes of service and categories of access defined in Recommendations X.1 and X.10;

(b) the need to standardize data transmission services, optional user facilities and *DTE services*, in public data networks and ISDNs, which should be made available on an international basis;

(c) the need to standardize additional optional user facilities and *DTE services* which may be provided by Administrations and which may be available on an international basis;

(d) that the optional user facilities indicated in this Recommendation are defined in other Recommendations, for example Recommendation X.301 for network implementations, where appropriate, and Recommendations X.21, X.25, etc., for network procedures;

Note – Alignment and interworking between the facilities in Recommendations X.2 and supplementary services in the I.250 series are for further study.

(e) the need to standardize the identification methods applicable to these *DTE services*, which identification methods should be made available on an international basis, and which identification methods may be provided by Administrations and may be available on an international basis;

(f) the impact which these optional user facilities and *DTE services* could have on tariff structures,

unanimously declares

(1) that the optional user facilities should be standardized for each of the user classes of service indicated in Recommendation X.1 for each of the following:

i) circuit switched data transmission services;

ii) packet switched data transmission services;

iii) leased circuit data transmission services.

Note 1 – Recommendation X.10 defines the various categories of access to public data communication services.

Note 2 – Further study is necessary to establish whether the service and optional user facilities provided by ISDNs for circuit switched data transmission services are adequately defined in Recommendation X.2.

(2) that the optional user facilities to be made available on an international basis are indicated in in the following sections. Some of the optional user facilities are available on a per-call basis and others may be assigned for an agreed contractual period. In all cases, the user has the option of requesting a given optional user facility;

(3) that the DTE services and the relative identification methods used when the packet switched data transmission service is obtained via a Public Switched Telephone Network (PSTN), a Circuit Switched Public Data Network (CSPDN) or an Integrated Services Digital Network (ISDN) should also be standardized and are indicated in the following sections.

1 Circuit switched data transmission service

Table 1/X.2 indicates the optional user facilities which should be made available on an international basis in the circuit switched data transmission service and those facilities which may be available in certain data networks and may also be available internationally.

Note – The subject of interworking between the packet switching service and the circuit switching service is for further study.

TABLE 1/X.2

Optional user facilities in circuit switched data transmission service

Optional user facility	All user classes of service
1. *Optional user facilities assigned for an agreed contractual period*	
1.1 Direct call	A
1.2 Closed user group	E
1.3 Closed user group with outgoing access	A
1.4 Closed user group with incoming access	A
1.5 Incoming call barred within a closed user group	A
1.6 Outgoing call barred within a closed user group	A
1.7 Calling line identification	A
1.8 Outgoing calls barred	A
1.9 Bilateral closed user group	A
1.10 Bilateral closed user group with outgoing access	A
1.11 Incoming calls barred	A
1.12 Reverse charging acceptance	A
1.13 Connect when free	A
1.14 Waiting allowed	A
1.15 Redirection of calls	A
1.16 On-line facility parameter registration/cancellation	A
1.17 DTE inactive registration/cancellation	A
1.18 Date and time indication	A
1.19 Hunt group	A
2. *Optional user facilities requested by the DTE on a per-call basis*	
2.1 Direct call	A
2.2 Abbreviated address calling	A
2.3 Multi-address calling (see Note)	A
2.4 Reverse charging	A
2.5 RPOA selection	A
2.6 Charging information	A
2.7 Called line identification	A

Note – This optional user facility provides also the user with the capability to request the establishment of a point-to-multipoint configuration amongst the following: centralized multipoint, decentralized multipoint, broadcasting.

2 Packet switched data transmission services

2.1 *Direct connection to a packet switched data transmission service*

Table 2/X.2 and Table 3/X.2 indicate the services and the optional user facilities, respectively, which should be made available on an international basis in the packet switched data transmission service and those which may be available on certain data networks and may also be available internationally, in case of a direct connection to a packet switched data transmission service.

These services and optional user facilities are described in Recommendation X.25.

A DTE may make use of one or more of these services and facilities.

It should be noted that Recommendation X.25 has inherent features (e.g. the conveying of an address extension), which can be used end-to-end by users for providing an OSI network service (see Recommendations X.213 and X.223). Such features are described in Recommendation X.25 and are so-called "CCITT-defined DTE facilties" (see Recommendation X.25, Annex G).

Note 1 – The subject of interworking between the packet switching service and the circuit switching service is for further study.

Note 2 – The study of "connectionless services" is for further study.

TABLE 2/X.2

Services in packet switched data transmission service (direct connection)

	User classes of service	
	8-11 and 13	20-23
Virtual call service	E	E
Permanent virtual circuit service	E (Note)	FS

Note – This service continues to be allocated an "E" classification. However, while some Administrations continue to believe that the offering of this service is an essential feature of the international service, other Administrations have expressed the view that they will not offer the service internationally. The international application depends on bilateral agreement. This service may not be available for the maritime mobile services.

TABLE 3/X.2

Facilities of packet switched data transmission service (direct connections)

Optional user facility	User classes of service			
	8-11 and 13		20-23 (Note 1)	
	VC	PVC	VC	PVC
1. *Optional user facilities assigned for an agreed contractual period*				
1.1 Extended frame sequence numbering	A	A	–	–
1.2 Multilink procedure	A	A	–	–
1.3 On-line facility registration	A	–	FS	–
1.4 Extended packet sequence numbering (modulo 128)	A	A	–	–
1.5 D-bit modification	A	A	FS	–
1.6 Packet retransmission	A	A	–	–
1.7 Incoming calls barred	E	–	A	–
1.8 Outgoing calls barred	E	–	A	–
1.9 One-way logical channel outgoing	E	–	–	–
1.10 One-way logical channel incoming	A	–	–	–
1.11 Nonstandard default packet sizes 16, 32, 64, 256, 512, 1024, 2048, 4096	A	A	FS	FS
1.12 Nonstandard default window sizes	A	A	–	–
1.13 Default throughput classes assignment	A	A	FS	FS
1.14 Flow control parameter negotiation	E	–	FS	–
1.15 Throughput class negotiation	E	–	FS	–
1.16 Closed user group	E	–	E	–
1.17 Closed user group with outgoing access	A	–	A	–
1.18 Closed user group with incoming access	A	–	A	–
1.19 Incoming call barred within a closed user group	A	–	A	–
1.20 Outgoing call barred within a closed user group	A	–	A	–
1.21 Bilateral closed user group	A	–	A	–
1.22 Bilateral closed user group with outgoing access	A	–	A	–
1.23 Fast select acceptance	E	–	FS	–
1.24 Reverse charging acceptance	A	–	A	–
1.25 Local charging prevention	A	–	FS	–
1.26 NUI subscription	A	–	A	–
1.27 NUI override	A	–	–	–
1.28 Charging information	A	–	A	–
1.29 RPOA subscription	A	–	A	–
1.30 Hunt group	A	–	A	–
1.31 Call redirection	A	–	FS	–
1.32 Call deflection subscription	A	–	–	–
1.33 TOA/NPI address subscription	FS	–	FS	–
1.34 Direct call	FS	–	A	–

TABLE 3/X.2 *(cont.)*

Optional user facility	User classes of service			
	8-11 and 13		20-23 (Note 1)	
	VC	PVC	VC	PVC
2. *Optional user facilities on a per-call basis*				
2.1 Flow control parameter negotiation	E	–	–	–
2.2 Throughput class negotiation	E	–	–	–
2.3 Closed user group selection	E	–	E	–
2.4 Closed user group with outgoing access selection	A	–	A	–
2.5 Bilateral closed user group selection	A	–	FS	–
2.6 Reverse charging	A	–	A	–
2.7 Fast select	E	–	FS	–
2.8 NUI selection	A	–	A	–
2.9 Charging information	A	–	A	–
2.10 RPOA selection	A	–	A	–
2.11 Call deflection selection	A	–	–	–
2.12 Call redirection or call deflection notification	A	–	FS	–
2.13 Called line address modified notification	A	–	FS	–
2.14 Transit delay selection and indication (see Note 2)	E	–	–	–
2.15 Abbreviated address calling	FS	–	A	–

E An essential user service or facility to be made available internationally.
A An additional user service or facility which may be available in certain data networks and may also be available internationally.
FS For further study.
– Not applicable.
VC Applicable when the virtual call service is being used.
PVC Applicable when the permanent virtual circuit service is being used.

Note 1 – The use of a PAD function is assumed for virtual call service (see Recommendation X.3). Its applicability for permanent virtual circuit service is for further study.

Note 2 – Attention of users is drawn to the fact that the implementation of such a facility might happen with different time schedules, depending on national conditions.

2.2 *Switched connection to a packet switched data transmission service (classes of service 20-23)*

The definition of services and optional user facilities is for further study.

2.3 *Switched connection to a packet switched data transmission service (classes of service 8-13)*

2.3.1 *DTE services and identification methods*

Table 4/X.2 indicates the *DTE services* and the relative *identification methods* which should be made available on an international basis with classes 8-13 of the packet switched data transmission service when the service is accessed via a switched connection, and those which may be available in certain data networks and may also be available internationally, in case of a direct connection to a packet switched data transmission service.

Permanent virtual circuits are not provided in the scope of § 2.3.

The detailed definitions of the DTE services and the identification methods are contained in Recommendation X.32.

TABLE 4/X.2

DTE services and identification methods

DTE services		User classes of service 8-13	DTE identification					DCE identification			
			NO	PSN	XID	Reg	NUI	NO	PSN	XID	Reg
1. Nonidentified (dial-in-by-the-DTE)		A/E (Note 1)	X (Note 1)					X		X	X
2. Nonidentified (dial-out-by-the-PSPDN)		A	X					X	X	X	X
3. Identified	Dial-in-by-the-DTE	A/E (Note 1)		X (Note 1)	X	X	X	X		X	X
	Dial-out-by-the-PSPDN			X				X			
4. Customized (Note 2)	Dial-in-by-the-DTE	A		X	X	X		X		X	X
	Dial-out-by-the-PSPDN			X	X	X		X	X	X	X

NO No identification.
PSN Identification provided by Public Switched Network.
XID Identification provided by means of the link layer XID procedure.
Reg Identification provided by means of the packet layer registration procedure.
NUI Identification provided by means of the *NUI selection* facility.
PSPDN Packet Switched Public Data Network.
E An essential *DTE service* to be made available internationally.
A An additional *DTE service* which may be available in certain data networks and may also be available internationally.
X DTE or DCE identification method which can be provided by the network when it provides the corresponding *DTE service.*

Note 1 – An Administration providing a switched connection to a packet switched data transmission service for classes of service 8-13 should provide at least the *nonidentified DTE service (dial-in-by-the-DTE)* with no DTE identification method or the *identified DTE service (dial-in-by-the-DTE)* with the provided-by-PSN DTE identification method.

Note 2 – The *customized DTE service* is one *DTE service* for which dial-out-by-the-PSPDN may be provided or not provided. However, the possible identification methods are different for dial-in-by-the-DTE and dial-out-by-the-PSPDN.

2.3.2 *Facilities*

For the *nonidentified (dial-in-by-the-DTE)*, the *nonidentified (dial-out-by-the-PSPDN)*, and the *identified DTE services*, the optional user facilities provided at the DTE/DCE interface are default values specified in Recommendation X.32.

For the *customized DTE service*, the optional user facilities which should be made available internationally, and those which may be available on certain data networks and may also be available internationally are indicated in Table 5/X.2.

TABLE 5/X.2

Facilities of packet switched data transmission service for customized DTE service

Optional user facility		User classes of service 8-13
1.	*Optional user facilities assigned for an agreed contractual period*	
1.1	Extended frame sequence numbering	A
1.2	Multilink procedure	FS
1.3	On-line facility registration	A
1.4	Extended packet sequence numbering (modulo 128)	A
1.5	D-bit modification	A
1.6	Packet retransmission	A
1.7	Incoming calls barred	E
1.8	Outgoing calls barred	E
1.9	One-way logical channel outgoing	E
1.10	One-way logical channel incoming	A
1.11	Nonstandard default packet sizes 16, 32, 64, 256, 512, 1024, 2048, 4096	A
1.12	Nonstandard default window sizes	A
1.13	Default throughput classes assignment	A
1.14	Flow control parameter negotiation	E
1.15	Throughput class negotiation	E
1.16	Closed user group	E
1.17	Closed user group with outgoing access	A
1.18	Closed user group with incoming access	A
1.19	Incoming call barred within a closed user group	A
1.20	Outgoing call barred within a closed user group	A
1.21	Bilateral closed user group	A
1.22	Bilateral closed user group with outgoing access	A
1.23	Fast select acceptance	E
1.24	Reverse charging acceptance	A
1.25	Local charging prevention	A
1.26	NUI subscription	A
1.27	NUI override	A
1.28	Charging information	A
1.29	RPOA subscription	A
1.30	Hunt group	A
1.31	Call redirection	A
1.32	Call deflection subscription	A
1.33	TOA/NPI address subscriprion	FS
1.34	Direct call	FS
2.	*Optional user facilities on a per-call basis*	
2.1	Flow control parameter negotiation	E
2.2	Throughput class negotiation	E
2.3	Closed user group selection	E
2.4	Closed user group with outgoing access selection	A
2.5	Bilateral closed user group selection	A
2.6	Reverse charging	A
2.7	Fast select	E
2.8	NUI selection	A
2.9	Charging information	A
2.10	RPOA selection	A
2.11	Call deflection selection	A
2.12	Call redirection or call deflection notification	A
2.13	Called line address modified notification	A
2.14	Transit delay selection and indication (see Note)	E
2.15	Abbreviated address calling	FS

TABLE 5/X.2 *(cont.)*

Optional user facility	User classes of service 8-13
3. *X.32 optional user facilities*	
3.1 Secure dial-back	A
3.2 Temporary location	A

E An essential user service or facility to be made available internationally.
A An additional user service or facility which may be available in certain data networks and may also be available internationally.
FS For further study.

Note – Attention of users is drawn to the fact that the implementation of such a facility might happen with different time schedules, depending on national conditions.

3 Leased circuit data transmission services

Table 6/X.2 indicates the optional user facilities which should be made available on an international basis with the leased circuit data transmission services and those which may be available in certain data networks and may also be available internationally.

TABLE 6/X.2

Facilities of leased circuit data transmission service

Optional user facility	User classes of service	
	1-2	3-7
1. Point to point	E	E
2. Multipoint		
2.1 Centralized multipoint	A	A
2.2 Decentralized multipoint	A	A
2.3 Broadcasting	A	A

E An essential user service or facility to be made available internationally.
A An additional user service or facility which may be made available in certain data networks and may also be made available internationally.

APPENDIX I

(to Recommendation X.2)

Recommendation X.25 uses facility codes in the facility field of call set-up and clearing packets, and registration codes in the registration field of registration packets. Recommendation X.32 uses X.32 facility codes and identification protocol elements in the user data field of the XID frames or the registration field of the registration packets. Recommendation X.75 uses utility codes in the utility field of call set-up and clearing packets.

The principles for the encoding of these codes (i.e., class A, B, C or D, depending on the length of the parameter following the code) are described in Recommendations X.25 and X.75.

As far as possible, the same code is used in several contexts only when it has an equivalent semantic. However, due to historical reasons, it is not always the case.

Table I-1/X.2 gives the list of the various codes used in these Recommendations.

TABLE I-1/X.2

Coding of the facility, registration, protocol element and utility codes

Code Bits 8 7 6 5 4 3 2 1	X.25 fac	X.25 dte	X.25 reg	X.32	X.75	
CLASS A						
0 0 0 0 0 0 0 0	X	X	X	X	X	Marker
0 0 0 0 0 0 0 1	X 				 X	Fast select and/or reverse charging Fast select and/or reverse charging indication
0 0 0 0 0 0 1 0	X 		 X 		 X	Throughput class negotiation Default throughput classes assignment Throughput class indication
0 0 0 0 0 0 1 1	X 				 X	Closed user group selection (basic format) Traffic class indication
0 0 0 0 0 1 0 0	X					Charging information (requesting service)
0 0 0 0 0 1 0 1			X			Facilities that may be negotiated only when all logical channels used for virtual calls are in state p1
0 0 0 0 0 1 1 0			X			Non-negotiable facilities values
0 0 0 0 0 1 1 1				X 	 X	Diagnostic element Tariffs
0 0 0 0 1 0 0 0	X				X	Called line address modified notification
0 0 0 0 1 0 0 1	X					Closed user group with outgoing access selection (basic format)
0 0 0 0 1 0 1 0		X				Quality of service negotiation: minimum throughput class
0 0 0 0 1 0 1 1		X				Expedited data negotiation
0 0 0 0 1 1 0 0 to 0 0 1 1 1 1 1 1						Unused

TABLE I-1/X.2 *(cont.)*

Code Bits 8 7 6 5 4 3 2 1	X.25 fac	X.25 dte	X.25 reg	X.32	X.75	
CLASS B						
0 1 0 0 0 0 0 0						Unused
0 1 0 0 0 0 0 1	X				X	Bilateral closed user group selection Transit network identification
0 1 0 0 0 0 1 0	X		X		X	Flow control parameter negotiation (packet size) Non-standard default packet sizes Packet size indication
0 1 0 0 0 0 1 1	X		X		X	Flow control parameter negotiation (window size) Non-standard default window sizes Window size indication
0 1 0 0 0 1 0 0	X				X	RPOA selection (basic format) RPOA selection
0 1 0 0 0 1 0 1			X			Facilities that may be negotiated at any time
0 1 0 0 0 1 1 0			X			Availability of facilities
0 1 0 0 0 1 1 1	X					Closed user group selection (extended format)
0 1 0 0 1 0 0 0	X					Closed user group with outgoing access selection (extended format)
0 1 0 0 1 0 0 1	X				X	Transit delay selection and indication Transit delay indication
0 1 0 0 1 0 1 0					X	Clearing network identification code
0 1 0 0 1 0 1 1					X	Transit delay selection
0 1 0 0 1 1 0 0 to 0 1 0 1 1 1 1 1						Unused
0 1 1 0 0 0 0 0						Reference number (see Note)
0 1 1 0 0 0 0 1 to 0 1 1 1 1 1 1 1						Unused
CLASS C						
1 0 0 0 0 0 0 0						Unused
1 0 0 0 0 0 0 1					X	Call identifier
1 0 0 0 0 0 1 0 to 1 0 1 1 1 1 1 1						Unused

TABLE I-1/X.2 *(cont.)*

Code Bits 8 7 6 5 4 3 2 1	X.25 fac	X.25 dte	X.25 reg	X.32	X.75	
CLASS D						
1 1 0 0 0 0 0 0						Unused
1 1 0 0 0 0 0 1	X					Charging information (call duration)
1 1 0 0 0 0 1 0	X					Charging information (segment count)
1 1 0 0 0 0 1 1	X 				 X	Call redirection or call deflection notification Closed user group indication
1 1 0 0 0 1 0 0	X					RPOA selection (extended format)
1 1 0 0 0 1 0 1	X					Charging information (monetary unit)
1 1 0 0 0 1 1 0	X 				 X	NUI selection NUI
1 1 0 0 0 1 1 1					X	Closed user group with outgoing access indication
1 1 0 0 1 0 0 0			X			Logical channel types ranges
1 1 0 0 1 0 0 1		X				Called address extension
1 1 0 0 1 0 1 0		X				Quality of service negotiation: end-to-end transit delay
1 1 0 0 1 0 1 1		X				Calling address extension
1 1 0 0 1 1 0 0				X		Identity element
1 1 0 0 1 1 0 1				X		Signature element
1 1 0 0 1 1 1 0				X		Random number element
1 1 0 0 1 1 1 1				X		Signed response element
1 1 0 1 0 0 0 0				X		Temporary location
1 1 0 1 0 0 0 1	X					Call deflection selection
1 1 0 1 0 0 1 0		X				Quality of service negotiation: priority
1 1 0 1 0 0 1 1		X				Quality of service negotiation: protection
1 1 0 1 0 1 0 0 to 1 1 1 1 1 1 1 0						Unused
1 1 1 1 1 1 1 1	X	X	X	X	X	Reserved for extension

Notes to Table I-1/X.2:

X.25 fac: code used in the facility field of X.25 call set-up and/or clearing packets for X.25 facilities.

X.25 dte: code used in the facility field of X.25 call set-up and/or clearing packets for CCITT-defined DTE facilities.

X.25 reg: code used in the registration field of registration packets.

X.32: code defined in Recommendation X.32 and used in the user data field of the XID frames or the registration field of the registration packets.

X.75: code defined in Recommendation X.75 and used in the utility field of the call set-up and/or clearing packets.

Note – This value is reserved for ISO/8208.

Recommendation X.3

PACKET ASSEMBLY DISASSEMBLY FACILITY (PAD) IN A PUBLIC DATA NETWORK

(provisional, Geneva, 1977; amended at Geneva, 1980, Malaga-Torremolinos, 1984 and Melbourne 1988)

Preface

The establishment in various countries of public data networks providing packet switched data transmission services creates a need to produce standards to facilitate access from the public telephone network, circuit switched public data networks and leased circuits.

The CCITT,

considering

(a) that Recommendations X.1 and X.2 define the user classes of service and user facilities in public data networks, Recommendation X.96 defines call progress signals, Recommendation X.29 defines the procedures between a packet assembly/disassembly facility (PAD) and a packet mode DTE or another PAD, Recommendation X.28 defines the DTE/DCE interface for a start-stop mode DTE accessing the PAD;

(b) that the logical control links for packet switched data transmission services are defined in Recommendation X.92, and that in particular Recommendation X.92 allows for the incorporation of a PAD;

(c) the urgent need to allow interworking between a start-stop mode DTE on a public switched telephone network, a public switched data network or leased circuit, and a packet mode DTE or another start-stop mode DTE using the virtual call facility of the packet switched data service;

(d) that DTEs operating in the start-stop mode will send and receive network control information and user information in the form of characters or the break signals;

(e) that DTEs operating in the packet mode will send and receive network control information and user information in the form of packets in accordance with Recommendation X.25;

(f) that the packet mode DTE shall not be obliged to use the control procedures for PAD functions, but that some packet mode DTEs may wish to control specific functions of the PAD;

unanimously declares

(1) that the functions performed by, and operational characteristics of, the PAD for the start-stop mode DTE are described below in § 1, *Description of the basic functions and user selectable functions of the PAD*;

(2) that the operation of the PAD for the start-stop mode DTE should depend on the possible values of internal variables known as PAD parameters which are described below in § 2, *Characteristics of PAD parameters*;

(3) that the PAD parameters for the start-stop mode DTE and their possible values should be those which are listed below in § 3, *List of PAD parameter and possible values*;

(4) that the PAD features described in §§ 1, 2 and 3 below could be expanded by future studies to allow interworking with non packet mode DTEs other than start-stop mode DTEs.

1 Description of the basic functions and user selectable functions of the PAD

1.1 The PAD performs a number of functions and exhibits operational characteristics. Some of the functions allow either or both the start-stop mode DTE and the packet mode DTE (or remote PAD) to configure the PAD so that its operation is adapted to the start-stop mode DTE characteristics, and possible to the application.

1.2 The operation of the PAD depends on the value of the set of internal variables called PAD parameters. This set of parameters exists for each start-stop mode DTE independently. The current value of each PAD parameter defines the operational characteristics of its related function.

1.3 *Functions of the PAD*

1.3.1 Basic functions include:

- assembly of characters into packets;
- disassembly of the *user data* field of packets;
- handling of virtual call set-up and clearing, resetting and interrupt procedures;
- generation of service signals;
- a mechanism for forwarding packets when the proper conditions exist, e.g., when a packet is full or an idle timer expires;
- a mechanism for transmitting data characters, including start, stop and parity elements as appropriate to the start-stop mode DTE;
- a mechanism for handling a *break* signal from the start-stop mode DTE;
- editing of *PAD command* signals;
- a mechanism for setting and reading the current value of PAD parameters.

1.3.2 Optional functions include:

- a mechanism for the selection of a standard profile;
- automatic detection of data rate, code, parity and operational characteristics;
- a mechanism for the remote DTE to request a virtual call between the start-stop mode DTE and another DTE.

1.4 *User selectable functions which may be provided by the PAD*

A number of packet-switched data network facilities may be available either on a subscription basis or on a per call basis, to start-stop mode DTEs as described in Recommendation X.2 for user classes of service 20-22. In addition, the following features may be available on a subscription basis:

- selection of an initial profile;
- modem type, speed, code and parity to be used by the PAD;
- other operational characteristics of the DTE.

As defined in this Recommendation, parameters provide for functions which concern:

- management of the procedure between the start-stop mode DTE and the PAD;
- management of the assembly and disassembly of packets;
- a number of additional functions related to the operational characteristics of the start-stop mode DTE.

The method for the control of these functions is specified in Recommendation X.28 for the start-stop mode DTE and in Recommendation X.29 for the packet mode DTE or for another PAD.

Table 1/X.3 shows details of the valid values and combination of values of PAD parameters standardized by CCITT. Other values and combinations of values are for further study.

1.4.1 *PAD recall using a character*

This function allows the start-stop mode DTE to initiate an escape from the *data transfer* state or the *connection in progress* state in order to send *PAD command signals.*

1.4.2 *Echo*

This function provides for characters received from the start-stop mode DTE to be transmitted back to the start-stop mode DTE as well as being interpreted by the PAD.

1.4.3 *Selection of the data forwarding characters*

This function allows the selection of defined sets of character(s) received from the start-stop mode DTE to be recognized by the PAD as an indication to complete the assembly and forward a complete packet sequence as defined in Recommendation X.25.

1.4.4 *Selection of idle timer delay*

This function allows the selection of the duration of an interval between successive characters received from the start-stop mode DTE which, when exceeded, will cause the PAD to terminate the assembly of a packet and to forward it as defined in Recommendation X.255.

1.4.5 *Ancillary device control*

This function allows for flow control between the PAD and the start-stop mode DTE. The PAD indicates whether it is ready or not to accept characters from the start-stop mode DTE by transmitting special characters. These characters are those which in International Alphabet No. 5 (IA5) are used to switch an ancillary transmitting device on and off.

1.4.6 *Control of PAD service signals*

This function provides the start-stop mode DTE with the ability to decide whether or not and in what format *PAD service* signals are transmitted.

1.4.7 *Selection of operation of the PAD on receipt of the break signal*

This function allows the selection of the operation of the PAD after the receipt of a *break* signal from the start-stop mode DTE.

1.4.8 *Discard output*

This function provides for a PAD to discard the content of user sequences in packets upon request rather than disassembling and transmitting these to the start-stop mode DTE.

1.4.9 *Padding after carriage return*

This function provides for the automatic insertion by the PAD of padding characters in the character stream transmitted to the start-stop mode DTE after the occurrence of a carriage return character. This allows for the printing mechanism for the start-stop mode DTE to perform the carriage return function correctly.

1.4.10 *Line folding*

This function provides for the automatic insertion by the PAD of appropriate format effectors in the character stream transmitted to the start-stop mode DTE. The predetermined maximum number of graphic characters per line may be set.

1.4.11 *Flow control of the PAD by the start-stop mode DTE*

This function allows for flow control between the start-stop mode DTE and the PAD. The start-stop mode DTE indicates whether it is ready or not to accept characters from the PAD by transmitting special characters. These characters are those which in IA5 are used to switch an ancillary transmitting device on and off.

1.4.12 *Linefeed insertion after carriage return*

This function provides for the automatic insertion by the PAD of a linefeed character in the character stream to or from the start-stop mode DTE or after each of each carriage return character. This function applies only in the data *transfer* state.

1.4.13 *Padding after linefeed*

This function provides for the automatic insertion by the PAD of padding characters in the character stream transmitted to the start-stop DTE after the occurrence of a linefeed character. This allows for the printing mechanism of the start-stop mode DTE to perform the linefeed operation correctly. This function applies only in the *data transfer* state.

1.4.14 *Editing*

This function provides for character delete, line delete and line display editing capabilities in the *PAD command* state and the data *transfer* state for the start-stop mode DTE. During the *PAD command* state the editing function is always available.

1.4.15 *Editing PAD service signals*

This function provides the start-stop mode DTE with the ability to decide whether or not editing *PAD service* signals are transmitted and which format should be used.

1.4.16 *Echo mask*

When echo is enabled (§ 1.4.2), this function allows selected defined sets of character(s) received from the start-stop mode DTE not to be transmitted back to the start-stop mode DTE.

1.4.17 *Parity treatment*

This function allows the PAD to check parity in the data stream from the start-stop mode DTE and/or generate parity in the data stream to the start-stop mode DTE.

1.4.18 *Page wait*

This function allows the PAD to suspend transmission of additional characters to the start-stop mode DTE after a specified number of linefeed characters have been transmitted by the PAD.

2 Characteristics of PAD parameters

2.1 In this Recommendation parameters are identified by decimal reference numbers.

2.2 In this Recommendation the possible values of the parameters are represented by decimal numbers.

2.3 Specific procedures, described in Recommendations X.28 and X.29 are available for initializing, reading and changing values of PAD parameters.

2.4 *Determination of the values of PAD parameters*

2.4.1 *Initial values of PAD parameters*

On initialization, the initial value of each PAD parameter is set according to a predetermined set of values called an *initial standard profile.* Table 1/X.28 gives details of the initial values of parameters for transparent and simple standard profiles which have been agreed by CCITT.

Networks may offer other standard profiles that provide different, predetermined sets of PAD parameter values.

2.4.2 *Current values of PAD parameters*

The current values of PAD parameters are the values resulting from possible modifications by the PAD, the start-stop mode DTE and/or the packet mode DTE (or remote PAD).

3 List of PAD parameters and possible values

Restrictions on the permissible relationships between the values of the various parameters is a subject for further study.

3.1 *PAD recall using a character*

Reference 1

The Parameter will have the following selectable values:

not possible	– represented by decimal 0;
possible by character 1/0 (DLE)	– represented by decimal 1;
possible by graphic character defined by the user	– represented by decimal 32-126.

A graphic character, defined by the user to escape from the *data transfer* state and to recall the PAD, is the binary representation of the decimal value in accordance with Recommendation T.50..

3.2 *Echo*

Reference 2

The parameter will have the following selectable values:

no echo	– represented by decimal 0;
echo	– represented by decimal 1.

Note – If parameter 20 is implemented, the selection of the characters to be echoed is dependent on the value of parameter 20.

3.3 *Selection of data forwarding character(s)*

Reference 3

This parameter is respresented by the following encoding of basic functions, each having a decimal value as shown below:

no data forwarding character	– represented by decimal 0;
alphanumeric characters (A-Z, a-z, 0-9)	– represented by decimal 1;
character CR	– represented by decimal 2;
characters ESC, BEL, ENQ, ACK	– represented by decimal 4;
characters DEL, CAN, DC2	– represented by decimal 8;
characters EXT, EOT	– represented by decimal 16;
characters HT, LF, VT, FF	– represented by decimal 32;
all other characters in columns 0 and 1 of IA5 not included in above	– represented by decimal 64.

Note – The decimal representation of individual values of this parameter allows coding to represent a single function or combination of functions, see Table 1/X.3.

3.4 *Selection of idle timer delay*

Reference 4

The parameter will have the following selectable values:

any number from 0 to 255	– represented by the respective decimal number.

The value 0 will indicate that no data forwarding on time-out is required; a value between 1 and 255 will indicate the value of the delay in twentieths of a second.

Note 1 – Some PAD implementations may not offer all possible values of idle timer delay within the selectable range. In such cases where the value selected is not available, the PAD will assume the next higher available value in the range.

Note 2 – The effect of the idle timer delay on data forwarding may be subject to flow control constraints.

3.5 *Ancillary device control*

Reference 5

The parameter will have the following selectable values:

no use of X-ON (DC1) and X-OFF (DC3)	– represented by decimal 0;
use of X-ON and X-OFF (data transfer)	– represented by decimal 1;
use of X-ON and X-OFF (data transfer and command)	– represented by decimal 2.

3.6 *Control of PAD service signals and PAD command signals*

Reference 6

The parameter is represented by the following encoding of basic functions, each having a decimal value as shown below:

no service signals are transmitted to the start-stop mode DTE	– represented by decimal 0;
service signals other than the *prompt PAD service signal* are transmitted in the standard format	– represented by decimal 1;
prompt PAD service signal is transmitted in the standard format	– represented by decimal 4;
PAD service signals are transmitted in a network-dependent format	– represented by decimal 8-15.

PAD service signals and PAD command signals in the extended dialogue mode format:

extended dialogue mode handling, with *PAD service* signals in English	– represented by decimal 16;
extended dialogue mode handling, with *PAD service* signals in French	– represented by decimal 32;
extended dialogue mode handling, with *PAD service* signals in Spanish	– represented by decimal 48.

Note 1 – The decimal representation of individual values of this parameter allows coding to represent a single function or combination of functions, see Table 1/X.3. The transmission of service signals is controlled by the values 0, 1, 4 and 5. In addition, the actual text of the service signal is controlled by the values 16 and above.

Note 2 – Values of 64 to 240 in multiples of 16 represent additional languages provided on a network dependent basis.

Note 3 – Values of 16 to 240 in multiples of 16 may be combined with values 8-15 to provide a network-dependent extended dialogue mode (e.g. a value of 41 is equivalent to 32+9, network-dependent French).

Note 4 – To enable or disable service signals in the extended dialogue mode, the values 16-240 in multiples of 16 can be combined with; 0 for no service signals, 1 for service signals other than the prompt, and 5 (4+1) for service signals and the prompt.

3.7 *Selection of operation of PAD on receipt of break signal from the start-stop mode DTE*

Reference 7

This parameter is represented by the following encoding of basic functions, each having a decimal value as shown below:

nothing	– represented by decimal 0;
send to packet mode DTE or other PAD an *interrupt* packet	– represented by decimal 1;
reset	– represented by decimal 2;
send to packet mode DTE or other PAD an *indication of break PAD* message	– represented by decimal 4;
escape from *data transfer* state	– represented by decimal 8;
discard output to start-stop mode DTE	– represented by decimal 16.

Note – The decimal reprsentation of individual values of this parameter allows coding to represent a single function or combination of functions, see Table 1/X.3.

3.8 *Discard output*

Reference 8

The parameter will have the following selectable values:

normal data delivery to the start-stop mode DTE	– represented by decimal 0;
discard output to start-stop mode DTE	– represented by decimal 1.

3.9 *Padding after carriage return*

Reference 9

The parameter will have the following selectable values:

any number from 0 to 255	– represented by the respective decimal number

A value between 0 and 255 will indicate the number of padding characters to be generated by the PAD after a carriage return character is transmitted to the start-stop mode DTE.

When parameter 9 is 0, there will be no padding except that *PAD service* signals will contain a number of padding characters according to the data rate of the start-stop mode DTE.

3.10 *Line folding*

Reference 10

The parameter will have the following selectable values:

no line folding	– represented by decimal 0;
any value between 1 and 255	– represented by the respective decimal number.

A value between 1 and 255 will indicate the number of graphic characters per line that will be transmitted by the PAD without inserting appropriate format effectors.

3.11 *Binary speed*

This parameter is a read-only parameter and cannot be changed by either of the DTEs. It enables the packet-mode DTE to access a characteristic of the start-stop mode DTE which is known by the PAD.

Reference 11

The parameter will have the following values:

50	bit/s	–	represented by decimal 10;
75	bit/s	–	represented by decimal 5;
100	bit/s	–	represented by decimal 9;

110	bit/s	–	represented by decimal 0;
134.5	bit/s	–	represented by decimal 1;
150	bit/s	–	represented by decimal 6;
200	bit/s	–	represented by decimal 8;
300	bit/s	–	represented by decimal 2;
600	bit/s	–	represented by decimal 4;
1 200	bit/s	–	represented by decimal 3;
1 800	bit/s	–	represented by decimal 7;
75/1 200	bit/s	–	represented by decimal 11;
2 400	bit/s	–	represented by decimal 12;
4 800	bit/s	–	represented by decimal 13;
9 600	bit/s	–	represented by decimal 14;
19 200	bit/s	–	represented by decimal 15;
48 000	bit/s	–	represented by decimal 16;
56 000	bit/s	–	represented by decimal 17;
64 000	bit/s	–	represented by decimal 18;

Note – The values implemented in individual PADs depend on the range of DTE data transmission rates which are supported. The allocation of decimal values to all known rates is to avoid revision of the Recommendation in the future.

3.12 *Flow control of the PAD by the start-stop mode DTE*

Reference 12

The parameter will have the following selectable values:

no use of X-ON (DC1) and X-OFF (DC3) for flow control	– represented by decimal 0;
use of X-ON and X-OFF for flow control	– represented by decimal 1.

3.13 *Linefeed insertion after carriage return*

Reference 13

This parameter is represented by the following encoding of basic functions, each having a decimal value as shown below:

no linefeed insertion	– represented by decimal 0;
insert linefeed after each carriage return in the data stream *to* the start-stop DTE	– represented by decimal 1;
insert linefeed after each carriage return in the data stream *from* the start-stop mode DTE	– represented by decimal 2;
insert linefeed after each carriage return in the echo stream to the start-stop mode DTE	– represented by decimal 4.

Note 1 – The decimal representation of individual values of this parameter allows coding to represent a single function or combination of functions, see Table 1/X.3.

Note 2 – This function applies only in the *data transfer* state.

3.14 *Linefeed padding*

Reference 14

The parameter will have the following selectable values:

any number from 0 to 255	– represented by the respective decimal number.

A value between 0 and 255 will indicate the number of padding characters to be generated by the PAD after a linefeed character is transmitted to the start-stop mode DTE during the data transfer state.

3.15 *Editing*

Reference 15

The parameter will have the following selectable values:

no use of editing in the *data transfer* state	– represented by decimal 0;
use of editing in the *data transfer* state	– represented by decimal 1.

The use of value 1 suspends the following operations of the PAD:

a) data forwarding on full packet until the editing buffer is full,

b) data forwarding on idle timer period expiry.

Note – The value of parameter 4 remains unchanged.

3.16 *Character delete*

Reference 16

The parameter will have the following selectable values:

one character from IA5	– represented by decimal 0-127.

The character defined by the user for character delete is the binary representation of the decimal value in accordance with Recommendation T.50.

3.17 *Line delete*

Reference 17

The parameter will have the following selectable values:

one character from IA5	– represented by decimal 0-127.

The character defined by the user for line delete is the binary representation of the decimal value in accordance with Recommendation T.50.

3.18 *Line display*

Reference 18

The parameter will have the following selectable values:

one character from IA5	– represented by decimal 0-127.

The character defined by the user for line display is the binary representation of the decimal value in accordance with Recommendation T.50.

3.19 *Editing PAD service signals*

Reference 19

The parameter will have the following selectable values:

no editing *PAD service* signals	– represented by decimal 0;
editing *PAD service* signals for printing terminals	– represented by decimal 1;
editing *PAD service* signals for display terminals	– represented by decimal 2;
editing *PAD service* signals using one character from the range of IA5	– represented by decimal 8 and 32-126.

Note – This parameter does not apply if the value of parameter 6 is set to 0.

3.20 *Echo mask*

Reference 20

This parameter is represented by the following encoding of basic functions, each having a decimal value as shown below:

no echo mask (all characters echoed)	– represented by decimal 0;
no echo of character CR	– represented by decimal 1;
no echo of character LF	– represented by decimal 2;
no echo of characters VT, HT, FF	– represented by decimal 4;
no echo of characters BEL, BS	– represented by decimal 8;
no echo of characters ESC, ENQ	– represented by decimal 16;
no echo of characters ACK, NAK, STX, SOH, EOT, ETB, ETX	– represented by decimal 32;
no echo of editing characters as designated by parameters 16, 17 and 18	– represented by decimal 64;
no echo of all other characters in columns 0 and 1 of IA5 not mentioned above, and the character DEL	– represented by decimal 128.

Note 1 – The decimal representation of individual values of this parameter allows coding to represent a single function or combination of functions, see Table 1/X.3.

Note 2 – If parameter 5, 12 or 22 is set to a non-zero value, then X-ON and X-OFF are not echoed.

Note 3 – The PAD recall character specified by the value of parameter 1 is not echoed.

Note 4 – A character need only be specified by a single value of parameter 20 in order for it not to be echoed.

Note 5 – This parameter applies only when parameter 2 is set to 1.

Note 6 – Parameter 20 value 64 (in combination) does not apply if editing is not enabled.

3.21 *Parity treatment*

Reference 21

This parameter will have the following selectable values:

no parity checking or generation	– represented by decimal 0;
parity checking	– represented by decimal 1;
parity generation	– represented by decimal 2.

Note 1 – The decimal representation of individual values of this parameter allows coding to represent a single function or a combination of functions, see Table 1/X.3.

Note 2 – Characters generated by the PAD itself (e.g. *PAD service signals*) have even parity when parameter 21 is set to zero unless the parity is determined by alternate means.

3.22 *Page wait*

Reference 22

This parameter will have the following selectable values:

page wait disabled	– represented by decimal 0;
page wait condition after *n* linefeed characters are sent by the PAD to the start-stop mode DTE	– represented by decimal 1-255.

TABLE 1/X.3

Possible values and combination of values of PAD parameters (Note 1)

Parameter reference number	Parameter description	Selectable possible values		PAD parameter meaning	Remarks
		Mandatory	Optional (Note 2)		
1	PAD recall using a character (E)	0		Not possible	
		1		Character DLE	
			32 to 126	Possible; using one graphic character defined by user	
2	Echo (E)	0		No echo	
		1		Echo	
3	Selection of character(s) (E) *data forwarding*	0		No *data forwarding* character(s)	
			1	Alphanumeric characters (A-Z, a-z, 0-9)	
		2		Character CR	
			4	Characters ESC, BEL, ENQ, ACK	
			6	Characters CR, ESC, BEL, ENQ, ACK	Value formed by combination (2+4)
			8	Characters DEL, CAN, DC2	
			16	Characters ETX, EOT	
			18	Characters CR, EOT, ETX	Value formed by combination (2+16)
			32	Characters HT, LF, VT, FF	
			64	All characters in columns 0 and 1 of IA5 except those shown above for values 2, 4, 8, 16, 32	
				Values 3, 5-7, 9-15, 17-31, 33-63, 65-125 127 may be formed by combinations of values 1, 2, 4, 8, 16, 32, 64	
		126		All characters in columns 0 and 1 and character DEL	Value formed by combination (2+4+8+16 +32+64)
4	Selection of idle timer delay (E)	0 20 255	1 to 19 21 to 254	Value of idle timer in twentieths of a second	(Note 3)
5	Ancillary device control (E)	0		No use of X-ON (DC1) and X-OFF (DC3)	
		1		Use of X-ON and X-OFF (data transfer)	
			2	Use of X-ON and X-OFF (data transfer and command)	

Recommendation X.3
Table 1/X.3 in the box at the cross-point o f "parameter reference number 3" and "parameter description" "Selection of data forward character(s) (E)" of which, the words "data forward" should be in italics.

TABLE 1/X.3 *(cont.)*

Parameter reference number	Parameter description	Selectable possible values		PAD parameter meaning	Remarks
		Mandatory	Optional (Note 2)		
6	Control of *PAD service* signals and PAD *command* signals (E)	0		No *PAD service* signals are transmitted to the start-stop mode DTE	
		1		*PAD service* signals are transmitted in the standard format	
			5	*PAD service* signals and the *prompt PAD service* signal are transmitted in the standard format	Value formed by combination (1+4)
			8 to 15	*PAD service* signals are transmitted in a network dependent format	
			16	Extended dialog mode, *PAD service* signals are in English	
			32	Extended dialog mode, *PAD service* signals are in French	
			48	Extended dialog mode, *PAD service* signals are in Spanish	
7	Selection of operation of the PAD on receipt of break signal from the start-stop mode DTE (E)	0		Nothing	
			1	Interrupt	
		2		Reset	
			4	Send to DTE an indication of *break PAD message*	
			5	Interrupt and indication of break	Value formed by combination (1+4)
		8		Escape from *data transfer* state	
			16	Discard output, to start-stop mode DTE	
		21		Discard output, interrupt and indication of break	Value formed by combination (1+4+16)
				Values 3, 4, 6, 7, 9-20, 22-31 may be formed by combination of values 1, 2, 4, 8, 16	
8	Discard output (E)	0		Normal data delivery	
		1		Discard output	
9	Padding after carriage return (CR) (E)	0		No padding after CR (Note 4)	
		1 to 7	8 to 255	Number of padding characters inserted after CR	

Parameter reference number	Parameter description	Selectable possible values		PAD parameter meaning	Remarks
		Mandatory	Optional (Note 2)		
10	Line folding (E)	0		No line folding	
		1 to 255		Number of graphic characters per line	
11 (read only)	Binary speed of start-stop mode DTE (E)	0		110 bit/s	The values implemented in individual PADs depend on the range of DTE data transmission rates which are supported. The allocation of decimal values to all known rates is to avoid revision of the Recommendation in the future
			1	134.5 bit/s	
		2		300 bit/s	
			3	1 200 bit/s	
			4	600 bit/s	
			5	75 bit/s	
			6	150 bit/s	
			7	1 800 bit/s	
			8	200 bit/s	
			9	100 bit/s	
			10	50 bit/s	
			11	75/1 200 bit/s	
			12	2 400 bit/s	
			13	4 800 bit/s	
			14	9 600 bit/s	
			15	19 200 bit/s	
			16	48 000 bit/s	
			17	56 000 bit/s	
			18	64 000 bit/s	
12	Flow control of the PAD (E)	0		No use of X-ON (DC1) and X-OFF (DC3) for flow control	
		1		Use of X-ON (DC1) and X-OFF (DC3) for flow control	
13	Linefeed insertion after carriage return (A)	0		No linefeed insertion	
		1		Insert linefeed after transmission of CR to the start-stop mode DTE	
			2	Insert linefeed after each carriage return in the data stream from the start-stop mode DTE	
		4		Insert linefeed after echo of CR to start-stop mode DTE	
		5		Insert linefeed after transmission to the start-stop mode DTE and after echo of CR	Combination (1 + 4)
		6		Insert linefeed in data stream after CR from the start-stop mode DTE and after echo of a CR to the start-stop mode DTE	Combination (2 + 4)
		7		Insert linefeed in the data stream to and from the start-stop mode DTE and after echo of a CR to the start-stop mode DTE	Combination (1 + 2 + 4) *Note* – Applies only to *data transfer* state

TABLE 1/X.3 *(cont.)*

Parameter reference number	Parameter description	Selectable possible values		PAD parameter meaning	Remarks
		Mandatory	Optional (Note 2)		
14	Padding after linefeed (A)	0		No padding after linefeed	*Note* – Applies only to *data transfer* state
		1 to 7	8 to 255	Number of padding characters inserted after linefeed	
15 (Note 5)	Editing (A)	0		No use of editing in the *data transfer* state	
		1		Use of editing in the *data transfer* state	
16 (Note 5)	Character delete (A)		0 to 126	One character from IA5	
		127		Character 7/15 (DEL)	
17 (Note 5)	Line delete (A)		0 to 23	One character from range of IA5	
		24		Character 1/8 (CAN)	
			25 to 127	One character from range of IA5	
18 (Note 5)	Line display (A)		0 to 17	One character from IA5	
		18		Character 1/2 (DC2)	
			19 to 127	One character from IA5	
19 (Note 5)	Editing PAD service signals (A)		0	No editing *PAD service* signals	
		1		Editing *PAD service* signals for printing terminals	
			2	Editing *PAD service* signals for display terminals	
			8 32 to 126	Editing *PAD service* signals using one character from the range of IA5	
20 (Notes 6 and 7)	Echo mask (A)	0		No echo mask (all characters echoed)	Values may be formed by combination of basic values
			1	No echo of CR	
			2	No echo of LF	
			4	No echo of VT, HT, FF	
			8	No echo of BEL, BS	
			16	No echo of ESC, ENQ	
			32	No echo of ACK, NAK, STX, SOH, EOT, ETB, ETX	
			64	No echo of editing characters as designated by Parameters 16, 17, 18 (Note 8)	
			128	No echo of all other characters in columns 0 and 1 not mentioned above and DEL	

TABLE 1/X.3 *(end)*

Parameter reference number	Parameter description	Selectable possible values		PAD parameter meaning	Remarks
		Mandatory	Optional (Note 2)		
21 (Note 9)	Parity treatment (A)	0		No parity checking or generation	
			1	Parity checking	
			2	Parity generation	
			3	Parity checking and parity generation	Value formed by combination (1+2)
22	Page wait (A)	0		Page wait disabled	
		23	1 to 22 24 to 255	Number of line feed characters considered by the PAD for the page wait function	

E An essential parameter to be made available internationally.

A An additional parameter which may be available on certain data networks and may also be available internationally.

Note 1 – Other values and possible combination of values are for further study.

Note 2 – These parameter values provide additional user facilities which are not necessarily provided in all PADs.

Note 3 – Some PAD implementations may not offer all possible values of idle timer delay within the selectable range. In such cases where the value selected is not available, the PAD will assume the next higher value available.

Note 4 – There is no padding after CR except that *PAD service* signals will contain a number of padding characters according to the data signalling rate of the start-stop mode DTE.

Note 5 – When parameter 15 is implemented, the values of parameters 16, 17, 18 and 19 are either default values or are selectable from the optional range shown. The editing function is provided during the *PAD command* state whether parameter 15 is implemented or not. If parameters 16, 17, 18 and 19 are implemented, the editing characters and editing *PAD service* signals during the *PAD command* state are defined by the appropriate values of these parameters. If parameters 16, 17, 18 and 19 are not implemented, the default values for the functions of these parameters are applicable to the *PAD command* state.

Note 6 – This parameter does not apply if parameter 2 is set to zero.

Note 7 – If parameter 5, 12 or 22 is set to a nonzero value, then the X-ON and X-OFF characters are not echoed.

Note 8 – Parameter 20 value 64 (in combination) does not apply if editing is not enabled.

Note 9 – Characters generated by the PAD itself (e.g., *PAD service* signals) have even parity when parameter 21 is set to zero unless the parity is determined by alternate means.

GENERAL STRUCTURE OF SIGNALS OF INTERNATIONAL ALPHABET No. 5 CODE FOR CHARACTER ORIENTED DATA TRANSMISSION OVER PUBLIC DATA NETWORKS[1)]

(Geneva, 1976; amended at Geneva, 1980 and Melbourne, 1988)

The CCITT,

I *considering, firstly,*

the agreement between the International Organization for Standardization (ISO) and the CCITT on the main characteristics of a seven-unit alphabet (International Alphabet No. 5) to be used for data transmission and for telecommunications requirements that cannot be met by the existing five-unit International Telegraph Alphabet No. 2;

the interest, both to the users and to the telecommunication services, of an agreement concerning the chronological order of transmission of bits in serial working;

recommends

that the agreed rank number of the unit in the alphabetical table of combinations should correspond to the chronological order of transmission in serial working on telecommunication circuits;

that, when this rank in the combination represents the order of the bit in binary numbering, the bits should be transmitted in serial working with the low order bit first;

that the numerical meaning corresponding to each information unit considered in isolation is that of the digit:

0 for a unit corresponding to condition A (travail = space), and

1 for a unit corresponding to condition Z (repos = mark),

in accordance with the definitions of these conditions for a two-condition transmission system;

II *considering, moreover,*

that it is often desirable, in character oriented data and messages transmission, to add an extra "parity" unit to allow for the detection of errors in received signals;

the possibility offered by this addition for the detection of faults in terminal equipment;

the need to reserve the possibility of making this addition during the transmission itself, after the seven information units proper have been sent;

recommends

that signals of International Alphabet No. 5 code for data and messages transmission should in general include an additional "parity" unit;

that the rank of this unit and, hence, the chronological order of the transmission in serial working should be the eighth of the combination thus completed;

III *considering*

that, in start-stop systems working with electromechanical equipment, the margin of such equipment and the reliability of the connection are considerably increased by the use of a stop element corresponding to the duration of two-unit intervals of the modulation;

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1) See Recommendation V.4 for data transmission over public telephone networks.

that for start-stop systems using International Alphabet No. 5 at modulation rates of 200 and 300 bauds, Recommendations X.1 and S.31 specify that transmit devices should use a stop element lasting at least two units;

that the previously expressed preference for a two-unit stop element arises from a transmission point of view where anisochronous public data networks are concerned;

recommends

that in start-stop systems using combinations of International Alphabet No. 5 normally followed by a parity unit, the first information unit of the transmitted combination should be preceded by a start element corresponding to condition A (space);

that the duration of this start element should be a one-unit interval for the modulation rate under consideration, at transmitter output;

that the combination of seven information units, normally completed by its parity unit, should be followed by a stop element corresponding to condition Z (mark);

that for public anisochronous data networks, data terminal equipment using International Alphabet No. 5 should comply with Recommendations X.1 and S.31 and use a stop element lasting at least two units;

that the start-stop receivers should be capable of correctly receiving start-stop signals from a source which appears to have a nominal cycle of 10 units (i.e., with a nominal one-unit stop element). However, for certain electromechanical equipment the receivers may only be capable of correctly receiving signals when the stop element is not reduced below one unit (even in the presence of distortion);

IV *considering, finally,*

that the direction of the parity unit can only be that of the even parity on the perforated tapes, particularly owing to the possibility of deletion (combination 7/15 of the alphabet) which causes a hole to appear in all tracks;

that, on the other hand, the odd parity is considered essential in the equipment which depends on transitions in the signals to maintain synchronism [in cases where combination 1/6 (SYNC) of the alphabet does not permit an economical solution];

recommends

that the parity unit of the signal should correspond to the even parity in links or connections operated on the principle of the start-stop system;

that this parity should be odd on links or connections using end-to-end character oriented synchronous operation;

that arrangements should be made when necessary to reverse the direction of the parity unit at the input and output of the synchronous equipment connected either to apparatus working on the start-stop principle or receiving characters on perforated tape;

that the detection of a character out-of-parity may be represented by:

a) a reverse question mark graphic character or a representation of the capital letter SB (see ISO 2047) provided that this letter occupies a single character position on a screen or printer, and which could have been entered by a single key stroke. It is recognized that it may be difficult to achieve a legible "SB" character from some matrix printers or displays where the characters are printed; or

b) a recording of the 1/10 (SUB) character in the tape or other storage medium, where provided.

Where a SUB character occurs in a received transmisson, or is presented to a DTE via a storage medium, e.g. paper tape, then the reaction should be as in a) and b) above.

Recommendation X.10

CATEGORIES OF ACCESS FOR DATA TERMINAL EQUIPMENT (DTE) TO PUBLIC DATA TRANSMISSION SERVICES

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

The CCITT,

considering

(a) that Recommendation X.1 defines the international user classes of service in public data networks (PDNs) and ISDN;

(b) that Recommendation X.2 defines the international user services and facilities in PDNs;

(c) that Recommendation X.3 defines the Packet Assembly/Disassembly facility (PAD) in packet switched public data networks;

(d) that Recommendation I.411 defines the reference configurations for access to ISDN services, including Terminal Adaptor (TA) functional grouping;

(e) that Recommendations X.30 (I.461), X.31 (I.462) and the I.230 series, define the circuit switched and packet switched data transmission services available from ISDN (including through Terminal Adaptors);

(f) the desirability for the users to have defined the various possibilities and requirements for accessing the different public data transmission services,

unanimously recommends

that categories of access for data terminal equipment (DTE) to the data transmission services provided by PDNs and by ISDNs through Terminal Adaptors should be as defined in this Recommendation.

1 Scope

This Recommendation defines the different categories of access for data terminal equipment to the different data transmission services provided by public data networks (PDNs) as defined in Recommendation X.2 and by ISDNs (including through Terminal Adaptors) as defined in Recommendations X.30 (I.461) X.31 (I.462) and the I.230 series, namely:

i) circuit switched data transmission services;

ii) packet switched data transmission services;

iii) leased circuit data transmission services.

The categories of access described in this Recommendation take into account direct connections (see Note) to public data networks and ISDNs and the various access cases where interworking with other public networks is involved. Access to the packet switched data transmission service via the PAD function as defined in Recommendation X.3 is also covered in this Recommendation.

Note – Direct connections may be provided by means of leased circuits or by dedicated access circuits.

2 General

Access for data terminal equipment to data transmission services may be achieved by either of the following (see Note):

a) by direct connection of the DTE to the public data network or ISDNs;

b) or by switched connection of the DTE to a PDN via an intermediate public network of another type (including a PDN, PSTN or ISDN);

c) or by switched connection of the DTE to an ISDN (including through a Terminal Adaptor) via an intermediate public network of another type.

For example, packet mode terminals may access the public packet switched data transmission service, in user classes of service 8 to 11, either directly or via a switched connection. The switched connection will be established using a circuit switched data network or a public switched telephone network. In both switched cases an interworking function will be required to access the packet switched data transmission service.

Note – It is not mandatory for Administrations to provide all the categories of access contained in this Recommendation.

3 Categories of access

§ 3.1 specifies the categories of access to the data transmission services provided by PDNs for the direct connection case.

§ 3.2 specifies the categories of access to the data transmission services provided by PDNs for the switched connection case.

§ 3.3 specifies the categories of access to the data transmission services provided by ISDNs through Terminal Adaptors for the direct connection case.

§ 3.4 specifies the categories of access to the data transmission services provided by ISDNs through Terminal Adaptors for the switched connection case.

3.1 *Direct connection to data transmission services provided by public data networks*

TABLE 1/X.10

Start-stop direct connection to a circuit switched data transmission service

(see Notes 1 and 2)

Category of access	Data signalling rate	DTE/DCE interface requirements
A1 A2	50 to 200 bit/s 300 bit/s	See Recommendations X.20 and X.20 *bis*

TABLE 2/X.10

Synchronous direct connection to a circuit switched data transmission service

(see Note 1)

Category of access	Data signalling rate	DTE/DCE interface requirements
B1 B2 B3 B4 B5 B6	600 bit/s 2 400 bit/s 4 800 bit/s 9 600 bit/s 48 000 bit/s 64 000 bit/s	See Recommendations X.21 and X.21 *bis*

TABLE 3/X.10

Start-stop direct connection to a packet switched data transmission service

(see Notes 1 and 2)

Category of access	Data signalling rate	DTE/DCE interface requirements
C1	110 bit/s	See Recommendation X.28
C2	200 bit/s	
C3	300 bit/s	
C4	1 200 bit/s	
C5	75/1 200 bit/s	
C6	2 400 bit/s	

TABLE 4/X.10

Synchronous direct connection to a packet switched data transmission service

(see Note 1)

Category of access	Data signalling rate	DTE/DCE interface requirements
D1	2 400 bit/s	See Recommendations X.25 and X.31 (case A) (see Note 3)
D2	4 800 bit/s	
D3	9 600 bit/s	
D4	48 000 bit/s	
D5	64 000 bit/s	

TABLE 5/X.10

Start-stop direct connection to a leased circuit data transmission service

(see Note 2)

Category of access	Data signalling rate	DTE/DCE interface requirements
E1	50 to 200 bit/s	See Recommendations X.20 and X.20 *bis*
E2	300 bit/s	

TABLE 6/X.10

Synchronous direct connection to a leased circuit data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements
F1	600 bit/s	See Recommendations X.21 and X.21 *bis*
F2	2 400 bit/s	
F3	4 800 bit/s	
F4	9 600 bit/s	
F5	48 000 bit/s	

3.2 *Switched connection to data transmission services provided by public data networks*

TABLE 7/X.10

Synchronous switched connection by means of the PSTN to a circuit switched data transmission service

For further study.

TABLE 8/X.10

Start-stop switched connection by means of a CSPDN to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements
K1	300 bit/s	See Recommendation X.28

TABLE 9/X.10

Start-stop switched connection by means of the PSTN to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements
L1	110 bit/s	See Recommendation X.28
L2	200 bit/s	
L3	300 bit/s	
L4	1 200 bit/s	
L5	75/1 200 bit/s	
L6	2 400 bit/s	

TABLE 10/X.10

Synchronous switched connection by means of a CSPDN to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements
O1	2 400 bit/s	See Recommendation X.32
O2	4 800 bit/s	
O3	9 600 bit/s	
O4	48 000 bit/s	
O5	64 000 bit/s	

TABLE 11/X.10

Synchronous switched connection by means of the PSTN to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements
P1	1 200 bit/s	See Recommendation X.32
P2	2 400 bit/s	
P3	4 800 bit/s	
P4	9 600 bit/s	

TABLE 12/X.10

Synchronous switched access by means of an ISDN B channel to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements at	
		Reference point S/T	Reference point R
Q1 Q2 Q3 Q4 Q5	2 400 bit/s 4 800 bit/s 9 600 bit/s 48 000 bit/s 64 000 bit/s	See Recommendation X.31 (case A) and Recommendation X.32	See Recommendation X.32

3.3 *Direct connection to data transmission services provided by ISDNs (including through Terminal Adaptors)*

TABLE 13/X.10

Synchronous direct connection to a circuit switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements at	
		Reference point S/T	Reference point R
S1 S2 S3 S4 S5 S6	600 bit/s 2 400 bit/s 4 800 bit/s 9 600 bit/s 48 000 bit/s 64 000 bit/s	See Recommendation X.30	See Recommendations X.21 and X.21 *bis*

TABLE 14/X.10

Synchronous direct connection via the ISDN B channel to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements at	
		Reference point S/T	Reference point R
T1 T2 T3 T4 T5	2 400 bit/s 4 800 bit/s 9 600 bit/s 48 000 bit/s 64 000 bit/s	See Recommendation X.31 (case B)	See Recommendation X.25

TABLE 15/X.10

Synchronous direct connection via the ISDN D channel to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements at	
		Reference point S/T	Reference point R
U1 U2 U3 U4 U5	2 400 bit/s 4 800 bit/s 9 600 bit/s 48 000 bit/s (see Note 4) 64 000 bit/s (see Note 4)	See Recommendation X.31	See Recommendation X.25

3.4 *Switched connection to data transmission services provided by ISDNs (including through Terminal Adaptors)*

TABLE 16/X.10

Start-stop switched connection by means of the PSTN to a packet switched data transmission service

For further study.

TABLE 17/X.10

Synchronous switched connection by means of a CSPDN to a packet switched data transmission service

For further study.

TABLE 18/X.10

Synchronous switched connection by means of the PSTN to a packet switched data transmission service

For further study.

TABLE 19/X.10

Synchronous switched connection by means of an ISDN B channel to a packet switched data transmission service

Category of access	Data signalling rate	DTE/DCE interface requirements at	
		Reference point S/T	Reference point R
Y1 Y2 Y3 Y4 Y5	2 400 bit/s 4 800 bit/s 9 600 bit/s 48 000 bit/s 64 000 bit/s	See Recommendation X.31 (case B)	See Recommendation X.25

Note 1 – Direct connections may be provided by means of leased circuits or by dedicated access circuits.

Note 2 – Some Administrations may offer the categories of access of 600 bit/s, 1200 bit/s, 2400 bit/s, 4800 bit/s and 9600 bit/s.

Note 3 – Recommendation X.31 (case A) is appropriate at the S/T reference point when category of access D5 is provided by means of ISDN B channel.

Note 4 – For 64 kbit/s D channel only.

SECTION 2

INTERFACES

Recommendation X.20

INTERFACE BETWEEN DATA TERMINAL EQUIPMENT (DTE) AND DATA CIRCUIT-TERMINATING EQUIPMENT (DCE) FOR START-STOP TRANSMISSION SERVICES ON PUBLIC DATA NETWORKS

(Geneva, 1972; amended at Geneva, 1976 and 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

The CCITT,

considering

(a) that Recommendations X.1 and X.2 define the services and facilities to be provided by a public data network;

(b) that Recommendation X.92 defines the hypothetical reference connections for public synchronous data networks;

(c) that Recommendation X.96 defines *call progress* signals;

(d) that the necessary elements for an interface Recommendation should be defined in architectural levels;

(e) that it is desirable for characteristics of the interface between the DTE and DCE of a public data network to be standardized,

unanimously recommends

that the interface between the DTE and DCE in public data networks for user classes of service employing start-stop transmission should be as defined in this Recommendation.

1 Scope

1.1 This Recommendation defines the physical characteristics and call control procedures for a general purpose interface between DTE and DCE for user classes of service, as defined in Recommendation X.1, employing start-stop transmission.

1.2 The formats and procedures for *selection*, *call progress* and *DCE provided information* are included in this Recommendation.

1.3 The provision for duplex operation is covered.

2 DTE/DCE physical interface elements

2.1 *Interchange circuits*

A list of the interchange circuits concerned is presented in Table 1/X.20. Definitions of these interchange circuits are given in Recommendation X.24.

TABLE 1/X.20

Interchange circuit	Interchange circuit name	Direction	
		to DCE	from DCE
G (see Note)	Signal ground or common return		
G_a	DTE common return	X	
G_b	DCE common return		X
T	Transmit	X	
R	Receive		X

Note – This conductor may be used to reduce environmental signal interference at the interface. In case of shielded interconnecting cable, the additional connection considerations are part of Recommendations X.24 and ISO 4903.

2.2 *Electrical characteristics*

The electrical characteristics of the interchange circuits at the DCE side of the interface will comply with Recommendation X.26.

The electrical characteristics at the DTE side of the interface may be applied according to Recommendations X.26, X.27 (without cable termination in the load), or Recommendation V.28.

For interworking between a V.28-DTE and a X.26-DCE refer to Recommendation X.26 and ISO 4903.

2.3 *Mechanical characteristics*

Refer to ISO 4903 (15-pole DTE/DCE interface connector and contact number assignments) for mechanical arrangements.

2.4 *Fault conditions of interchange circuits*

For the association of the receiver circuit-failure detection to particular interchange circuits in accordance with the type of failure detection, see Recommendation X.26, § 11 and Recommendation X.27, § 9.

2.4.1 *Circuit R in failure state*

The DTE should interpret a fault condition on circuit R as r = 0, using failure detection type 2. When the electrical characteristics are applied according to Recommendation V.28, the DTE should interpret generator in power-off condition or open-circuited interconnecting cable as a binary 0.

2.4.2 *Circuit T in failure state*

The DCE will interpret a fault condition on circuit T as t = 0, using failure detection type 2.

3 **Call control characters and error checking**

All characters for call control purposes are selected from International Alphabet No. 5 according to Recommendation T.50.

Even parity according to Recommendation X.4 applies for IA5 characters interchanged for call control purposes.

4 Elements of the call control phase for circuit switched service

The state diagram provided in Figure A-1/X.20 shows the relationship between the various *call control* phase states as defined below, together with the recognized transactions between these states under normal operating conditions. Illustrated examples of the time sequence relationships between these states and associated time-out operation are provided in Figure B-1/X.20.

The *call control* phase can be terminated by either the DTE or the DCE by *clearing* as defined in § 6 below.

4.1 *Events of the call control procedures*

(See Figure A-1/X.20.)

4.1.1 *Ready (state 1)*

Circuits T and R show binary 0.

4.1.2 *Call request (state 2)*

The calling DTE shall indicate a request for a call by signalling steady binary condition t = 1 provided that it was previously signalling *DTE ready* (t = 0).

4.1.3 *Proceed-to-select (state 3)*

When the network is prepared to receive selection information, the DCE will signal steady binary condition r = 1.

The *proceed-to-select* signal will start within 6 seconds of the *call request* being sent.

4.1.4 *Selection signal sequence (state 4)*

The *selection* signal sequence shall be transmitted by the DTE on circuit T.

The format of *selection* signal sequence is defined in § 4.6.1 below.

The information content and coding of the *selection* signal sequence is contained in Annex G and Recommendation X.121.

The *selection* signal sequence shall start within 6 seconds of the *proceed-to-select* being received and shall be completed within 36 seconds.

The maximum permissible interval between individual selection characters is 6 seconds.

4.1.5 *DTE waiting (state 5)*

During *DTE waiting*, the DTE signals steady binary condition t = 1.

4.1.6 *Incoming call (state 8)*

The DCE will indicate an incoming call by signalling steady binary condition r = 1.

4.1.7 *Call accepted (state 9)*

The DTE shall accept the incoming call not later than 600 ms by signalling the steady state binary condition t = 1.

10-100 ms thereafter, the DTE transmits the call control character 0/6 (ACK).

4.1.8 *Call not accepted (state 18)*

If the DTE does not wish to accept the incoming call it shall signal this not later than 600 ms by changing circuit T to steady binary condition 1.

10-100 ms thereafter, the DTE shall transmit the call control character 1/5 (NAK) followed by *DTE clear request* (state 13).

4.1.9 *Call progress signal sequence (state 6)*

The *call progress* signal sequence will be transmitted by the DCE to the calling DTE on the R circuit when an appropriate condition is encountered by the network.

A *call progress* signal sequence will consist of one or more *call progress* signal blocks. A *call progress* signal block will consist of one or more *call progress* signals.

The format of the *call progress* signal sequence is defined in § 4.6.2 below.

The coding of *call progress* signals is provided in Annex E.

The description of *call progress* signals is provided in Recommendation X.96.

A *call progress* signal sequence will be transmitted by the DCE within 60 seconds of: 1) the *end-of-selection* signal or 2) in case of *direct call*, the *proceed-to-select* signal being sent by the DTE. The *call progress* signal sequence, however, will not be sent by the DCE before the reception of the *end-of-selection* signal except in the case of expiration of time-outs described in § 4.1.4 where there may be a *call progress* signal sequence followed by the *clear indication.*

Note – When an error is detected in a received *call progress* signal sequence, the DTE may choose to either ignore the signal or attempt a new call after clearing.

4.1.10 *DCE provided information sequence (states 7A and 7B)*

The *DCE provided information* sequences will be transmitted by a DCE to the calling DTE (state 7A) or a called DTE (state 7B) on circuit R.

A *DCE provided information* sequence will consist of 1 or more *DCE provided information* blocks. Each *DCE provided information* block will be limited to a maximum length of 128 characters.

The format of the *DCE provided information* sequences is defined in § 4.6.3 below.

The information content of *DCE provided information* is given in Annex G.

A *DCE provided information* sequence (state 7B) will be sent to the called DTE within 60 seconds of the *call accepted* signal being sent.

4.1.10.1 *Line identification*

Calling and *called line identification* is an optional additional facility.

The information content of *calling* and *called line identification* is provided in Annex G.

Calling and *called line identification* will be transmitted by the DCE on the R circuit during states 7B or 7A respectively.

When provided, *called line identification* (state 7A) will be transmitted by the DCE to the calling DTE after all *call progress* signals, if any.

When provided, *calling line identification* (state 7B) will be transmitted by the DCE to the called DTE after *call accepted* has been sent by the DTE.

In the case where the *calling line identification* facility is not provided by the originating network, or the *called line identification* facility is not provided by the destination network, a *dummy line identification* shall be provided by the DCE to the DTE.

4.1.10.2 *Charging information*

Charging information is an optional additional facility provided during state 7B.

Upon completion of clearing the call for which *charging information* has been requested, the DCE will, within 200 ms after entering *ready* (state 1), establish an incoming call to the DTE for the purpose of giving *charging information.*

Charging information will be transmitted by the DCE on circuit R.

The DCE will send *clear indication* (state 16) upon sending the last *charging information* block. The DTE should send *clear request* (state 13) when it has correctly received the *charging information* signal, if the DCE has not previously signalled the *clear indication.*

The format of *charging information* is defined in § 4.6.3 below.

4.1.11 *Connected (state 10)*

The DCE signals that the connection is being established by the transmission of the call control character 0/6 (ACK) on circuit R. Because of possible switching delays in the network, the DTE must keep circuit T in steady binary condition 1 during this state.

4.1.12 *Ready for data (state 11)*

20 ms after the reception of the call control character 0/6 (ACK) in state 10, the connection is available for data transfer between both DTEs.

4.1.13 *Events of the call control procedures for multipoint circuit-switched service*

4.1.13.1 *Ready (state 1)*

See § 4.1.1.

4.1.13.2 *Call request (state 2)*

See § 4.1.2.

4.1.13.3 *Proceed to select (state 3)*

See § 4.1.3.

4.1.13.4 *Selection signal sequence (state 4)*

See § 4.1.4.

A *facility request* signal is used to indicate the category of the point to multipoint service which is required.

The coding is defined in Annex F.

4.1.13.5 *DTE waiting (state 5)*

See § 4.1.5.

4.1.13.6 *Incoming call (state 8)*

See § 4.1.6.

4.1.13.7 *Call accepted (state 9)*

See § 4.1.7.

4.1.13.8 *Call not accepted (state 18)*

See § 4.1.8.

4.1.13.9 *Call progress signal sequence (state 6)*

See § 4.1.9.

The *call progress* signals related to each of the called DTEs are transmitted and then, in the same order, the *called line identification* signals of the different called DTEs.

When no specific *call progress* signals are necessary for a given called DTE, then the call progress signal "00" is used for this DTE so that the order could be kept.

4.1.13.10 *DCE provided information sequence (states 7A and 7B)*

The DCE provided information sequences will be transmitted by a DCE to the calling DTE (state 7A) or a called DTE (state 7B) on circuit R.

A DCE provided information sequence will consist of one or more *DCE provided information* blocks. Each *DCE provided information* block will be limited to a maximum length of 128 characters, except for *called line identification* in case of multipoint calls where the maximum length is 512 characters.

The format of the *DCE provided information* sequences is defined in § 4.6.3 below.

The information content of DCE provided information is given in Annex G.

A *DCE provided information* sequence will be sent to the called DTE within 60 seconds of the call accepted signal being sent.

4.1.13.10.1 *Line identification*

See § 4.1.10.1.

The *called line identification* related to the different called DTEs are provided in sequence.

4.1.13.10.2 *Charging information*

See § 4.1.10.2.

4.1.13.11 *Connected (state 10)*

See § 4.1.11.

4.1.13.12 *Ready for data (state 11)*

See § 4.1.12.

4.2 *Unsuccessful call*

If the required connection cannot be established, the DCE will indicate this and the reason to the calling DTE by means of a *call progress* signal. Afterwards the DCE will signal *DCE clear indication* (state 16).

4.3 *Call collision (state 19)*

A *call collision* is detected by the DCE when it receives *call request* in response to an *incoming call.* The DCE may either accept the *call request* or may perform *DCE clearing.*

4.4 *Direct call*

For the *direct call* facility, *selection* signals (state 4) are always bypassed.

Note – The *direct call* facility can only be provided on a subscription basis and not on a per-call basis.

4.5 *Facility registration/cancellation procedure*

Registration/cancellation of optional user facilities shall be carried out by a DTE in accordance with normal call establishment procedures using the *selection* sequence, which is defined in § 4.6.1 below.

The format of the *facility registration/cancellation* signal is defined in § 4.6.1.3 below.

The *facility registration/cancellation* procedure shall not be combined with establishment of a normally addressed call, but shall be taken as an independent procedure.

In response to acceptance or rejection of the *facility registration/cancellation* procedure, the network will provide the appropriate *call progress* signal followed by *clear indication.*

4.6 *Selection, call progress and DCE provided information formats*

(See also Annex D for a syntactic description of the formats.)

4.6.1 *Format of selection sequence*

A selection sequence shall consist of a *facility request* block, or an *address* block, or a *facility request* block followed by an *address* block, or a *facility registration/cancellation* block.

4.6.1.1 *Facility request block*

A *facility request* block shall consist of one or more *facility request* signals.

Multiple *facility request* signals shall be separated by character 2/12 (" , ").

A *facility request* signal shall consist of a *facility request* code and may contain one or more *facility* parameters. The *facility request* code, *facility* parameter and subsequent *facility* parameters shall be separated by character 2/15 (" / "). For an interim period the 2/15 (" / ") separator will not be used in some networks.

The end of a *facility request* block shall be indicated by character 2/13 ("–").

The coding of *facility request*, indicator and parameter is provided in Annex F.

4.6.1.2 *Address block*

An *address* block shall consist of one or more *address* signals.

An *address* signal shall consist of either a *full address* signal or an *abbreviated address* signal.

Start of an *abbreviated address* signal shall be indicated by a prefix character 2/14 (" . ").

Multiple *address* signals shall be separated by character 2/12 (" , ").

4.6.1.3 *Facility registration/cancellation block*

A *facility registration/cancellation* block shall consist of one or more *facility registration/cancellation* signals.

A *facility registration/cancellation* signal shall consist of up to four elements in order: *facility request* code, *indicator*, *registration* parameter, *address* signal.

The elements of a *facility registration/cancellation* signal shall be separated by character 2/15 (" / ").

If a *facility registration/cancellation* signal contains less than four of the elements, the elements should be eliminated in reverse order (e.g. a two-element *facility registration/cancellation* signal will contain the *facility request* code " / " *indicator*). If any element to be sent within the sequence is not required, a 3/0 ("0") character should be inserted in the position of each missing element (e.g. *facility request* code /0/0/*Address* signal).

Multiple *facility registration/cancellation* signals shall be separated by character 2/12 (" , ").

The end of a *facility registration/cancellation* block shall be indicated by character 2/13 ("–") followed by character 2/11 ("+").

4.6.1.4 *End of selection sequence*

The end of a selection sequence shall be indicated by character 2/11 ("+").

4.6.2 *Format of a call progress sequence*

A *call progress* block shall consist of one or more *call progress* signals.

Each *call progress* signal need not be repeated.

Multiple *call progress* signals shall be separated by characters 0/13 ("CR") and 0/10 ("LF").

The end of a *call progress* block shall be indicated by character 2/11 ("+").

4.6.3 *Formats of DCE provided information*

The following formats are specified for *DCE provided information* signals which have been identified.

The *DCE provided information* shall be preceded by the IA5 characters 0/13 ("CR"), 0/10 ("LF"), and except for *calling* and *called line identification,* by the IA5 character 2/15 (" / "). To distinguish between different types of *DCE provided information,* the prefix should be followed by one or more numerical characters followed by the character 2/15 (" / ") before the actual information is presented. The end of a *DCE provided information* block shall be indicated by character 2/11 ("+"). The order in which the *DCE provided information* blocks are presented to the DTE is variable.

4.6.3.1 *Format of called and calling line identification*

Calling line identification block and *called line identification* block shall be preceded by character 2/10 (" * ").

When a *calling* or *called line identification* block contains Data Network Identification Codes (DNIC) or Data Country Codes (DCC), the blocks shall be preceded by 2 characters 2/10 (" ** ").

A *called line identification* block shall consist of one or more *called line identification* signals.

Multiple *called line identification* signals shall be separated by characters 0/13 ("CR") and 0/10 ("LF").

The end of *calling line identification* signal and *called line identification* block shall be indicated by character 2/11 ("+").

The *dummy line identification* block shall be indicated by character 2/10 (" * ") followed by 2/11 ("+").

4.6.3.2 *Format of charging information*

The *charging information* block will be preceded by characters 0/13 ("CR"), 0/10 ("LF"), and 2/15 (" / ") followed by a second IA5 numerical character (1 or 2 or 3) followed by character 2/15 (" / "). The end of the *charging information* block shall be indicated by character 2/11 ("+").

5 Data transfer phase

5.1 *Data transfer (state 12), point-to-point circuit switched service*

The events during *data transfer* are the responsibility of the DTE.

5.2 *Data transfer, leased circuit service*

5.2.1 *Ready*

Circuits T and R show binary 1.

5.2.2 *Send data (state 12S)*

Data transmitted by the DTE on circuit T are delivered to the remote DTE on circuit R.

5.2.3 *Receive data (state 12R)*

Data transmitted by a distant DTE are received on circuit R.

5.2.4 *Data transfer (state 12)*

Data are transferred on circuits T and R.

5.2.5 *Termination of data transfer*

The termination of *data transfer* is the responsibility of the DTE.

5.3 *Data transfer (state 12), centralized multipoint circuit-switched service*

The events during data transfer are the responsibility of the DTE.

6 Clearing phase

In centralized multipoint calls:

- clearing by the central DTE implies clearing of the call;
- clearing by a remote DTE clears the call for this DTE, and has no effect on the calls which remain established for the other remote DTEs;
- clearing by the last remote DTE which is still in the call leads to the clearing of the call.

6.1 *Clearing by the DTE (states 13, 14, 15)*

The DTE should indicate clearing by signalling the steady binary condition t = 0, *DTE clear request* (state 13) for more than 210 ms.

The DCE will respond within 6 seconds by signalling the steady state condition r = 0, *DCE clear confirmation* (state 14), for more than 210 ms and will not reverse circuit R to binary 1 before *DCE ready* (state 1).

Within 210-490 ms after the beginning of DCE *clear confirmation* the DTE shall be ready to accept an *incoming call*, i.e. it shall be in the state 15, *DTE ready.*

6.2 *Clearing by the DCE (states 16, 17, 15)*

The DCE will indicate clearing to the DTE by signalling the steady binary condition r = 0, *DCE clear indication* (state 16) for more than 210 ms.

Within 210-490 ms after the beginning of *DCE clear indication* , the DTE should signify *DTE clear confirmation* (state 17) by signalling the steady binary condition t = 0 for more than 210 ms.

Within 490 ms after the beginning of the *DTE clear confirmation*, the DTE shall be ready to accept an *incoming call*, i.e. it shall be in the state 15, *DTE ready.*

6.3 *DCE ready (state 1)*

490 ms after the beginning of *DCE* or *DTE clear confirmation*, respectively, the DCE is ready to accept a new *call request.*

6.4 *Clear collision*

In case *DTE clear request* and *DCE clearing* occur at the same instant or during an overlapping time of 210 ms, the DTE shall proceed in its clearing procedure.

7 Test loops

The definitions of test loops and the principles of maintenance testing using the test loops are provided in Recommendation X.150.

7.1 *DTE test loop – type 1 loop*

This loop is used as a basic test of the operation of the DTE, by looping back the transmitted signals inside the DTE for checking. The loop should be set up inside the DTE as close as possible to the DTE/DCE interface.

Circuit T is connected to circuit R of the DTE while the DTE is in test condition.

Loop 1 may be established from either the *data transfer* or *ready* state.

In some networks, for short routine tests during the *data transfer* state, the DTE should maintain the same status on the interchange circuits as before the test.

If the loop is established from the *data transfer* state, the DCE may continue to deliver data to the DTE during the test as though the DTE were in normal operation. It will be the responsibility of the DTEs to recover from any errors that might occur while the test loop is activated.

7.2 *Local test loop – type 3 loop*

Local test loops (type 3 loops) are used to test the operation of the DTE, the interconnecting cable and either all or parts of the local DCE, as discussed below.

Loop 3 may be established from any state.

For testing on leased circuits and for short duration testing on circuit-switched connections the DCE should continue to present toward the line the conditions that existed before the test (e.g. either *data transfer* or *ready* state). Where this is not practical (e.g. in some cases for loop 3a) or desirable (e.g. for long duration testing in circuit-switched applications) the DCE should terminate an existing call.

Manual control should be provided on the DCE for activation of the test loop.

The precise implementation of the test loop within the DCE is a national option. At least one of the following local loops should be implemented:

7.2.1 *Loop 3d*

This loop is used to test the operation of the DTE, including the interconnecting cable, by returning transmitted signals to the DTE for checking. The loop is set up inside the local DCE and does not include interchange circuit generators and loads.

Circuit T is connected to circuit R inside of the DCE while the DCE is in test condition.

Note – While test loop 3d is operated, the effective length of the interface cable is doubled. Therefore, to ensure proper operation of loop 3d, the maximum DTE/DCE interface cable length should be one-half the length normally appropriate for the data signalling rate in use.

7.2.2 *Loop 3c*

This loop is used to test the operation of the DTE, including the interconnecting cable and DCE interchange circuit generators and loads.

The configuration is identical to that given for loop 3d in § 7.2.1 with the exception that the looping of circuit T to circuit R includes the interchange circuit generators and loads. The note concerning restriction of interface cable length is not applicable.

7.2.3 *Loop 3b*

This loop is used as a test of the operation of the DTE and the line coding and control logic and circuitry of the DCE. It includes all the circuitry of the DCE with the exclusion of the line signal conditioning circuitry (e.g. impedance matching transformers, amplifiers, equalizers, etc.).

The configuration is identical to that given for loop 3c in § 7.2.2 except for the location of the point of loopback.

Note – In some networks the setting of loop 3b will cause clearing of existing connections.

7.2.4 *Loop 3a*

This loop is used to test the operation of the DTE and the DCE. The loop should include the maximum amount of circuitry used in DCE working including, in particular, the line signal conditioning circuitry. It is recognized that, in some cases, the inclusion of devices (e.g. attenuators, equalizers or test loop translators) may be necessary in the loopback path. The subscriber line is suitably terminated during a loop 3a test condition.

The configuration is identical to that given for test loop 3b in § 7.2.3 except for the location of the point of loopback.

Note – In some networks the setting of loop 3a will cause clearing of existing connections.

7.3 *Network test loop – type 2 loop*

Network test loops (type 2 loops) are used by the Administration's test centre to test the operation of the leased line or subscriber line and either all or part of the DCE, as discussed below.

7.3.1 *General*

Loop 2 may be controlled manually on the DCE or automatically from the network. The control of the loop and the method used for automatic control, when implemented, is a national option.

In case of a collision between *call request* and the activation of the loop, the loop activation command will have priority.

When the test is in progress, the DCE will signal r = 0.

7.3.2 *Implementation of type 2 loops*

The precise implementation of the test loop within the DCE is a national option. At least one of the following network test loops should be implemented.

7.3.2.1 *Loop 2b*

This loop is used by the Administration's test centre(s) and/or the remote DTE to test the operation of the subscriber line and all the circuitry of the DCE with the exception of interchange circuit generators and loads.

Circuit R is connected to circuit T inside of the DCE while the DCE is in loop 2b test condition.

At the interface, the DCE signal r = 0.

7.3.2.2 *Loop 2a*

This loop is used by either the Administration's test centre(s) or the remote DTE to test the operation of the subscriber line and the entire DCE.

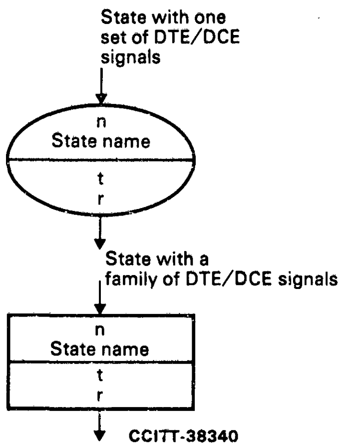
The configuration is identical to that given for loop 2b in § 7.3.2.1 except for the location of the point of loopback.

ANNEX A

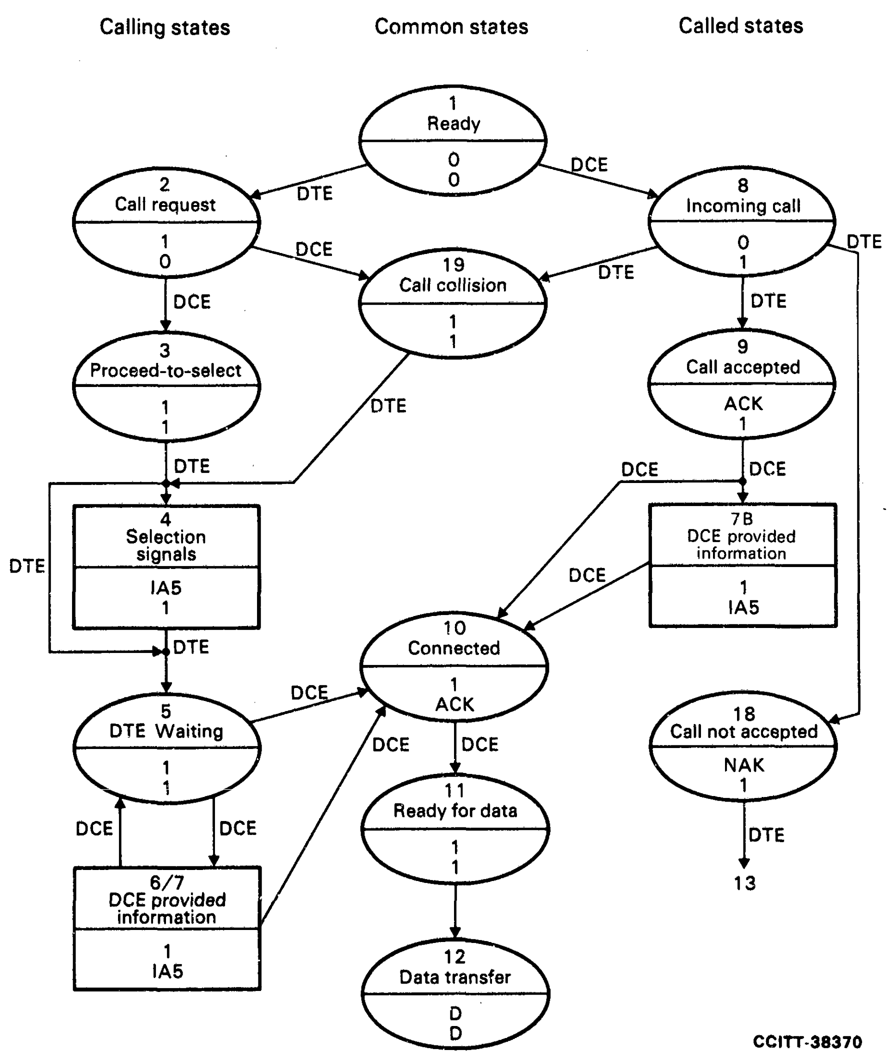
(to Recommendation X.20)

Interface signalling state diagrams

Definition of symbols used in state diagrams



n	State number
t	Signal on T circuit
r	Signal on R circuit
T	Transmit interchange circuit
R	Receive interchange circuit
D	DTE or DCE data signals
0 and 1	Steady binary conditions
X	Any value
IA5	Characters from International Alphabet No. 5 (Recommendations V.3 and X.4)
ACK	IA5 character 0/6
NAK	IA5 character 1/5
↓	Transition with indication of whether DTE or DCE is responsible for transition



Note – For simplification of the state diagram, state 6 *(call progress signals)* is merged with state 7 *(DCE provided information)*.

FIGURE A-1/X.20

Call control phase for circuit switched service

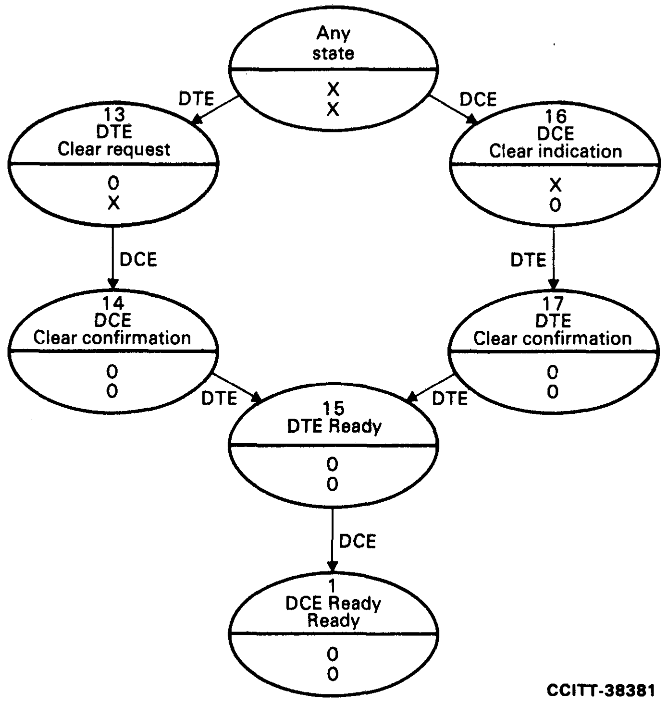


FIGURE A-2/X.20

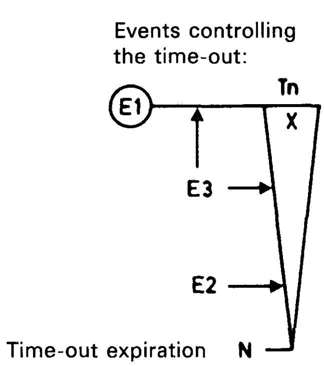
Clearing phase

ANNEX B

(to Recommendation X.20)

Interface signalling sequence diagrams and time-out operations

Definition of symbols used to illustrate time-out operation in the signalling sequence diagrams



Tn	Time-out number
X	Time-out figure in seconds
(E1)	Start of time-out at event indicated
E2	Stop of time-out at event indicated
E3	Stop, reset to zero and restart of time-out at event indicated
N	Number of the state to be entered after expiration of time-out

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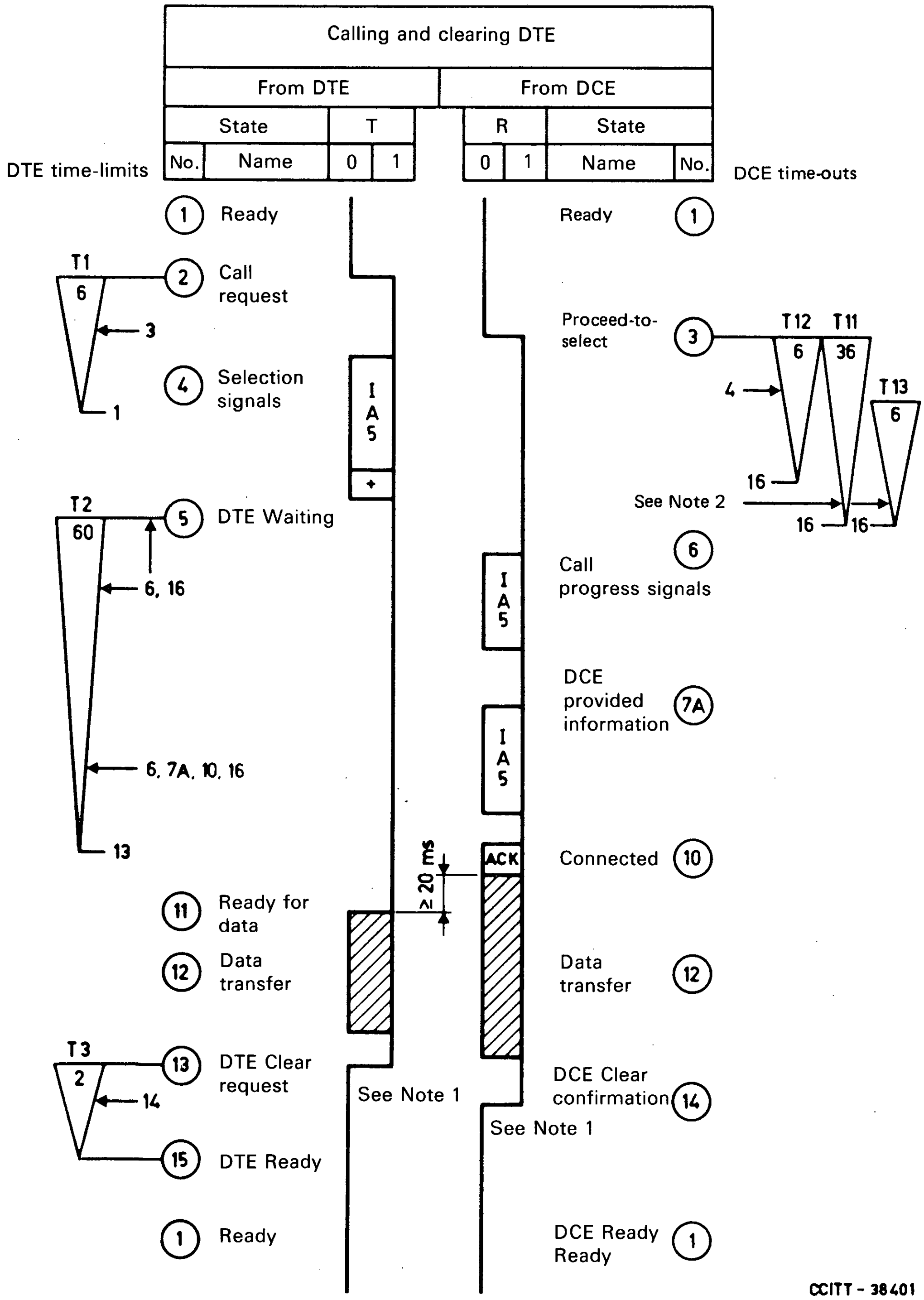
Note – For additional alternative assignments of DTE time-limits or DCE time-outs not shown together with the signalling sequence diagrams, see Table C-1/X.20.

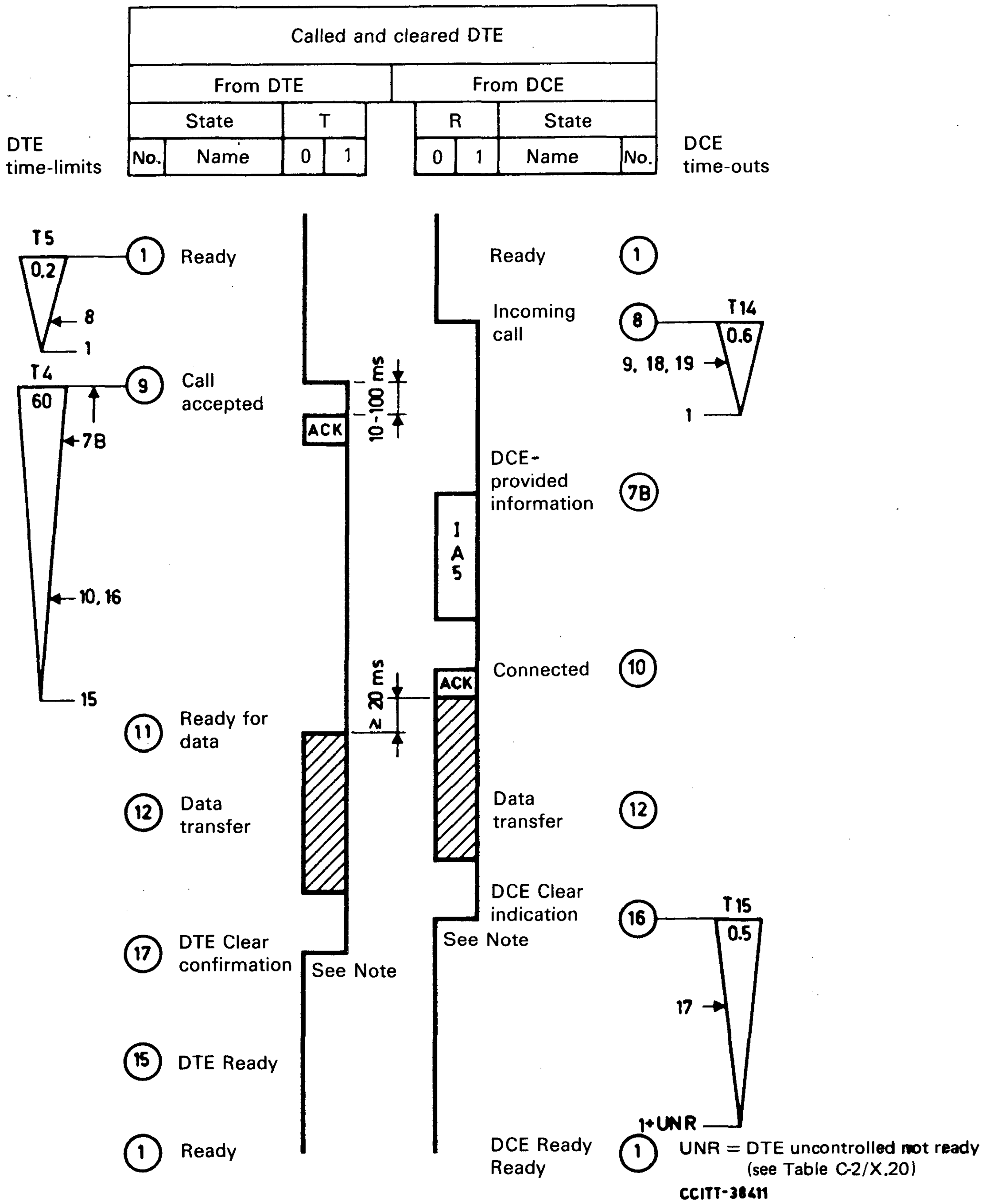


Note 1 – For proper detection, steady state conditions shall last at least 210 ms.

Note 2 – For additional alternative assignments of DTE time-limits or DCE time-outs not shown together with the signalling sequence diagrams, see Table C-1/X.20.

FIGURE B-1/X.20

Example of sequence of events: successful call and clear for circuit-switched service (calling and clearing DTE)



Note – For proper detection, steady state conditions shall last at least 210 ms.

FIGURE B-2/X.20

Example of sequence of events: successful call and clear for circuit-switched service (called and cleared DTE)

ANNEX C

(to Recommendation X.20)

DTE time-limits and DCE time-outs

C.1 *DTE time-limits*

Under certain circumstances this Recommendation requires the DCE to respond to a signal from the DTE within a stated maximum time. If any of these maximum times is exceeded, the DTE should initiate the action indicated in Table C-1/X.20. To maximize efficiency, the DTE should incorporate time-limits to send the appropriate signal under the defined circumstances summarized in Table C-1/X.20. The time-limits given in the first column are the maximum times allowed for the DCE to respond and are consequently the lower limits of the times a DTE must allow for proper network operation. A time-limit longer than the time shown may be optionally used in the DTE; for example, all DTE time-limits could have one single value equal to or greater than the longest time-limit shown in this table. However, the use of a longer time-limit will result in reduced efficiency of network utilization. The actual DCE response time should be as short as is consistent with the implementing technology and in normal operation should be well within the specified time-limit. The rare situation where a time-limit is exceeded should only occur when there is a failure in DCE operation.

C.2 *DCE time-outs*

Under certain circumstances this Recommendation requires the DTE to respond to a signal from the DCE within a stated maximum time. If any of these maximum times is exceeded, a time-out in the DCE will initiate the actions summarized in Table C-2/X.20. These constraints must be taken into account in the DTE design. The time-outs given in the first column of the table are the minimum time-out values used in the DCE for the appropriate DTE response and are consequently the maximum times available to the DTE for response to the indicated DCE action. The actual DTE response time should be as short as is consistent with the implementing technology and in normal operation should be within the specified time-out. The rare situation where a time-out is exceeded should only occur when there is a failure in the DTE operation.

TABLE C-1/X.20

DTE time-limits

Time-limit	Time-limit number	Started by	Normally terminated by	Preferred action to be taken when time-limit exceeded
6 s	T1	Signalling of *call request* (state 2)	Reception of *proceed-to-select* (state 3)	DTE signals *DTE ready* (state 1)
60 s	T2	Signalling *end-of-selection* or *DTE waiting* (direct call) (state 5)	Reception of *call progress* signals, *DCE-provided information, connected* or *DCE clear indication* (states 6, 7A, 10 or 16), reset by additional *call progress* signals (state 6)	DTE signals *DTE clear request* (state 13)
2 s	T3	Change of state to *DTE clear request* (state 13)	Change of state to *DCE clear confirmation* (state 14) or *DCE ready* (state 1)	DTE regards the DCE as DCE not ready and signals *DTE ready* (state 15)
60 s	T4	Change of state to *call accepted* (state 9)	Reception of connected or *DCE clear indication* (state 10 or 16), reset by *DCE provided information* (state 7B)	
200 ms	T5	Change of state to *ready* (state 1) when *charge information* has been requested	Reception of *incoming call* (state 8)	DTE returns to normal operation and may note absence of *charge information*

TABLE C-2/X.20

DTE time-outs

Time-out	Time-out number	Started by	Normally terminated by	Action to be taken when time-out expires
36 s	T11 (see Note)	DCE signalling of *proceed-to-select* (state 3)	DCE reception of *end-of-selection* signal	DCE will signal *DCE clear indication* (state 16) or transmit appropriate call progress signal followed by *DCE clear indication* (state 16)
6 s	T12	DCE signalling of *proceed-to-select* (state 3)	DCE reception of first selection character or in the case of *direct call, DTE waiting* (state 5)	
6 s	T13 (see Note)	DCE reception of nth selection character (state 4)	DCE reception of (n + 1)th selection character or *end-of-selection* signal	
600 ms	T14	DCE signalling of *incoming call* (state 8)	Change of state to *call accepted* (state 9) or *call not accepted* (state 18)	The DTE is noted as not answering. The DCE will signal *DCE ready* (state 1)
500 ms	T15	Change of state to *DCE clear indication* (state 16)	Change of state to *DTE clear confirmation* (state 17)	DCE will signal *DCE ready* and mark *DTE uncontrolled not ready*

Note – T11, T12 and T13 do not apply in the case of a direct call.

ANNEX D

(to Recommendation X.20)

Formats of Selection, Call Progress, and DCE-provided information signals

The following description uses Backus Normal Form as the formalism for syntactic description. A vertical line " | " separates alternatives.

<LF> : : = IA 5 character 0/10

<CR> : : = IA 5 character 0/13

<*> : : = IA 5 character 2/10

<+> : : = IA 5 character 2/11

< , > : : = IA 5 character 2/12

< – > : : = IA 5 character 2/13

< . > : : = IA 5 character 2/14

< / > : : = IA 5 character 2/15

<η> : : = IA 5 characters 3/0-3/9

< : > : : = IA 5 character 3/10

<Facility request signal> : : = See Annex F

<Facility parameter> : : = See Annex F

<Full address signal> : : = See Recommendation X.121

<Abbreviated address signal> : : = National option

<Calling line identification signal> : : = See Annex G

<Called line identification signal> : : = See Annex G

<Charging information> : : = See Annex G

<Indicator> : : = See Annex F

<Facility request code> : : = See Annex F

<Registration parameters> : : = See Annex F

<Call progress signal> : : = See Annex E

The above signals are combined as follows:

<Address signal> : : = <Full address signal> | < . > <Abbreviated address signal>

<Address block> : : = <Address signal> | <Address block> < , > <Address signal>

<Facility registration/cancellation signal> : : = <Facility request code> < / > <Indicator> < / > <Registration parameter> < / > <Address signal>

<Facility registration/cancellation block> : : = <Facility registration/cancellation signal> | <Facility registration/cancellation block> < , > <Facility registration/cancellation signal>

<Facility request signal> : : = <Facility request code> | <Facility request signal> < / > <Facility parameter>

<Facility request block> : : = <Facility request signal> | <Facility request block> < , > <Facility request signal>

<Selection sequence> : : = <Facility request block> <–> <Address block> <+> | <Facility request block> <–> <+> | <Address block> <+> | <Facility registration/cancellation block> <–> <+>

<Call progress signal> : : = <Call progress code> | <Call progress code> <–> <indicator>

<Call progress block> : : = <CR> <LF> <Call progress signal> <+> | <Call progress signal> <,> <Call progress block>

<Calling line identification> : : = <CR> <LF> <*> <Calling line identification signal> <+>

<Calling line identification (with DNIC or DCC)> : : = <CR> <LF> <**> <Calling line identification signal> <+>

<Called line identification> : : = <CR> <LF> <*> <Called line identification block> <+>

<Called line identification block> : : = <Called line identification signal> | <Called line identification block> <CR> <LF> <Called line identification signal>

<Called line identification (with DNIC or DCC)> : : = <CR> <LF> <**> <Called line identification block> <+>

<Dummy line identification> : : = <CR> <LF> <*> <+>

<DCE-provided information block> : : = <DCE-provided information signal> <+> | <DCE-provided information signal> <,> <DCE-provided information block> (see Note)

Note – For *DCE-provided information* signals and blocks other than *calling* or *called line identification* signals and blocks.

ANNEX E

(to Recommendation X.20)

Coding of call progress signals

TABLE E-1/X.20

Code group (see Note 1)	Code	Indicator	Significance	Category
0	00 01 02 03	– – – –	See Note 2 Terminal called Redirected call Connect when free	Without clearing
2	20 21 22 23	– – – –	No connection Number busy Selection signals procedure error Selection signals transmission error	With clearing due to short-term conditions
3	–	–	–	Unassigned
4 and 5	41 42 43 44 45 45 46 47 48 49 51 52	– – – – – YY-MM-DD-hh:mm – – – – – –	Access barred Changed number Not obtainable Out of order Controlled not ready DTE inactive until . . . Uncontrolled not ready DCE power off Invalid facility request Network fault in local loop Call information service Incompatible user class of service	With clearing due to long-term conditions
6	61	–	Network congestion	With clearing due to network short-term conditions
7	71 72	– –	Long-term network congestion RPOA out of order	With clearing due to network long-term conditions
8	81 82 83	– – –	Registration/cancellation confirmed Redirection activated Redirection deactivated	With clearing due to network procedure
9	Reserved for national purposes			

Note 1 – From the DTE point of view group 0 means "wait"; groups 2 and 6 mean "try again, next try may result in a call set-up"; groups 4 and 5, and 7 mean "there is no reason for the DTE to try again because the answer will be the same for a longer period of time". Since group 8 results from a procedure between the DTE and the network, no special action is expected to be taken by the DTE.

Some Administrations may specify by regulation both the delay between and the maximum number of call re-attempts permitted by a DTE in these circumstances (see Recommendation X.96).

Note 2 – Reserved for future use.

ANNEX F

(to Recommendation X.20)

Facility request, indicator, and parameter coding

(for use as appropriate in *facility request* signals and *facility registration/cancellation* signals)

TABLE F-1/X.20

(see Annex D for formats and Note 1 below)

Facility request code	Facility parameter	Indicator	Registration parameter	Address	Facility
0	–	–	–	–	Reserved for future use (may be combined with second character)
1	XX (see Note 2)	–	–	–	Closed user group (other than preferential)
2	–	–	–	–	Unassigned
3	–	–	–	–	Unassigned
45	–	1	YY-MM-DD-hh:mm	–	DTE inactive registration
45	–	2	–	–	DTE inactive cancellation
4	–	–	–	–	Reserved
50	–	–	–	–	Reserved
51	–	–	–	–	Reserved
53	–	–	–	–	Reserved
60	0, 1, 2, 3, 4	–	–	–	Multiple address calling
61	–	–	–	–	Charging information
62	–	–	–	–	Called line identification
63	–	1	–	–	Activation of redirection of call
63	–	2	–	–	Cancellation of redirection of call
63	–	3	–	–	Status of redirection of call
64	–	–	–	–	Reverse charging
65	–	1	–	AS	Direct call registration
65	–	2	–	–	Direct call cancellation
66	–	1	AAS	AS	Abbreviated address registration
66	–	2	AAS	–	Abbreviated address cancellation
68	–	–	–	–	Reserved
7	–	–	–	–	Reserved
8	–	–	–	–	Reserved
9	Reserved for national purposes				

AAS: Abbreviated address signal
AS: Address signal

Note 1 – For an interim period, the 2/15 (i.e. "/") separator in the formats will not be used in some networks.

Note 2 – XX is an index number, i.e. a key code for closed user group other than the preferential group. The index number shall be used to distinguish between parts of groups within one facility. The index number shall furthermore be chosen from IA5, column 3, positions 3/0-3/9, giving a range of possible numbers from 00 to 99.

F.1 *Multiple address calling*

This facility provides the DTE with the capability to request a category of point to multipoint service.

The coding is as follows:

<60> < / > <i> < – > <Address block> < + >

where i is numerical character with the following significance:

0 Reserved
1 Reserved
2 Reserved
3 Centralized multipoint
4 Reserved
5 Reserved

F.2 *Charging information*

This facility enables the DTE to request at the call establishment phase that charging information for the call be provided at the end of the call:

<61> < – > <Address> < + >

F.3 *Redirection of call*

This facility enables the DTE to request the network to route its incoming calls towards another address. The use of this facility is assigned for an agreed contractual period.

Activation of redirection of call – The activation of this facility is coded as follows:

<63> < / > <1> < – > < + >

Cancellation of redirection of call – The cancellation of this facility is coded as follows:

<63> < / > <2> < – > < + >

Status of redirection of call – The DTE has the capability to ask the network for the status of its redirection. The coding is as follows:

<63> < / > <3> < – > < + >

F.4 *Reverse charging*

This facility enables the DTE to request that reverse charging be applied for the call.

The coding is as follows:

<64> < – > <Address> < + >

F.5 *Abbreviated address calling*

This facility enables the DTE to define a full address by an abbreviated address.

The registration coding of an abbreviated address is as follows:

<66> < / > <1> < / > <xy> < / > <Address> < – > < + >

where

<xy> = abbreviated address corresponding to the full address,

<address> = full address

Cancellation – The coding of the cancellation of an abbreviated address is as follows:

<66> < / > <2> < / > <xy> < / > < – > < + >

The coding of the abbreviated address is as follows:

< . > <xy> < + >

F.6 *DTE inactive registration/cancellation*

This facility enables the DTE to inform the network about a period of time during which the DTE is unable to accept incoming calls for circuit-switched service.

DTE inactive registration – The activation of this facility is as follows:

<45> < / > <1> < / > <YY-MM-DD-hh:mm> < – > < + >

where

YY: year, MM: month, DD: day, hh: hour, mm: minute

IA5 characters are used for "YY", "MM", "DD", "hh", "mm", " – ", and " : ".

DTE inactive cancellation – The coding is as follows:

<45> < / > <2> < – > < + >

ANNEX G

(to Recommendation X.20)

Information content of DCE provided information

G.1 *General*

Except for the *calling* and *called line identification* , the general format for *DCE-provided information,* as defined in § 4.6.3 should apply.

The coding of the numerical character used to distinguish between different types of *DCE-provided information* is indicated in Table H-1/X.21.

G.2 *Information content of calling and called line identification*

Two formats are defined:

i) *Calling* and *called line identification* consist of the international data number as defined in Recommendation X.121 preceded by *two* prefixes 2/10 (" ** ").

   In the case where the originating network does not provide *calling line identification,* only the Data Network Identification Code (DNIC) part of the international data number preceded by two prefixes 2/10 (" ** ") may be sent in place of the *dummy line identification.*

ii) Calling and called line identification consist of the National Number (NN) or Network Terminal Number (NTN) preceded by the prefix 2/10 (" * ").

G.3 *General coding of the DCE provided information*

TABLE G-1/X.20

Coding of DCE provided information

Identifier	Meaning	Remarks
0	Reserved	
1 2 3	Charging information Charging information Charging information	See details in § G.3
4		
5	Date and time indication	See details in § G.4
6	Characteristics of the call	See details in § G.5
7	Type of call indication	See details in § G.6
8	Reserved	
9	Reserved	

G.4 *Information content of charging information*

The *charging information* will inform the subscriber of either the monetary charges for a call, the duration of the call, or the number of units used during the call.

When *charging information* is given in monetary charges for the call, n = 1 and the information shall consist of x number of integer digits optionally followed by a colon and two digits representing the fraction. The format applied is as follows:

< / > <1> < / > <X . . . >

< / > <1> < / > <X . . . > < : > <yy>

When the *charging information* is presented as the duration of a call, n = 2 and the information shall consist of x number of integer digits representing seconds. The format applied is as follows:

< / > <2> < / > <X . . . >

When the *charging information* is presented as the number of units used, n = 3, and the information shall consist of x number of integer digits representing the units. The format applied is as follows:

< / > <3> < / > <X . . . >

G.5 *Date and time indication*

The *date and time indication* will inform the subscriber of the date and time the call is established.

The format for the *date and time indication* is as follows:

< / > <5> < / > <YY-MM-DD-hh:mm>

where

<5> is the DCE-provided information identification number

YY: year, MM: month, DD: day, hh: hour, mm: minute

IA5 characters are used for "YY", "MM", "DD", "hh", "mm", "–" and ":".

G.6 *Characteristics of the call*

The *characteristics of the call* will inform the called DTE of the different facilities that have been requested by the calling DTE.

The format of the *characteristic of the call* is as follows:

< / > <6> < / > <xy>

where

x and y are two numerical characters.

Table G-2/X.20 indicates the allocation of values of these two characters to facilities.

TABLE G-2/X.20

00	Reserved
01	Reverse charging
02	Reserved
03	Reserved

G.7 *Type of call indication*

The *type of call indication* will inform the called DTE of the configuration of the incoming call.

The format of the *type of call indication* is as follows:

< / > <7> < / > <xy>

where

x and y are two numerical characters.

Table G-3/X.20 indicates the allocation of values of those two characters to different configurations of calls.

TABLE G-3/X.20

00	Reserved
01	Reserved
02	Reserved
03	Centralized multipoint
04	Reserved

G.8 *Closed user group indication*

The *closed user group indication* will inform the called DTE to which closed user group the indication call belongs.

The format of the *closed user group indication* is as follows:

< / > <81> < / > <xxxx . . . x>

where

<x> is the closed user group index number.

G.8.1 *Closed user group outgoing access indication*

The *closed user group outgoing access* indication will inform the called DTE from a DTE belonging to a closed user group with outgoing access facility. If the called DTE belongs to the same closed user group, the local user group index number will be indicated. In other cases no indication will be given.

The format of the *closed user group outgoing access indication* is as follows:

< / > <82> < / > <xx . . . x>

where

<x> is the closed user group index number.

Recommendation X.20 ***bis***

USE ON PUBLIC DATA NETWORKS OF DATA TERMINAL EQUIPMENT (DTE) WHICH IS DESIGNED FOR INTERFACING TO ASYNCHRONOUS DUPLEX V-SERIES MODEMS

(Geneva, 1976; amended at Geneva, 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

The CCITT,

considering

(a) that the interface between Data Terminal Equipment (DTE) and Data Circuit Terminating Equipment (DCE) for start-stop transmission on public data networks is specified in Recommendation X.20,

(b) that several Administrations are planning to provide as an interim measure the connection to public data networks of start-stop DTEs which are designed for interfacing to V-Series modems for start-stop transmission, *unanimously declares*

that the interface between a V-Series type DTE and a DCE in public data networks for user classes of service employing start-stop transmission should be as defined in this Recommendation.

1 Scope

This Recommendation applies to the interface between a DTE designed for interfacing to duplex V-Series modems for start-stop transmission and a DCE on public data networks.

The operation is limited to start-stop transmission at data signalling rates and character structures specified for start-stop transmission in Recommendation X.1.

The application comprises:

a) circuit switched service,

b) leased circuit service (point-to-point and centralized multipoint).

2 Interchange circuits

2.1 *Functional characteristics*

The functional characteristics of the interchange circuits concerned (see Table 1/X.20 *bis*) comply with Recommendation V.24.

TABLE 1/X.20 *bis*

Interchange circuit	
Number	Designation
102	Signal ground or common return
103	Transmitted data
104	Received data
106	Ready for sending
107	Data set ready
108/1[a)]	Connect data set to line
108/2[b)]	Data terminal ready
109	Data channel received line signal detector
125[c)]	Calling indicator
141[d)]	Local loop back
142	Test indicator

a) Used in case of automatic control of the direct call facility.

b) Used in case of switched data network service.

c) Not provided in leased circuit service.

d) Not provided in those networks which do not provide automatic activation of the test loops.

2.2 *Electrical characteristics*

The electrical characteristics of the interchange circuits comply with Recommendation V.28, using the 25-pole DTE/DCE interface connector and contact number assignments in ISO Standard 2110.

3 Use of interchange circuits

3.1 *Operation of interchange circuit 107 – Data set ready*

This circuit is used to indicate the operational functions given in Table 2/X.20 *bis.*

TABLE 2/X.20 *bis*

Condition of circuit 107	Meaning in the data network
ON	Ready for data (see Note)
OFF	DCE clear indication
OFF	DCE clear confirmation

Note – Since no circuit 105 is operated, the ON condition on circuit 106 is applied 0 to 20 milliseconds after circuit 107 is turned ON.

3.2 *Use of interchange circuits 108/1 and 108/2*

3.2.1 *Circuit 108/1 – Connect data set to line*

This circuit is used alternatively to circuit 108/2. The operational functions given in Table 3/X.20 *bis* should be indicated.

TABLE 3/X.20 *bis*

Condition of circuit 108/1	Meaning in the data network
ON	Call request for direct call (see § 3.4.1)
ON	Call accepted
OFF	DTE clear request
OFF	DTE clear confirmation (see § 3.4.4)

3.2.2 *Circuit 108/2 – Data terminal ready*

This circuit is used alternatively to circuit 108/1. The operational functions given in Table 4/X.20 *bis* should be indicated.

TABLE 4/X.20 *bis*

Condition of circuit 108/2	Meaning in the data network
ON	Call accepted
OFF	DTE clear request
OFF	DTE clear confirmation (see § 3.4.4)

3.3 *Circuit 125 – Calling indicator*

The ON condition indicates *incoming call.* The circuit will be turned OFF as follows:

– in conjunction with circuit 107 turned ON, or
– *DCE ready* is received from the network, or
– *DCE clear indication* is received from the network.

3.4 *Operational requirements for circuits 106, 107, 108/1, 108/2 and 109*

3.4.1 *Call request for direct call*

For a *direct call* facility the DTE indicates a call request by turning circuit 108/1 ON. Circuit 108/2 cannot be used for this purpose.

3.4.2 *Call accepted*

A DTE receiving an *incoming call* should turn circuit 108/1 or 108/2 from OFF to ON within 500 ms to indicate *call accepted,* otherwise the call will be cleared. A DCE presenting an *incoming call* to a DTE which already has circuit 108/2 ON will regard the ON condition on circuit 108/2 as an indication of *call accepted.*

Optionally when a DTE does not provide circuit 108/1 or 108/2, the *call accepted* signal to the network would be generated within the DCE as an answer to the *incoming call* signal received from the network. However, it may also be possible to signal to the network a *DTE controlled not ready* by a manual action on the DCE.

3.4.3 *Operation of interchange circuits 109 and 106*

The DCE switches circuit 109 to ON together with circuit 107. Circuit 106 is put to ON 0 to 20 ms after the appearance of the ON condition on circuit 107.

The circuits 109 and 106 are switched to OFF either when circuit 108 is switched to OFF or when circuit 108 is ON and the DCE signals *DCE clear indication* (see § 3.4.4).

3.4.4 *DCE clear indication and DTE clear confirmation*

DCE clear indication is signalled to the DTE by turning circuit 107 OFF. The *DTE clear confirmation,* when implemented, should be given by the DTE turning OFF circuit 108/1 or 108/2 within 500 ms after the *DCE clear indication* is signalled on circuit 107. Otherwise, the DCE may consider the DTE as being *uncontrolled not ready* until circuit 108/1 or 108/2 is turned OFF or a *ready* signal is generated by a manual action on the DCE.

Circuit 108/1 should always be able to give *DTE clear confirmation.*

Optionally, when a DTE does not turn circuit 108/2 OFF for *DTE clear confirmation* this would be automatically generated within the DCE as an answer to the *clear indication* received from the network and the DTE will be considered in the *ready* condition.

In the case when the DTE expects to have circuit 107 OFF only as a response to circuit 108/1 or 108/2 OFF, the DCE will not turn circuit 107 OFF as a *DCE clear indication* and in this case the DCE indication will not be signalled to the DTE across the interface. The necessary *DTE clear confirmation* signal will then be automatically generated within the DCE as an answer to the *clear indication* signal received from the network. The DTE may be regarded as *uncontrolled not ready* until circuit 108/1 or 108/2 is turned OFF.

3.4.5 *Centralized multipoint operation*

As the circuits 106 and 109 are always in the ON condition, the transmission disciplines must be determined by end-to-end control procedures of the DTEs.

4 Call progress signals and DCE provided information

Call progress signals and *DCE provided information* cannot be handled by V-Series DTEs.

5 Failure detection and isolation

5.1 *Fault conditions of interchange circuits*

If the DTE or DCE is unable to determine the condition of circuits 107, 108/1 or 108/2 and possibly circuits 103 and 104, it shall interpret this as an OFF condition or binary 1 (circuits 103 and 104) as specified in the relevant electrical interface specifications.

5.2 *DCE fault conditions*

If the DCE is unable to provide service (e.g. loss of incoming line signal) for a period longer than a fixed duration it will turn circuit 107 to the OFF condition. The value of this duration is network dependent.

5.3 *Test loops*

The definitions of the test loops and the principles of maintenance testing using the test loops are provided in Recommendation X.150.

5.3.1 *DTE test loop – type 1 loop*

This loop is used as a basic test of the operation of the DTE, by looping back the transmitted signals inside the DTE for checking. The loop should be set up inside the DTE as close as possible to the DTE/DCE interface.

Except as noted below, while the DTE is in loop 1 test condition:

- circuit 103 is connected to circuit 104 inside of the DTE;
- circuit 103 as presented to the DCE must be in the binary 1 condition;
- circuit 108/1 or 108/2 may be in the same condition as it was before the test;
- circuits 140 and 141, if implemented, must be in the OFF condition.

The conditions of the other interchange circuits are not specified but they should if possible permit normal working.

Loop 1 may be established from either the *data transfer* phase or the *idle* phase.

If the loop is established from the *data transfer* phase, the DCE may continue to deliver data to the DTE during the test as though the DTE were in normal operation. It will be the responsibility of the DTE to recover from any errors that might occur while the test loop is activated.

If the loop is established from the *idle* phase, the DTE should continue to monitor circuit 125 so that an incoming call may be given priority over a routine test.

5.3.2 *Local test loop – type 3 loop*

Local test loops (type 3 loops) are used to test the operation of the DTE, the interconnecting cable and either all or parts of the local DCE, as discussed below.

Where allowed by national testing principles loop 3 may be established from any state.

For testing on leased circuits and for short duration testing, on circuit-switched connections the DCE should continue to present toward the line the conditions that existed before the test (e.g. either *data transfer* or *ready* state). Where this is not practical (e.g. in some cases for loop 3a) or desirable (e.g. for long duration testing in circuit-switched applications) the DCE should terminate an existing call.

Manual control should be provided on the DCE for activation of the test loop.

The automatic activation on this loop, if provided, should be controlled by circuit 141.

The precise implementation on the test loop within the DCE is a national option. At least one of the following local test loops should be implemented.

5.3.2.1 *Loop 3d*

This loop is used to test the operation of the DTE, including the interconnecting cable, by returning transmitted signals to the DTE for checking. The loop is set up inside the local DCE and does not include interchange circuit generators and loads.

While the DCE is in the loop 3d test condition:

– circuit 103 is connected to the circuit 104;

– circuits 107 and 142 are placed in the ON condition.

Note – While test loop 3d is operated, the effective length of the interconnecting cable is doubled. Therefore, to insure proper operation of loop 3d, the maximum DTE/DCE interface cable length should be one-half the length normally appropriate for the data signalling rate in use.

5.3.2.2 *Loop 3c*

This loop is used to test the operation of the DTE, including the interconnecting cable and DCE interchange circuit generators and loads.

The configuration is identical to that given for loop 3d in § 5.3.2.1 with the exception that the looping of circuit 103 to circuit 104 includes the interchange circuit generators and loads. The notes concerning restriction of interface cable length and load input impedance are not applicable.

5.3.2.3 *Loop 3b*

This loop is used as a test of the operation of the DTE and the line coding and control logic and circuitry of the DCE. It includes all the circuitry of the DCE with the exclusion of the line signal conditioning circuitry (e.g., impedance matching transformers, amplifiers, equalizers, etc.). The delay between transmitted and received test data is a few octets. (See Note).

The configuration is identical to that given for loop 3c in § 5.3.2.2 except for the location of the point of loopback.

Note – In some networks the setting of loop 3b will cause clearing of existing connections.

5.3.2.4 *Loop 3a*

This loop is used to test the operation of the DTE and the DCE. The loop should include the maximum amount of circuitry used in DCE working including, in particular, the line signal conditioning circuitry. It is recognized that, in some cases, the inclusion of devices (e.g., attenuators, equalizers or test loop translators) may be necessary in the loopback path. The subscriber line is suitably terminated during a loop 3a test condition.

The configuration is identical to that given for test loop 3b in § 5.3.2.3 except for the location of the point of loopback.

Note – In some networks the setting of loop 3a will cause clearing of existing connections.

5.3.3 *Network test loop – type 2 loop*

Network test loops (test 2 loops) are used by the Administration's test centre to test the operation of the leased line or subscriber line and either all or part of the DCE, as discussed below.

Where, allowed by national testing principles loop 2 may be used by a DTE, as follows:

a) In the case of switched circuit networks in the *data transfer* phase to test the operation of the network connection including the remote DCE. It should be possible to reenter the *data transfer* phase after completion of the network loop test.

b) In the case of leased lines in the *idle* phase to test the operation of the line including the remote DCE. When the test is in progress the DCE will return circuits 107 and 109 in the OFF condition, circuit 104 in the binary 1 condition and circuit 142 in the ON condition.

The loop may be controlled manually by a switch on the DCE or automatically by the network. The control of the loop and the method used for automatic control, when implemented, is a national option.

In case of a collision between a *call request* and the activation of the loop, the loop activation command will have priority and the call request is ignored.

The precise implementation of the test loop within the DCE is a national option. One of the following network test loops should be implemented:

5.3.3.1 *Loop 2b*

This loop is used by the Administration's test centre(s) and/or the remote DTE to test the operation of the subscriber line and all the circuitry of the DCE with the exception of interchange circuit generators and loads.

While the DCE is in the loop 2b test condition:

- circuit 104 is connected to circuit 103 inside of the DCE,
- at the interface, the DCE places circuit 104 in the binary 1 condition and circuit 109 in the OFF condition, or alternatively, may present an open circuit or power off condition on circuits 104 and 109,
- circuits 106, 107 and 125 to the DTE are placed in the OFF condition,
- circuit 142 to the DTE is placed in the ON condition.

5.3.3.2 *Loop 2a*

This loop is used by either the Administration's test centre(s) or the remote DTE to test the operation of the subscriber line and the entire DCE.

The configuration is identical to that given for loop 2b in § 5.3.3.1 except for the location of the point of loopback.

5.3.4 *Subscriber-line test loop – type 4 loop*

Subscriber-line test loops (type 4 loops) are provided for the maintenance of lines by the Administrations.

5.3.4.1 *Loop 4a*

This loop is only provided in the case of 4-wire subscriber lines. Loop 4a is for the maintenance of lines by Administrations. When receiving and transmitting pairs are connected together, the resulting circuit cannot be considered normal. Loop 4a may be established inside the DCE or in a separate device.

While the DCE is in the loop 4a test condition:

- circuit 104 to the DTE is placed in the binary 1 condition,
- circuits 106, 107, 109 and 125 to the DTE are placed in the OFF condition,
- circuit 142 to the DTE is placed in the ON condition.

5.3.4.2 *Loop 4b*

This loop is used by Administrations to test the operation of the subscriber line including the line signal conditioning circuitry in the DCE. When the receiving and transmitting circuits are connected at this point, loop 4b provides a connection that can be considered as normal; however, some impairment of the performance is expected since the DCE does not perform a complete signal regeneration.

The configuration is identical to that given for loop 4a in § 5.3.4.1 except for the location of the point of loopback.

Recommendation X.21

INTERFACE BETWEEN DATA TERMINAL EQUIPMENT (DTE) AND DATA CIRCUIT-TERMINATING EQUIPMENT (DCE) FOR SYNCHRONOUS OPERATION ON PUBLIC DATA NETWORKS

(Geneva, 1972; amended at Geneva, 1976 and 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

CONTENTS

Preface

The CCITT,

considering

(a) that Recommendations X.1 and X.2 define the services and facilities to be provided by a public data network;

(b) that Recommendation X.92 defines the hypothetical reference connections for synchronous public data networks;

(c) that Recommendation X.96 defines *call progress* signals;

(d) that the necessary elements for an interface Recommendation should be defined in architectural levels;

(e) that it is desirable for characteristics of the interface between the DTE and DCE of a public data network to be standardized,

unanimously declares the view

that the interface between the DTE and DCE in public data networks for user classes of service employing synchronous transmission should be as defined in this Recommendation.

1 Scope

1.1 This Recommendation defines the physical characteristics and call control procedures for a general purpose interface between DTE and DCE for user classes of service, as defined in Recommendation X.1, employing synchronous transmission.

1.2 The formats and procedures for *selection, call progress* and *DCE-provided information* are included in this Recommendation.

1.3 The prcvision for duplex operation is covered.

1.4 The operation of the interface for half duplex operation when the data circuit interconnects with Recommendation X.21 *bis* DTEs is described in Annex E. Half duplex operation between X.21 DTEs is for further study when such new facilities are identified.

2 DTE/DCE physical interface elements

2.1 *Electrical characteristics*

2.1.1 *Data signalling rates of 9600 bit/s and below*

The electrical characteristics of the interchange circuits at the DCE side of the interface will comply with Recommendation X.27 without cable termination in the load. The electrical characteristics at the DTE side of the interface may be applied according to either Recommendation X.27 either with or without cable termination in the load, or Recommendation X.26. The B′ leads of receivers in an X.26 DTE must be brought out to the interface individually and not connected together. (See § 2.2 below.)

Note – In certain instances where X.27 circuits are implemented on both sides of the interface, it may be necessary to add either serial impedance matching resistors or parallel cable terminating resistors as specified in X.27 to assure proper operation of the interchange circuits.

2.1.2 *Data signalling rates above 9600 bit/s*

The electrical characteristics of the interchange circuits at both the DCE side and the DTE side of the interface will comply with Recommendation X.27 with or without implementation of the cable termination in the load.

2.2 *Mechanical characteristics*

Refer to ISO 4903 (15-pole DTE/DCE interface connector and contact number assignments) for mechanical arrangements.

2.3 *Functional characteristics of interchange circuits*

Definitions of the interchange circuits concerned (see Table 1/X.21) are given in Recommendation X.24.

In this Recommendation, signal conditions on interchange circuits T, C, R, and I are designated by t, c, r, and i, respectively.

Signal conditions on circuit C (*Control*) and I (*Indication*) refer to continuous ON (significant level binary 0) and continuous OFF (significant level binary 1) conditions.

TABLE 1/X.21

Interchange circuit	Name	Direction		Remarks
		to DCE	from DCE	
G	Signal ground or common return			See Note 1
G_a	DTE common return	X		
T	Transmit	X		
R	Receive		X	
C	Control	X		
I	Indication		X	
S	Signal element timing		X	See Note 2
B	Byte timing		X	See Note 3
X	DTE signal element timing	X		See Note 4

Note 1 – This conductor may be used to reduce environmental signal interference at the interface. In the case of shielded interconnecting cable, the additional connection considerations are part of Recommendation X.24 and ISO 4903.

Note 2 – Timing for continuous isochronous data transmission will be provided.

Note 3 – May be provided as an optional additional facility (see § 3.1.1 below).

Note 4 – The use and the termination of this circuit by the DCE is a national matter.

2.4 *Physical link control conditions*

The DTE and DCE shall be prepared to send steady binary conditions 0 and 1 on circuit R or T, together with associated conditions on circuit C or I, for a period of at least 24 bit intervals. Detection of steady binary 0 or 1 on circuit R or T for 16 contiguous bit intervals with the associated condition on circuit I or C may be interpreted by the DTE or DCE as a steady state condition.

If the DTE (or DCE) recognizes that the device on the other side of the interface is signalling recognition of the current state, then the DTE (or DCE) may begin signalling the next valid state. If the DTE (or DCE) is not ready to begin signalling the next valid state, it is obliged to continue signalling the current state until it is so ready.

Note – As for state 12, § 5.1 has precedence over this § 2.4.

2.5 *Quiescent phase*

During the quiescent phase, the DTE and the DCE signal their ability to enter operational phases such as the call control phase or the data transfer phase as defined for the appropriate service. The basic quiescent signals of the DTE and the DCE can appear at the interface in various combinations which result in different interface states as defined below and shown in Figure A-1/X.21.

2.5.1 *DTE quiescent signals*

2.5.1.1 *DTE ready*

The DTE indicates its readiness to enter operational phases, according to the appropriate service, by signalling t = 1, c = OFF.

2.5.1.2 *DTE uncontrolled not ready*

The DTE indicates that it is unable to enter operational phases, according to the appropriate service, generally because of abnormal operating conditions, by signalling t = 0, c = OFF.

For leased circuit service point-to-point when the DTE enters *DTE uncontrolled not ready*, the remote interface may signal r = 0, i = OFF. Additional actions to be taken by the DCE are for further study.

For leased circuit-centralized multipoint when a DTE enters *DTE uncontrolled not ready*, no indication of this signal will be given at the other connected DTE/DCE interfaces.

2.5.1.3 *DTE controlled not ready*

DTE controlled not ready indicates that, although the DTE is operational, it is temporarily unable to accept incoming calls for circuit switched service.

This signal is indicated by t = 01 ... (alternate bits are binary 0 and binary 1), c = OFF. This signal shall persist for a minimum of 24 bit intervals.

Note – *DTE controlled not ready* is normally entered from the *ready* state, as defined in § 2.5.3.1 below. In some networks, the DCE may not recognize the *DTE controlled not ready* signal if the DTE does not first signal *DTE ready* at the same time the DCE signals *DCE ready.*

2.5.2 *DCE quiescent signals*

2.5.2.1 *DCE ready*

The DCE indicates its readiness to enter operational phases, according to the appropriate service, by signalling r = 1, i = OFF.

2.5.2.2 *DCE not ready*

DCE not ready indicates that no service is available and will be signalled whenever possible during network fault conditions and when test loops are activated. This signal is indicated by r = 0, i = OFF.

2.5.2.3 *DCE controlled not ready*

DCE controlled not ready indicates that, although the DCE is operational, it is temporarily unable to render service.

This signal is indicatd by r = 01 ... (alternate bits are binary 0 and binary 1), i = OFF. This signal shall persist for a minimum of 24 bit intervals.

Note 1 – *DCE controlled not ready* may be entered from any state.

Note 2 – *DCE controlled not ready* may be provided as an optional facility.

2.5.3 *Quiescent states* (see Figure A-1/X.21)

2.5.3.1 *Ready (state 1)*

Ready is entered when the DTE and the DCE simultaneously signal *DTE ready* and *DCE ready*, respectively.

2.5.3.2 *State 14*

State 14 is entered when the DTE and the DCE simultaneously signal *DTE controlled not ready* and *DCE ready*, respectively.

2.5.3.3 *State 18*

State 18 is entered when the DTE and the DCE simultaneously signal *DTE ready* and *DCE not ready*, respectively.

2.5.3.4 *State 22*

State 22 is entered when the DTE and the DCE simultaneously signal *DTE uncontrolled not ready* and *DCE not ready*, respectively.

2.5.3.5 *State 23*

State 23 is entered when the DTE and the DCE simultaneously signal *DTE controlled not ready* and *DCE not ready*, respectively.

2.5.3.6 *State 24*

State 24 is entered when the DTE and the DCE simultaneously signal *DTE uncontrolled not ready* and *DCE ready*, respectively.

2.6 *Failure detection*

2.6.1 *Fault conditions of interchange circuits*[1)]

The DTE should interpret a fault condition on circuit R as r = 0, using failure detection type 2, a fault condition on circuit I as i = OFF, using failure detection type 1, and a fault condition on both circuits R and I as r = 0, i = OFF, *DCE not ready*. Alternatively, a fault condition on one of these circuits, R or I, may be interpreted by the DTE as *DCE not ready*, r = 0, i = OFF using failure detection type 3.

The DCE will interpret a fault condition on circuit T as t = 0, using failure detection type 2, a fault condition on circuit C as c = OFF, using failure detection type 1, and a fault condition on both circuits T and C as t = 0, c = OFF, *DTE uncontrolled not ready*. Alternatively, a fault condition on one of these circuits, T or C, may be interpreted by the DCE as *DTE uncontrolled not ready*, t = 0, c = OFF using failure detection type 3.

2.6.2 *DCE fault conditions*

If the DCE is unable to provide service (e.g., loss of alignment or loss of incoming line signal) after a period longer than a fixed duration, it will indicate *DCE not ready* by signalling r = 0, i = OFF (see § 2.5.2.2 above). The value of that duration is network dependent. Prior to this *DCE not ready* signal, the DTE should be prepared to receive garbled signals or contiguous binary 1 on circuit R with i = ON.

2.6.3 *Signal element timing provision*

The signal element timing signal is delivered to the DTE on circuit S whenever possible, even when the DCE loses alignment or the incoming line signal. The signal element timing rate should in no case deviate from the nominal value by more than ± 1%.

[1)] For the association of the receiver circuit-failure detection to particular interchange circuits in accordance with the type of failure detection, see Recommendation X.26, § 11 and Recommendation X.27, § 9.

3 Alignment of call control characters and error checking

All characters for call control purposes are selected from International Alphabet No. 5 according to Recommendation T.50.

3.1 *Character alignment*

For the interchange of information between the DTE and the DCE for call control purposes, it is necessary to establish correct alignment of characters. Each sequence of call control characters to and from the DCE shall be preceded by two or more contiguous 1/6 (SYN) characters.

3.1.1 Certain Administrations will require the DTE to align call control characters transmitted from the DTE to either SYN characters delivered to the DTE or to signals on the byte timing interchange circuit.

Administrations who require this alignment shall provide the byte timing interchange circuit, but its use and termination by the DTE shall not be mandatory.

3.1.2 Certain Administrations will permit call control characters to be transmitted from the DTE independently of the SYN characters delivered to the DTE.

3.1.3 Additionally, for an intermediate period (see Note), Administrations will provide connection to the public data network of DTEs operating as described in § 3.1.2 above.

Note – The intermediate period would be determined by customer demand and other relevant factors as interpreted by individual Administrations.

3.2 *Error checking*

Odd parity according to Recommendation X.4 applies for IA5 characters interchanged for call control purposes.

4 Elements of the call control phase for circuit switched service

The state diagram provided in Figure A-2/X.21, shows the relationship between the various *call control* phase states as defined below, together with the recognized transactions between these states under normal operating conditions. Illustrated examples of the time sequence relationships between these states and associated time-out operation are provided in Figures B-1/X.21 and B-2/X.21.

States which are indicated by an IA5 character on circuits T and R shall be entered and exited on a character boundary. At this time, in some networks, the transition from state 6 to state 11, or state 6 to state 12 may not be on a character boundary.

Once character alignment has been established by the DCE in response to an outgoing call request, or for presentation of an incoming call, the alignment will be maintained until entering *connection in progress*, state 11 or *ready for data* if state 11 is by-passed. This implies that all IA5 character sequences transmitted on circuit R, such as 2/11 ("+"), *call progress* signals, *DCE-provided information*, etc., appear on the same character boundary even if they are separated by two or more SYN characters.

The call control phase can be terminated by either the DTE or the DCE by *clearing* as defined in § 6 below.

4.1 *Events of the call control procedures* (see Figure A-2/X.21)

4.1.1 *Call request (state 2)*

The calling DTE shall indicate a request for a call by signalling steady binary condition t = 0, c = ON, provided that it was previously signalling *DTE ready.*

The change of state from *ready* (t = 1, c = OFF) to *call request* (t = 0, c = ON) shall be such that the transition to t = 0 occurs within a maximum of 7 bit intervals of the transition to c = ON. Either transition may occur first.

Note – When optimizing the use of the byte timing circuit B, the transition to t = 0 shall occur within the same bit interval as the transition to c = ON. This might become a requirement for use with special user facilities which might arise from further study.

If the DTE signals *call request* (state 2) and the DCE simultaneously signals r = 0, i = OFF, the DCE will be assumed to be in state 19 *(DCE clear indication).*

4.1.2 *Proceed to select (state 3)*

When the network is prepared to receive selection information the DCE will transmit continuously character 2/11 ("+") preceded by 2 or more contiguous characters 1/6 ("SYN") on the R circuit with i = OFF.

Proceed-to-select is maintained until receipt of the *end-of-selection* signal, or in the case of *direct call*, receipt of *DTE waiting*.

The *proceed-to-select* signal will start within 3 seconds of the *call request* being sent.

4.1.3 *Selection signal sequence (state 4)*

The *selection* signal sequence shall be transmitted by the DTE on the T circuit with c = ON and shall be preceded by two or more contiguous 1/6 ("SYN") characters with c = ON.

The format of the *selection* signal sequence is defined in § 4.6.1 below.

The information content and coding of the *selection* signal sequence is contained in Annex G and Recommendation X.121.

The *selection* signal sequence shall start within 6 seconds of *proceed-to-select* being received and shall be completed within 36 seconds.

The maximum permissible interval between individual selection characters is 6 seconds.

The period, if any, between individual selection characters shall be filled by character 1/6 ("SYN") with c = ON.

4.1.4 *DTE waiting (state 5)*

During *DTE waiting*, the DTE signals steady binary condition t = 1, c = ON. (See also § 4.4 below for *direct call* conditions.)

4.1.5 *Incoming call (state 8)*

The DCE will indicate an incoming call by continuous transmission of character 0/7 ("BEL") preceded by two or more contiguous 1/6 ("SYN") characters on the R circuit with i = OFF.

If the DCE signals *incoming call* and the DTE simultaneously signals t = 0, c = OFF, the DTE will be assumed to be in state 16 *(clear request)*.

The connection of incoming calls will be inhibited when the DTE signals either *DTE uncontrolled not ready* or *DTE controlled not ready*.

4.1.6 *Call accepted (state 9)*

4.1.6.1 *General case*

The DTE shall accept the incoming call as soon as possible by signalling the steady state binary condition t = 1, c = ON.

1) The DCE will return to *DCE ready* if the incoming call is not accepted within 500 milliseconds,

   or, where manual answering is permitted,

2) the DCE will return to *DCE ready* if the incoming call is not accepted within 60 seconds.

4.1.6.2 *Sub-addressing*

Sub-addressing is an optional procedure.

Two procedures for sub-addressing at the called end are defined: the simple sub-addressing procedure and the enhanced sub-addressing procedure. Choice of the provision of these procedures is a national matter.

4.1.6.2.1 *Simple sub-addressing procedure* (see Figure A-6/X.21)

The procedure is as follows:

a) *Call accept*, see § 4.1.6.1.

b) *DCE waiting*, see § 4.1.7.

c) *DCE-provided information:* when provided, sub-addressing information will be transmitted by the DCE to the called DTE after *call accepted* has been sent by the DTE, and prior to any other *DCE-provided information* if any.

The format of sub-addressing information is defined in § 4.6.3 below.

The information content of sub-addressing information is defined in Annex H.

d) *Connection in progress*, see § 4.1.10.

e) *Ready for data*, see § 4.1.11.

4.1.6.2.2 *Enhanced sub-addressing procedure* (see Figures A-5/X.21 and B-3/X.21)

4.1.6.2.2.1 *Proceed with call information (state 9B)*

Note – State 9B is only entered in the case of a DTE with sub-addressing.

The DTE shall accept the incoming call as soon as possible by transmitting continuously character 2/10 ("*") preceded by 2 or more contiguous characters 1/6 ("SYN") on the T circuit with c = OFF.

Proceed with call information is maintained until receipt of *end of call information* signal. The *proceed with call information* signal will start within 500 ms of the *incoming call* signal being received.

4.1.6.2.2.2 *Call information signal sequence (state 10C)*

Note – State 10C is only entered in the case of a DTE with sub-addressing.

The *call information signal* sequence will be transmitted by the DCE on the R circuit with i = OFF and will appear on the same boundary as it was entered in state 8.

The call information signal may be preceded by two or more contiguous 1/6 ("SYN") characters.

The *call information* is also a *DCE-provided information* (see also § 4.1.9).

The information content and coding of the *call information signal* sequence is contained in Annex H and Recommendation X.121.

The *call information signal* sequence will start and will be completed within 2 seconds after the *proceed with call information* being sent.

The maximum period, if any, between individual call information characters will be filled by character 1/6 ("SYN") with i = OFF.

The format of *call information* is the same as the format of *DCE-provided information* and is defined in § 4.6.3 below.

4.1.6.2.2.3 *DCE waiting (states 6D and 6C)*

During *DCE waiting*, the DCE will signal 2 or more contiguous 1/6 ("SYN") characters with i = OFF.

4.1.6.2.2.4 *DTE-provided information (state 25)*

The *DTE-provided information* shall be transmitted by the DTE with sub-addressing on circuit T with c = OFF.

A *DTE-provided information* shall consist of 1 or more *DTE-provided information* blocks. *Each DTE-provided information* block shall be limited to a maximum length of 128 characters.

Note – The figure of 128 characters maximum length is provisional and may be changed to another value in the future.

The format of the *DTE-provided information* is defined in § 4.6.4 below.

The coding of *DTE-provided information* should be in line with Annex F and Recommendation X.96.

The *DTE-provided information* shall be sent on the same character boundary as it was entered in state 9B. *DTE-provided information* blocks within a *DTE-provided information* may be preceded and separated by 1/6 ("SYN") characters.

A *DTE-provided information* (state 25) shall be sent to the DCE within 20 seconds after the *end of call information* signal, character 2/11 ("+") being received.

After reception of a *DTE-provided information* block, the DCE will reset and restart time-out T14C.

4.1.7 *DCE waiting (state 6A and state 6B)*

During *DCE waiting*, the DCE will signal two or more contiguous 1/6 ("SYN") characters on the R circuit with i = OFF. In the state diagram, Figure A-2/X.21, state 6A applies to calling procedures and state 6B applies to called procedures.

4.1.8 *Call progress signal (state 7)*

The *call progress* signal will be transmitted by the DCE to the calling DTE on the R circuit with i = OFF when an appropriate condition is encountered by the network.

A *call progress* signal will consist of 1 or more *call progress* signal blocks. A *call progress* signal block will consist of 1 or more *call progress* signals.

The format of the *call progress* signal sequence is defined in § 4.6.2 below.

The coding of *call progress* signals is provided in Annex F.

The description of *call progress* signals is provided in Recommendation X.96.

A *call progress* signal will be preceded by two or more contiguous 1/6 ("SYN") characters sent during state 6A. The period between these blocks will also be filled by *DCE waiting* (state 6A).

A *call progress* signal will be transmitted by the DCE within 20 seconds of: (1) the *end-of-selection* signal or (2) in the case of *direct call*, the *DTE waiting* signal being sent by the DTE. The *call progress* signal, however, will not be sent by the DCE before the reception of the *end-of-selection* signal or *DTE waiting* signal is sent by the DTE, except in the case of expiration of time-out T11, T12, or T13 where there may be a *call progress* signal followed by *clear indication.*

Note – When an error is detected in a received *call progress* signal sequence, the DTE may choose to either ignore the signal or attempt a new call after clearing.

4.1.9 *DCE-provided information (states 10A and 10B)*

The *DCE-provided information* will be transmitted by a DCE to the calling DTE (state 10A) or a called DTE (state 10B) on circuit R with i = OFF.

A *DCE-provided information* will consist of 1 or more *DCE-provided information* blocks. Each *DCE-provided information* block will be limited to a maximum length of 128 characters.

The format of the *DCE-provided information* is defined in § 4.6.3 below.

The information content of *DCE-provided information* is provided in Annex H.

The *DCE-provided information* will be preceded by two or more contiguous 1/6 ("SYN") characters. *DCE-provided information* blocks within a *DCE-provided information* will be separated by 1/6 ("SYN") characters (the time between blocks to be filled by two or more SYN characters is for further study). In the case of a calling DTE (state 10A), the preceding and separating SYN characters will be from *DCE waiting* (state 6A). In the case of a called DTE (state 10B), the preceding SYN characters and the separating SYN characters will be from *DCE waiting* (state 6B).

In certain circumstances, SYN characters may be inserted between characters within a *DCE-provided information* block. Each insertion shall contain at least 2 SYN characters, and the inserted SYN characters will be counted as part of the maximum limit of 128 characters per block. In any case, the insertion of SYN characters should be rare and minimized.

A *DCE-provided information* (state 10B) will be sent to the called DTE within 6 seconds of the *call accepted* signal being sent. After reception of a *DCE-provided information* block, the called DTE should reset time-limit T4B.

4.1.9.1 *Line identification*

Calling and *called line identification* is an optional additional facility.

The information content of *calling* and *called line identification* is provided in Annex H.

Calling and *called line identification* will be transmitted by the DCE on the R circuit with i = OFF during states 10B or 10A, respectively.

When provided, *called line identification* (state 10A) will be transmitted by the DCE to the calling DTE after all *call progress* signals, if any.

When provided, *calling line identification* (state 10B) will be transmitted by the DCE to the called DTE after *call accepted* has been sent by the DTE.

In the case where the *calling line identification* facility is not provided by the originating network, or the *called line identification* facility is not provided by the destination network, a *dummy line identification* shall be provided by the DCE to the DTE. In some networks, when the *calling line identification* is not provided by the originating network, the DNIC will be provided by the DCE to the DTE in place of the *dummy line identification.*

4.1.9.2 *Charging information*

Charging information is an optional additional facility provided during state 10B.

Upon completion of clearing the call for which *charging information* has been requested, the DCE will, within 200 ms after entering *ready* (state 1), establish an incoming call to the DTE for the purpose of giving *charging information.*

Note – The DTE is advised not to signal *call request* or *not ready* during the above 200 ms period. If the DTE does, the *charging information* will not be transmitted to the DTE.

Charging information will be transmitted by the DCE on R circuit with i = OFF.

The DCE will send *clear indication* (state 19) upon sending the last *charging information* block. The DTE should send *clear request* (state 16) when it has correctly received the *charging information* signal, if the DCE has not previously signalled *clear indication.*

The format of *charging information* is defined in § 4.6.3 below.

4.1.10 *Connection in progress (state 11)*

While the connection process is in progress, the DCE will indicate *connection in progress* (state 11) by signalling r = 1, i = OFF.

In some circumstances, *connection in progress* (state 11) may be bypassed.

4.1.11 *Ready for data (state 12)*

When the connection is available for data transfer between both DTEs, the DCE will indicate *ready for data* (state 12) by signalling r = 1, i = ON.

1) *Ready for data* will be indicated by the DCE to the calling DTE within 6 seconds of the last *call progress* signal or *DCE-provided information* signals being received by the DTE or within 20 seconds of the *end-of-selection* signal being signalled by the DTE,

   or, when manual answering is permitted at the called DTE.

2) *Ready for data* will be indicated by the DCE to the calling DTE within 60 seconds of the appropriate *call progress* signal being received or within 20 seconds of the *end-of-selection* signal being received.

   It will be indicated to the called DTE within 6 seconds of *call accepted* being signalled by the DTE or receipt of *DCE-provided information* signal.

   Subsequent procedures are described in § 5 below, *data transfer* phase.

4.1.12 *Events of the call control procedure for centralized multipoint circuit-switched service*

4.1.12.1 *Call request (state 2)*

See § 4.1.1.

4.1.12.2 *Proceed to select request (state 3)*

See § 4.1.2.

4.1.12.3 *Selection signal sequence (state 4)*

See § 4.1.3.

A *facility request* signal is used to indicate the category of point-to-multipoint service which is required.

The coding is defined in Annex G.

4.1.12.4 *DTE waiting (state 5)*

See § 4.1.4.

4.1.12.5 *Incoming call (state 8)*

See § 4.1.5.

4.1.12.6 *Call accepted (state 9)*

See § 4.1.6.1.

4.1.12.7 *DCE waiting (state 6A and state 6B)*

See § 4.1.7.

4.1.12.8 *Call progress signal sequence (state 7)*

See § 4.1.8.

In a point-to-multipoint call, the *call progress* signals related to each of the called DTEs are transmitted and then in the same order, the *called line identification* signals of the different called DTEs.

When no specific call progress signals are necessary for a given called DTE, then the call progress signal "00" is used for this DTE so that the order can be kept.

4.1.12.9 *DCE-provided information sequence (states 10A and 10B)*

The *DCE-provided information* sequences will be transmitted by a DCE to the calling DTE (state 10A) or a called DTE (state 10B) on circuit R with i = OFF.

A *DCE-provided information* sequence will consist of one or more *DCE-provided information* blocks. Each *DCE-provided information* block will be limited to a maximum length of 128 characters, except for called line identification in case of point-to-multipoint calls where the maximum length is 512 characters.

The format of the *DCE-provided information* sequence is defined in § 4.6.3 below.

The information content of *DCE-provided information* is provided in Annex H.

The *DCE-provided information* sequence will be preceded by two or more contiguous 1/6 ("SYN") characters. *DCE-provided information* blocks within a *DCE-provided information* sequence will be separated by 1/6 ("SYN") characters (the time between blocks to be filled by two or more SYN characters is for further study). In the case of a calling DTE (state 10A), the preceding and separating SYN characters will be from *DCE waiting* (state 6A). In the case of a called DTE (state 10B), the preceding SYN characters and the separating SYN characters will be from *DCE waiting* (state 6B).

In certain circumstances, SYN characters may be inserted between characters within a *DCE-provided information* block. Each insertion shall contain at least 2 SYN characters, and the inserted SYN characters will be counted as part of the maximum limit of 128 characters per block. In any case, the insertion of SYN characters should be rare and minimized.

A *DCE-provided information* sequence (state 10B) will be sent to the called DTE within 6 s of the *call accepted* signal being sent. After reception of a *DCE-provided information* block, the called DTE should reset time-limit T4.

4.1.12.9.1 *Line identification*

The *called line identification* related to the different called DTEs is provided in sequence.

See § 4.1.9.1.

4.1.12.9.2 *Charging information*

See § 4.1.9.2.

4.1.12.10 *Connection in progress (state 11)*

See § 4.1.10.

4.1.12.11 *Ready for data (state 12)*

See § 4.1.11.

4.2 *Unsuccessful call*

If the required connection cannot be established, the DCE will indicate this and the reason to the calling DTE by means of a *call progress* signal. Afterwards the DCE will signal *DCE clear indication* (state 19).

4.3 *Call collision (state 15)*

A *call collision* is detected by a DTE when it receives *incoming call* in response to *call request.* The DTE shall not deliberately cause a *call collision* by responding to *incoming call* with *call request.*

A *call collision* is detected by a DCE when it receives *call request* in response to *incoming call.*

When a *call collision* is detected by the DCE, the DCE will indicate *proceed-to-select* (state 3) and cancel the incoming call.

4.4 *Direct call*

For a *direct call* facility, the entering of *DTE waiting* (state 5) directly upon receipt of *proceed-to-select* (state 3) indicates the request for the direct call. When the *direct call* facility is provided on a per-call basis, the DTE may choose either an addressed call by presenting *selection* signal (state 4) or a direct call by presenting *DTE waiting* (state 5). When the *direct call* facility only is provided on a subscription basis, *selection* signals (state 4) are always bypassed.

4.5 *Facility registration/cancellation procedure*

Registration/cancellation of optional user facilities shall be accomplished by a DTE using normal call establishment procedures using the *selection* sequence which is defined in § 4.6.1 below.

The format of the *facility registration/cancellation* signal is defined in § 4.6.1.3 below.

The *facility registration/cancellation* procedure shall not be combined with establishment of a normally addressed call, but shall be taken as an independent procedure.

In response to acceptance or rejection of the *facility registration/cancellation* actions, the network will provide the appropriate *call progress* signal followed by *clear indication.*

4.6 *Selection, call progress and DCE provided information formats*

(See also Annex D for a syntactic description of the formats.)

4.6.1 *Format of selection sequence*

A *selection* sequence shall consist of a *facility request* block, or an *address* block, or a *facility request* block followed by an *address* block, or a *facility registration/cancellation* block.

4.6.1.1 *Facility request block*

A *facility request* block shall consist of one or more *facility request* signals.

Multiple *facility request* signals shall be separated by character 2/12 (" , ").

A *facility request* signal shall consist of a *facility request* code and may contain one or more *facility* parameters. The *facility request* code, *facility* parameter and subsequent *facility* parameters shall be separated by character 2/15 (" / "). For an interim period the 2/15 (" / ") separator will not be used in some networks.

The end of a *facility request* block shall be indicated by character 2/13 ("–").

4.6.1.2 *Address block*

An *address* block shall consist of one or more *address* signals.

An *address* signal shall consist of either a *full address* signal or an *abbreviated address* signal.

Start of an *abbreviated address* signal shall be indicated by a prefix character 2/14 (" . ").

Multiple *address* signals shall be separated by character 2/12 (" , ").

4.6.1.3 *Facility registration/cancellation block*

A *facility registration/cancellation* block shall consist of one or more *facility registration/cancellation* signals.

A *facility registration/cancellation* signal shall consist of up to four elements in order: *facility request* code, *indicator, registration* parameter, *address* signal.

The elements of a *facility registration/cancellation* signal shall be separated by character 2/15 (" / ").

If a *facility registration/cancellation* signal contains less than four of the elements, the elements should be eliminated in reverse order (e.g., a two-element *facility registration/cancellation* signal will contain the *facility request* code " / " *indicator*). If any element to be sent within the sequence is not required, a 3/0 ("0") character should be inserted in the position of each missing element (e.g., *facility request* code /0/0/ *address* signal).

Multiple *facility registration/cancellation* signals shall be separated by character 2/12 (" , ").

The end of a *facility registration/cancellation* block shall be indicated by character 2/13 ("–") and shall be followed by an end of selection.

4.6.1.4 *End of selection*

The end of *selection* shall be indicated by character 2/11 ("+").

4.6.2 *Format of a call progress block*

A *call progress* block shall consist of one or more *call progress* signals.

A call progress signal shall consist of a call progress code and may contain an indicator.

The call progress code and the indicator shall be separated by character 2/13 ("–").

Each *call progress* signal need not be repeated.

Multiple *call progress* signals shall be separated by character 2/12 (" , ").

The end of a *call progress* block shall be indicated by character 2/11 ("+").

4.6.3 *Formats of DCE-provided information*

The following formats are specified for *DCE-provided information* signals which have been identified.

The *DCE-provided information* shall, except for *calling* and *called line identification,* be started by the IA5 character 2/15 (" / "). To distinguish between different types of *DCE-provided information* the prefix should be followed by one or more numerical characters, followed by the character 2/15 (" / ") before the actual information is presented. The end of a *DCE-provided information* block shall be indicated by character 2/11 ("+"). The order in which the *DCE-provided information* blocks are presented to the DTE is variable.

Multiple *DCE-provided information* signals shall be separated by character 2/12 (",").

A dummy *DCE-provided information* block may be sent in the case of sub-addressing and will be indicated by the prefix as described above ("/", "4", "/") followed by 2/11 ("+").

The dummy sub-address should be sent if the network supports sub-addressing but no sub-address has been sent by the calling DTE.

4.6.3.1 *Format of called and calling line identification*

Calling line identification block and *called line identification* block shall be preceded by character 2/10 (" * ").

When a *calling* or *called line identification* block contains Data Network Identification Codes (DNIC) or Data Country Codes (DCC), the block shall instead of one character 2/10 (" * ") be preceded by 2 characters 2/10 (" ** ").

A *called line identification* block shall consist of one or more *called line identification* signals.

Multiple *called line identification* signals shall be separated by character 2/12 (" , ").

End of *calling line identification* block and *called line identification* block shall be indicated by character 2/11 (" + ").

The *dummy line identification* block shall be indicated by character 2/10 (" * ") followed by 2/11 ("+").

4.6.3.2 *Format of charging information*

The *charging information* block will be preceded by character 2/15 (" / ") followed by a second IA5 numerical character, followed by character 2/15 (" / "). The end of *charging information* block shall be indicated by character 2/11 ("+").

4.6.4 *Format of DTE-provided information*

A *DTE-provided information* block shall consist of 1 or more *DTE-provided information* signals.

Each *DTE-provided information* signal need not be repeated.

Multiple *DTE-provided information* signals shall be separated by character 2/12 (",").

End of *DTE-provided information* block shall be indicated by character 2/11 ("+").

5 Data transfer phase

During the data transfer phase, any bit sequence may be sent by either DTE.

For the interchange of information between one DTE and another DTE during the data transfer phase, the DTEs will be responsible for establishing their own alignment.

The byte timing interchange circuit, when implemented, may be utilized by the DTEs for mutual character alignment.

Data link control procedures and any other DTE-to-DTE protocols are not the subject of this Recommendation.

5.1 *Circuit-switched service*

All bits sent by a DTE after indication of *ready for data* for 16-bit intervals (see § 2.4) and before sending *DTE clear request* will be delivered to the corresponding DTE after that corresponding DTE has received *ready for data* and before it has received *DCE clear indication* (provided that the corresponding DTE does not take the initiative of clearing).

All bits received by a DTE, after indication of *ready for data* for 16-bit intervals (see § 2.4) and before receiving *DCE clear indication* or receiving *DCE clear confirmation,* were sent by the corresponding DTE. Some of those bits may have originated as *DTE waiting* before that corresponding DTE has received *ready for data*; those bits are binary 1.

During *data transfer* (state 13), c = ON, i = ON and data are transferred on circuits T and R.

Data transfer may be terminated by *clearing,* as defined in § 6 below, by either:

i) the DCE, or
ii) any connected DTE.

The action to be taken when circuit C is turned OFF during *data transfer* (state 13), except when the DTE is signalling *DTE clear request* (state 16) by t = 0, c = OFF, is for further study except for the procedures for half-duplex operation between DTEs conforming to Recommendations X.21 and X.21 *bis* as described in Annex E.

5.2 *Leased circuit service – point-to-point* (see Figure A-3/X.21) *and packet-switched service* (Recommendation X.25, level 1)

In this section, for the case of packet-switched service, one of the DTEs must be understood as being the packet network data switching exchange (DSE).

Data transmitted by the DTE on circuit T with c = ON are delivered to the remote DTE on circuit R with i = ON.

Both DTEs may employ duplex operation for the exchange of data.

Any bit sequence may be sent by either DTE during the ON-condition of its circuit C.

Note – The entering of the DTE/DCE-interface of *DTE uncontrolled not ready* (state 22) will be signalled on the remote end as *DCE not ready* (state 18).

In Figure A-3/X.21 a state diagram indicating a possible data connection is shown. Apart from state 13, two additional states, 13S and 13R, can be identified.

5.2.1 *Send data (state 13S)*

Data transmitted by the DTE on circuit T with c = ON are delivered to the remote DTE on circuit R with i = ON.

5.2.2 *Receive data (state 13R)*

Data transmitted by a distant DTE with c = ON are received on circuit R with i = ON.

5.2.3 *Data transfer (state 13)*

When c = ON, i = ON, data are transferred on circuits T and R.

5.2.4 *Termination of data transfer*

The DTE signals the termination of *data transfer* by signalling t = 1, c = OFF. The DCE indicates termination of *data transfer* by signalling r = 1, i = OFF.

Note – The action taken by the DCE when the DTE signals c = OFF and t does not equal 1, is for further study except for the *DTE uncontrolled not ready* procedures described in § 2.5.1.2 above.

5.3 *Leased circuit service – centralized multipoint* (see Figure A-3/X.21)

5.3.1 *Central DTE data transfer*

5.3.1.1 *Send data (state 13S)*

Data transmitted by the central DTE on circuit T with c = ON are delivered to all remote DTEs on circuit R with i = ON.

5.3.1.2 *Receive data (state 13R)*

Data transmitted by any remote DTE with c = ON (one at a time as determined by the data link protocol) during state 13S are delivered to the central DTE on circuit R with i = ON.

5.3.2 *Remote DTE data transfer*

Data transmitted by a remote DTE are not delivered to other remote DTEs.

Note – Transmission of data by two or more remote DTEs at the same time may result in unsatisfactory conditions.

5.3.2.1 *Send data (state 13S)*

Data transmitted by remote DTEs with c = ON (one at a time as determined by the data link protocol) are delivered to the central DTE on circuit R with i = ON.

5.3.2.2 *Receive data (state 13R)*

Data transmitted by the central DTE with c = ON are delivered to the remote DTE on circuit R with i = ON.

5.3.3 *Data transfer (state 13)*

When c = ON, i = ON data transmitted by the central DTE are delivered to all remote DTEs, and data transmitted by a remote DTE (one at a time as determined by data link protocol) are delivered to the central DTE. A remote DTE may send (one at a time as determined by the data link protocol) while the central DTE is sending to all remote DTEs.

5.4 *Circuit-switched service – Point-to-multipoint service*

The different configurations of point-to-multipoint are defined in Recommendation X.2.

5.4.1 *Centralized multipoint*

All bits sent by the central DTE after indication of *ready for data* for 16-bit intervals (see § 2.4) and before clearing procedure has been started by the central DTE or by the network, will be delivered to all remote DTEs after they have received *ready for data* and before they have received *DCE clear indication* (provided that the remote DTEs do not take the initiative of clearing).

All bits received by a remote DTE, after indication of *ready for data* for 16-bit intervals (see § 2.4) and before clearing procedure has been started by the central DTE, by the network or the remote DTE, were sent by the central DTE. Some of those may have originated as *DTE waiting* before the central DTE has received *ready for data*; those bits are binary 1.

All bits sent by a remote DTE, after indication of *ready for data* for 16-bit intervals (see § 2.4) and before clearing procedure has been started by the central DTE, by the network or by the remote DTE, will be delivered to the central DTE after that central DTE has received *ready for data* and before it has received *DCE clear confirmation* or *DCE clear indication*, provided that the the other remote DTEs are transmitting binary 1.

All bits received by the central DTE, after receiving *ready for data* for 16-bit intervals (see § 2.4) and before receiving *DCE clear indication* or *DCE clear confirmation*, were sent by one of the remote DTEs. Some of these may have originated as *DTE waiting* before the remote DTEs have received *ready for data*; those bits are binary 1.

During *data transfer* (state 13), c = ON, i = ON and data are transferred on circuits T and R.

Data transfer may be terminated by clearing, as defined in § 6 below, by either:

i) the central DTE or,
ii) all the remote DTEs or,
iii) the DCEs.

6 **Clearing phase** (see Figure A-4/X.21)

In centralized multipoint calls:

- clearing by the central DTE imply clearing of the call;
- clearing by a remote DTE clears the call for this DTE, and has no effect on the calls which remain established for the other remote DTEs;
- clearing by the last remote DTE still in the call leads to the clearing of the call.

6.1 *Clearing by the DTE (states 16, 17, 21)*

The DTE should indicate clearing by signalling the steady binary condition t = 0, c = OFF, *DTE clear request* (state 16).

The DCE will respond by signalling the steady state condition r = 0, i = OFF, *DCE clear confirmation* (state 17), followed by the steady binary condition r = 1, i = OFF, *DCE ready* (state 21). The *DCE ready* signal will be sent within 2 seconds after the receipt of the *DTE clear request* signal.

The DTE shall recognize DCE clear confirmation and, except as noted below, shall then respond to DCE ready, when presented, within 100 millisecondes by signalling t = 1, c = OFF, ready (state 1).

In the case where DCE clear confirmation is either not presented by the DCE or not recognized by the DTE, the DTE shall remain in the DTE clear request state for a minimum of 2 seconds and then go to DTE ready. In this case, the DTE may not respond to DCE ready within the 100 milliseconds stipulated above and may be considered by the DCE to be uncontrolled not ready (state 24) for a finite period of time (until it goes to DTE ready).

6.2 *Clearing by the DCE (states 19, 20, 21)*

The DCE will indicate clearing to the DTE by signalling the steady binary condition r = 0, i = OFF, *DCE clear indication* (state 19).

The DTE should signify *DTE clear confirmation* (state 20) by signalling the steady binary condition t = 0, c = OFF, within 500 milliseconds. The DCE will signal r = 1, i = OFF, *DCE ready* (state 21) within 2 seconds of receiving *DTE clear confirmation.*

The DTE should respond to *DCE ready* within 100 milliseconds by signalling t = 1, c = OFF, *ready* (state 1).

7 **Test loops**

The definitions of the test loops and the principles of maintenance testing using the test loops are provided in Recommendation X.150.

7.1 *DTE test loop – type 1 loop*

This loop is used as a basic test of the operation of the DTE, by looping back the transmitted signals inside the DTE for checking. The loop should be set up inside the DTE as close as possible to the DTE/DCE interface.

While the DTE is in the loop 1 test condition:

- circuit T is connected to circuit R inside of the DTE;
- circuit C is connected to circuit I inside of the DTE;
- the DCE continues to present signal element timing on circuit S and, if implemented, byte timing on circuit B. The DTE need not make use of the timing information.

Loop 1 may be established from either the *data transfer* or *ready* state.

In some networks, for short routine tests during the *data transfer* state, the DTE should either maintain the same status on the interchange circuits as before the test or send the *controlled not ready* signal. If the loop is established from the *data transfer* state, the DCE may continue to deliver data to the DTE during the test as though the DTE were in normal operation. It will be the responsibility of the DTEs to recover from any errors that might occur while the test loop is activated.

If the loop is established from the *ready* state, the DTE should signal one of the *not ready* states.

7.2 *Local test loop – type 3 loop*

Local test loops (type 3 loops) are used to test the operation of the DTE, the interconnecting cable and either all or parts of the local DCE, as discussed below.

Loop 3 may be established from any state.

For testing on leased circuits and for short duration testing on circuit-switched connections the DCE should either continue to present toward the line the conditions that existed before the test (e.g. either *data transfer* or *ready* state) or send the *controlled not ready* state to the remote DTE. Where this is not practical (e.g. in some cases for loop 3a) or desirable (e.g. for long duration testing in circuit-switched applications) the DCE should terminate an existing call and, if possible, signal toward the subscriber-line one of the *not ready* states.

Manual and/or automatic control should be provided on the DCE for activation of the test loop.

The precise implementation of the test loop within the DCE is a national option. At least one of the following local loops should be implemented:

7.2.1 *Loop 3d*

This loop is used to test the operation of the DTE, including the interconnecting cable, by returning transmitted signals to the DTE for checking. The loop is set up inside the local DCE and does not include interchange circuit generators and loads.

While the DCE is in the loop 3d test condition:

- circuit T is connected to circuit R inside of the DCE;
- circuit C is connected to circuit I inside of the DCE;
- the DCE continues to present signal element timing on circuit S and, if implemented, byte timing on circuit B. The DTE must make use of the timing information.

Note – While test loop 3d is operated, the effective length of the interface cable is doubled. Therefore, to insure proper operation of loop 3d, the maximum DTE/DCE interface cable length should be one-half the length normally appropriate for the data signalling rate in use.

7.2.2 *Loop 3c*

This loop is used to test the operation of the DTE, including the interconnecting cable and DCE interchange circuit generators and loads.

The configuration is identical to that given for loop 3d in § 7.2.1 with the exception that the looping of circuit T to circuit R and the looping of circuit C to circuit I includes the interchange circuit generators and loads. The note concerning restriction of interface cable length is not applicable.

7.2.3 *Loop 3b*

This loop is used as a test of the operation of the DTE and the line coding and control logic and circuitry of the DCE. It includes all the circuitry of the DCE with the exclusion of the line signal conditioning circuitry (e.g. impedance matching transformers, amplifiers, equalizers, etc.). The delay between transmitted and received test data is a few octets (see Note).

The configuration is identical to that given for loop 3c in § 7.2.2 except for the location of the point of loopback.

Note – In some DCEs, the setting of loop 3b will result in momentary loss of envelope alignment causing random signals to appear on the receiving interchange circuit for a period of time. This may impact upon the DTE test procedure. In some networks the setting of loop 3b will cause clearing of existing connections.

7.2.4 *Loop 3a*

This loop is used to test the operation of the DTE and the DCE. The loop should include the maximum amount of circuitry used in DCE working including, in particular, the line signal conditioning circuitry. It is recognized that, in some cases, the inclusion of devices (e.g. attenuators, equalizers or test loop translators) may be necessary in the loopback path. The subscriber line is suitably terminated during a loop 3a test condition. The delay between transmitted and received test data is a few octets (see Note).

The configuration is identical to that given for test loop 3b in § 7.2.3 except for the location of the point of loopback.

Note – In some DCEs, the setting of loop 3a will result in momentary loss of envelope alignment causing random signals to appear on the receiving interchange circuit for a period of time. This may impact upon the DTE test procedure. In some networks the setting of loop 3a will cause clearing of existing connections.

7.2.5 *Automatic operation of test loop 3* (see Figure A-9/X.21)

The procedure provides for transparent loop testing and may be entered from any state.

7.2.5.1 *Send loop 3 command (state L31)*

The testing DTE shall indicate a request for a local loop 3 by signalling t = 00001111 (alternate bit quadruples are binary 0 and binary 1), c = OFF. The loop command shall persist until the DCE signals r = 00001111 ..., i = OFF, but not longer than 6 s. Some networks may require the loop command to be preceded by 2 or more contiguous 1/6 ("SYN") characters and to appear on a character boundary 00001111. Some networks will not require the preceding SYN-characters to be sent, i.e. they will treat the loop command as a bit pattern which, therefore, does not need to appear on a character boundary. However, this would impose no restrictions on DTEs sending the loop command on a character boundary with preceding SYN-characters.

7.2.5.2 *Loop 3 confirmation (state L32)*

The DCE indicates that the local loop 3 is established by signalling r = 00001111, i = OFF.

Note – This bit pattern received on circuit R is the loop command reflected by the local loop 3.

7.2.5.3 *Test data (state L33)*

The DTE enters the transparent *test data* state by turning c = ON. During the test any bit sequence may be sent by the DTE. The looped back data are received on circuit R with i = ON.

7.2.5.4 *Loop 3 clear request (state L34A)*

The DTE signals the termination of the test data by turning c = OFF.

7.2.5.5 *Loop 3 clear request (state L34B)*

In cases where the DTE does not wish to enter state L33 it may leave state L32 by signalling t $\neq$ 00001111, c = OFF for a minimum time of 24 bits.

7.2.5.6 *Loop 3 clear confirmation (state L35)*

Release of the loop is confirmed by the DCE signalling r ≠ 00001111, i = OFF.

7.3 *Network test loop – type 2 loop*

Network test loops (type 2 loops) are used by the Administration's test centre to test the operation of the leased line or subscriber line and either all or part of the DCE, as discussed below.

7.3.1 *General*

Loop 2 may be controlled manually on the DCE or automatically from the network or where allowed by national testing principles automatically from the remote DTE.

In case of a collision between call request and the activation of the loop, the loop activation command will have priority.

When the test is in progress, the DCE will signal r = 0, i = OFF or r = 0101, i = OFF. The choice as to which of these signals is sent is a national matter.

7.3.2 *Automatic operation of test loop 2* (see Figures A-7/X.21 and A-8/X.21)

The procedure provides for transparent loop testing and is entered from the *data transfer* phase, state 13 in circuit switched service point-to-point. It may also be entered from any state in leased circuit service.

7.3.2.1 *Send loop 2 command* (state L21)

The testing DTE shall indicate a request for a remote loop 2 by signalling t = 00110011 (alternate bit pairs are binary 0 and binary 1), c = OFF. The loop command shall persist until the DCE signals r = 00110011 . . . , i = OFF, but not longer than 2 s. Some networks may require the loop command to be preceded by 2 or more contiguous 1/6 ("SYN") characters and to appear on a character boundary 00110011. Some networks will not require the preceding SYN-characters to be sent, i.e. they will treat the loop command as a bit pattern which, therefore, does not need to appear on a character boundary. However, this would impose no restrictions on DTEs sending the loop command on a character boundary with preceding SYN-characters.

7.3.2.2 *Loop 2 confirmation (state L22)*

The DCE indicates that the remote loop 2 is established by signalling r = 001100 . . . , i = OFF.

Note – This bit pattern received on circuit R is the loop command reflected by the remote loop 2.

7.3.2.3 *Test data (state L23)*

The DTE enters the transparent *test data* state by turning c = ON.

During the test any bit sequence may be sent by the DTE. The looped back data are received on circuit R with i = ON.

Note – Allowance must be made for propagation delay in the network.

7.3.2.4 *Loop 2 clear request (state L24A)*

The DTE signals the termination of the *test data* state by turning c = OFF.

In the case where the DTE wishes to clear the connection it signals t = 0, c = OFF (state 16).

In the case where the DTE wishes to re-enter the *data transfer* phase it signals t ≠ 0 ≠ 0011, c = OFF until the DCE signals state L25 *loop 2 clear confirmation*, r ≠ 0 ≠ 0011, i = OFF. After that, the DTE re-enters the *data transfer* phase by signalling t = D, c = ON.

7.3.2.5 *Loop 2 clear request (state L24B)*

In cases where the DTE does not wish to enter state L23 it may leave state L22 by signalling t ≠ 0011, c = OFF for a minimum time of 24 bits.

In the case where the DTE wishes to clear the connection it signals t = 0, c = OFF (state 16).

In the case where the DTE wishes to re-enter the data transfer phase it signals t ≠ 0 ≠0011, c = OFF until the DCE signals state L25 loop 2 clear confirmation, r ≠ 0 ≠ 0011, i = OFF. After that, the DTE re-enters the data transfer phase by signalling t = D, c = ON.

7.3.2.6 *Loop 2 clear confirmation (state L25)*

Release of the loop is confirmed by the DCE signalling r ≠ 0011 . . . , i = OFF.

Note – The DCE signalling of r = 0, i = OFF must be interpreted by the DTE as *loop clear confirmation* and *DCE clear indication* (state 19).

7.3.2.7 *Receive loop 2 command (state L26)*

The DCE will indicate the receipt of a *loop command* by transmission of 0011 ... on circuit R with i = OFF.

Note – In some networks state L26 will be bypassed if the loop 2 is operated from the Administration's test centre.

7.3.2.8 *Loop 2 consent (state L26A)*

The DTE of the tested station will indicate its readiness for a loop test by signalling t = X, c = OFF.

Note – Some networks may require this state for additional security against malicious test loop operation.

7.3.2.9 *DCE controlled not ready (state L27)*

When the DCE has closed the loop 2 it transmits 0101 ... on circuit R and i = OFF to the DTE.

This DTE should not interpret this state as a *clear* indication, if it was in the *data transfer* phase before the test procedure began.

7.3.2.10 *Loop 2 released (state L28)*

When the DCE stops transmitting 0101 ... for more than 24 bits on circuit R, the DTE is informed that it may continue with the state it had left at the beginnng of state L27.

7.3.2.11 *DCE not ready (state L29)*

In the case when the DCE is not able to send *DCE controlled not ready*, it will signal *DCE not ready* (state L29). This state will persist until the loop is released.

Note – It is not possible to re-enter the *data transfer* phase in this case.

7.3.3 *Implementation of type 2 loops*

The precise implementation of the test loop within the DCE is a national option. At least one of the following network test loops should be implemented:

7.3.3.1 *Loop 2b*

This loop is used by either the Administration's test centre(s) and/or the remote DTE to test the operation of the subscriber line and all the circuitry of the DCE with the exception of interchange circuit generators and loads.

While the DCE is in the loop 2b test condition:

- circuit R is connected to circuit T inside of the DCE,
- circuit I is connected to circuit C inside of the DCE,
- at the interface, the DCE signals r = 0, i = OFF, or where provided r = 0101 ..., i = OFF,
- the DCE provides timing information on circuits S and, if implemented, on circuit B.

7.3.3.2 *Loop 2a*

This loop is used by either the Administration's test centre(s) or the remote DTE to test the operation of the subscriber line and the entire DCE.

The configuration is identical to that given for loop 2b in § 7.3.3.1 except for the location of the point of loop back. Alternatively, the DCE may present an open circuit or power off condition on circuits R and I.

7.4 *Subscriber-line test loop – type 4 loop*

Subscriber-line test loops (type 4 loops) are provided for the maintenance of lines by the Administrations.

Note – In the case of loops 4 and 2 (see § 7.3 above) the DCE may signal the local DTE in such a manner that the DTE can distinguish a test mode from a network failure. This is for further study.

7.4.1 *Loop 4a*

This loop is only provided in the case of 4-wire subscriber lines. Loop 4a is for the maintenance of lines by Administrations. When receiving and transmitting pairs are connected together, the resulting circuit cannot be considered normal. Loop 4a may be established inside the DCE or in a separate device.

While the DCE is in the loop 4a test condition:

- the DCE signals to the local DTE r = 0, i = OFF, or where provided r = 0101 ..., i = OFF.
- the DCE provides timing information on circuit S and, if implemented, circuit B.

7.4.2 *Loop 4b*

This loop is used by Administrations to test the operation of the subscriber line including the line signal conditioning circuitry in the DCE. When the receiving and transmitting circuits are connected at this point, loop 4b provides a connection that can be considered as normal; however, some impairment of the performance is expected since the DCE does not perform a complete signal regeneration.

The configuration is identical to that given for loop 4a in § 7.4.1 except for the location of the point of the loopback.

7.5 *Signal element timing provision*

The provision of signal element timing to the DTE is maintained when any of the loops, described above, are activated.

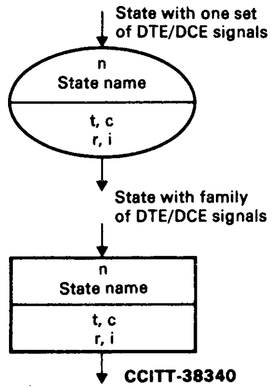
When test loops are activated, the signal element timing should in no case deviate from the nominal value by more than ± 1%.

ANNEX A

(to Recommendation X.21)

Interface signalling state diagrams

Definition of symbols used in the state diagrams



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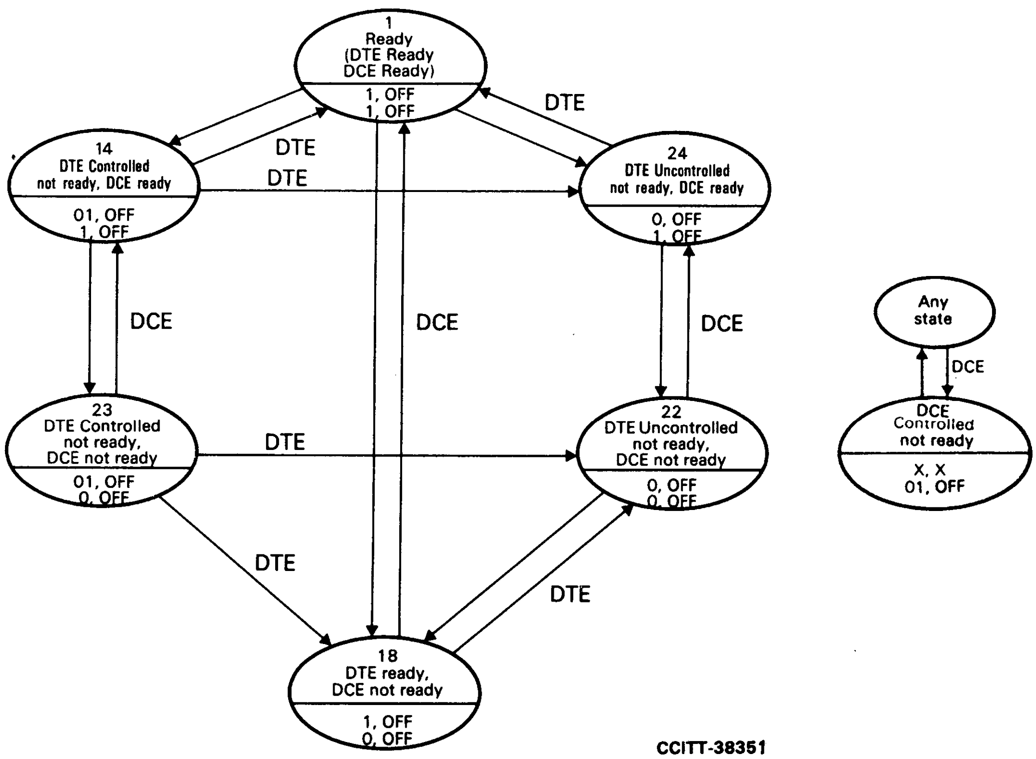
n	State number
t	Signal on T circuit
c	Signal on C circuit
r	Signal on R circuit
i	Signal on I circuit
T	Transmit interchange circuit
C	Control interchange circuit
R	Receive interchange circuit
I	Indication interchange circuit
D	DTE or DCE data signals
0 and 1	Steady binary conditions
01	Alternate binary 0 and binary 1
X	Any value
OFF	Continuous OFF (binary 1)
ON	Continuous ON (binary 0)
IA5	Characters from International Alphabet No. 5 (Recommendations V.3 and X.4)
+	IA5 character 2/11
BEL	IA5 character 0/7
SYN	IA5 character 1/6
↓	Transition with indication of whether DTE or DCE is responsible for transition



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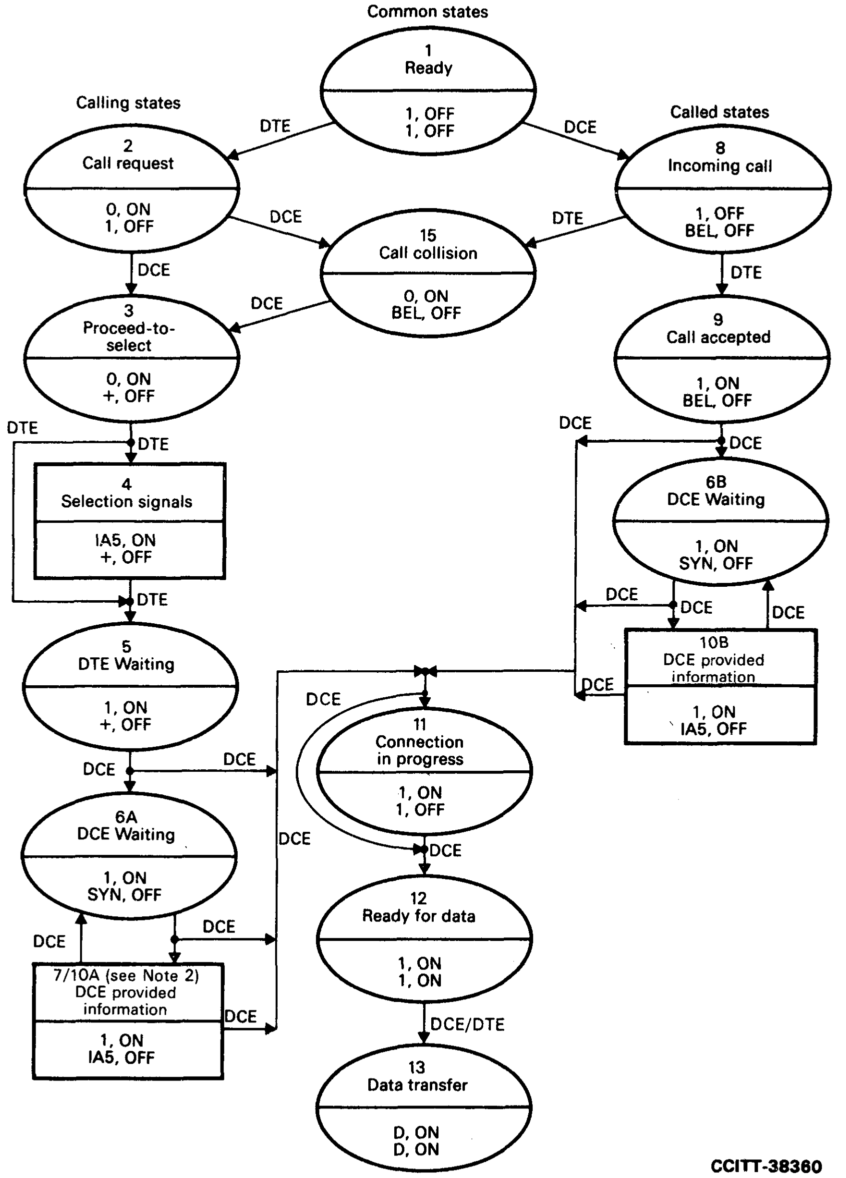
Note 1 – This state diagram shows transitions that will be allowed by all Administrations. Other transitions are possible and may be allowed by some Administrations.

Note 2 – *DCE controlled not ready* appearing during the call establishment phase should be interpreted as a *DCE clear indication.*

FIGURE A-1/X.21

Quiescent states

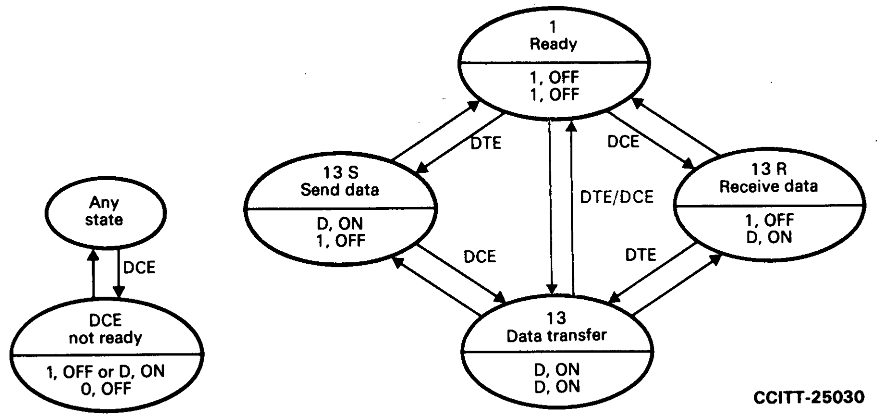


Note 1 – As indicated in Figure A-4/X.21, the DCE may enter state 19 from any state and the DTE may enter state 16 from any state except *ready*.

Note 2 – For simplification of the state diagram, state 7 (*call progress* signals) is merged with state 10A *(DCE provided information).*

FIGURE A-2/X.21

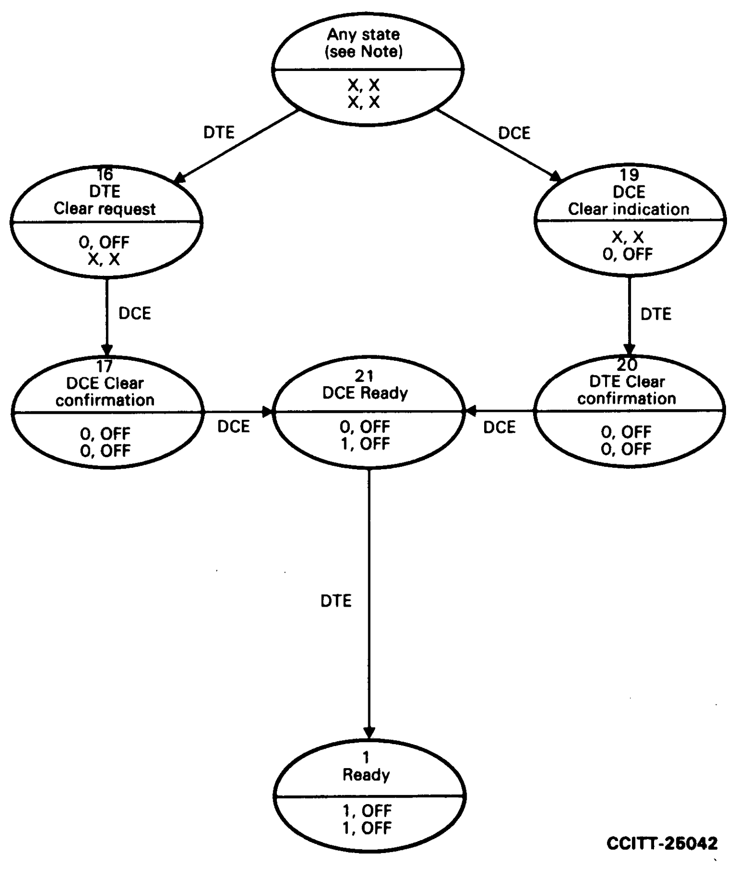
Call control phase for circuit-switched service



Note – States 13S, 13R and 13 may be entered from any of the quiescent states shown in Figure A-1/X.21.

FIGURE A-3/X.21

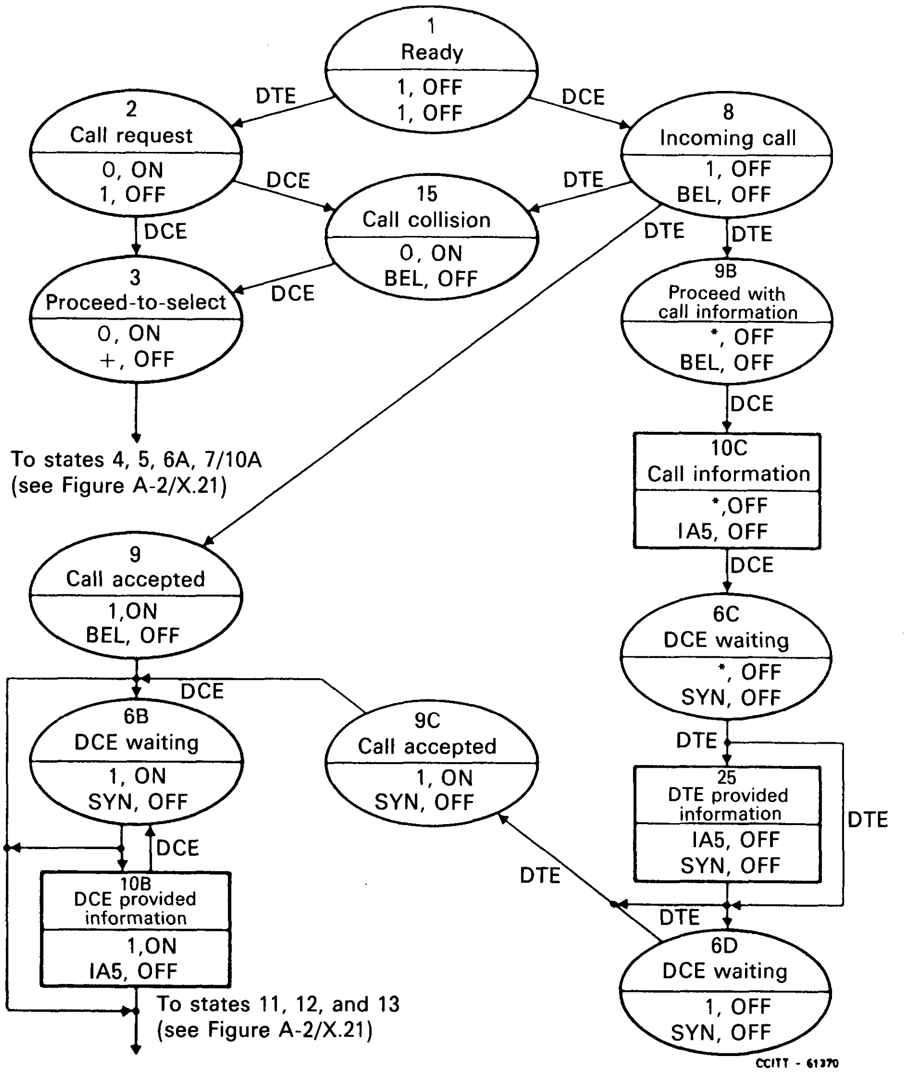
Leased circuit service – point-to-point and packet-switched service



Note – Any state in Figure A-2/X.21 except *ready*.

FIGURE A-4/X.21

Clearing phase



Note 1 – States 2, 3 and 15 are drawn for clarification only.

Note 2 – Transition from state 8 to state 9 only in the case of the DTE being unable to accept *call information.*

FIGURE A-5/X.21

Call control phase for DTEs with enhanced sub-addressing for circuit-switched service

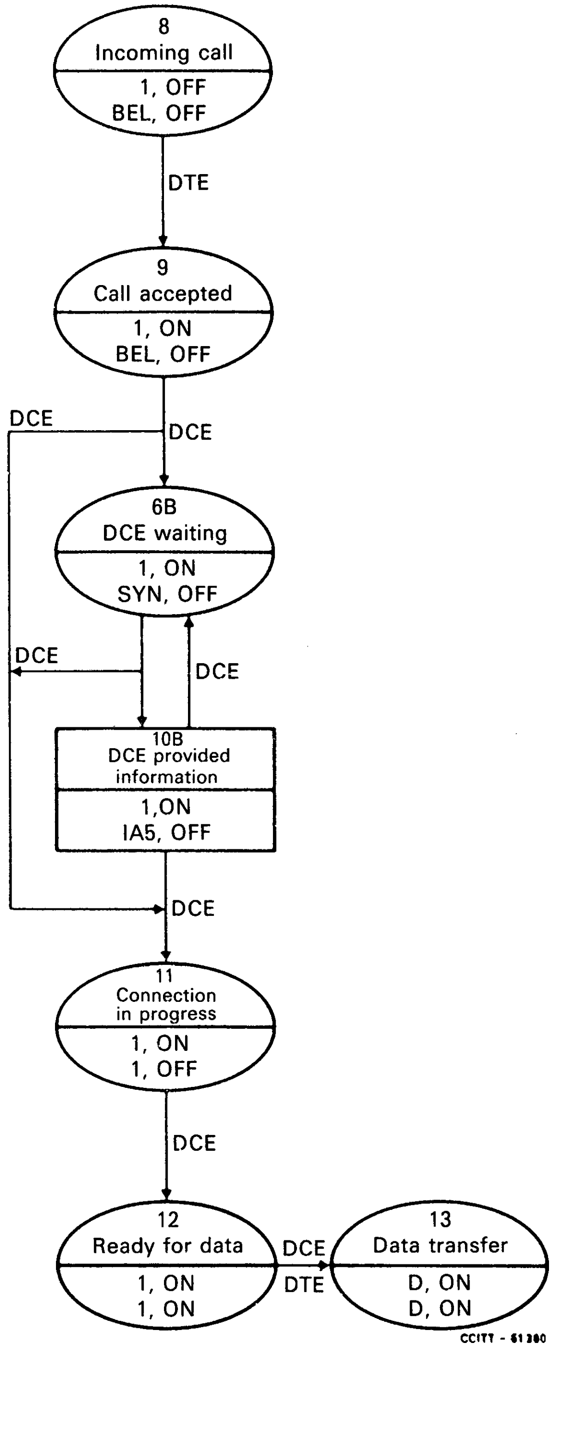
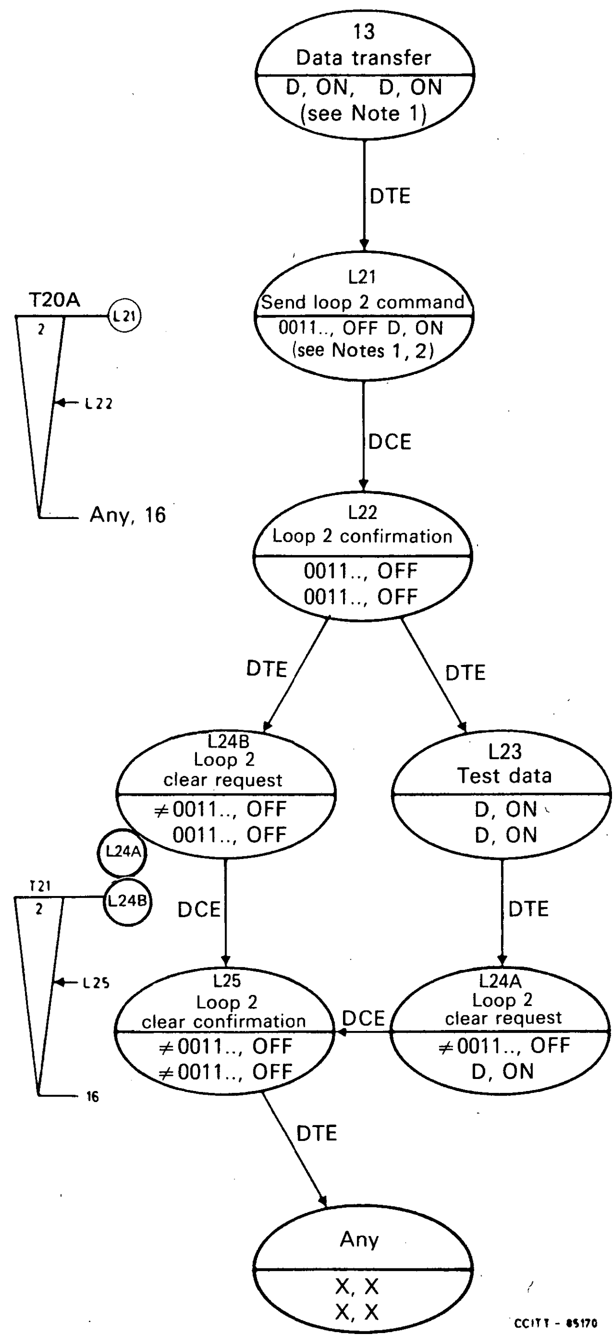


FIGURE A-6/X.21

Call control phase for called DTE with simple sub-addressing for the circuit-switched service

Figure A-6/X.21, p.6

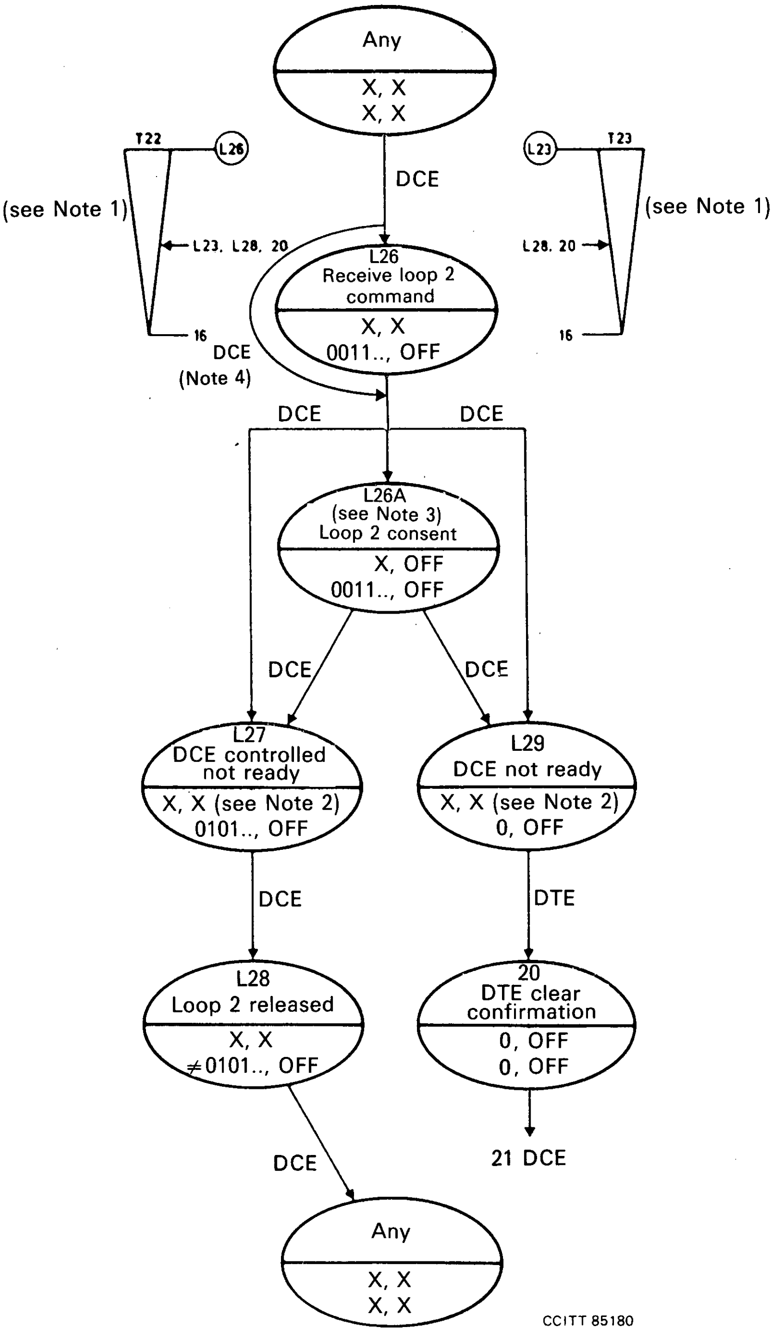


Note 1 — In leased circuit service any state.

Note 2 — Networks which implement state L26A *loop 2 consent* will require the remote DTE to be signalling c = OFF.

FIGURE A-7/X.21

Loop 2 activation/deactivation — Testing station



Note 1 – T22 and T23 are a national matter.

Note 2 – Networks which implement state L26A *loop 2 consent* will require the remote DTE to be signalling c = OFF.

Note 3 – Some networks may require this state for additional security against malicious test loop operation.

Note 4 – In some networks state L26 will be bypassed if loop 2 is operated from the Administration's test centre or the sequence is less than 24 bits.

FIGURE A-8/X.21

Loop 2 activation/deactivation – Tested station

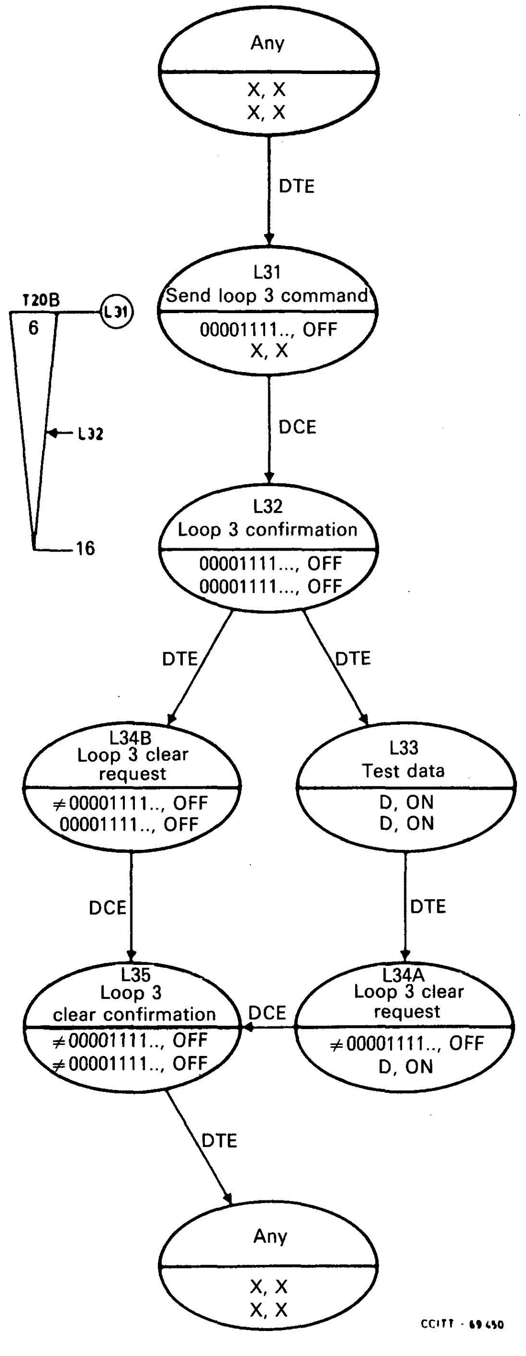


FIGURE A-9/X.21

Loop 3 activation/deactivation

Figure A-9/X.21

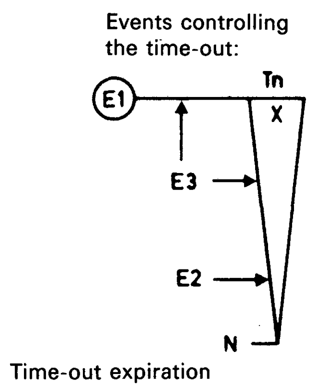
"T20 B" should be closed up and shown as "T20B".:

ANNEX B

(to Recommendation X.21)

Interface signalling sequence diagrams and time-out operations

Definition of symbol used to illustrate time-out operation
in the signalling sequence diagrams:



Tn	Time-out number
X	Time-out figure in seconds
(E1)	Start of time-out at event indicated
E2	Stop of time-out at event indicated
E3	Stop, reset to ZERO and restart of time-out at event indicated
N	Number of the state to be entered after expiration of time-out

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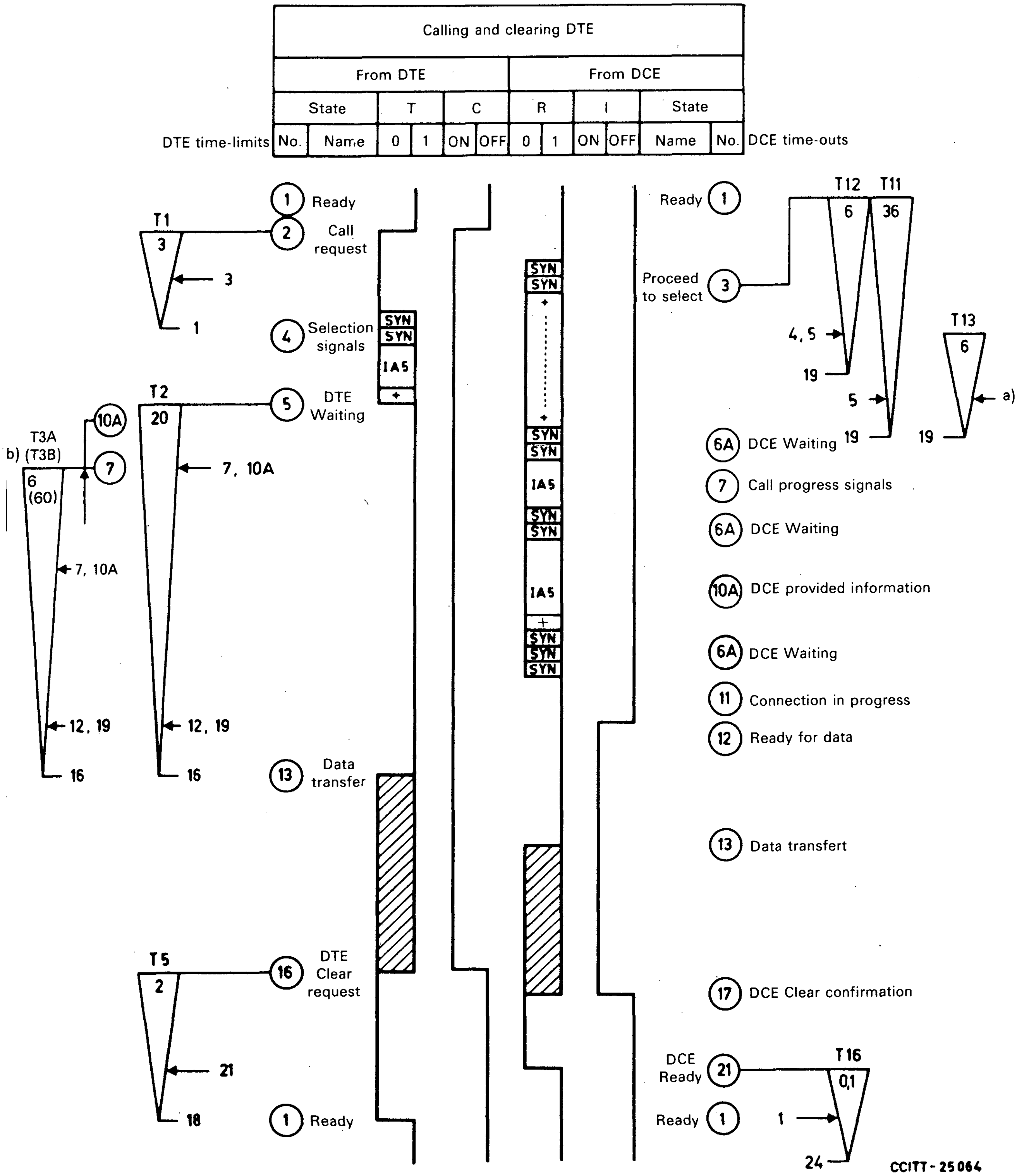
Note – For additional alternative assignments of DTE time-limits or DCE time-outs not shown together with the signalling sequence diagrams, see Table C-2/X.21.



a) For additional alternative assignments of DTE time-limits or DCE time-outs not shown together with the signalling sequence diagrams, see Table C-2/X.21.

b) For full details, see Table C-1/X.21.

FIGURE B-1/X.21

Example of sequence of events: successful call and clear for circuit-switched service (calling and clearing DTE)

4

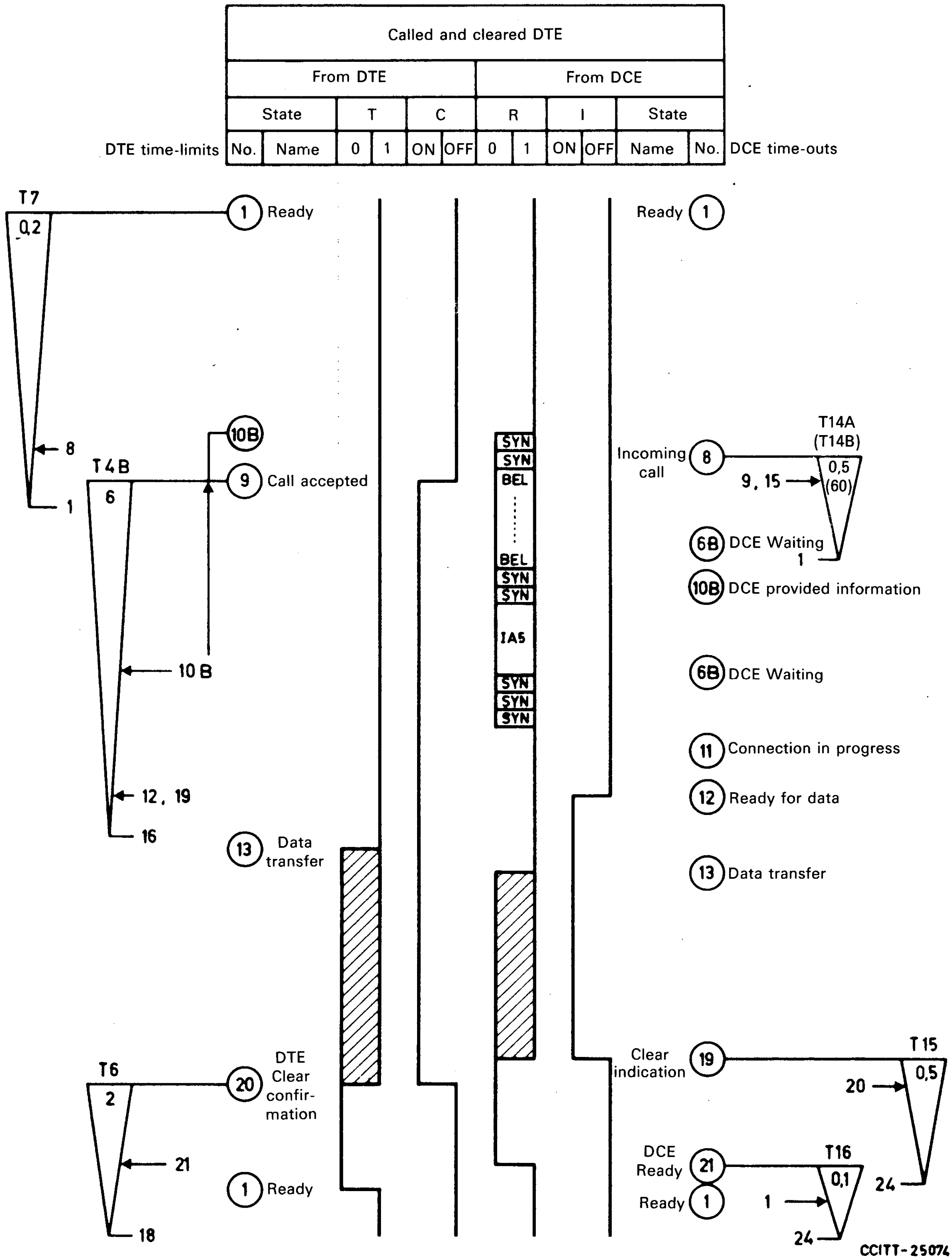


FIGURE B-2/X.21

Example of sequences of events: successful call and clear for circuit-switched service (called and cleared DTE)

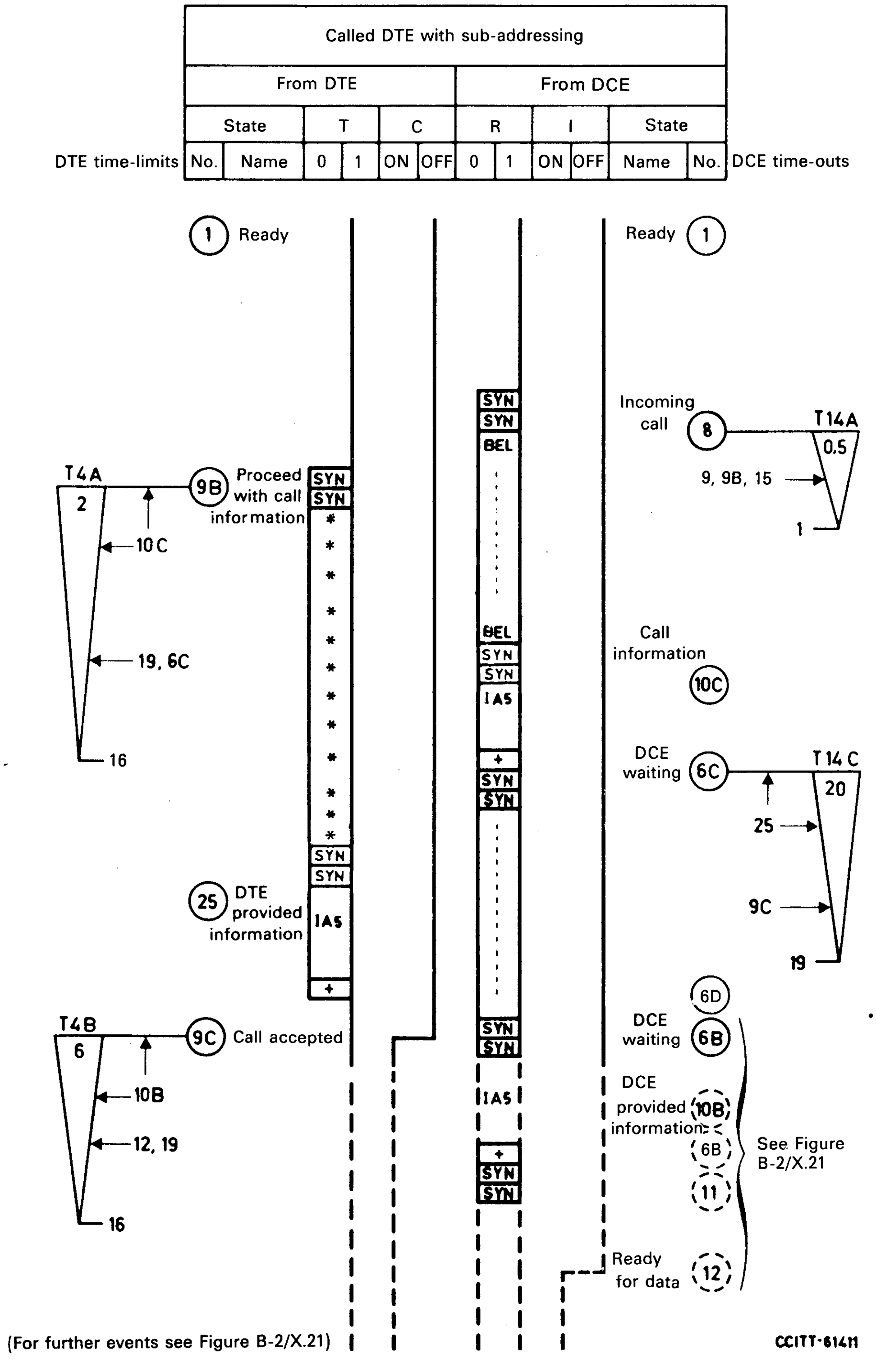


FIGURE B-3/X.21

Example of sequences of events: successful call of a DTE with enhanced sub-addressing for circuit-switched service

ANNEX C

(to Recommendation X.21)

DTE time-limits and DCE time-outs

C.1 *DTE time-limits*

Under certain circumstances this Recommendation requires the DCE to respond to a signal from the DTE within a stated maximum time. If any of these maximum times is exceeded, the DTE should initiate the action indicated in Table C-1/X.21. To maximize efficiency, the DTE should incorporate time-limits to send the appropriate signal under the defined circumstances summarized in Table C-1/X.21. The time-limits given in the first column are the maximum times allowed for the DCE to respond and are consequently the lower limits of the times a DTE must allow for proper network operation. A time-limit longer than the time shown may be optionally used in the DTE; for example, all DTE time-limits could have one single value equal to or greater than the longest time-limit shown in this table. However, the use of a longer time-limit will result in reduced efficiency of network utilization. The actual DCE response time should be as short as is consistent with the implementing technology and in normal operation should be well within the specified time-limit. The rare situation where a time-limit is exceeded should only occur when there is a failure in DCE operation.

The time-limits and actions for loop testing are given in Table C-3/X.21.

C.2 *DCE Time-outs*

Under certain circumstances this Recommendation requires the DTE to respond to a signal from the DCE within a stated maximum time. If any of these maximum times is exceeded, a time-out in the DCE will initiate the actions summarized in Table C-2/X.21. These constraints must be taken into account in the DTE design. The time-outs given in the first column of the table are the minimum time-out values used in the DCE for the appropriate DTE response and are consequently the maximum times available to the DTE for response to the indicated DCE action. The actual DTE response time should be as short as is consistent with the implementing technology and in normal operation should be within the specified time-out. The rare situation where a time-out is exceeded should only occur when there is a failure in the DTE operation.

The time-outs and actions for loop testing are given in Table C-4/X.21.

TABLE C-1/X.21

DTE time-limits

Time-limit	Time-limit number	Started by	Normally terminated by	Preferred action to be taken when time-limit exceeded
3 s	T1	Signalling of *call request* (state 2)	Reception of *proceed-to-select* (state 3)	DTE signals *DTE ready* (state 1)
20 s	T2	Signalling *end-of-selection* or *DTE waiting* (direct call) (state 5)	Reception of *call progress* signals, *DCE provided information, ready for data* or *DCE clear indication* (states 7, 10A, 12 or 19)	DTE signals *DTE clear request* (state 16)
6 s	T3A	Reception of *call progress signals* or *DCE-provided information* (states 7 or 10A). Restarted by additional *call progress signals* or *DCE-provided information* (states 7 or 10A) (see Note 2)	Reception of *ready for data* or *DCE clear indication* (states 12 or 19)	DTE signals *DTE clear request* (state 16)
60 s	T3B (see Note 1)	Reception of applicable *call progress signals* (state 7). Restarted by additional *call progress signals* or *DCE provided information* (states 7 or 10A) (see Note 2)	Reception of *ready for data* or *DCE clear indication* (states 12 or 19)	DTE signals *DTE clear request* (state 16)
2 s	T4A	Signalling of *proceed with call information* (state 9B). Restarted by reception of *call information* (state 10C) (see Note 2)	Reception of *end of call information character* or *DCE clear indication* (state 19) or DCE waiting (state 6C)	DTE signals *DTE clear request* (state 16)
6 s	T4B	Signalling of *call accepted* (states 9 and 9C). Restarted by reception of *DCE-provided information* (state 10B) (see Note 2)	Reception of *ready for data* or *DCE clear indication* (states 12 or 19)	DTE signals *DTE clear request* (state 16)

TABLE C-1/X.21 *(cont.)*

Time-limit	Time-limit number	Started by	Normally terminated by	Preferred action to be taken when time-limit exceeded
2 s	T5	Change of state to *DTE clear request* (state 16)	Change of state to *DCE ready* (state 21)	DTE regards the DCE as *DCE not ready* and signals *DTE ready* (state 18)
2 s	T6	Change of state to *DTE clear confirmation* (state 20)	Reception of *DCE ready* (state 21)	
0,2 s	T7	Change of state to *ready* (state 1) when *charge information* (state 10B) has been requested	Reception of *incoming call* (state 8)	DTE returns to normal operation and may note absence of *charge information* (state 10B)

Note 1 – T38 shall be used when receiving CPS 01 and may also be used when receiving other CPS in code group 0.

Note 2 – Restart means time-out set to ZERO and restarted.

TABLE C-2/X.21

DCE time-outs

Time-out	Time-out number	Started by	Normally terminated by	Action to be taken when time-out expires
36 s	T11	DCE signalling of *proceed-to-select* (state 3)	DCE reception of *end-of-selection* signal or in the case of direct call, *DTE waiting* (state 5)	DCE will signal *DCE clear indication* (state 19) or transmit appropriate *call progress* signals (state 7) followed by *DCE clear indication* (state 19)
6 s	T12	DCE signalling of proceed-to-select (state 3)	DCE reception of first selection character or in the case of direct call, *DTE waiting* (state 5)	
6 s	T13	DCE reception of nth selection character (state 4)	DCE reception of (n + 1)th selection character or *end-of-selection* signal	
0,5 s	T14A	DCE signalling of *incoming call* (state 8)	Signalling of *proceed with call information* (state 9B) or *call accepted* (state 9) or *call collision* (state 15)	The DTE is noted as not answering. The DCE will signal *ready* (state 1)
60 s	T14B (see Note 1)			
20 s	T14C (see Note 2)	DCE transmitting *end of call information character.* Restarted by state 25 *DTE-provided information* (see Note 3)	Change of state to *call accepted* (state 9C)	DCE will signal *DCE clear indication* (state 19) or transmit appropriate *call progress* signals followed by *DCE clear indication* (state 19)
0,5 s	T15	Change of state to *DCE clear indication* (state 19)	Change of state to *DTE clear confirmation* (state 20)	DCE will signal *DCE ready* and mark *DTE uncontrolled not ready* (state 24)
100 ms	T16	Change of state to *DCE ready* (state 21)	Change of state to *ready* (state 1)	DCE will mark *DTE uncontrolled not ready* (state 24)

Note 1 – T14B will be provided when manual answering DTEs are allowed. It is not envisaged that manual answering DTEs will use the enhanced sub-addressing procedure (see § 4.1.6.2.2).

Note 2 – T14C applies only to enhanced sub-addressing.

Note 3 – Restart means time-out set to ZERO and restarted.

TABLE C-3/X.21

DTE time-limits for loop testing

Time-limit	Time-limit number	Started by	Normally terminated by	Preferred action to be taken when time-limit expires
2 s	T20A	DTE sending the *loop command* (state L21)	DCE signalling *loop confirmation* (state L22)	DTE stops sending *loop command* and enters any state or signals *DTE clear request* (state 16)
6 s	T20B	DTE sending the *loop command* (state L31)	DCE signalling *loop confirmation* (state L32)	
2 s	T21	DTE sending *loop 2 clear request* (state L24A or L24B)	DCE signalling *loop 2 clear confirmation* (state L25)	DTE signals *DTE clear request* (state 16)

TABLE C-4/X.21

DCE time-outs for loop testing

Time-out	Time-out number	Started by	Normally terminated by	Action to be taken when time-out expires
Duration is a national option	T22	DCE signalling *receive loop 2 command* (state L26)	DCE reception of *loop released* (state L28) or *test data* (state L23) or *DTE clear confirmation* (state 20)	DCE at the tested side causes the connection to be cleared
Duration is a national option	T23	*Test data* (state L23) being received by the tested DCE	*Loop released* (state L28) or *DTE clear confirmation* (state 20) being received by the tested DCE	DCE at the tested side causes the connection to be cleared

ANNEX D

(to Recommendation X.21)

Formats of selection, call progress, and DCE-provided information signals

The following description uses Backus Normal Form as the formalism for syntactic description. A vertical line " | " separates alternatives.

<*> : : = IA 5 character 2/10

<+> : : = IA 5 character 2/11

<,> : : = IA 5 character 2/12

<−> : : = IA 5 character 2/13

<.> : : = IA 5 character 2/14

</> : : = IA 5 character 2/15

<η> : : = IA 5 characters 3/0-3/9

<:> : : = IA 5 character 3/10

<Facility parameter> : : = See Annex G

<Facility request signal> : : = See Annex G

<Full address signal> : : = See Recommendation X.121

<Abbreviated address signal> : : = National option

<Calling line identification signal> : : = See Annex H

<Called line identification signal> : : = See Annex H

<Indicator> : : = See Annexes F and G

<Facility request code> : : = See Annex G

<Registration parameter> : : = See Annex G

<Call progress signal> : : = See Annex F

<DCE-provided information signal> : : = See Annex H

<DTE provided information signal> : : = See Annex F

The above signals are combined as follows:

<Address signal> : : = <Full address signal> | <.> <Abbreviated address signal>

<Address block> : : = <Address signal> | <Address block> <,> <Address signal>

<Facility registration/cancellation signal> : : = <Facility request code> </> <Indicator> </> <Registration parameter> </> <Address signal>

<Facility registration/cancellation block> : : = <Facility registration/cancellation signal> | <Facility registration/cancellation block> <,> <Facility registration/cancellation signal>

<Facility request signal> : : = <Facility request code> | <Facility request signal> </> <Facility parameter>

<Facility request block> : : = <Facility request signal> | <Facility request block> <,> <Facility request signal>

<Selection sequence> : : = <Facility request block> <−> <Address block> <+> | <Facility request block> <−> <+> | <Address block> <+> | <Facility registration/cancellation block> <−> <+>

<Call progress signal> : : =	<Call progress code> | <Call progress code> <–> <indicator>
<Call progress block> : : =	<Call progress signal> <+> | <Call progress signal> <,> <Call progress block>
<Calling line identification> : : =	<*> <Calling line identification signal> <+>
<Calling line identification (with DNIC or DCC)> : : =	<**> <Calling line identification signal> <+>
<Called line identification block> : : =	<Called line identification signal> | <Called line identification block> <,> <Called line identification signal>
<Called line identification> : : =	<*> <Called line identification block> <+>
<Called line identification (with DNIC or DCC)> : : =	<**> <Called line identification block> <+>
<Dummy line identification> : : =	<*> <+>
<DCE-provided information block> : : =	<DCE-provided information signal> <+> | <DCE-provided information signal> <,> <DCE-provided information block> (Note)
<DTE-provided information block> : : =	<DTE-provided information signal> <+> | <DTE-provided information signal> <,> <DTE-provided information block>

Note – For *DCE-provided information* signals and blocks other than *calling* or *called line identification* signals and blocks.

ANNEX E

(to Recommendation X.21)

Interworking between DTEs conforming to Recommendations X.21 and X.21 *bis*

It is recognized that interworking between V-Series DTEs connected to a public data network according to Recommendation X.21 *bis* at one end and Recommendation X.21 at the other end should always be possible for DTEs not using half-duplex operation.

Certain Administrations may provide facilities allowing interworking between DTEs operating in accordance with Recommendations X.21 and X.21 *bis* using half-duplex operation by switching circuit C, I and circuit 109, 105 during the data transfer phase in accordance with Figure E-1/X.21.

Those Administrations not providing this facility shall cause the Recommendation X.21 DCE to signal r = 1, i = ON when the Recommendation X.21 *bis* DTE signals circuit 105 OFF. This will permit half-duplex operation for those DTEs that do not require circuit 109 to be OFF before signalling circuit 105 ON.

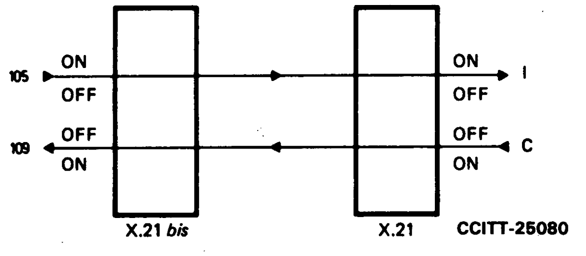


FIGURE E-1/X.21

ANNEX F

(to Recommendation X.21)

TABLE F-1/X.21

Coding of call progress signals and DTE provided information

Code group (see Note 1)	Code	Indicator	Significance	Category
0	00	–	Note 2	Without clearing
	01	–	Terminal called	
	02	–	Redirected call	
	03	–	Connect when free	
	04	–	Private network reached (see Note 3)	
	05	–	Public network reached (see Note 4)	
2	20	–	No connection	With clearing due to short-term conditions
	21	–	Number busy	
	22	–	Selection signals procedure error	
	23	–	Selection signals transmission error	
3				Unassigned
4 and 5	41	–	Access barred	With clearing due to long-term conditions
	42	–	Changed number	
	43	–	Not obtainable	
	44	–	Out of order	
	45	–	Controlled not ready	
	45	YY-MM-DD-hh:mm	DTE inactive until	
	46	–	Uncontrolled not ready	
	47	–	DCE power off	
	48	–	Invalid facility request	
	49	–	Network fault in local loop	
	51	–	Call information service	
	52	–	Incompatible user class of service	
6	61	–	Network congestion	With clearing due to network short-term conditions
7	71	–	Long-term network congestion	With clearing due to network long-term conditions
	72	–	RPOA out of order	
8	81	–	Registration/cancellation confirmed	With clearing due to network procedure
	82	–	Redirection activated	
	83	–	Redirection deactivated	
9	Reserved for national purposes			

Notes to Table F-1/X.21:

Note 1 – From the DTE point of view group 0 means "wait", groups 2 and 6 mean "try again, next try may result in a call set-up", groups 4 and 5, and 7 mean "there is no reason for the DTE to try again because the answer will be the same for a longer period of time". Since group 8 results from a procedure between the DTE and the network, no special action is expected to be taken by the DTE.

Some Administrations may specify by regulation both the delay between and the maximum number of call re-attempts permitted by a DTE in these circumstances (see Recommendation X.96).

Note 2 – Reserved for use in case of point-to-multipoint calls. This coding is used for a remote DTE to indicate that the call can be established with this one (i.e. no clearing due to the remote DTE or to the network), so that the same order of sequence of *call progress* signals and *called lines identification* can be kept.

Note 3 – In the case of sub-addressing, the DTE may see *call progress* signals which have originated in the public network and/or the private network. In such cases the call progress signal *private network reached* shall be used to discriminate between the different origins.

Note 4 – In the case of a DTE being connected to a private network which also provides for access to a public network, the DTE may see *call progress* signals which have originated in the private network and/or the public network. In such cases the call progress signal *public network reached* should be used by the private network in order to discriminate between the different origins.

ANNEX G

(to Recommendation X.21)

Facility request, indicator and parameter coding
(for use as appropriate in *facility request* signals and *facility registration/cancellation* signals)

TABLE G-1/X.21

(see Annex D for formats and Note 1 below)

Facility request code	Facility parameter	Indicator	Registration parameter	Address signal	Facility
0	–	–	–	–	Reserved for future use (may be combined with second character)
1	XX (see Note 2)	–	–	–	Closed user group (other than preferential)
2	–	–	–	–	Unassigned
3	–	–	–	–	Unassigned
45	–	1	YY-MM-DD-hh:mm	–	DTE inactive registration
45	–	2	–	–	DTE inactive cancellation
50	–	–	–	–	Reserved
51	–	–	–	–	Reserved
53	–	–	–	–	Reserved
60	0, 1, 2, 3, 4, 5	–	–	–	Multiple address calling
61	–	–	–	–	Charging information
62	–	–	–	–	Called line identification
63	–	1	–	–	Redirection of call activation
63	–	2	–	–	Redirection of call cancellation
63	–	3	–	–	Redirection of call status
64	–	–	–	–	Reverse charging
65	–	1	–	AS	Direct call registration
65	–	2	–	–	Direct call cancellation
66	–	1	AAS	AS	Abbreviated address registration
66	–	2	AAS	–	Abbreviated address cancellation
68	–	–	–	–	Reserved
7	–	–	–	–	Reserved
8	–	–	–	–	Reserved
9	Reserved for national purposes				

AAS abbreviated address signal.
AS address signal.

Note 1 – For an interim period, the 2/15 "/" separator in the formats will not be used in some networks.

Note 2 – XX is an index number, i.e., a key code for closed user group other than the preferential group. The index number shall be used to distinguish between parts or groups within one facility. The index number shall furthermore be chosen from IA5, column 3, positions 3/0-3/9, giving a range of possible numbers from 00 to 99.

G.1 *Multiple address calling*

This facility provides the calling DTE with the capability to request a category of point to multipoint service.

The coding is as follows:

<60> </> <η> <–> <Address block> <+>

where

η is a numerical character with the following signficance:

0 Reserved
1 Reserved
2 Reserved
3 Centralized multipoint
4 Reserved
5 Reserved.

G.2 *Charging information*

This facility enables the calling DTE to request at the *call establishment phase* that charging information for the call be provided at the end of the call.

<61> <–> <address> <+>

G.3 *Redirection of call*

This facility enables the DTE to request the network to route its incoming calls towards another address. The use of this facility is assigned for an agreed contractual period.

Activation of redirection of call – The activation of this facility is coded as follows:

<63> </> <1> <–> <+>

Cancellation of redirection of call – The cancellation of this facility is coded as follows:

<63> </> <2> <–> <+>

Status of redirection of call – The DTE has the capability to ask the network for the status of its redirection. The coding is as follows:

<63> </> <3> <–> <+>

G.4 *Reverse charging*

This facility enables the calling DTE to request that reverse charging be applied for the call.

The coding is as follows:

<64> <–> <address> <+>

G.5 *Direct call on a per call basis*

This facility enables the DTE to designate the address to which all calls will be established when the *selection signals* phase (state 4) is bypassed during call establishment.

Registration – The coding of this registration of the address is as follows:

<65> </> <1> </> <0> </> <Address> <–> <+>

where

<Address> is the designated address.

The DTE is able to amend the designated address by performing a cancellation procedure followed by the registration procedure.

The coding of the cancellation procedure is as follows:

<65> </> <2> <–> <+>

G.6 *Abbreviated address calling*

This facility enables the DTE to define a full address by an abbreviated address.

The registration coding of an abbreviated address is as follows:

<66> </> <1> </> <xy> </> <Address> <–> <+>

where

<xy> = abbreviated address corresponding to the full address,

<address> = full address.

Cancellation – The coding of the cancellation of an abbreviated address is as follows:

<66> </> <2> </> <xy> <–> <+>

where

<xy> is the abbreviated address.

G.7 *Closed user group selection*

This facility provides the calling DTE with the possibility to communicate within more than one closed user group.

The coding is as follows:

<1> </> <xx> <–> <Address block> <+>

where

<xx> is the closed user group index number, i.e. the key code for the closed user group other than the preferential group. The index number shall be used to distinguish between parts or groups within one facility. The index numbers are numerical characters chosen from column 3 of IA5.

G.8 *DTE inactive registration/cancellation*

This facility enables the DTE to inform the network about a period of time during which the DTE is unable to accept incoming calls for circuit-switched service.

DTE inactive registration – The activation of this facility is as follows:

<45> </> <1> </> <YY-MM-DD-hh:mm> <–> <+>

where

YY: Year, MM: Month, DD: Day, hh: Hour, mm: Minute

IA5 characters are used for "YY", "MM", "DD", "hh", "mm", "–", and ":".

DTE inactive cancellation is as follows:

<45> </> <2> <–> <+>

ANNEX H

(to Recommendation X.21)

Information content of DCE provided information

H.0 *General*

Except for the *calling* and *called line identification*, the general format for *DCE-provided information*, as defined in § 4.6.3 should apply.

The coding of numerical character used to distinguish between different types of *DCE-provided information* is indicated in Table H-1./X.21.

H.1 *Information content of calling and called line identification*

Two formats are defined:

i) *Calling* and *called line identification* consist of the international data number as defined in Recommendation X.121 preceded by *two* prefixes 2/10 (" ** "). In the case where the originating network does not provide *calling line identification*, only the data network identification code (DNIC) part of the International Data Number preceeded by two prefixes 2/10 (" ** ") may be sent in place of the *dummy line identification*.

ii) *Calling* and *called line identification* consist of the national number (NN) or network terminal number (NTN) preceded by the prefix 2/10 (" * ").

H.2 *General coding of the DCE-provided information*

TABLE H-1/X.21

Coding of DCE provided information

Identifier	Meaning	Remarks
0	Reserved	
1 2 3	Charging information Charging information Charging information	See details in § H.3
4	Sub-addressing	See details in § H.4
5	Date and time indication	See details in § H.5
6	Characteristics of the call	See details in § H.6
7	Type of call indication	See details in § H.7
81	Closed user group indication	See details in § H.8
82	Closed user group outgoing access indication	See details in § H.8.1
9	Reserved	

H.3 *Information content of charging information*

The *charging information* will inform the subscriber of either the monetary charges for a call, the duration of the call, or the number of units used during the call.

When *charging information* is given in monetary charges for the call, n = 1 and the information shall consist of x number of integer digits optionally followed by a colon and two digits representing the fraction. The format applied is as follows:

</> <1> </> <X...>

</> <1> </> <X...> <:> <yy>

When the *charging information* is presented as the duration of a call, n = 2 and the information shall consist of x number of integer digits representing seconds, the format applied is as follows:

</> <2> </> <X...>

When the *charging information* is presented as the number of units used, n = 3, and the information shall consist of x number of integer digits representing the units, the format applied is as follows:

</> <3> </> <X...>

H.4 *Sub-addressing information*

The *sub-addressing information* will inform the called DTE of the sub-address sent by the calling DTE.

The format of the sub-addressing information is as follows:

</> <4> </> <X...>

The format of the dummy information is as follows:

</> <4> </>

H.5 *Date and time indication*

The *date and time indication* will inform the subscriber of the date and time the call is established. The format for the *date and time indication* is as follows:

</> <5> </> <YY-MM-DD-hh:mm>

where

YY: Year, MM: Month, DD: day, hh: hour and mm: minute

IA5 characters are used for "YY", "MM", "DD", "hh", "mm", "–" and ":".

H.6 *Characteristics of the call*

The *characteristics of the call* will inform the called DTE of the different facilities that have been requested by the calling DTE.

The format of the characteristic of the call is as follows:

</> <6> </> <XY>

where

X and Y are two numerical characters.

Table H-2/X.21 indicates the allocation of values of these two characters to facilities.

TABLE H-2/X.21

00	Reserved
01	Reverse charging
02	Reserved
03	Reserved

H.7 *Type of call indication*

The *type of call indication* will inform the called DTE of the configuration of the incoming call.

The format of the *type of call indication* is as follows:

</> <7> </> <XY>

where

X and Y are two numerical characters.

Table H-3/X.21 indicates the allocation of values of those two characters to different configurations of calls.

TABLE H-3/X.21

00	Reserved
01	Reserved
02	Reserved
03	Centralized multipoint
04	Reserved

H.8 *Closed user group indication*

The *closed user group indication* will inform the called DTE to which closed user group the incoming call belongs.

The format of the *closed user group indication* is as follows:

</> <81> </> <xxxx...x>

where

<x> : closed user group index number.

H.8.1 *Closed user group outgoing access indication*

The *closed user group outgoing access indication* will inform the called DTE from a DTE belonging to a closed user group with outgoing access facility. If the called DTE belongs to the same closed user group, the local closed user group index number will be indicated. In other cases, no indication will be given.

The format of the *closed user group outgoing access indication* is as follows:

</> <82> </> <xx . . . x>

where

<x> is the closed user group index number.

ANNEX I

(of Recommendation X.21)

Reference and transition tables

TABLE I-1/X.21

Cross reference of interchange circuit signals, states, and reference section

T,	C	R,	I	State No.	Reference in the Recommendation (§)
1,	OFF	1,	OFF	1	2.5.3.1
1,	OFF	0,	OFF	18	2.5.3.3
0,	OFF	1,	OFF	21, 24	2.5.3.6
0,	OFF	0,	OFF	17, 20, 22	2.5.3.4
1,	OFF	BEL,	OFF	8	4.1.5
01,	OFF	1,	OFF	14	2.5.3.2
01,	OFF	0,	OFF	23	2.5.3.5
X,	X	01,	OFF	L27	7.3.2.8
0011,	OFF	D,	ON	L21	7.3.2.1
0011,	OFF	0011,	OFF	L22	7.3.2.2
*,	OFF	BEL,	OFF	9B	4.1.6.2.2.1
*,	OFF	IA5,	OFF	10C	4.1.6.2.2.2
IA5,	OFF	SYN,	OFF	25	4.1.6.2.2.4
*,	OFF	SYN,	OFF	6C	4.1.6.2.2.3
1,	OFF	D,	ON	13R	5.2.2, 5.3.1.2, 5.3.2.2
0,	OFF	1,	ON	16	6.1
0,	OFF	0,	ON	16	6.1
0,	OFF	D,	ON	16	6.1
1,	ON	1,	OFF	11	4.1.10
1,	ON	0,	OFF	19	6.2
0,	ON	1,	OFF	2	4.1.1
0,	ON	0,	OFF	19	6.2
1,	ON	BEL,	OFF	9	4.1.6
1,	ON	+,	OFF	5	4.1.4
1,	ON	SYN,	OFF	6A, 6B, 9C	4.1.7
1,	ON	IA5, [a]	OFF	7, 10A, 10B	4.1.8, 4.1.9
0,	ON	BEL,	OFF	15	4.3
0,	ON	+,	OFF	3	4.1.2
IA5,	ON	+,	OFF	4	4.1.3
D,	ON	1,	OFF	13S	5.2.1, 5.3.1.1, 5.3.2.1
D,	ON	0,	OFF	19	6.2, Fig. A-3/X.21
1,	ON	1,	ON	12	4.1.1.1
D,	ON	D,	ON	13	5.1, 5.2.3, 5.3.3

[a] An IA5 character other than BEL.

TABLE I-2/X.21

Recognized transitions between states

(other transitions are not considered valid)

State No.	Name	T,	C	R,	I	DTE transition to state No.	DCE transition to state No.	Time-out transition		
								To state No.	Time-out No.	Terminated by state No.
1	Ready	1,	OFF	1,	OFF	2, 13S, 14, 24	8, 13R, 18	1	T7	8
2	Call request	0,	ON	1,	OFF	–	3, 15	1	T1	3
3	Proceed-to-select	0,	ON	+,	OFF	4, 5	–	19	T11, T12	4, 5
4	Selection signal	IA5,	ON	+,	OFF	5	–	19	T13	End of selection (EOS)
5	DTE waiting	1,	ON	+,	OFF	–	6A, 11, 12	16	T2	7, 10A, 12, 19
6A	DCE waiting	1,	ON	SYN,	OFF	–	7, 10A, 11, 12	–	–	–
6B	DCE waiting	1,	ON	SYN,	OFF	–	10B, 11, 12	–	–	–
6C	DCE waiting	*,	OFF	SYN,	OFF	6D, 9C, 25	–	19	T14C	9C, 25
6D	DCE waiting	1,	OFF	SYN,	OFF	9C	–	–	–	–
7	Call progress signal	1,	ON	IA5,	OFF	–	6A, 10A, 11, 12	16	T3A, T3B	7, 10A, 12, 19
8	Incoming call	1,	OFF	BEL,	OFF	15, 9, 9B	–	1	T14A, T14B	9, 15
9	Call accepted	1,	ON	BEL,	OFF	–	6B, 11, 12	16	T4B	10B, 12, 19
9B	Proceed with call information	*,	OFF	BEL,	OFF	–	10C	16	T4A	10B, 10C, 19
9C	Call accepted	1,	ON	SYN,	OFF	–	6B, 11, 12	16	T4A	10B, 12, 19
10A	DCE-provided information	1,	ON	IA5,	OFF	–	6A, 11, 12	–	– – –	–
10B	DCE-provided information	1,	ON	IA5,	OFF	–	6B, 11, 12	–	–	–
10C	Call information	*,	OFF	IA5,	OFF	–	6C	19	T4A	9C, 25
11	Connection in progress	1,	ON	1,	OFF	–	12	–	–	–
12	Ready for data	1,	ON	1,	ON	13	13	–	–	–
13	Data transfer	D,	ON	D,	ON	13R	13S, DCE not ready	–	–	–
13R	Receive data	1,	OFF	D,	ON	13	1	–	–	–
13S	Send data	D,	ON	1,	OFF	1	13	–	–	–
14	DTE controlled not ready, DCE ready	01,	OFF	1,	OFF	1, 24	23	–	–	–

TABLE I-2/X.21 *(cont.)*

State No.	Name	T,	C	R,	I	DTE transition to state No.	DCE transition to state No.	Time-out transition		
								To state No.	Time-out No.	Terminated by state No.
15	Call collision	0,	ON	BEL,	OFF	–	3	–	–	–
16	DTE clear request	0, (see Note)	OFF	X	X	–	17	18	T5	21
17	DCE clear confirmation	0,	OFF	0,	OFF	–	21	–	–	–
18	DTE ready, DCE not ready	1,	OFF	0,	OFF	22	1	–	–	–
–	DCE not ready	D,	ON	0,	OFF	–	1, 13, 13S	–	–	–
19	DCE clear indication	X (see Note)	X	0,	OFF	20	–	24	T15	20
20	DTE clear confirmation	0,	OFF	0,	OFF	–	21	18	T6	21
21	DCE ready	0,	OFF	1,	OFF	1	–	24	T16	1
22	DTE uncontrolled not ready, DCE not ready	0,	OFF	0,	OFF	18	24	–	–	–
23	DTE controlled not ready, DCE not ready	01,	OFF	0,	OFF	18, 22	14	–	–	–
24	DTE uncontrolled not ready, DCE ready	0,	OFF	1,	OFF	1	22	–	–	–
–	DCE controlled not ready	X,	X	01,	OFF	–	–	–	–	–
L21	Send loop 2 command	0011,	OFF	D,	ON	–	L22	Any, 16	T20A	L22
L22	Loop 2 confirmation	0011,	OFF	0011,	OFF	L23, L24B	–	–	–	–
L23	Test data	D,	ON	D,	ON	L24A	–	16	T23	L28
L24A	Loop 2 clear request	≠0011,	OFF	D,	ON	–	L25	16	T21	L25
L24B	Loop 2 clear request	≠0011,	OFF	0011,	OFF	–	L25	16	T21	L25

TABLE I-2/X.21 *(end)*

State No.	Name	T,	C	R,	I	DTE transition to state No.	DCE transition to state No.	Time-out transition		
								To state No.	Time-out No.	Terminated by state No.
L25	Loop 2 clear confirmation	≠0011,	OFF	≠0011,	OFF	Any	–	–	–	–
L26	Receive loop 2 command	X	X	0011,	OFF	L26A	L27, L29	16	T22	L23, L28, 20
L26A	Loop 2 consent	X	OFF	0011,	OFF	–	L27, L29	–	–	–
L27	DCE controlled not ready	X,	X	0101,	OFF	–	L28	–	–	–
L28	Loop 2 released	X,	X	≠0101,	OFF	–	Any	–	–	–
L29	DCE not ready	X,	X	0,	OFF	29	–	–	–	–
L31	Send loop 3 command	00001111,	OFF	X,	X	–	L32	Any	T20B	L32
L32	Loop 3 confirmation	00001111,	OFF	00001111,	OFF	L33, L34B	–	–	–	–
L33	Test data	D,	ON	D,	ON	L34A	–	–	–	–
L34A	Loop 3 clear request	≠00001111,	OFF	D,	ON	–	L35	–	–	–
L34B	Loop 3 clear request	≠00001111,	OFF	00001111,	OFF	–	L35	–	–	–
L35	Loop 3 clear confirmation	≠00001111,	OFF	≠00001111,	OFF	Any	–	–	–	–
Any state (see Note)		X,	X	X,	X	16	19	–	–	–

Note – *DCE clear indication* (state 19) or *DTE clear request* (state 16) may be entered from any state except *ready* (state 1).

Tableau I-2/X.21

In state No. L29, the “DTE transition to state No.” should be “20” instead of “29”.

USE ON PUBLIC DATA NETWORKS OF DATA TERMINAL EQUIPMENT (DTE) WHICH IS DESIGNED FOR INTERFACING TO SYNCHRONOUS V-SERIES MODEMS

(Geneva, 1976; amended at Geneva, 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

The CCITT,

considering that

(a) the interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for synchronous operation on public data networks is specified in Recommendation X.21;

(b) several Administrations are also planning to provide as an interim measure the connection to public data networks of synchronous DTEs which are designed for interfacing to synchronous V-Series modems,

unanimously recommends

(1) the connection of DTEs with V-Series-type interface to public data networks allow for:

i) the leased circuit service (point-to-point and centralized multipoint),

ii) the *direct call facility,*

iii) the *address call facility*;

(2) this Recommendation specifies the operational modes and the optional features which apply when the data circuit interconnects V-Series DTEs. Interworking between V-Series DTEs and X.21 DTEs is described in Annex A.

1 The use of V-Series DTEs for leased circuit service and packet-switched service (X.25, Layer 1)

1.1 *General*

The use of V-Series DTEs utilizing the leased circuit service in public data networks is discussed in the following.

The data signalling rates are those defined in Recommendation X.1 for user classes of service employing synchronous transmission.

1.2 *Use of interchange circuits*

The electrical characteristics of the interchange circuits at both the DCE side and the DTE side of the interface may comply either with Recommendation V.28 using the 25-pole DTE/DCE interface connector and contact number assignments standardized by ISO 2110 or with Recommendation X.26 using the 37-pole DTE/DCE interface connector and contact number assignments standardized by ISO 4902. Administrations may choose to offer only one of the interface options. Where the Administration permits interworking between V.28 equipment on one side of the interface and X.26 equipment on the other side of the interface, refer to Recommendation X.26 and ISO 4902. (The onus is on the provider of X.26 equipment to supply the adaptor needed to interwork with the V.28 equipment.)

For applications of the data signalling rate of 48 kbit/s, the connector and electrical characteristics at both the DCE side and the DTE side of the interface are given in the ISO standard for the assignment of the 34-pin interface connector ISO 2593 and in Recommendation V.35 respectively. Alternatively for the data signalling rate of 48 kbit/s, the connector and electrical characteristics at both the DCE side and the DTE side of the interface may use ISO 4902 and Recommendations X.26/X.27 respectively as applied for Recommendation V.36. Interworking with ISO 2593 and Recommendation V.35 configuration is for further study. Administrations may choose to offer only one of the interface options at 48 kbit/s.

Table 1/X.21 *bis* shows the use of interchange circuits for the leased circuit service.

TABLE 1/X.21 *bis*

V.24 Interchange circuit No.	Designation
102	Signal ground or common return
103	Transmitted data
104	Received data
105	Request to send
106	Ready for sending
107	Data set ready (see Note 1)
108/1	Connect data set to line (see Notes 2 and 3)
109	Data channel received line signal detector
114	Transmitter signal element timing (DCE) (see Note 4)
115	Receiver signal element timing (DCE) (see Note 4)
140	Loopback/maintenance test (see Note 5)
141	Local loopback (see Note 5)
142	Test indicator (DCE)

Note 1 – Circuit 107 shall go OFF only in cases of DCE power-off (normally the indeterminate state is interpreted as OFF), loss of service (see § 3.2 below) or when circuit 108/1, when implemented, is turned OFF.

Note 2 – Not required for V.29, V.35 and V.36 compatible interfaces.

Note 3 – The DCE interprets the ON condition on circuit 108/1, when implemented, as an indication that the DTE is operational. If circuit 108/1 is not provided the DCE will consider the lack of circuit 108/1 as the ON condition. The DCE turns circuit 107 ON while circuit 108/1, if present, is ON and the circuit connection is available.

Note 4 – The DCE shall provide the DTE with transmitter and receiver signal element timings; this is donne by feeding circuits 114 and 115 with the same timing signal from the DCE.

Note 5 – Not required in those networks which do not provide automatic activation of the loops.

All these circuit functions are in accordance with Recommendation V.24 and the appropriate modem Recommendations (see also § 1.2.1 below).

1.2.1 *Operational requirements*

1.2.1.1 *Half-duplex operation*

In principle the data circuit provided has duplex transmission capability. However, when a remote response from circuit 105 to circuit 109 is required it may be provided on an optional basis (see also Annex A).

Note – Attention is drawn to the fact that, although circuit 105 can control circuit 109 at the other end, in case of the half-duplex facility, the detection of a line signal should be replaced by some other control mechanism.

1.2.1.2 *Response times*

The response time of the OFF to ON transition of circuit 106 as a response to circuit 105 OFF to ON should provisionally be between 30 and 50 ms for the 600 bit/s user rate, and 10 to 20 ms for the higher user rate.

1.2.1.3 *Clamping*

The following conditions apply:

- In the event of line failure (e.g. channel out of service, loss of alignment) the DCE shall clamp circuit 104 to steady binary 1 condition and circuit 109 to OFF condition.
- In all applications the DCE shall hold circuit 104 in binary 1 condition, when circuit 109 is in the OFF condition.
- In addition, when the half-duplex facility is provided, the DCE shall hold circuit 104 in the binary 1 condition and circuit 109 in the OFF condition when circuit 105 is in the ON condition.
- When circuit 105 or circuit 106 or both are OFF, the DTE shall maintain a binary 1 condition on circuit 103.

1.2.1.4 *Timing arrangements*

Timing signals on circuits 114 and 115 should always be maintained when the DCE is capable of generating them, disregarding the conditions of the other circuits. Circuits 114 and 115 should be held by the DCE in the OFF condition when the DCE is unable to generate the timing information.

2 The use of V-Series DTEs for direct call and address call facilities

2.1 *General*

The use of V-Series DTEs utilizing the *direct call* or the *address* facility in public data networks is discussed below.

The data signalling rates are those defined in Recommendation X.1 for user classes of service employing synchronous transmission.

2.2 *Use of interchange circuits*

The electrical characteristics of the interchange circuits at both the DCE side and the DTE side of the interface may comply either with Recommendation V.28 using the 25-pole DTE/DCE interface connector and contact number assignments standardized by ISO 2110 or with Recommendation X.26 using the 37-pole DTE/DCE interface connector and contact number assignments standardized by ISO 4902. Administrations may choose to offer only one of the interface options. Where the Administrations permit interworking between V.28 equipment on one side of the interface and X.26 equipment on the other side of the interface, refer to Recommendation X.26 and ISO 4902. (The onus is on the provider of the X.26 equipment to supply the adaptor needed to interwork with the V.28 equipment.)

For applications of the data signalling rate of 48 kbit/s, the connector and electrical characteristics at both the DCE side and the DTE side of the interface are given in the ISO standard for the assignment of the 34-pin interface connector ISO 2593 and in Recommendation V.35 respectively. Alternatively for the data signalling rate of 48 kbit/s, the connector and electrical characteristics at both the DCE side and the DTE side of the interface may use ISO 4902 and Recommendations X.26/X.27 respectively as applied for Recommendation V.36. Interworking with ISO 2593 and Recommendation V.35 configuration is for further study. Administrations may choose to offer only one of the interface options at 48 kbit/s.

Table 2/X.21 *bis* shows the list of interchange circuits.

TABLE 2/X.21 *bis*

V.24 Interchange circuit No.	Designation
102	Signal ground or common return
103	Transmitted data
104	Received data
105	Request to send
106	Ready for sending
107	Data set ready
108/1 or	Connect data set to line
108/2	Data terminal ready
109	Data channel received line signal detector
114	Transmitter signal element timing (DCE)
115	Receiver signal element timing (DCE)
125	Calling indicator
141	Local loopback
142	Test indicator (DCE)

For further definitions of the interchange circuits outlined below, refer to Recommendation V.24 and the appropriate V-Series modem Recommendations.

2.2.1 *Call establishment and disconnection phases*

The following interchange circuits should be used for control signalling in the call establishment and disconnection phases:

Circuit 102 – Signal ground or common return

Circuit 107 – Data set ready

This circuit is used to indicate the following operational functions.

Condition of circuit 107	Function in the network (see § 2.2.1.1)
ON	Ready for data
OFF	DCE clear indication
OFF	DCE clear confirmation

Note – In duplex transmission when no circuit 105 operation is used by the DTE, circuit 106 will be set to ON with a delay from 0 to 20 ms with respect to the transition of circuit 107 to ON.

Circuit 108/1 – Connect data set to line

This circuit is used alternatively to circuit 108/2. The following operational functions should be indicated.

Condition of circuit 108/1	Function in the network (see § 2.2.1.1)
ON	Call request
ON	Call accepted
OFF	DTE clear request
OFF	DTE clear confirmation

Note – This circuit should not be operated when the DTE is connected to a modem which does not terminate this circuit.

Circuit 108/2 – Data terminal ready

This circuit is used alternatively to circuit 108/1. The following operational functions should be indicated.

Condition of circuit 108/2	Function in the network (see § 2.2.1.1)
ON	Call accepted
OFF	DTE clear request
OFF	DTE clear confirmation

Note – This circuit should not be operated when the DTE is connected to a modem which does not terminate this circuit.

Circuit 114 – Transmitter signal element timing (DCE)

Circuit 115 – Receiver signal element timing (DCE)

The DCE shall provide the DTE with transmitter and receiver element timings. This is done by feeding circuits 114 and 115 with the same timing signal from the DCE.

Circuit 125 – Calling indicator

The ON condition indicates *incoming call*. The circuit will be turned OFF as follows:

- in conjunction with circuit 107 turned ON, or
- *DCE ready* is received from the network, or
- *DCE clear indication* is received from the network.

Circuit 141 – Local loopback

Signals on this circuit are used to control the loop 3 test condition in the local DCE. Not required in those networks which do not provide automatic activation of the loops.

Circuit 142 – Test indicator

This circuit is used to indicate to the DTE the test-mode status of the DCE.

2.2.1.1 *Operational requirements*

2.2.1.1.1 *Call request*

For a *direct call facility* the DTE indicates a *call request* by turning circuit 108/1 ON. Circuit 108/2 cannot be used for this purpose.

2.2.1.1.2 *Call accepted*

A DTE receiving an *incoming call* should turn circuit 108/1 or 108/2 from OFF to ON within 500 ms to indicate *call accepted*, otherwise the call will be cleared. A DCE presenting an *incoming call* to a DTE which already has circuit 108/2 ON will regard the ON condition on circuit 108/2 as an indication of *call accepted*. Optionally when a DTE does not provide circuit 108/1 or 108/2, the *call accepted* signal to the network would be generated within the DCE as an answer to the *incoming call* signal received from the network. However, it may be also possible to signal to the network a *DTE controlled not ready* by a manual action on the DCE.

2.2.1.1.3 *DCE clear indication/DTE clear confirmation*

DCE clear indication is signalled to the DTE by turning circuit 107 OFF. The *DTE clear confirmation*, when implemented, should be given by the DTE turning OFF circuit 108/1 or 108/2 within 500 ms after the *DCE clear indication* is signalled on circuit 107. Otherwise, the DCE may consider the DTE as being *uncontrolled not ready* until circuit 108/1 or 108/2 is turned OFF or a *ready* signal is generated by a manual action on the DCE.

Circuit 108/1 should always be able to give *DTE clear confirmation*.

Optionally, when a DTE does not turn circuit 108/2 OFF for *DTE clear confirmation* this would be automatically generated within the DCE as an answer to the *clear indication* received from the network and the DTE will be considered in the ready condition.

In the case when the DTE expects to have circuit 107 OFF only as a response to circuit 108/1 or 108/2 OFF, the DCE will not turn circuit 107 OFF as a *DCE clear indication* and in this case the *DCE clear indication* will not be signalled to the DTE across the interface. The *DTE clear confirmation* signal will then be automatically generated within the DCE as an answer to the *clear indication* signal received from the network. The DTE may be regarded as *uncontrolled not ready* until circuit 108/1 or 108/2 is turned OFF.

2.2.1.1.4 *Line identification*

Calling and *called line identification* signals cannot be handled by V-Series DTEs.

2.2.1.1.5 *Call progress signals*

Call progress signals cannot be handled by V-Series DTEs. If automatic address calling is provided in accordance with Recommendation V.25, the reception of negative *call progress* signals will be indicated to the DTE on circuit 205.

2.2.2 *Data transfer phase*

The interchange circuits shown in Table 3/X.21 *bis* should be used in the *data transfer* phase.

TABLE 3/X.21 *bis*

V.24 Interchange circuit No.	Designation
102	Signal ground or common return
103	Transmitted data
104	Received data
105	Request to send
106	Ready for sending
109	Data channel received line signal detector
114	Transmitter signal element timing (DCE) (see Note)
115	Receiver signal element timing (DCE) (see Note)

Note – The DCE shall provide the DTE with transmitter and receiver element timings. This is donne by feeding circuits 114 and 115 with the same timing signal from the DCE.

All the circuit functions are in accordance with Recommendation V.24 and the appropriate modem Recommendations.

2.2.2.1 *Operational requirements*

2.2.2.1.1 *Half-duplex operation*

In principle the data circuit provided has duplex transmission capability. However, when a remote response from circuit 105 to circuit 109 is required it may be provided on an optional basis (see also Annex A).

2.2.2.1.2 *Response times*

The response time of the OFF to ON transition of circuit 106 as a response to circuit 105 OFF to ON should provisionally be between 30 and 50 ms for the 600 bit/s user rate, and 10 to 20 ms for the higher user rate.

2.2.2.1.3 *Clamping*

The following conditions shall apply:

- In the event of line failure (e.g. channel out of service, loss of alignment) the DCE shall clamp circuit 104 to steady binary 1 condition and circuit 109 to OFF condition.
- In all applications the DCE shall hold circuit 104 in binary 1 condition, when circuit 109 is in the OFF condition.
- In addition, when the half-duplex facility is provided, the DCE shall hold circuit 104 in the binary 1 condition and circuit 109 in the OFF condition when circuit 105 is in the ON condition.
- When circuit 105 or circuit 106 or both are OFF, the DTE shall maintain a binary 1 condition on circuit 103.

2.2.2.1.4 *Timing arrangements*

Timing signals on circuits 114 and 115 should always be maintained when the DCE is capable of generating them, disregarding the conditions of the other circuits. Circuits 114 and 115 should be held by the DCE in the OFF condition when the DCE is unable to generate the timing information.

Continuous isochronous operation should be used.

2.3 *Operational modes*

2.3.1 *Direct call facility*

The following operational modes may be provided for:

i) Automatic direct call and automatic disconnection from the DTE. Circuit 108/1 should be used. In this case manual disconnection from the DCE should not be used.

ii) Manual direct call from the DCE and automatic disconnection from the DTE. Circuit 108/2 should be used.

iii) Manual direct call and manual disconnection from the DCE; for DTEs not providing circuit 108 or unable to use circuit 108/2 for disconnection.

Only automatic call answering controlled by circuit 108/1 or 108/2 when provided, or automatically within the DCE itself, should be implemented. However in the last case it is possible to signal to the network *DTE controlled not ready* by a manual action on the DCE.

Note – Consideration of manual answering and the implications of manual *DTE clear confirmation* are for further study.

2.3.2 *Address call facility*

The following operational modes may be provided for:

i) Manual address calling from the DCE and automatic disconnection from DTE. Circuit 108/2 should be used.

ii) Manual address calling and manual disconnection from the DCE; for DTEs not providing circuit 108/1 or 108/2 or unable to use circuit 108/2 for disconnection.

Only automatic answering controlled by circuit 108/2 when provided, or automatically within the DCE itself, should be implemented. However in the last case it is possible to signal to the network *DTE controlled not ready* by a manual action on the DCE.

iii) Automatic address calling and automatic disconnection from DTE if provided, should use the 200 series interchange circuits and the Recommendation V.25 relevant procedures. The spare and code positions on the digit signal circuits 206-209 may be used for special purposes during the selection sequence in public data networks. The relationship between control characters on circuits 206-209 and those of Recommendation X.21 is as shown in Table 4/X.21 *bis.*

TABLE 4/X.21 *bis*

Binary states 209	208	207	206	Corresponding X.21 control characters
1	1	0	0	+
1	1	0	1	,
1	1	1	1	/
1	1	1	0	.
1	0	1	0	–

For an interim period some Administrations may provide a relationship according to Table 5/X.21 *bis*.

TABLE 5/X.21 *bis*

Binary states 209	208	207	206	Corresponding X.21 control characters
1	0	1	1	+
1	1	0	0	,
1	1	1	1	/
1	1	1	0	.
1	1	0	1	–

3 Failure detection and isolation

3.1 *Indeterminate conditions on interchange circuits*

If the DTE or DCE is unable to determine the condition of circuits 105, 107, 108/1 or 108/2 and possibly circuits 103 and 104 as specified in the relevant electrical interfaces specifications, it shall interpret this as the OFF condition or binary 1 (circuits 103 and 104).

3.2 *DCE fault conditions*

If the DCE is unable to provide service (e.g. loss of alignment or of incoming line signal) for a period longer than a fixed duration it will turn circuit 107 to the OFF condition. The value of this duration is network dependent.

Moreover, as soon as the DCE detects this condition it turns circuit 109 in the OFF condition and circuit 104 in the binary 1 condition.

3.3 *Test loops*

The definitions of the loops and the principles of maintenance testing using the test loops are provided in Recommendation X.150.

3.3.1 *DTE test loop – type 1 loop*

This loop is used as a basic test of the operation of the DTE, by looping back the transmitted signals inside the DTE for checking. The loop should be set up inside the DTE as close as possible to the DTE/DCE interface.

Except as noted below, while the DTE is in the loop 1 test condition:

- circuit 103 is connected to circuit 104 of the DTE;
- circuit 103 as presented to the DCE must be in the binary 1 condition;
- circuit 105 must be in the OFF condition;
- circuit 108/1 or 108/2 may be in the same condition as it was before the test;
- circuits 140 and 141, if implemented, must be in the OFF condition;
- the DCE continues to present signal element timing information on circuits 114 and 115. The DTE need not make use of the timing information.

The conditions of the other interchange circuits are not specified but they should if possible permit normal working.

Loop 1 may be established from either the *data transfer* phase or the *idle* phase.

If the loop is established from the *data transfer* phase, the DCE may continue to deliver data to the DTE during the test as though the DTE were in normal operation. It will be the responsibility of the DTE to recover from any errors that might occur while the test loop is activated.

If the loop is established from the *idle* phase, the DTE should continue to monitor circuit 125 so that an incoming call may be given priority over a routine test.

3.3.2 *Local test loop – type 3 loop*

Local test loops (type 3 loop) are used to test the operation of the DTE, the interconnecting cable and either all or parts of the local DCE, as discussed below.

Where allowed by national testing principles, loop 3 may be established from any state.

For testing on leased circuits and for short duration testing, on circuit-switched connections the DCE should either continue to present toward the line the conditions that existed before the test (e.g. either *data transfer* or *ready* state) or send the *controlled not-ready* state to the remote DTE. Where this is not practical (e.g. in some cases for loop 3a) or desirable (e.g. for long duration testing in circuit-switched applications), the DCE should terminate an existing call and, if possible, signal toward the subscriber line one of the *not-ready* states.

Manual control should be provided on the DCE for activation of the test loop.

The automatic activation of this loop, if provided, should be controlled by circuit 141.

The precise implementation of the test loop within the DCE is a national option. At least one of the following local test loops should be implemented.

3.3.2.1 *Loop 3d*

This loop is used to test the operation of the DTE, including the interconnecting cable, by returning transmitted signals to the DTE for checking. The loop is set up inside the local DCE and does not include interchange circuit generators and loads.

While the DCE is in the loop 3d test condition:

- circuit 103 is conneced to the circuit 104;
- circuit 105 is connected to both circuits 106 and 109;

  Note – DTE designers should note that this connection results in one generator driving two loads in parallel.
- circuits 107 and 142 are placed in the ON condition;
- the DCE continues to present signal element timing information on circuits 114 and 115. The DTE must make use of the timing information.

Note – While test loop 3d is operated, the effective length of the interface cable is doubled. Therefore, to insure proper operation of loop 3d, the maximum DTE/DCE interface cable length should be one-half the length normally appropriate for the data signalling rate in use.

3.3.2.2 *Loop 3c*

This loop is used to test the operation of the DTE, including the interconnecting cable and DCE interchange circuit generators and loads.

The configuration is identical to that given for loop 3d in § 3.3.2.1 with the exception that the looping of circuit 103 to circuit 104 and the looping of circuit 105 to circuit 109 includes the interchange circuit generators and loads. Circuit 106 should follow circuit 105 with the usual delay or with no delay. The notes concerning restriction of interface cable length and load input impedance are not applicable.

3.3.2.3 *Loop 3b*

This loop is used as a test of the operation of the DTE and the line coding and control logic and circuitry of the DCE. It includes all the circuitry of the DCE with the exclusion of the line signal conditioning circuitry (e.g., impedance matching transformers, amplifiers, equalizers, etc.). The delay between transmitted and received test data is a few octets (see Note).

The configuration is identical to that given for loop 3c in § 3.3.2.2 except for the location of the point of loopback.

Note – In some DCEs, the setting of loop 3b will result in momentary loss of envelope alignment causing random signals to appear on the receiving interchange circuit for a period of time. This may impact upon the DTE test procedure. In some networks, the setting of loop 3b will cause clearing of existing connections.

3.3.2.4 *Loop 3a*

This loop is used to test the operation of the DTE and the DCE. The loop should include the maximum amount of circuitry used in DCE working including, in particular, the line signal conditioning circuitry. It is recognized that, in some cases, the inclusion of devices (e.g. attenuators, equalizers or test loop translators) may be necessary in the loopback path. The subscriber line is suitably terminated during a loop 3a test condition. The delay between transmitted and received test data is a few octets (see Note).

The configuration is identical to that given for test loop 3b in § 3.3.2.3 except for the location of the point of loopback.

Note – In some DCEs, the setting of loop 3a will result in momentary loss of envelope alignment causing random signals to appear on the receiving interchange circuit for a period of time. This may impact upon the DTE test procedure. In some networks, the setting of loop 3a will cause clearing of existing connections.

3.3.3 *Network test loop – type 2 loop*

Network test loops (test 2 loops) are used by the Administration's test centre to test the operation of the leased line or subscriber line and either all or part of the DCE, as discussed below.

Where allowed by national testing principles, loop 2 may be used by a DTE, as follows:

a) In the case of switched circuit networks in the *data transfer* phase to test the operation of the network connection including the remote DCE. It should be possible to re-enter the *data transfer* phase after completion of the network loop test.

b) In the case of leased lines in the *idle* phase to test the operation of the line including the remote DCE. When the test is in progress, the DCE will return circuits 107 and 109 in the OFF condition, circuit 104 in the binary 1 condition and circuit 142 in the ON condition.

The loop may be controlled manually by a switch on the DCE or automatically by the network. The control of the loop and the method used for automatic control, when implemented, is a national option. In the leased circuit service, customer control of the loop, if provided, should be by circuit 140.

In case of a collision between a *call request* and the activation of the loop, the loop activation command will have priority and the *call request* is ignored.

The precise implementation of the test loop within the DCE is a national option. One of the following network test loops should be implemented:

3.3.3.1 *Loop 2b*

This loop is used by either the Administration's test centre(s) and/or the remote DTE to test the operation of the subscriber line and all the circuitry of the DCE with the exception of interchange circuit generators and loads.

While the DCE is in the loop 2b test condition:

- circuit 104 is connected to circuit 103 inside of the DCE;
- circuit 109 is connected to circuit 105 inside of the DCE;
- at the interface, the DCE places circuit 104 in the binary 1 condition and circuit 109 in the OFF condition, or alternatively, may present an open circuit or power off condition on circuits 104 and 109;
- circuits 106, 107 and 125 to the DTE are placed in the OFF condition;
- circuit 142 to the DTE is placed in the ON condition;
- the DCE provides timing information on circuits 114 and 115.

3.3.3.2 *Loop 2a*

This loop is used by either the Administration's test centre(s) or the remote DTE to test the operation of the subscriber line and the entire DCE.

The configuration is identical to that given for loop 2b in § 3.3.3.1 except for the location of the point of loopback.

3.3.4 *Subscriber-line test loop – type 4 loop*

Subscriber-line test loops (type 4 loops) are provided for the maintenance of lines by the Administrations.

3.3.4.1 *Loop 4a*

This loop is only provided in the case of 4-wire subscriber lines. Loop 4a is for the maintenance of lines by Administrations. When receiving and transmitting pairs are connected together, the resulting circuit cannot be considered normal. Loop 4a may be established inside the DCE or in a separate device.

While the DCE is in the loop 4a test condition:

- circuit 104 to the DTE is placed in the binary 1 condition;
- circuits 106, 107, 109 and 125 to the DTE are placed in the OFF condition;
- circuit 142 to the DTE is placed in the ON condition;
- the DCE provides timing information on circuits 114 and 115.

3.3.4.2 *Loop 4b*

This loop is used by Administrations to test the operation of the subscriber line including the line signal conditioning circuitry in the DCE. When the receiving and transmitting circuits are connected at this point, loop 4b provides a connection that can be considered as normal; however, some impairment of the performance is expected since the DCE does not perform a complete signal regeneration.

The configuration is identical to that given for loop 4a in § 3.3.4.1 except for the location of the point of loopback.

3.4 *Signal element timing*

The signal element timing signal is delivered to the DTE on circuits 114 and 115 whenever possible. In particular it is delivered to the DTE when one of the loops described in § 3.3 above is activated or when the DCE loses alignment or the incoming line signal. The tolerance of the signal element timing during these conditions will be ± 1%.

ANNEX A

(to Recommendation X.21 *bis*)

Interworking between DTEs conforming to Recommendations X.21 and X.21 *bis*

It is recognized that interworking between V-Series DTEs connected to a public data network according to Recommendation X.21 *bis* at one end and Recommendation X.21 DTEs at the other end should always be possible for DTEs not using half duplex operation.

Certain Administrations may provide facilities allowing interworking between DTEs operating in accordance with Recommendation X.21 and Recommendation X.21 *bis* using half-duplex operation by switching circuits C, I and circuits 109, 105 during data transfer phase in accordance with Figure A-1/X.21 *bis*.

Those Administrations not providing this facility shall cause the X.21 DCE to signal r = 1, i = ON when the X.21 *bis* DTE signals circuit 105 OFF. This will permit half-duplex operation for those DTEs that do not require circuit 109 to be OFF before signalling circuit 105 ON.

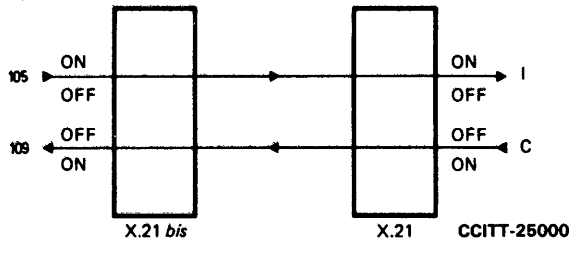


FIGURE A-1/X.21 *bis*

Recommendation X.22

MULTIPLEX DTE/DCE INTERFACE FOR USER CLASSES 3-6

Geneva, 1980, amended at Melbourne, 1988)

The CCITT,

considering

(a) that Recommendations X.1 and X.2 define the services and facilities to be provided by a public data network;

(b) that Recommendation X.21 defines the interface between a Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for synchronous operation on public data networks;

(c) that it is desirable for characteristics of the interface carrying a multiplexed bit stream between a DTE and a multiplex DCE of a public data network to be standardized;

unanimously declares

that the interface between the DTE and the DCE in a public data network using a multiplexed channel configuration employing synchronous transmission should be as defined in this Recommendation.

1 Scope

1.1 This Recommendation defines the interface between a DTE and a multiplex DCE, operating at 48 000 bit/s and multiplexing a number of Recommendation X.21 subscriber channels employing synchronous transmission.

1.2 The number of Recommendation X.21 subscriber channels is limited by the number of subscriber channels allowed in the network multiplex structure (see § 4).

1.3 The provision of all services supported by Recommendation X.21 is possible.

2 **DTE/DCE physical interface elements** (see Table 1/X.22)

2.1 *Electrical characteristics*

The electrical characteristics of the interchange circuits at both the DCE side and the DTE side of the interface will comply with Recommendation X.27 with implementation of the cable termination in the load.

2.2 *Mechanical characteristics*

Refer to ISO 4903 (15-pole DTE/DCE interface connector and contact number assignments) for mechanical arrangements.

2.3 *Functional characteristics of the interchange circuits*

Definitions of the interchange circuits G, T, R, C, I, S and F are given in Recommendation X.24 and in § 4 below.

TABLE 1/X.22

Interchange circuit	Name	Direction		Remark
		to DCE	from DCE	
G	Signal ground or common return			See Note
T	Transmit	X		
R	Receive		X	
C	Control	X		
I	Indication		X	
S	Signal element timing		X	
F	Frame start identification		X	

Note – This conductor may be used to reduce environmental signal interference at the interference. In the case of shielded interconnecting cable, the additional connection considerations are part of Recommendation X.24 and ISO 4903.

2.4 *Call control and failure detection procedures*

Call control and *failure detection* procedures shall operate as specified in Recommendation X.21 on each subscriber channel independent of other subscriber channels.

2.4.1 *Quiescent states*

The quiescent states shall be in accordance with Recommendation X.21, § 2.5.

2.4.2 *Failure detection*

See Recommendation X.27, § 9 for association of the receiver circuit failure detection types.

2.4.2.1 *Fault conditions on interchange circuits*

The DTE should interpret a fault condition on circuit R as r = 0 on all channels using failure detection type 2, a fault condition on circuit I as i = OFF on all channels using failure detection type 1, and a fault condition on both circuits R and I as r = 0, i = OFF *(DCE not ready)* on all channels.

Alternatively a fault condition on one of these circuits, R or I, may be interpreted by the DTE as r = 0, i = OFF *(DCE not ready)*, using failure detection type 3.

The DCE will interpret a fault condition on circuit T as t = 0 on all channels using failure detection type 2, a fault condition on circuit C as c = OFF on all channels using failure detection type 1, and a fault condition on both circuits T and C as t = 0, c = OFF on all channels *(DTE uncontrolled not ready).*

Alternatively, a fault condition on one of these circuits, T or C, may be interpreted by the DCE as t = 0, c = OFF *(DTE uncontrolled not ready)*, using failure detection type 3.

2.4.2.2 *DCE fault condition*

Indication of the DCE failure condition shall be in accordance with Recommendation X.21, § 2.6.2.

A DCE failure condition may effect all subscriber channels at the DTE/DCE interface.

2.4.2.3 *Signal element timing provision*

The provision of signal element timing shall be in accordance with Recommendation X.21, § 2.6.3.

2.4.3 *Elements of the call control phase*

The elements of the call control phase, for each channel, shall be in accordance with Recommendation X.21, § 4 with the exception that byte timing is not used.

2.4.4 *Data transfer phase*

The data transfer phase, for each channel, shall be in accordance with Recommendation X.21, § 5.

2.4.5 *Clearing phase*

The clearing phase, for each channel, shall be in accordance with Recommendation X.21, § 6.

3 Alignment of call control characters and error checking

3.1 *Character alignment*

For the interchange of information between the DTE and the DCE for call control purposes, it is necessary to establish correct alignment of characters. Each sequence of call control characters to and from the DCE shall be preceded by two or more contiguous 1/6 ("SYN") characters.

3.1.1 Certain Administrations will require the DTE to align call control characters transmitted from the DTE to either SYN characters delivered to the DTE or to the signals on the *frame start identification* interchange circuit (F).

3.1.2 Certain Administrations will permit call control characters to be transmitted from the DTE independently of the SYN characters delivered to the DTE.

3.2 *Error checking*

Odd parity according to Recommendation X.4 applies for the interchange of IA5 characters for call control purposes.

4 Multiplex structure

Depending on the multiplex structure used by the network, the structure of the multiplexed bit stream will be one of two different types.

4.1 *Multiplex structure in networks providing 6 bit-bytes*

The DCE shall deliver to and receive from the DTE a 6-bit byte interleaved multiplexed bit stream containing a number of subscriber channels. The allocation of the subscriber channels should be:

5 channels (phases)	of 9600 bit/s or
10 channels	of 4800 bit/s or
20 channels	of 2400 bit/s or
80 channels	of 600 bit/s or

an appropriate mix of channel data signalling rates having an aggregate bit rate of 48 kbit/s.

The multiplex structure is divided into five phases of 9600 bit/s, where each phase shall be homogeneous with regard to the subscriber data signalling rates.

4.1.1 *Interchange circuits and interface signalling scheme*

The interchange circuits between the DTE and the DCE are shown in Figure 1/X.22 and a timing diagram for the signals is given in Figure 2/X.22.

The signalling over the interchange circuits is as follows.

The transmit (T) and receive (R) circuits will convey in one time slot six consecutive user data bits for one subscriber channel (see Figure 2/X.22).

The control (C) and indication (I) circuits will convey the appropriate signal levels in accordance with Recommendation X.21 for the data channel which in the same time slot have bits conveyed over the respective data circuits.

Change of condition on circuit C shall take place at the OFF to ON transition of circuit S at the beginning of the first bit in the 6-bit byte. The condition on circuit C shall be steady for the whole 6-bit byte.

Change of condition on circuit I will take place at the OFF to ON transition of circuit S at the beginning of the first bit in the 6-bit byte and the condition will be steady for the whole 6-bit byte.

The signal element timing (S) will operate for continuous isochronous transmission at 48 kbit/s.

The *frame start identification* circuit (F) will indicate the frame start with an OFF condition appearing in the last bit of each frame. For networks using Recommendation X.50 division 2 multiplexing, the frame length will be 480 bits. For networks using Recommendation X.50 division 3 multiplexing in which the user rate of 600 bit/s is not included, the frame length will be 120 bits.

4.2 *Multiplex structure in networks providing 8-bit bytes*

The DCE shall deliver to and receive from the DTE an 8-bit byte interleaved multiplexed bit stream containing a number of subscriber channels. The allocation of the subscriber channels should be:

5 channels (phases)	of 9600 bit/s or
10 channels	of 4800 bit/s or
20 channels	of 2400 bit/s or
80 channels	of 600 bit/s or

an appropriate mix of channel data signalling rates having an aggregate bit rate of 48 kbit/s.

The multiplex bit stream is divided into five phases of 9600 bit/s, where each phase shall be homogeneous with regard to the subscriber data signalling rates.

4.2.1 *Interchange circuits and interface signalling scheme*

The interchange circuits between the DTE and DCE are shown in Figure 1/X.22 and a timing diagram for the signals is given in Figure 3/X.22. The signalling over the interchange circuits is as follows.

The transmit (T) and receive (R) circuits will convey in one time slot eight consecutive user data bits for one subscriber channel (see Figure 3/X.22).

The control (C) and indication (I) circuits will convey the appropriate signal levels in accordance with Recommendation X.21 for the data channel which in the same time slot have bits conveyed over the respective data circuits.

Change of condition on circuit C shall take place at the OFF to ON transition of circuit S at the beginning of the first bit in the 8-bit byte. The condition on circuit C shall be steady for the whole 8-bit byte.

Change of condition on circuit I will take place at the OFF to ON transition of circuit S at the beginning of the first bit in the 8-bit byte and the condition will be steady for the whole 8-bit byte.

The signal element timing (S) will operate for continuous isochronous transmission at 48 kbit/s.

The *frame start identification* circuit (F) will indicate the frame start with an OFF condition appearing in the position of the last bit of each 640-bit frame. As an optional facility each frame start could be followed by a code which will indicate the actual channel allocation. This facility is for further study.

5 Test loops

Establishment of test loops for DTE tests and network maintenance is for further study.

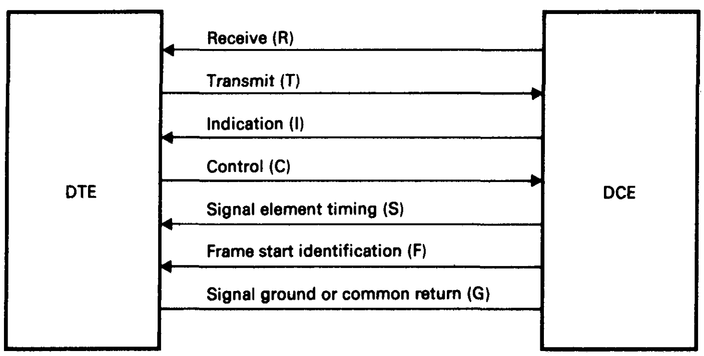
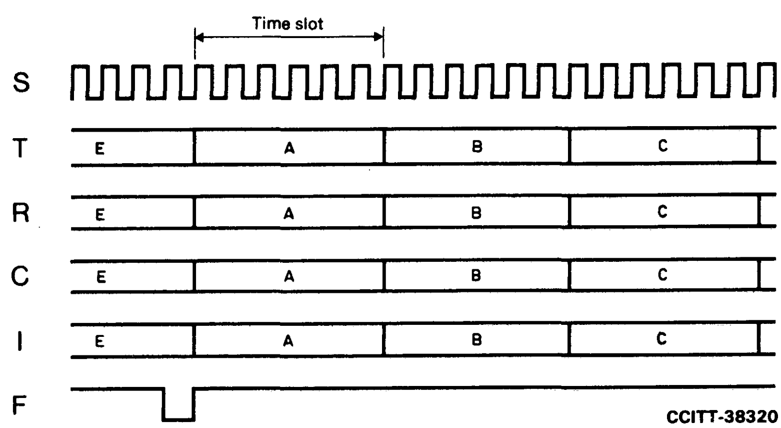


FIGURE 1/X.22

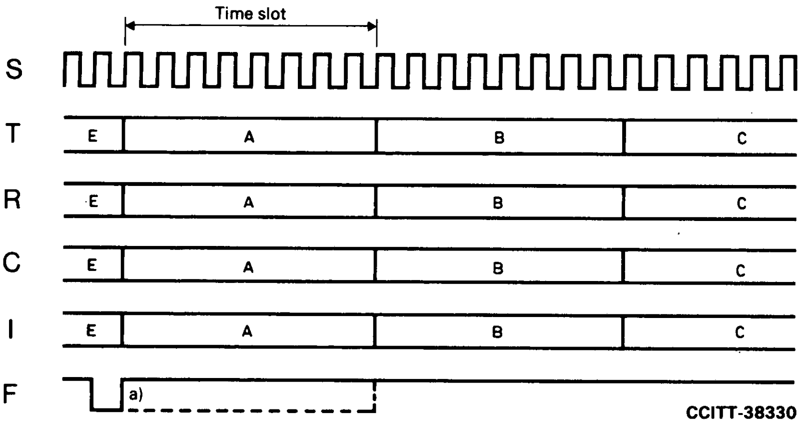
Interchange circuits in the multiplexed DTE/DCE interface



Note – This figure gives as an example the case of five 9600 bit/s subscriber channels labelled A, B, C, D and E.

FIGURE 2/X.22

Timing diagram for the interchange circuits when 6-bit bytes are used



a) Channel allocation code (for further study)

Note – The figure gives as an example the case of five 9600 bit/s subscriber channels labelled A, B, C, D and E.

FIGURE 3/X.22

Timing diagram for the interchange circuits when 8-bit bytes are used

Recommendation X.24

LIST OF DEFINITIONS FOR INTERCHANGE CIRCUITS BETWEEN DATA TERMINAL EQUIPMENT (DTE) AND DATA CIRCUIT-TERMINATING EQUIPMENT (DCE) ON PUBLIC DATA NETWORKS

(Geneva, 1976; amended at Geneva, 1980, Malaga-Torremolinos, 1984, and Melbourne, 1988)

The CCITT,

considering that

(a) the interface between DTE and DCE on public data neworks requires, in addition to the electrical and functional characteristics of the interchange circuits, the definition of procedural characteristics for call control functions and selection of the facilities according to Recommendation X.2;

(b) the functions of the circuits defined in Recommendation V.24 are based on the requirements of data transmission over the general telephone network and are not appropriate for use at DTE/DCE interfaces in public data networks;

unanimously declares

a Recommendation to include the list of definitions of interchange circuits for use in public data networks is required.

1 Scope

1.1 This Recommendation applies to the functions of the interchange circuits provided at the interface between DTE and DCE of data networks for the transfer of binary data, call control signals and timing signals.

For any type of practical equipment, a selection will be made from the range of interchange circuits defined in this Recommendation, as appropriate. The actual interchange circuits to be used in a particular DCE for a user class of service according to Recommendation X.1 and defined user facilities according to Recommendation X.2, are those indicated in the relevant Recommendation for the procedural characteristics of the interface, e.g., Recommendation X.20 or X.21.

To enable a standard DTE to be developed, the use and termination by the DTE of certain circuits even when implemented in the DCE are not mandatory. This is covered by the individual interface Recommendations.

The interchange circuits defined for the transfer of binary data are also used for the exchange of call control signals.

The electrical characteristics of the interchange circuits are detailed in the appropriate Recommendation for electrical characteristics of interchange circuits. The application of those characteristics for a particular DCE is specified in the Recommendation for the procedural characteristics of the interface.

1.2 The range of interchange circuits defined in this Recommendation is applicable to the range of services which could be offered on a public data network, e.g., circuit switching services (synchronous and start/stop), telex service, packet switching services, message registration and retransmission service and facsimile service.

2 Line of demarcation

The interface between DTE and DCE is located at a connector which is the interchange point between these two classes of equipment shown in Figure 1/X.24.

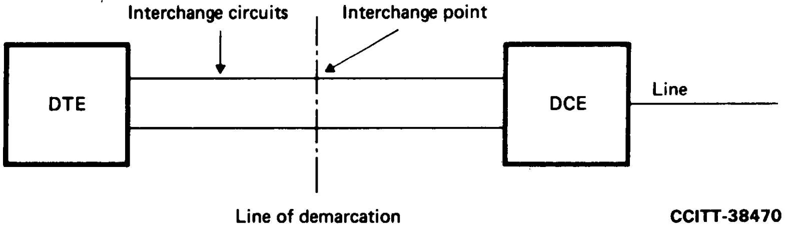


FIGURE 1/X.24

General illustration of interface equipment layout

2.1 The connector will not necessarily be physically attached to the DCE and may be mounted in a fixed position near the DTE. The female part of the connector belongs to the DCE.

2.2 An interconnecting cable will normally be provided together with the DTE. The cable length is limited by electrical parameters specified in the appropriate Recommendations for the electrical characteristics of the interchange circuits.

3 Definition of interchange circuits

A list of the data network series interchange circuits is presented in tabular form in Table 1/X.24.

TABLE 1/X.24

Data network interchange circuits

Interchange circuit designation	Interchange circuit name	Data		Control		Timing	
		From DCE	To DCE	From DCE	To DCE	From DCE	To DCE
G	Signal ground or common return						
Ga	DTE common return				X		
Gb	DCE common return			X			
T	Transmit		X		X		
R	Receive	X		X			
C	Control				X		
I	Indication			X			
S	Signal element timing					X	
B	Byte timing					X	
F	Frame start identification					X	
X	DTE signal element timing						X

3.1 *Circuit G – Signal ground or common return*

This conductor establishes the signal common reference potential for unbalanced double-current interchange circuits with electrical characteristics according to Recommendation V.28. In the case of interchange circuits according to Recommendations V.10 and V.11, it interconnects the zero volt reference points of a generator and a receiver to reduce environmental signal interference, if required.

Within the DCE, this conductor shall be brought to one point, protective ground or earth, by means of a metallic strap within the equipment. This metallic strap can be connected or removed at installation, as may be required, to minimize the introduction of noise into electronic circuitry or to meet applicable regulations.

Note – Where a shielded interconnecting cable is used at the interface, the shield may be connected either to circuit G, or to protective ground in accordance with national regulations. Protective ground may be further connected to external grounds as required by applicable electrical safety regulations.

For unbalanced interchange circuits with electrical characteristics in accordance with Recommendation V.10, two common-return conductors are required, one for each direction of signalling, each conductor being connected to ground only on the generator side of the interface. Where used, these shall be designated circuits Ga and Gb, and they are defined as follows:

Circuit Ga – DTE common return

This conductor is connected to the DTE circuit common and is used as the reference potential for the unbalanced X.26 type interchange circuit receivers within the DCE.

Circuit Gb – DCE common return

This conductor is connected to the DCE circuit common and is used as the reference potential for the unbalanced X.26 type interchange circuit receivers within the DTE.

3.2 *Circuit T – Transmit*

Direction: To DCE

The binary signals originated by the DTE to be transmitted during the data transfer phase via the data circuit to one or more remote DTEs are transferred on this circuit to the DCE.

This circuit also transfers the call control signals originated by the DTE, to be transmitted to the DCE in the call establishment and other call control phases as specified by the relevant Recommendations for the procedural characteristic of the interface.

The DCE monitors this circuit for detection of electrical circuit fault conditions, according to the specifications of the electrical characteristics of the interface. A circuit fault is to be interpreted by the DCE as defined in the Recommendation for the procedural characteristics of the interface.

3.3 *Circuit R – Receive*

Direction: From DCE

The binary signals sent by the DCE as received during the data transfer phase from a remote DTE, are transferred on this circuit to the DTE.

This circuit also transfers the call control signals sent by the DCE as received during the call establishment and other call control phases as specified by the relevant Recommendations for the procedural characteristics of the interface.

The DTE monitors this circuit for detection of electrical circuit fault conditions, according to the specifications of the electrical characteristics of the interface. A circuit fault is to be interpreted by the DTE as defined in the Recommendation for the procedural characteristics of the interface.

3.4 *Circuit C – Control*

Direction: To DCE

Signals on this circuit control the DCE for a particular signalling process.

Representation of a control signal requires additional coding of circuit T-*Transmit* as specified in the relevant Recommendation for the procedural characteristics of the interface. During the data phase, this circuit shall remain ON. During the call control phases, the condition of this circuit shall be as specified in the relevant Recommendation for the procedural characteristics of the interface.

Note – After appropriate selection of special user facilities (not yet defined), it might be required to change the ON condition after entering the data phase in accordance with the regulations for the use of these facilities. This subject is for further study.

The DCE monitors this circuit for detection of electrical circuit fault conditions, according to the specifications of the electrical characteristics of the interface. A circuit fault is to be interpreted by the DCE as defined in the Recommendation for the procedural characteristics of the interface.

3.5 *Circuit I – Indication*

Direction: From DCE

Signals on this circuit indicate to the DTE the state of the call control process.

Representation of a control signal requires additional coding of circuit R-*Receive*, as specified in the relevant Recommendation for the procedural characteristics of the interface. The ON condition of this circuit signifies that signals on circuit R contain information from the distant DTE. The OFF condition signifies a control signalling condition which is defined by the bit sequence on circuit R as specified by the procedural characteristics of the interface.

The DTE monitors this circuit for detection of electrical circuit fault conditions, according to the specifications of the electrical characteristics of the interface. A circuit fault is to be interpreted by the DTE as defined in the Recommendation for the procedural characteristics of the interface.

Note – For use with special user facilities (not yet defined) it might be required to use the OFF condition after entering the data transfer phase in accordance with the regulations for the use of these facilities. This subject is for further study.

3.6 *Circuit S – Signal element timing*

Direction: From DCE

Signals on this circuit provide the DTE with signal element timing information. The condition of this circuit shall be ON and OFF for nominally equal periods of time. However, for burst isochronous operations, longer periods of OFF condition may be permitted equal to an integer odd number of the nominal period of the ON condition as specified by the relevant procedural characteristics of the interface.

The DTE shall present a binary signal on circuit T-*Transmit* and a condition on circuit C-*Control*, in which the transitions nominally occur at the time of the transitions from OFF to ON condition of this circuit.

The DCE presents a binary signal on circuit R-*Receive* and a condition on circuit I-*Indication* in which the transitions nominally occur at the time of the transitions from OFF to ON condition of this circuit.

The transition from ON to OFF condition shall nominally indicate the centre of each signal element on circuit R.

The DCE shall transfer signal element timing information on this circuit across the interface at all times that the timing source is capable of generating this information.

3.7 *Circuit B – Byte timing* (see Note 2)

Direction: From DCE

Signals on this circuit provide the DTE with 8-bit byte timing information. The condition of this circuit shall be OFF for nominally the period of the ON condition of circuit S-*Signal element timing* which indicates the last bit of an 8-bit byte and shall be ON at all other times within the period of the 8-bit byte.

During the call control phases, the call control characters and steady state conditions used for all information transfers between the DCE and the DTE, in either direction, shall be correctly aligned to the signals of circuit B.

The DTE shall present the beginning of the first bit of each call control character on circuit T-*Transmit* nominally at the time of the OFF to ON transition of circuit S which follows the OFF to ON transition of circuit B.

A change of condition of circuit C-*Control* may occur at any OFF to ON transition of circuit S, but it will be sampled in the DCE at the time of the OFF to ON transition of circuit B, i.e., for evaluation of the following call control character on circuit T.

The centre of the last bit of each call control character will be presented by the DCE on circuit R-*Receive* nominally at the time of the OFF to ON transition of circuit B.

A change of condition of circuit I-*Indication* will occur nominally at the OFF to ON transition of circuit S which follows the OFF to ON transition of circuit B.

The DCE shall transfer byte timing information on this circuit across the interface at all times that the timing source is capable of generating this information.

Note 1 – During the data transfer phase, DTEs communicating by means of an 8-bit code may utilize the byte timing information for mutual character alignment.

It is a prerequisite for the provision of this feature that character alignment is preserved after the call has entered the data transfer phase and that the alignment obtained at one interface is synchronized to the alignment at the other interface. (This is only possible on some connections.)

Furthermore, where this feature is available, a change of condition on circuit C as defined above may result in an equivalent change in the relative alignment on circuit I at the distant interface.

Note 2 – In some Recommendations for the procedural characteristics of the interface (e.g., X.21), the use and termination of this circuit by the DTE is not mandatory even when implemented in the DCE.

3.8 *Circuit F — Frame start identification*

Direction: From DCE

Signals on this circuit continuously provide the DTE with a multiplex frame start indication when connected to a multiplexed DTE/DCE interface.

The condition on this circuit shall be OFF for the nominal period of one bit, indicating the last bit of the multiplex frame. At other times the circuit shall remain ON.

The first data bit on subscriber channel 1 shall be transmitted or received beginning nominally at the OFF to ON transition of circuit F.

3.9 *Circuit X — DTE transmit signal element timing* (see Note)

Direction: To DCE

Signals on this circuit provide signal element timing information for the transmit direction in cases where circuit S only provides signal element timing for the receive direction. The condition of this circuit shall be ON and OFF for nominally equal periods of time. However, for burst isochronous operations, longer periods of OFF condition may be permitted equal to an integer odd number of the nominal period of the ON condition as specified by the relevant procedural characteristics of the interface.

The DTE shall present a binary signal on the circuit T-*Transmit* and a condition on circuit C-*Control*, in which the transitions nominally occur at the time of the transitions from OFF to ON condition of this circuit.

The transition from ON to OFF condition shall nominally indicate the centre of each signal element on circuit T.

Note — The use and termination of this circuit by the DCE is a national matter.

Recommendation X.25

INTERFACE BETWEEN DATA TERMINAL EQUIPMENT (DTE) AND DATA CIRCUIT-TERMINATING EQUIPMENT (DCE) FOR TERMINALS OPERATING IN THE PACKET MODE AND CONNECTED TO PUBLIC DATA NETWORKS BY DEDICATED CIRCUIT

(Geneva, 1976; amended at Geneva, 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

The establishment in various countries of public data networks providing packet switched data transmission services creates a need to produce standards to facilitate international interworking.

The CCITT,

considering

(a) that Recommendation X.1 includes specific user classes of service for data terminal equipments operating in the packet mode, Recommendation X.2 defines user facilities, Recommendation X.10 defines categories of access, Recommendations X.21 and X.21 *bis* define DTE/DCE physical layer interface characteristics, Recommendation X.92 defines the hypothetical reference connections for packet switched data transmission service and Recommendation X.96 defines *call progress* signals;

(b) that data terminal equipments operating in the packet mode will send and receive network control information in the form of packets;

(c) that certain data terminal equipments operating in the packet mode will use a packet interleaved synchronous data circuit;

(d) the desirability of being able to use a single data circuit to a Data Switching Exchange (DSE) for all user facilities;

(e) that Recommendation X.2 specifies which of the various data transmission services and optional user facilities described in the present Recommendation are "essential" and have thus to be made available internationally, and which are not;

(f) the need for defining an international Recommendation for the exchange between DTE and DCE of control information for the use of packet switched data transmission services;

(g) that this definition is made in Recommendation X.32 with regard to the access through a public switched telephone network, an integrated services digital network (ISDN), or a circuit switched public data network;

(h) that Recommendation X.31 defines the support of packet-mode terminal equipment by an integrated services digital network (ISDN);

(i) that, when this Recommendation is used to support the Network Service defined in Recommendation X.213, the physical, data link and packet layers correspond to the Physical, Data link and Network Layers respectively, as defined in Recommendation X.200;

(j) that this Recommendation includes all the features necessary to support the services included in Recommendation X.213 as well as other features; that Recommendation X.223 defines the use of X.25 packet layer protocol to provide the OSI connection mode Network service;

(k) that the necessary elements for an interface Recommendation should be defined independently as:

Physical layer – the mechanical, electrical, functional and procedural characteristics to activate, maintain and deactivate the physical link between the DTE and the DCE;

Data link layer – the link access procedure for data interchange across the link between the DTE and the DCE;

Packet layer – the packet format and control procedures for the exchange of packets containing control information and user data between the DTE and the DCE;

unanimously declares

that for public data networks accessed via dedicated circuits by data terminal equipments operating in the packet mode:

(1) the mechanical, electrical, functional and procedural characteristics to activate, maintain and deactivate the physical link between the DTE and the DCE should be as specified in § 1 below, *DTE/DCE interface characteristics*;

(2) the link access procedure for data interchange across the link between the DTE and the DCE should be as specified in § 2 below, *Link access procedure across the DTE/DCE interface*;

(3) the packet layer procedures for the exchange of control information and user data at the DTE/DCE interface should be as specified in § 3 below, *Description of the packet layer DTE/DCE interface*;

(4) the procedures for virtual call and permanent virtual circuit services should be as specified in § 4 below, *Procedures for virtual circuit services*;

(5) the format for packets exchanged between the DTE and the DCE should be as specified in § 5 below, *Packet formats*;

(6) the procedures for optional user facilities should be as specified in § 6 below, *Procedures for optional user facilities*;

(7) the formats for optional user facilities should be as specified in § 7 below, *Formats for facility fields and registration fields.*

Note – This Recommendation fully specifies the behaviour of the DCE. In addition, a minimum set of requirements is specified for the DTE. Additional guidance for the design of DTEs is available in ISO standards ISO 7776 (data link layer) and ISO 8208 (packet layer). It is not required by this Recommendation that these ISO standards be used. If using these ISO standards, note must be taken that their scope is expanded beyond that of just interfacing with packet switched public data networks.

It should also be noted that this Recommendation uses the term DTE to refer to the equipment to which the DCE interfaces. In ISO 8208, distinction is made between a DTE and a packet switched private data network, which are both considered as DTEs in this Recommendation.

CONTENTS

1 DTE/DCE interface characteristics (physical layer)

Administrations may offer one or more of the interfaces specified below. The exact use of the relevant points in these Recommendations is detailed below.

1.1 *X.21 interface*

1.1.1 *DTE/DCE physical interface elements*

The DTE/DCE physical interface elements shall be according to §§ 2.1 through 2.5 of Recommendation X.21.

1.1.2 *Procedures for entering operational phases*

The procedures for entering operational phases shall be as described in § 5.2 of Recommendation X.21. The data exchanged on circuits T and R when the interface is in states 13S, 13R and 13 of Figure A-3/X.21 will be as described in subsequent sections of this Recommendation.

The *not ready* states given in § 2.5 of Recommendation X.21 are considered to be *non-operational* states and may be considered by the higher layers to be *out of order* states (see § 4.6 below).

1.1.3 *Failure detection and test loops*

The failure detection principles shall be according to § 2.6 of Recommendation X.21. In addition, i = OFF may be signalled due to momentary transmission failures. Higher layers may delay for several seconds before considering the interface to be out of order.

The definitions of test loops and the principles of maintenance testing using the test loops are provided in Recommendation X.150.

A description of the test loops and the procedures for their use is given in § 7 of Recommendation X.21.

Automatic activation by a DTE of a test loop 2 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2, at the local DSE, to verify the operation of the leased line or subscriber line and/or all or part of the DCE or line terminating equipment. Control of the loop, if provided, may be either manual or automatic, as described in Recommendations X.150 and X.21 respectively.

1.1.4 *Signal element timing*

Signal element timing shall be in accordance with § 2.6.3 of Recommendation X.21.

1.2 *X.21 bis interface*

1.2.1 *DTE/DCE physical interface elements*

The DTE/DCE physical interface elements shall be according to § 1.2 of Recommendation X.21 *bis*.

1.2.2 *Operational phases*

When circuit 107 is in the ON condition, and circuits 105, 106, 108 and 109, if provided, are in the ON condition, data exchange on circuits 103 and 104 will be as described in subsequent sections of this Recommendation.

When circuit 107 is in the OFF condition, or any of circuits 105, 106, 108 or 109, if provided, are in the OFF condition, this is considered to be in a *non-operational* state, and may be considered by the higher layers to be in an *out of order* state (see § 4.6 below).

1.2.3 *Failure detection and test loops*

The failure detection principles, the description of test loops and the procedures for their use shall be according to §§ 3.1 through 3.3 of Recommendation X.21 *bis*. In addition, circuits 106 and 109 may enter the OFF condition due to momentary transmission failures. Higher layers may delay for several seconds before considering the interface to be out of order.

Automatic activation by a DTE of test loop 2 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2, at the local DSE, to verify the operation of the leased line or subscriber line and/or all or part of the DCE or line terminating equipment. Control of the loop, if provided, may be either manual or automatic, as described in Recommendations X.150 and X.21 *bis* respectively.

1.2.4 *Signal element timing*

Signal element timing shall be in accordance with § 3.4 of Recommendation X.21 *bis.*

1.3 *V-Series interface*

General operation with V-Series modems is as described in § 1.2 above. However, for specific details, particularly related to failure detection principles, loop testing, and the use of circuits 107, 109, 113 and 114, refer to the appropriate V-Series Recommendations.

The delay between 105-ON and 106-ON (when these circuits are present) will be more than 10 ms and less than 1 s. In addition, circuits 106 or 109 may enter the OFF condition due to momentary transmission failures or modem retraining. Higher layers may delay for several seconds before considering the interface to be out of order.

1.4 *X.31 interface*

1.4.1 *DTE/DCE physical interface*

The DTE/DCE physical interface shall coincide with the R reference point between the DTE and the Terminal Adaptor (TA). The purpose of the TA is to allow the operation of a DTE over an ISDN. The functionalities of such a TA when accessing a packet switched data transmission service through a semi-permanent ISDN connection (i.e., a non switched B-channel) are described in § 7 of Recommendation X.31.

Note 1 – This type of access is considered a dedicated access to a public switched data transmission service. Non dedicated access to a public switched data transmission service is defined in Recommendations X.32 and X.31.

Note 2 – The DTE and the TA functionalities may be implemented in the same piece of equipment in the case of a packet mode terminal TE1 conforming to the I-series Recommendations. In this case, this Recommendation covers layer 2 and layer 3 operation on the semi-permanent B-channel.

1.4.2 *Operational phases*

The operational phases are as described in § 7 of Recommendation X.31.

1.4.3 *Maintenance*

The maintenance shall be made as described in § 7.6 of Recommendation X.31.

1.4.4 *Synchronization*

The synchronization shall be made as described in § 7 of Recommendation X.31.

2 Link access procedures across the DTE/DCE interface

2.1 *Scope and field of applications*

2.1.1 The Link Access Procedures (LAPB and LAP) are described as the Data Link Layer Element and are used for data interchange between a DCE and a DTE over a single physical circuit (LAPB and LAP), or optionally over multiple physical circuits (LAPB), operating in user classes of service 8 to 11 as indicated in Recommendation X.1. The optional, subscription-time selectable, multiple physical circuit operation with LAPB (known as multilink operation) is required if the effects of circuit failures are not to disrupt the Packet Layer operation.

The single link procedures (SLPs) described in §§ 2.2, 2.3 and 2.4 (LAPB) and in §§ 2.2, 2.6 and 2.7 (LAP) are used for data interchange over a single physical circuit, conforming to the description given in § 1, between a DTE and a DCE. When the optional multilink operation is employed with LAPB, a single link procedure (SLP) is used independently on each physical circuit, and the multilink procedure (MLP) described in § 2.5 is used for data interchange over these multiple parallel LAPB data links. In addition, when only a single physical circuit is employed with LAPB, agreements may be made with the Administration to use this optional multilink procedure over the one LAPB data link.

2.1.2 The single link procedures (SLPs) use the principles and terminology of the High-level Data Link Control (HDLC) procedures specified by the International Organization for Standardization (ISO). The multilink procedure (MLP) is based on the principles and terminology of the Multilink Control Procedures specified by ISO.

2.1.3 Each transmission facility is duplex.

2.1.4 DCE compatibility of operation with the ISO balanced classes of procedure (Class BA with options 2, 8 and Class BA with options 2, 8, 10) is achieved using the LAPB procedure described in §§ 2.3 and 2.4. Of these classes, Class BA with options 2, 8 (LAPB modulo 8) is the basic service, and is available in all networks. Class BA with options 2, 8, 10 (LAPB modulo 128) is recognized as an optional, subscription-time selectable, extended sequence numbering service that may be available in those networks wishing to serve DTE applications having a need for modulo 128 sequence numbering.

DTE manufacturers and implementors must be aware that the procedure hereunder described as LAPB modulo 8 will be the only one available in all networks.

Likewise, a DTE may continue to use the LAP procedure described in §§ 2.2, 2.6 and 2.7 (in those networks supporting such a procedure), but for new DTE implementations, LAPB should be preferred. The LAP procedures are defined for modulo 8 basic service only.

Note – Other possible applications for further study are, for example:

- two-way alternate, asynchronous response mode;
- two-way simultaneous, normal response mode;
- two-way alternate, normal response mode.

2.1.5 For those networks that choose to support both the basic and extended LAPB sequence numbering services, the choice of either basic mode (modulo 8) or extended mode (modulo 128) may be made at subscription time. The choice of the mode employed for each data link procedure is independent of all others and of the choice of mode for the corresponding Packet Layer procedures. All choices are matters for agreement for a period of time with the Administration.

2.1.6 In the case of those networks that support both the LAPB procedure and the LAP procedure, the DCE will maintain an internal mode variable B, which it will set as follows:

- to 1, upon acceptance of an SABM/SABME (modulo 8/modulo 128) command from the DTE, or upon issuance of an SABM/SABME command by the DCE;
- to 0, upon acceptance of an SARM command from the DTE.

Whenever B is 1, the DCE will use the LAPB procedure described in §§ 2.2, 2.3 and 2.4 below, and is said to be in the LAPB (balanced) mode.

Whenever B is 0, the DCE will use the LAP procedure described in §§ 2.2, 2.6 and 2.7 below, and is said to be in the LAP mode.

Changes to the mode variable B by the DTE should occur only when the data link has been disconnected as described in §§ 2.4.4.3 or 2.7.3.3 below.

Should a DCE malfunction occur that negates the current setting of internal mode variable B, the DCE will, upon restoration of operation, not send either a SARM or SABM/SABME command. The DCE may send a DISC command or a DM response to notify the DTE that the DCE is in the disconnected phase. This will result in the DTE attempting to reinitialize the data link with what the DTE considers to be the proper mode-setting command (SARM or SABM/SABME). The DCE will then be able to set the internal mode variable B to its proper value.

2.2 *Frame structure*

2.2.1 All transmissions on an SLP are in frames conforming to one of the formats of Table 1/X.25 for basic (modulo 8) operation, or alternatively one of the formats of Table 2/X.25 for extended (modulo 128) operation. The flag preceding the address field is defined as the opening flag. The flag following the FCS field is defined as the closing flag.

TABLE 1/X.25

Frame formats – Basic (modulo 8) operation

Bir order of transmission

12345678	12345678	12345678	16 to 1	12345678
Flag	Address	Control	FCS	Flag
F 01111110	A 8 bits	C 8 bits	FCS 16 bits	F 01111110

FCS Frame check sequence

Bit order of transmission

12345678	12345678	12345678		16 to 1	12345678
Flag	Address	Control	Information	FCS	Flag
F 01111110	A 8 bits	C 8 bits	Info N bits	FCS 16 bits	F 01111110

FCS Frame check sequence

TABLE 2/X.25

Frame formats – Extended (modulo 128) operation

Bit order of transmission

12345678	12345678	1 to *)	16 to 1	12345678
Flag	Address	Control	FCS	Flag
F 01111110	A 8 bits	C *) bits	FCS 16 bits	F 01111110

FCS Frame check sequence

Bit order of transmission

12345678	12345678	1 to *)		16 to 1	12345678
Flag	Address	Control	Information	FCS	Flag
F 01111110	A 8 bits	C *) bits	Info N bits	FCS 16 bits	F 01111110

FCS Frame check sequence

*) 16 for frame formats that contain sequence numbers; 8 for frame formats that do not contain sequence numbers.

2.2.2 *Flag sequence*

All frames shall start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The DTE and DCE shall only send complete eight-bit flag sequences when sending multiple flag sequences (see § 2.2.11). A single flag may be used as both the closing flag for one frame and the opening flag for the next frame.

2.2.3 *Address field*

The address field shall consist of one octet. The address field identifies the intended receiver of a command frame and the transmitter of a response frame. The coding of the address field is described in § 2.4.2 (LAPB) and in § 2.7.1 (LAP) below.

2.2.4 *Control field*

For modulo 8 (basic) operation, the control field shall consist of one octet. For modulo 128 (extended) operation, the control field shall consist of two octets for frame formats that contain sequence numbers, and one octet for frame formats that do not contain sequence numbers. The content of this field is described in § 2.3.2 (LAPB) and in § 2.6.2 (LAP) below.

2.2.5 *Information field*

The information field of a frame, when present, follows the control field (see § 2.2.4 above) and precedes the frame check sequence field (see § 2.2.7 below).

See §§ 2.3.4.9, 2.5.2, 2.6.4.8 and 5 for the various codings and groupings of bits in the information field as used in this Recommendation.

See §§ 2.3.4.9, 2.4.8.5, 2.6.4.8 and 2.7.7.5 below with regard to the maximum information field length.

2.2.6 *Transparency*

The DCE or DTE, when transmitting, shall examine the frame content between the two flag sequences including the address, control, information and FCS fields and shall insert a 0 bit after all sequences of 5 contiguous 1 bits (including the last 5 bits of the FCS) to ensure that a flag sequence is not simulated. The DCE or DTE, when receiving, shall examine the frame content and shall discard any 0 bit which directly follows 5 contiguous 1 bits.

2.2.7 *Frame check sequence (FCS) field*

The notation used to describe the FCS is based on the property of cyclic codes that a code vector such as 1000000100001 can be represented by a polynomial $P(x) = x^{12} + x^5 + 1$. The elements of an n-element code word are thus the coefficients of a polynomial of order $n - 1$. In this application, these coefficients can have the value 0 or 1 and the polynomial operations are performed modulo 2. The polynomial representing the content of a frame is generated using the first bit received after the frame opening flag as the coefficient of the highest order term.

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

1) the remainder of $x^k(x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$ divided (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency, and

2) the remainder of the division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the product of x^{16} by the content of the frame, existing between but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency.

As a typical implementation, at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all 1s and is then modified by division by the generator polynomial (as described above) on the address, control and information fields; the ones complement of the resulting remainder is transmitted as the 16-bit FCS.

At the receiver, the initial content of the register of the device computing the remainder is preset to all 1s. The final remainder, after multiplication by x^{16} and then division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits and the FCS, will be 0001110100001111 (x^{15} through x^0, respectively) in the absence of transmission errors.

Note – Examples of transmitted bit patterns by the DCE and the DTE illustrating application of the transparency mechanism and the frame check sequence to the SABM command and the UA response are given in Appendix I.

2.2.8 *Order of bit transmission*

Addresses, commands, responses and sequence numbers shall be transmitted with the low-order bit first (for example, the first bit of the sequence number that is transmitted shall have the weight 2^0). The order of transmitting bits within the information field is not specified under § 2 of this Recommendation. The FCS shall be transmitted to the line commencing with the coefficient of the highest term, which is found in bit position 16 of the FCS field (see Tables 1/X.25 and 2/X.25).

Note – In Tables 1/X.25 to 13/X.25, bit 1 is defined as the low-order bit.

2.2.9 *Invalid frames*

The definition of an invalid frame is described in § 2.3.5.3 (LAPB) and in § 2.6.5.3 (LAP) below.

2.2.10 *Frame abortion*

Aborting a frame is performed by transmitting at least seven contiguous 1 bits (with no inserted 0 bits).

2.2.11 *Interframe time fill*

Interframe time fill is accomplished by transmitting contiguous flags between frames, i.e. multiple eight-bit flag sequences (see § 2.2.2).

2.2.12 *Link channel states*

A link channel as defined here is the means for transmission for one direction.

2.2.12.1 *Active channel state*

The DCE incoming or outgoing channel is defined to be in an active condition when it is receiving or transmitting, respectively, a frame, an abortion sequence or interframe time fill.

2.2.12.2 *Idle channel state*

The DCE incoming or outgoing channel is defined to be in an idle condition when it is receiving or transmitting, respectively, a continuous 1s state for a period of at least 15 bit times.

See § 2.3.5.5 for a description of DCE action when an idle condition exists on its incoming channel for an excessive period of time.

2.3 *LAPB elements of procedures*

2.3.1 The LAPB elements of procedures are defined in terms of actions that occur on receipt of frames at the DCE or DTE.

The elements of procedures specified below contain the selection of commands and responses relevant to the LAPB data link and system configurations described in § 2.1 above. Together, §§ 2.2 and 2.3 form the general requirements for the proper management of a LAPB access data link.

2.3.2 *LAPB control field formats and parameters*

2.3.2.1 *Control field formats*

The control field contains a command or a response, and sequence numbers where applicable.

Three types of control field formats are used to perform numbered information transfer (I format), numbered supervisory functions (S format) and unnumbered control functions (U format).

The control field formats for basic (modulo 8) operation are depicted in Table 3/X.25.

The control field formats for extended (modulo 128) operation are depicted in Table 4/X.25.

TABLE 3/X.25

LAPB control field format – Basic (modulo 8) operation

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

N(S) Transmitter send sequence number (bit 2 = low-order bit)

N(R) Transmitter receive sequence number (bit 6 = low-order bit)

S Supervisory function bit

M Modifier function bit

P/F Poll bit when issued as a command, final bit when issued as a response (1 = Poll/Final)

P Poll bit (1 = Poll)

TABLE 4/X.25

LAPB control field formats – Extended (modulo 128) operation

Control field bits	1st octet								2nd octet							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I format	0	N(S)							P	N(R)						
S format	1	0	S	S	X	X	X	X	P/F	N(R)						
U format	1	1	M	M	P/F	M	M	M								

N(S) Transmitter send sequence number (bit 2 = low-order bit)

N(R) Transmitter receive sequence number (bit 10 = low-order bit)

S Supervisory function bit

M Modifier function bit

X Reserved and set to 0

P/F Poll bit when issued as a command, final bit when issued as a response (1 = Poll/Final)

P Poll bit (1 = Poll)

2.3.2.1.1 *Information transfer format – I*

The I format is used to perform an information transfer. The functions of N(S), N(R) and P are independent; i.e., each I frame has an N(S), an N(R) which may or may not acknowledge additional I frames received by the DCE or DTE, and a P bit that may be set to 0 or 1.

2.3.2.1.2 *Supervisory format – S*

The S format is used to perform data link supervisory control functions such as acknowledge I frames, request retransmission of I frames, and to request a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent; i.e., each supervisory frame has an N(R) which may or may not acknowledge additional I frames received by the DCE or DTE, and a P/F bit that may be set to 0 or 1.

2.3.2.1.3 *Unnumbered format – U*

The U format is used to provide additional data link control functions. This format contains no sequence numbers, but does include a P/F bit that may be set to 0 or 1. The unnumbered frames have the same control field length (one octet) in both basic (modulo 8) operation and extended (modulo 128) operation.

2.3.2.2 *Control field parameters*

The various parameters associated with the control field formats are described below.

2.3.2.2.1 *Modulus*

Each I frame is sequentially numbered and may have the value 0 through modulus minus 1 (where "modulus" is the modulus of the sequence numbers). The modulus equals either 8 or 128 and the sequence numbers cycle through the entire range.

2.3.2.2.2 *Send state variable V(S)*

The send state variable V(S) denotes the sequence number of the next in-sequence I frame to be transmitted. V(S) can take on the values 0 through modulus minus 1. The value of V(S) is incremented by 1 with each successive I frame transmission, but cannot exceed the N(R) of the last received I or supervisory frame by more than the maximum number of outstanding I frames (*k*). The value of k is defined in § 2.4.8.6 below.

2.3.2.2.3 *Send sequence number N(S)*

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

2.3.2.2.4 *Receive state variable V(R)*

The receive state variable V(R) denotes the sequence number of the next in-sequence I frame expected to be received. V(R) can take on the values 0 through modulus minus 1. The value of V(R) is incremented by 1 by the receipt of an error-free, in-sequence I frame whose send sequence number N(S) equals the receive state variable V(R).

2.3.2.2.5 *Receive sequence number N(R)*

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

2.3.2.2.6 *Poll/Final bit P/F*

All frames contain P/F, the Poll/Final bit. In command frames, the P/F bit is referred to as the P bit. In response frames, it is referred to as the F bit.

2.3.3 *Functions of the Poll/Final bit*

The Poll bit set to 1 is used by the DCE or DTE to solicit (poll) a response from the DTE or DCE, respectively. The Final bit set to 1 is used by the DCE or DTE to indicate the response frame transmitted by the DTE or DCE, respectively, as a result of the soliciting (poll) command.

The use of the P/F bit is described in § 2.4.3 below.

2.3.4 *Commands and responses*

For basic (modulo 8) operation, the commands and responses represented in Table 5/X.25 will be supported by the DCE and the DTE.

For extended (modulo 128) operation, the commands and responses represented in Table 6/X.25 will be supported by the DCE and the DTE.

For purposes of the LAPB procedures, the supervisory function bit encoding "11" and those encodings of the modifier function bits in Tables 3/X.25 and 4/X.25 not identified in Tables 5/X.25 or 6/X.25 are identified as "undefined or not implemented" command and response control fields.

The commands and responses in Tables 5/X.25 and 6/X.25 are defined as follows:

2.3.4.1 *Information (I) command*

The function of the information (I) command is to transfer across a data link a sequentially numbered frame containing an information field.

TABLE 5/X.25

LAPB commands and responses – Basic (modulo 8) operation

Format	Command	Response	Encoding							
			1	2	3	4	5	6	7	8
Information transfer	I (information)		0	N(S)			P	N(R)		
Supervisory	RR (receive ready)	RR (receive ready)	1	0	0	0	P/F	N(R)		
	RNR (receive not ready)	RNR (receive not ready)	1	0	1	0	P/F	N(R)		
	REJ (reject)	REJ (reject)	1	0	0	1	P/F	N(R)		
Unnumbered	SABM (set asynchronous balanced mode)		1	1	1	1	P	1	0	0
	DISC (disconnect)		1	1	0	0	P	0	1	0
		DM (disconnect mode)	1	1	1	1	F	0	0	0
		UA (unnumbered acknowledgment)	1	1	0	0	F	1	1	0
		FRMR (frame reject)	1	1	1	0	F	0	0	1

TABLE 6/X.25

LAPB commands and responses – Extended (modulo 128) operation

Format	Command	Response	Encoding									
			1	2	3	4	5	6	7	8	9	10 to 16
Information transfer	I (information)		0	N(S)							P	N(R)
Supervisory	RR (receive ready)	RR (receive ready)	1	0	0	0	0	0	0	0	P/F	N(R)
	RNR (receive not ready)	RNR (receive not ready)	1	0	1	0	0	0	0	0	P/F	N(R)
	REJ (reject)	REJ (reject)	1	0	0	1	0	0	0	0	P/F	N(R)
Unnumbered	SABME (set asynchronous balanced mode extended)		1	1	1	1	P	1	1	0		
	DISC (disconnect)		1	1	0	0	P	0	1	0		
		DM (disconnected mode)	1	1	1	1	F	0	0	0		
		UA (unnumbered acknowledgment)	1	1	0	0	F	1	1	0		
		FRMR (frame reject)	1	1	1	0	F	0	0	1		

2.3.4.2 *Receive ready (RR) command and response*

The receive ready (RR) supervisory frame is used by the DCE or DTE to:

1) indicate it is ready to receive an I frame; and

2) acknowledge previously received I frames numbered up to and including N(R) – 1.

An RR frame may be used to indicate the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). In addition to indicating the DCE or DTE status, the RR command with the P bit set to 1 may be used by the DCE or DTE to ask for the status of the DTE or DCE, respectively.

2.3.4.3 *Receive not ready (RNR) command and response*

The receive not ready (RNR) supervisory frame is used by the DCE or DTE to indicate a busy condition; i.e. temporary inability to accept additional incoming I frames. I frames numbered up to and including N(R) – 1 are acknowledged. I frame N(R) and any subsequent I frames received, if any, are not acknowledged; the acceptance status of these I frames will be indicated in subsequent exchanges.

In addition to indicating the DCE or DTE status, the RNR command with the P bit set to 1 may be used by an DCE or DTE to ask for the status of the DTE or DCE, respectively.

2.3.4.4 *Reject (REJ) command and response*

The reject (REJ) supervisory frame is used by the DCE or DTE to request transmission of I frames starting with the frame numbered N(R). I frames numbered N(R) – 1 and below are acknowledged. Additional I frames pending initial transmission may be transmitted following the retransmitted I frame(s).

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

An REJ frame may be used to indicate the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). In addition to indicating the DCE or DTE status, the REJ command with the P bit set to 1 may be used by the DCE or DTE to ask for the status of the DTE or DCE, respectively.

2.3.4.5 *Set asynchronous balanced mode (SABM) command/Set asynchronous balanced mode extended (SABME) command (subscription time option)*

The SABM unnumbered command is used to place the addressed DCE or DTE in an asynchronous balanced mode (ABM) information transfer phase where all command/response control fields will be one octet in length.

The SABME unnumbered command is used to place the addressed DCE or DTE in an asynchronous balanced mode (ABM) information transfer phase where numbered command/response control fields will be two octets in length, and unnumbered command/response control fields will be one octet in length.

No information field is permitted with the SABM or SABME command. The transmission of a SABM/SABME command indicates the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). The DCE or DTE confirms acceptance of SABM/SABME [modulo 8 (basic) operation/modulo 128 (extended) operation] command by the transmission, at the first opportunity, of a UA response. Upon acceptance of this command, the DCE or DTE send state variable V(S) and receive state variable V(R) are set to 0.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher layer (e.g. Packet Layer or MLP) to recover from the possible loss of the contents (e.g. packets) of such I frames.

Note – The mode of operation of a data link [basic (modulo 8) or extended (modulo 128)] is determined at subscription time and is only changed by going through a new subscription process.

2.3.4.6 *Disconnect (DISC) command*

The DISC unnumbered command is used to terminate the mode previously set. It is used to inform the DCE or DTE receiving the DISC command that the DTE or DCE sending the DISC command is suspending operation. No information field is permitted with the DISC command. Prior to actioning the DISC command, the DCE or DTE receiving the DISC command confirms the acceptance of the DISC command by the transmission of a UA response. The DTE or DCE sending the DISC command enters the disconnected phase when it receives the acknowledging UA response.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher layer (e.g. Packet Layer or MLP) to recover from the possible loss of the contents (e.g., packets) of such I frames.

2.3.4.7 *Unnumbered acknowledgement (UA) response*

The UA unnumbered response is used by the DCE or DTE to acknowledge the receipt and acceptance of the mode-setting commands. Received mode-setting commands are not actioned until the UA response is transmitted. The transmission of a UA response indicates the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). No information field is permitted with the UA response.

2.3.4.8 *Disconnected mode (DM) response*

The DM unnumbered response is used to report a status where the DCE or DTE is logically disconnected from the data link, and is in the disconnected phase. The DM response may be sent to indicate that the DCE or DTE has entered the disconnected phase without benefit of having received a DISC command, or, if sent in response to the reception of a mode setting command, is sent to inform the DTE or DCE that the DCE or DTE, respectively, is still in the disconnected phase and cannot execute the set mode command. No information field is permitted with the DM response.

A DCE or DTE in a disconnected phase will monitor received commands and will react to an SABM/SABME command as outlined in § 2.4.4 below, and will respond with a DM response with the F bit set to 1 to any other command received with the P bit set to 1.

2.3.4.9 *Frame reject (FRMR) response*

The FRMR unnumbered response is used by the DCE or DTE to report an error condition not recoverable by retransmission of the identical frame; i.e. at least one of the following conditions, which results from the receipt of a valid frame:

1) the receipt of a command or response control field that is undefined or not implemented;
2) the receipt of an I frame with an information field which exceeds the maximum established length;
3) the receipt of an invalid N(R); or
4) the receipt of a frame with an information field which is not permitted or the receipt of a supervisory or unnumbered frame with incorrect length.

An undefined or not implemented control field is any of the control field encodings that are not identified in Tables 5/X.25 or 6/X.25.

A valid N(R) must be within the range from the lowest send sequence number N(S) of the still unacknowledged frame(s) to the current DCE send state variable inclusive (or to the current internal variable x if the DCE is in the timer recovery condition as described in § 2.4.5.9).

An information field which immediately follows the control field, and consists of 3 or 5 octets [modulo 8 (basic) operation or modulo 128 (extended) operation, respectively], is returned with this response and provides the reason for the FRMR response. These formats are given in Tables 7/X.25 and 8/X.25.

2.3.5 *Exception condition reporting and recovery*

The error recovery procedures which are available to effect recovery following the detection/occurrence of an exception condition at the Data Link Layer are described below. Exception conditions described are those situations which may occur as the result of transmission errors, DCE or DTE malfunction, or operational situations.

2.3.5.1 *Busy condition*

The busy condition results when the DCE or DTE is temporarily unable to continue to receive I frames due to internal constraints, e.g. receive buffering limitations. In this case an RNR frame is transmitted from the busy DCE or DTE. I frames pending transmission may be transmitted from the busy DCE or DTE prior to or following the RNR frame.

An indication that the busy condition has cleared is communicated by the transmission of a UA (only in response to a SABM/SABME command), RR, REJ or SABM/SABME (modulo 8/modulo 128) frame.

TABLE 7/X.25

LAPB FRMR information field format – Basic (modulo 8) operation

Information field bits

1 2 3 4 5 6 7 8	9	10 11 12	13	14 15 16	17	18	19	20	21	22	23	24
Rejected frame control field	0	V(S)	C/R	V(R)	W	X	Y	Z	0	0	0	0

– Rejected frame control field is the control field of the received frame which caused the frame reject.

– V(S) is the current send state variable value at the DCE or DTE reporting the rejection condition (bit 10 = low-order bit).

– C/R set to 1 indicates the rejected frame was a response. C/R set to 0 indicates the rejected frame was a command.

– V(R) is the current receive state variable value at the DCE or DTE reporting the rejection condition (bit 14 = low-order bit).

– W set to 1 indicates that the control field received and returned in bits 1 through 8 was undefined or not implemented.

– X set to 1 indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this frame or is a supervisory or unnumbered frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.

– Y set to 1 indicates that the information field received exceeded the maximum established capacity.

– Z set to indicates the control field received and returned in bits 1 through 8 contained an invalid N(R).

Note – Bits 9 and 21 to 24 shall be set to 0.

TABLE 8/X.25

LAPB FRMR information field format – Extended (modulo 128) operation

Information field bits

1 to 16	17	18 to 24	25	26 to 32	33	34	35	36	37	38	39	40
Rejected frame control field	0	V(S)	C/R	V(R)	W	X	Y	Z	0	0	0	0

– Rejected frame control field is the control field of the received frame which caused the frame reject. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in bit positions 1-8, with 9-16 set to 0.

– V(S) is the current send state variable value at the DCE or DTE reporting the rejection condition (bit 18 = low-order bit).

– C/R set to 1 indicates the rejected frame was a response. C/R set to 0 indicates the rejected frame was a command.

– V(R) is the current receive state variable value at the DCE or DTE reporting the rejection condition (bit 26 = low-order bit).

– W set to 1 indicates that the control field received and returned in bits 1 through 16 was undefined or not implemented.

– X set to 1 indicates that the control field received and returned in bits 1 through 16 was considered invalid because the frame contained an information field which is not permitted with this frame or is a supervisory or unnumbered frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.

– Y set to 1 indicates that the information field received exceeded the maximum established capacity.

– Z set to indicates the control field received and returned in bits 1 through 16 contained an invalid N(R).

Note – Bits 17 and 37 to 40 shall be set to 0.

2.3.5.2 *N(S) sequence error condition*

The information field of all I frames received whose N(S) does not equal the receive state variable V(R) will be discarded.

An N(S) sequence error exception condition occurs in the receiver when an I frame received contains an N(S) which is not equal to the receive state variable V(R) at the receiver. The receiver does not acknowledge (increment its receive state variable) the I frame causing the sequence error, or any I frame which may follow, until an I frame with the correct N(S) is received.

A DCE or DTE which receives one or more valid I frames having sequence errors or subsequent supervisory frames (RR, RNR and REJ) shall accept the control information contained in the N(R) field and the P or F bit to perform data link control functions; e.g. to receive acknowledgement of previously transmitted I frames and to cause the DCE or DTE to respond (P bit set to 1).

The means specified in §§ 2.3.5.2.1 and 2.3.5.2.2 shall be available for initiating the retransmission of lost or errored I frames following the occurrence of an N(S) sequence error condition.

2.3.5.2.1 *REJ recovery*

The REJ frame is used by a receiving DCE or DTE to initiate a recovery (retransmission) following the detection of an N(S) sequence error.

With respect to each direction of transmission on the data link, only one "sent REJ" exception condition from a DCE or DTE, to a DTE or DCE, is established at a time. A "sent REJ" exception condition is cleared when the requested I frame is received.

A DCE or DTE receiving a REJ frame initiates sequential (re-)transmission of I frames starting with the I frame indicated by the N(R) contained in the REJ frame. The retransmitted frames may contain an N(R) and a P bit that are updated from, and therefore different from, the ones contained in the originally transmitted I frames.

2.3.5.2.2 *Time-out recovery*

If a DCE or DTE, due to a transmission error, does not receive (or receives and discards) a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an N(S) sequence error condition and, therefore, will not transmit a REJ frame. The DTE or DCE which transmitted the unacknowledged I frame(s) shall, following the completion of a system specified time-out period (see §§ 2.4.5.1 and 2.4.5.9 below), take appropriate recovery action to determine at which I frame retransmission must begin. The retransmitted frame(s) may contain an N(R) and a P bit that is updated from, and therefore different from, the ones contained in the originally transmitted frame(s).

2.3.5.3 *Invalid frame condition*

Any frame which is invalid will be discarded, and no action is taken as the result of that frame. An invalid frame is defined as one which:

a) is not properly bounded by two flags;

b) in basic (modulo 8) operation, contains fewer than 32 bits between flags; in extended (modulo 128) operation, contains fewer than 40 bits between flags of frames that contain sequence numbers or 32 bits between flags of frames that do not contain sequence numbers;

c) contains a Frame Check Sequence (FCS) error; or

d) contains an address other than A or B (for single link operation) or other than C or D (for multilink operation).

For those networks that are octet aligned, a detection of non-octet alignment may be made at the Data Link Layer by adding a frame validity check that requires the number of bits between the opening flag and the closing flag, excluding bits inserted for transparency, to be an integral number of octets in length, or the frame is considered invalid.

2.3.5.4 *Frame rejection condition*

A frame rejection condition is established upon the receipt of an error-free frame with one of the conditions listed in § 2.3.4.9 above.

At the DCE or DTE, this frame rejection exception condition is reported by an FRMR response for appropriate DTE or DCE action, respectively. Once a DCE has established such an exception condition, no additional I frames are accepted until the condition is reset by the DTE, except for examination of the P bit. The FRMR response may be repeated at each opportunity, as specified in § 2.4.7.3, until recovery is effected by the DTE, or until the DCE initiates its own recovery in case the DTE does not respond.

2.3.5.5 *Excessive idle channel state condition on incoming channel*

Upon detection of an idle channel state condition (see § 2.2.12.2 above) on the incoming channel, the DCE shall wait for a period T3 (see § 2.4.8.3 below) without taking any specific action, waiting for detection of a return to the active channel state (i.e., detection of at least one flag sequence). After the period T3, the DCE shall notify the higher layer (e.g. the Packet Layer or the MLP) of the excessive idle channel state condition, but shall not take any action that would preclude the DTE from establishing the data link by normal data link set-up procedures.

Note – Other actions to be taken by the DCE at the Data Link Layer upon expiration of period T3 is a subject for further study.

2.4 *Description of the LAPB procedure*

2.4.1 *LAPB basic and extended modes of operation*

In accordance with the system choice made by the DTE at subscription time, the DCE will either support modulo 8 (basic) operation or will support modulo 128 (extended) operation. Changing from basic operation to extended operation, or vice versa, in the DCE requires resubscription by the DTE for the desired service, and is not supported dynamically.

Table 5/X.25 indicates the command and response control field formats used with the basic (modulo 8) service. The mode-setting command employed to initialize (set up) or reset the basic mode is the SABM command. Table 6/X.25 indicates the command and response control field formats used with the extended (modulo 128) service. The mode-setting command employed to initialize (set up) or reset the extended mode is the SABME command.

2.4.2 *LAPB procedure for addressing*

The address field identifies a frame as either a command or a response. A command frame contains the address of the DCE or DTE to which the command is being sent. A response frame contains the address of the DCE or DTE sending the frame.

In order to allow differentiation between single link operation and the optional multilink operation for diagnostic and/or maintenance reasons, different address pair encodings are assigned to data links operating with multilink procedure compared to data links operating with the single link procedure.

Frames containing commands transferred from the DCE to the DTE will contain the address A for the single link operation and address C for the multilink operation.

Frames containing responses transferred from the DCE to the DTE will contain the address B for the single link operation and address D for the multilink operation.

Frames containing commands transferred from the DTE to the DCE shall contain the address B for the single link operation and address D for the multilink operation.

Frames containing responses transferred from the DTE to the DCE shall contain the address A for the single link operation and address C for the multilink operation.

These addresses are coded as follows:

	Address	1 2 3 4 5 6 7 8
Single link operation	A	1 1 0 0 0 0 0 0
	B	1 0 0 0 0 0 0 0
Multilink operation	C	1 1 1 1 0 0 0 0
	D	1 1 1 0 0 0 0 0

Note – The DCE will discard all frames received with an address other than A or B (single link operation), or C or D (multilink operation).

2.4.3 *LAPB procedure for the use of the P/F bit*

The DCE or DTE receiving an SABM/SABME, DISC, supervisory command or I frame with the P bit set to 1 will set the F bit to 1 in the next response frame it transmits.

The response frame returned by the DCE to an SABM/SABME or DISC command with the P bit set to 1 will be a UA or DM response with the F bit set to 1. The response frame returned by the DCE to an I frame with the P bit set to 1, received during the information transfer phase, will be an RR, REJ, RNR or FRMR response with the F bit set to 1. The response frame returned by the DCE to a supervisory command with the P bit set to 1, received during the information transfer phase, will be an RR, REJ, RNR or FRMR response with the F bit set to 1. The response frame returned by the DCE to an I frame or supervisory frame with the P bit set to 1, received during the disconnected phase, will be a DM response with the F bit set to 1.

The P bit may be used by the DCE in conjunction with the timer recovery condition (see § 2.4.5.9 below).

Note – Other use of the P bit by the DCE is a subject for further study.

2.4.4 *LAPB procedure for data link set-up and disconnection*

2.4.4.1 *Data link set-up*

The DCE will indicate that it is able to set up the data link by transmitting contiguous flags (active channel state).

Either the DTE or the DCE may initiate data link set-up. Prior to initiation of data link set-up, either the DCE or the DTE may initiate data link disconnection (see § 2.4.4.3) for the purpose of insuring that the DCE and the DTE are in the same phase. The DCE may also transmit an unsolicited DM response to request the DTE to initiate data link set-up.

The DTE shall initiate data link set-up by transmitting an SABM/SABME command to the DCE. If, upon receipt of the SABM/SABME command correctly, the DCE determines that it can enter the information transfer phase, it will return a UA response to the DTE, will reset its send and receive state variables V(S) and V(R) to zero, and will consider that the data link is set up. If, upon receipt of the SABM/SABME command correctly, the DCE determines that it cannot enter the information transfer phase, it will return a DM response to the DTE as a denial to the data link set-up initialization and will consider that the data link is *not* set up. In order to avoid misinterpretation of the DM response received, it is suggested that the DTE always sends its SABM/SABME command with the P bit set to 1. Otherwise, it is not possible to differentiate a DM response intended as a denial to data link set-up from a DM response that is issued in a separate unsolicited sense as a request for a mode-setting command (as described in § 2.4.4.4.2).

The DCE will initiate data link set-up by transmitting an SABM/SABME command to the DTE and starting its Timer T1 in order to determine when too much time has elapsed waiting for a reply (see § 2.4.8.1 below). Upon reception of a UA response from the DTE, the DCE will reset its send and receive state variables V(S) and V(R) to zero, will stop its Timer T1, and will consider that the data link is set up. Upon reception of a DM response from the DTE as a denial to the data link set-up initialization, the DCE will stop its Timer T1 and will consider that the data link is *not* set up.

The DCE, having sent the SABM/SABME command, will ignore and discard any frames except an SABM/SABME or DISC command, or a UA or DM response received from the DTE. The receipt of an SABM/SABME or DISC command from the DTE will result in a collision situation that is resolved per § 2.4.4.5 below. Frames other than the UA and DM responses sent in response to a received SABM/SABME or DISC command will be sent only after the data link is set up and if no outstanding SABM/SABME command exists.

After the DCE sends the SABM/SABME command, if a UA or DM response is not received correctly, Timer T1 will run out in the DCE. The DCE will then resend the SABM/SABME command and will restart Timer T1. After transmission of the SABM/SABME command N2 times by the DCE, appropriate higher layer recovery action will be initiated. The value of N2 is defined in § 2.4.8.4 below.

2.4.4.2 *Information transfer phase*

After having transmitted the UA response to the SABM/SABME command or having received the UA response to a transmitted SABM/SABME command, the DCE will accept and transmit I and supervisory frames according to the procedures described in § 2.4.5 below.

When receiving the SABM/SABME command while in the information transfer phase, the DCE will conform to the data link resetting procedure described in § 2.4.7 below.

2.4.4.3 *Data link disconnection*

The DTE shall initiate a disconnect of the data link by transmitting a DISC command to the DCE. On correctly receiving a DISC command in the information transfer phase, the DCE will send a UA response and enter the disconnected phase. On correctly receiving a DISC command in the disconnected phase, the DCE will send a DM response and remain in the disconnected phase. In order to avoid misinterpretation of the DM response received, it is suggested that the DTE always sends its DISC command with the P bit set to 1. Otherwise, it is not possible to differentiate a DM response intended as an indication that the DCE is already in the disconnected phase from a DM response that is issued in a separate unsolicited sense as a request for a mode-setting command (as described in § 2.4.4.4.2).

The DCE will initiate a disconnect of the data link by transmitting a DISC command to the DTE and starting its Timer T1 (see § 2.4.8.1 below). Upon reception of an UA response from the DTE, the DCE will stop its Timer T1 and will enter the disconnected phase. Upon reception of a DM response from the DTE as an indication that the DTE was already in the disconnected phase, the DCE will stop its Timer T1 and will enter the disconnected phase.

The DCE, having sent the DISC command, will ignore and discard any frames except an SABM/SABME or DISC command, or a UA or DM response received from the DTE. The receipt of an SABM/SABME or DISC command from the DTE will result in a collision situation that is resolved per § 2.4.4.5 below.

After the DCE sends the DISC command, if a UA or DM response is not received correctly, Timer T1 will run out in the DCE. The DCE will then resend the DISC command and will restart Timer T1. After transmission of the DISC command N2 times by the DCE, appropriate higher layer recovery action will be initiated. The value of N2 is defined in § 2.4.8.4 below.

2.4.4.4 *Disconnected phase*

2.4.4.4.1 After having received a DISC command from the DTE and returned a UA response to the DTE, or having received the UA response to a transmitted DISC command, the DCE will enter the disconnected phase.

In the disconnected phase, the DCE may initiate data link set-up. In the disconnected phase, the DCE will react to the receipt of an SABM/SABME command as described in § 2.4.4.1 above and will transmit a DM response in answer to a received DISC command. When receiving any other command (defined, or undefined or not implemented) with the P bit set to 1, the DCE will transmit a DM response with the F bit set to 1. Other frames received in the disconnected phase will be ignored by the DCE.

2.4.4.4.2 When the DCE enters the disconnected phase after detecting error conditions as listed in § 2.4.6 below, or after an internal malfunction, it may indicate this by sending a DM response rather than a DISC command. In these cases, the DCE will transmit a DM response and start its Timer T1 (see § 2.4.8.1 below).

If Timer T1 runs out before the reception of an SABM/SABME or DISC command from the DTE, the DCE will retransmit the DM response and restart Timer T1. After transmission of the DM response N2 times, the DCE will remain in the disconnected phase and appropriate recovery actions will be initiated. The value of N2 is defined in § 2.4.8.4 below.

Alternatively, after an internal malfunction, the DCE may either initiate a data link resetting procedure (see § 2.4.7 below) or disconnect the data link (see § 2.4.4.3 above) prior to initiating a data link set-up procedure (see § 2.4.4.1 above).

2.4.4.5 *Collision of unnumbered commands*

Collision situations shall be resolved in the following way:

2.4.4.5.1 If the sent and received unnumbered commands are the same, the DCE and the DTE shall each send the UA response at the earliest possible opportunity. The DCE shall enter the indicated phase either,

1) after receiving the UA response,
2) after sending the UA response, or
3) after timing out waiting for the UA response having sent a UA response.

In the case of 2) above, the DCE will accept a subsequent UA response to the mode-setting command it issued without causing an exception condition if received within the time-out interval.

2.4.4.5.2 If the sent and received unnumbered commands are different, the DCE and the DTE shall each enter the disconnected phase and issue a DM response at the earliest possible opportunity.

2.4.4.6 *Collision of DM response with SABM/SABME or DISC command*

When a DM response is issued by the DCE or DTE as an unsolicited response to request the DTE or DCE, respectively, to issue a mode-setting command as described in § 2.4.4.4, a collision between an SABM/SABME or DISC command and the unsolicited DM response may occur. In order to avoid misinterpretation of the DM response received, the DTE always sends its SABM/SABME or DISC command with the P bit set to 1.

2.4.4.7 *Collision of DM responses*

A contention situation may occur when both the DCE and the DTE issue a DM response to request a mode-setting command. In this case, the DTE will issue an SABM/SABME command to resolve the contention situation.

2.4.5 *LAPB procedures for information transfer*

The procedures which apply to the transmission of I frames in each direction during the information transfer phase are described below.

In the following, "number one higher" is in reference to a continuously repeated sequence series, i.e., 7 is 1 higher than 6 and 0 is 1 higher than 7 for modulo 8 series, and 127 is 1 higher than 126 and 0 is 1 higher than 127 for modulo 128 series.

2.4.5.1 *Sending I frames*

When the DCE has an I frame to transmit (i.e. an I frame not already transmitted, or having to be retransmitted as described in § 2.4.5.6 below), it will transmit it with an N(S) equal to its current send state variable V(S), and an N(R) equal to its current receive state variable V(R). At the end of the transmission of the I frame, the DCE will increment its send state variable V(S) by 1.

If Timer T1 is not running at the time of transmission of an I frame, it will be started.

If the send state variable V(S) is equal to the last value of N(R) received plus *k* (where *k* is the maximum number of outstanding I frames – see § 2.4.8.6 below), the DCE will not transmit any new I frames, but may retransmit an I frame as described in §§ 2.4.5.6 or 2.4.5.9 below.

When the DCE is in the busy condition, it may still transmit I frames, provided that the DTE is not busy. When the DCE is in the frame rejection condition, it will stop transmitting I frames.

2.4.5.2 *Receiving an I frame*

2.4.5.2.1 When the DCE is not in a busy condition and receives a valid I frame whose send sequence number N(S) is equal to the DCE receive state variable V(R), the DCE will accept the information field of this frame, increment by one its receive state variable V(R), and act as follows:

a) If the DCE is still not in a busy condition:
   i) If an I frame is available for transmission by the DCE, it may act as in § 2.4.5.1 above and acknowledge the received I frame by setting N(R) in the control field of the next transmitted I frame to the value of the DCE receive state variable V(R). Alternatively, the DCE may acknowledge the received I frame by transmitting an RR frame with the N(R) equal to the value of the DCE receive state variable V(R).
   ii) If no I frame is available for transmission by the DCE, it will transmit an RR frame with N(R) equal to the value of the DCE receive state variable V(R).
b) If the DCE is now in a busy condition, it will transmit an RNR frame with N(R) equal to the value of the DCE receive state variable V(R) (see § 2.4.5.8).

2.4.5.2.2 When the DCE is in a busy condition, it may ignore the information field contained in any received I frame.

2.4.5.3 *Reception of invalid frames*

When the DCE receives an invalid frame (see § 2.3.5.3), this frame will be discarded.

2.4.5.4 *Reception of out-of-sequence I frames*

When the DCE receives a valid I frame whose send sequence number N(S) is incorrect, i.e., not equal to the current DCE receive state variable V(R), it will discard the information field of the I frame and transmit an REJ frame with the N(R) set to one higher than the N(S) of the last correctly received I frame. The REJ frame will be a command frame with the P bit set to 1 if an acknowledged transfer of the retransmission request is required; otherwise the REJ frame may be either a command or a response frame. The DCE will then discard the information field of all I frames received until the expected I frame is correctly received. When receiving the expected I frame, the DCE will then acknowledge the I frame as described in § 2.4.5.2 above. The DCE will use the N(R) and P bit information in the discarded I frames as described in § 2.3.5.2 above.

2.4.5.5 *Receiving acknowledgement*

When correctly receiving an I frame or a supervisory frame (RR, RNR or REJ), even in the busy condition, the DCE will consider the N(R) contained in this frame as an acknowledgement for all I frames it has transmitted with an N(S) up to and including the received N(R) − 1. The DCE will stop Timer T1 when it correctly receives an I frame or a supervisory frame with the N(R) higher than the last received N(R) (actually acknowledging some I frames), or an REJ frame with an N(R) equal to the last received N(R).

If Timer T1 has been stopped by the receipt on an I, RR or RNR frame, and if there are outstanding I frames still unacknowledged, the DCE will restart Timer T1. If Timer T1 then runs out, the DCE will follow the recovery procedure (§ 2.4.5.9 below) with respect to the unacknowledged I frames. If Timer T1 has been stopped by the receipt of an REJ frame, the DCE will follow the retransmission procedures in § 2.4.5.6 below.

2.4.5.6 *Receiving an REJ frame*

When receiving an REJ frame, the DCE will set its send state variable V(S) to the N(R) received in the REJ control field. It will transmit the corresponding I frame as soon as it is available or retransmit it in accordance with the procedures described in § 2.4.5.1 above. (Re)transmission will conform to the following procedure:

i) if the DCE is transmitting a supervisory command or response when it receives the REJ frame, it will complete that transmission before commencing transmission of the requested I frame;

ii) if the DCE is transmitting an unnumbered command or response when it receives the REJ frame, it will ignore the request for retransmission;

iii) if the DCE is transmitting an I frame when the REJ frame is received, it may abort the I frame and commence transmission of the requested I frame immediately after abortion;

iv) if the DCE is not transmitting any frame when the REJ frame is received, it will commence transmission of the requested I frame immediately.

In all cases, if other unacknowledged I frames had already been transmitted following the one indicated in the REJ frame, then those I frames will be retransmitted by the DCE following the retransmission of the requested I frame. Other I frames not yet transmitted may be transmitted following the retransmitted I frames.

If the REJ frame was received from the DTE as a command with the P bit set to 1, the DCE will transmit an RR, RNR or REJ response with the F bit set to 1 before transmitting or retransmitting the corresponding I frame.

2.4.5.7 *Receiving an RNR frame*

After receiving an RNR frame whose N(R) acknowledges all frames previously transmitted, the DCE will stop Timer T1 and may then transmit an I frame, with the P bit set to 0, whose send sequence number is equal to the N(R) indicated in the RNR frame, restarting Timer T1 as it does. After receiving an RNR frame whose N(R) indicates a previously transmitted frame, the DCE will not transmit or retransmit any I frame, Timer T1 being already running. In either case, if the Timer T1 runs out before receipt of a busy clearance indication, the DCE will follow the procedure described in § 2.4.5.9 below. In any case, the DCE will not transmit any other I frames before receiving an RR or REJ frame, or before the completion of a link resetting procedure.

Alternatively, after receiving an RNR frame, the DCE may wait for a period of time (e.g., the length of the Timer T1) and then transmit a supervisory command frame (RR, RNR or REJ) with the P bit set to 1, and start Timer T1, in order to determine if there is any change in the receive status of the DTE. The DTE shall respond to the P bit set to 1 with a supervisory response frame (RR, RNR or REJ) with the F bit set to 1 indicating either continuance of the busy condition (RNR) or clearance of the busy condition (RR or REJ). Upon receipt of the DTE response, Timer T1 is stopped.

1) If the response is the RR or REJ response, the busy condition is cleared and the DCE may transmit I frames beginning with the I frame identified by the N(R) in the received response frame.

2) If the response is the RNR response, the busy condition still exists, and the DCE will after a period of time (e.g. the length of Timer T1) repeat the enquiry of the DTE receive status.

If Timer T1 runs out before a status response is received, the enquiry process above is repeated. If N2 attempts to get a status response fail (i.e. Timer T1 runs out N2 times), the DCE will initiate a data link resetting procedure as described in § 2.4.7.2 below or will transmit a DM response to ask the DTE to initiate a data link set-up procedure as described in § 2.4.4.1 and enter the disconnected phase. The value of N2 is defined in § 2.4.8.4 below.

If, at any time during the enquiry process, an unsolicited RR or REJ frame is received from the DTE, it will be considered to be an indication of clearance of the busy condition. Should the unsolicited RR or REJ frame be a command frame with the P bit set to 1, the appropriate response frame with the F bit set to 1 must be transmitted before the DCE may resume transmission of I frames. If Timer T1 is running, the DCE will wait for the non-busy response with the F bit set to 1 or will wait for Timer T1 to run out and then either may reinitiate the enquiry process in order to realize a successful P/F bit exchange or may resume transmission of I frames beginning with the I frame identified by the N(R) in the received RR or REJ frame.

2.4.5.8 *DCE busy condition*

When the DCE enters a busy condition, it will transmit an RNR frame at the earliest opportunity. The RNR frame will be a command frame with the P bit set to 1 if an acknowledged transfer of the busy condition indication is required; otherwise the RNR frame may be either a command or a response frame. While in the busy condition, the DCE will accept and process supervisory frames, will accept and process the contents of the N(R) fields of I frames, and will return an RNR response with the F bit set to 1 if it receives a supervisory command or I command frame with the P bit set to 1. To clear the busy condition, the DCE will transmit either an REJ frame or an RR frame, with N(R) set to the current receive state variable V(R), depending on whether or not it discarded information fields of correctly received I frames. The REJ frame or the RR frame will be a command frame with the P bit set to 1 if an acknowledged transfer of the busy-to-non-busy transition is required, otherwise the REJ frame or the RR frame may be either a command or a response frame.

2.4.5.9 *Waiting acknowledgement*

The DCE maintains an internal transmission attempt variable which is set to 0 when the DCE sends a UA response, when the DCE receives a UA response or an RNR command or response, or when the DCE correctly receives an I frame or supervisory frame with the N(R) higher than the last received N(R) (actually acknowledging some outstanding I frames).

If Timer T1 runs out waiting for the acknowledgement from the DTE for an I frame transmitted, the DCE will enter the timer recovery condition, add one to its transmission attempt variable and set an internal variable x to the current value of its send state variable V(S). The DCE will then restart Timer T1, set its send state variable V(S) to the last value of N(R) received from the DTE and retransmit the corresponding I frame with the P bit set to 1, or transmit an appropriate supervisory command frame (RR, RNR or REJ) with the P bit set to 1.

The timer recovery condition is cleared when the DCE receives a valid supervisory frame with the F bit set to 1.

If, while in the timer recovery condition, the DCE correctly receives a supervisory frame with the F bit set to 1 and with the N(R) within the range from its current send state variable V(S) to x included, it will clear the timer recovery condition (including stopping Timer T1) and set its send state variable V(S) to the value of the received N(R), and may then resume with I frame transmission or retransmission, as appropriate.

If, while in the timer recovery condition, the DCE correctly receives an I or supervisory frame with the P/F bit set to 0 and with a valid N(R) (see § 2.3.4.9), it will not clear the timer recovery condition. The value of the received N(R) may be used to update the send state variable V(S). However, the DCE may decide to keep the last transmitted I frame in store (even if it is acknowledged) in order to be able to retransmit it with the P bit set to 1 when Timer T1 runs out at a later time.

If the received supervisory frame with the P/F bit set to 0 is an REJ frame with a valid N(R), the DCE may either immediately initiate (re)transmission from the value of the send state variable V(S), or it may ignore the request for retransmission and wait until the supervisory frame with the F bit set to 1 is received before initiating (re)transmission of frames from the value identified in the N(R) field of the supervisory frame with the F bit set to 1. In the case of immediate retransmission, in order to prevent duplicate retransmissions following the clearance of the timer recovery condition, the DCE shall inhibit retransmission of a specific I frame [same N(R) in the same numbering cycle] if the DCE has retransmitted that I frame as the result of a received REJ frame with the P/F bit set to 0.

If, while in the timer recovery condition, the DCE receives a REJ command with the P bit set to 1, the DCE will respond immediately with an appropriate supervisory response with the F bit set to 1. The DCE may then use the value of the N(R) in the REJ command to update the send state variable V(S), and may either immediately begin (re)transmission from the value N(R) indicated in the REJ frame or ignore the request for retransmission and wait until the supervisory frame with the F bit set to 1 is received before initiating (re)transmission of I frames from the value identified in the N(R) field of the supervisory frame with the F bit set to 1. In the case of immediate retransmission, in order to prevent duplicate retransmissions following the clearance of the timer recovery condition, the DCE shall inhibit retransmission of a specific I frame [same N(R) in the same numbering cycle] if the DCE has retransmitted that I frame as the result of the received REJ command with the P bit set to 1.

If Timer T1 runs out in the timer recovery condition, and no I or supervisory frame with the P/F bit set to 0 and with a valid N(R) has been received, or no REJ command with the P bit set to 1 and with a valid N(R) has been received, the DCE will add one to its transmission attempt variable, restart Timer T1, and either retransmit the I frame sent with the P bit set to 1 or transmit an appropriate supervisory command with the P bit set to 1.

If the transmission attempt variable is equal to N2, the DCE will initiate a data link resetting procedure as described in § 2.4.7.2 below, or will transmit a DM response to ask the DTE to initiate a data link set-up procedure as described in § 2.4.4.1 above and enter the disconnected phase. N2 is a system parameter (see § 2.4.8.4 below).

Note – Although the DCE may implement the internal variable *x*, other mechanisms do exist that achieve the identical function.

2.4.6 *LAPB conditions for data link resetting or data link re-initialization (data link set-up)*

2.4.6.1 When the DCE receives, during the information transfer phase, a frame which is not invalid (see § 2.3.5.3) with one of the conditions listed in § 2.3.4.9 above, the DCE will request the DTE to initiate a data link resetting procedure by transmitting an FRMR response to the DTE as described in § 2.4.7.3.

2.4.6.2 When the DCE receives, during the information transfer phase, an FRMR response from the DTE, the DCE will either initiate the data link resetting procedures itself as described in § 2.4.7.2 or return a DM response to ask the DTE to initiate the data link set-up (initialization) procedure as described in § 2.4.4.1. After transmitting a DM response, the DCE will enter the disconnected phase as described in § 2.4.4.4.2.

2.4.6.3 When the DCE receives, during the information transfer phase, a UA response, or an unsolicited response with the F bit set to 1, the DCE may either initiate the data link resetting procedures itself as described in § 2.4.7.2, or return a DM response to ask the DTE to initiate the data link set-up (initialization) procedure as described in § 2.4.4.1. After transmitting a DM response, the DCE will enter the disconnected phase as described in § 2.4.4.4.2.

2.4.6.4 When the DCE receives, during the information transfer phase, a DM response from the DTE, the DCE will either initiate the data link set-up (initialization) procedures itself as described in § 2.4.4.1, or return a DM response to ask the DTE to initiate the data link set-up (initialization) procedures as described in § 2.4.4.1. After transmitting a DM response, the DCE will enter the disconnected phase as described in § 2.4.4.4.2.

2.4.7 *LAPB procedure for data link resetting*

2.4.7.1 The data link resetting procedure is used to initialize both directions of information transfer according to the procedure described below. The data link resetting procedure only applies during the information transfer phase.

2.4.7.2 Either the DTE or the DCE may initiate the data link resetting procedure. The data link resetting procedure indicates a clearance of a DCE and/or DTE busy condition, if present.

The DTE shall initiate a data link resetting by transmitting an SABM/SABME command to the DCE. If, upon correct receipt of the SABM/SABME command, the DCE determines that it can continue in the information transfer phase, it will return a UA response to the DTE, will reset its send and receive state variables V(S) and V(R) to zero, and will remain in the information transfer phase. If, upon correct receipt of the SABM/SABME command, the DCE determines that it cannot remain in the information transfer phase, it will return a DM response as a denial to the resetting request and will enter the disconnected phase.

The DCE will initiate a data link resetting by transmitting an SABM/SABME command to the DTE and starting its Timer T1 (see § 2.4.8.1 below). Upon reception of a UA response from the DTE, the DCE will reset its send and receive state variables V(S) and V(R) to zero, will stop its Timer T1, and will remain in the information transfer phase. Upon reception of a DM response from the DTE as a denial to the data link resetting request, the DCE will stop its Timer T1 and will enter the disconnected phase.

The DCE, having sent an SABM/SABME command, will ignore and discard any frames received from the DTE except an SABM/SABME or DISC command, or a UA or DM response. The receipt of an SABM/SABME or DISC command from the DTE will result in a collision situation that is resolved per § 2.4.4.5 above. Frames other than the UA or DM response sent in response to a received SABM/SABME or DISC command will be sent only after the data link is reset and if no outstanding SABM/SABME command exists.

After the DCE sends the SABM/SABME command, if a UA or DM response is not received correctly, Timer T1 will run out in the DCE. The DCE will then resend the SABM/SABME command and will restart Timer T1. After N2 attempts to reset the data link, the DCE will initiate appropriate higher layer recovery action and will enter the disconnected phase. The value of N2 is defined in § 2.4.8.4 below.

2.4.7.3 The DCE may ask the DTE to reset the data link by transmitting an FRMR response (see § 2.4.6.1 above). After transmitting an FRMR response, the DCE will enter the frame rejection condition.

The frame rejection condition is cleared when the DCE receives an SABM/SABME command, a DISC command, a FRMR response, or a DM response; or if the DCE transmits an SABM/SABME command, a DISC command, or a DM response. Other commands received while in the frame rejection condition will cause the DCE to retransmit the FRMR response with the same information field as originally transmitted.

The DCE may start Timer T1 on transmission of the FRMR response. If Timer T1 runs out before the frame rejection condition is cleared, the DCE may retransmit the FRMR response, and restart T1. After N2 attempts (time outs) to get the DTE to reset the data link, the DCE may reset the data link itself as described in § 2.4.7.2 above. The value of N2 is defined in § 2.4.8.4 below.

In the frame rejection condition, I frames and supervisory frames will not be transmitted by the DCE. Also, received I frames and supervisory frames will be discarded by the DCE except for the observance of a P bit set to 1. When an additional FRMR response must be transmitted by the DCE as a result of the receipt of a P bit set to 1 while Timer T1 is running, Timer T1 will continue to run. Upon reception of an FRMR response (even during a frame rejection condition), the DCE will initiate a resetting procedure by transmitting an SABM/SABME command as described in § 2.4.7.2 above, or will transmit a DM response to ask the DTE to initiate the data link set-up procedure as described in § 2.4.4.1 and enter the disconnected phase.

2.4.8 *List of LAPB system parameters*

The DCE and DTE system parameters are as follows:

2.4.8.1 *Timer T1*

The value of the DTE Timer T1 system parameter may be different than the value of the DCE Timer T1 system parameter. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The period of Timer T1, at the end of which retransmission of a frame may be initiated (see § 2.4.4 and § 2.4.5 above for the DCE), shall take into account whether T1 is started at the beginning or the end of the transmission of a frame.

The proper operation of the procedure requires that the transmitter's (DCE or DTE) Timer T1 be greater than the maximum time between transmission of a frame (SABM/SABME, DISC, I or supervisory command, or DM or FRMR response) and the reception of the corresponding frame returned as an answer to that frame (UA, DM or acknowledging frame). Therefore, the receiver (DCE or DTE) should not delay the response or acknowledging frame returned to one of the above frames by more than a value T2, where T2 is a system parameter (see § 2.4.8.2).

The DCE will not delay the response or acknowledging frame returned to one of the above DTE frames by more than a period T2.

2.4.8.2 *Parameter T2*

The value of the DTE parameter T2 may be different than the value of the DCE parameter T2. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The period of parameter T2 shall indicate the amount of time available at the DCE or DTE before the acknowledging frame must be initiated in order to ensure its receipt by the DTE or DCE, respectively, prior to Timer T1 running out at the DTE or DCE (parameter T2 < Timer T1).

Note – The period of parameter T2 shall take into account the following timing factors: the transmission time of the acknowledging frame, the propagation time over the access data link, the stated processing times at the DCE and the DTE, and the time to complete the transmission of the frame(s) in the DCE or DTE transmit queue that are neither displaceable or modifiable in an orderly manner.

Given a value for Timer T1 for the DTE or DCE, the value of parameter T2 at the DCE or DTE, respectively, must be no larger than T1 minus 2 times the propagation time over the access data link, minus the frame processing time at the DCE, minus the frame processing time at the DTE, and minus the transmission time of the acknowledging frame by the DCE or DTE, respectively.

2.4.8.3 *Timer T3*

The DCE shall support a Timer T3 system parameter, the value of which shall be made known to the DTE.

The period of Timer T3, at the end of which an indication of an observed excessively long idle channel state condition is passed to the Packet Layer, shall be sufficiently greater than the period of the DCE Timer T1 (i.e. T3 > T1) so that the expiration of T3 provides the desired level of assurance that the data link channel is in a non-active, non-operational state, and is in need of data link set-up before normal data link operation can resume.

2.4.8.4 *Maximum number of attempts to complete a transmission N2*

The value of the DTE N2 system parameter may be different than the value of the DCE N2 system parameter. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The value of N2 shall indicate the maximum number of attempts made by the DCE or DTE to complete the successful transmission of a frame to the DTE or DCE, respectively.

2.4.8.5 *Maximum number of bits in an I frame N1*

The value of the DTE N1 system parameter may be different than the value of the DCE N1 system parameter. These values shall be made known to both the DTE and the DCE.

The values of N1 shall indicate the maximum number of bits in an I frame (excluding flags and 0 bits inserted for transparency) that the DCE or DTE is willing to accept from the DTE or DCE, respectively.

In order to allow for universal operation, a DTE should support a value of DTE N1 which is not less than 1080 bits (135 octets). DTEs should be aware that the network may transmit longer packets (see § 5.2), that may result in a data link layer problem.

All networks shall offer to a DTE which requires it, a value of DCE N1 which is greater than or equal to 2072 bits (259 octets) plus the length of the address, control and FCS fields at the DTE/DCE interface, and greater than or equal to the maximum length of the data packets which may cross the DTE/DCE interface plus the length of the address, control and FCS fields at the DTE/DCE interface.

Appendix II provides a description of how the values stated above are derived.

2.4.8.6 *Maximum number of outstanding I frames k*

The value of the DTE k system parameter shall be the same as the value of the DCE k system parameter. This value shall be agreed to for a period of time by both the DTE and the DCE.

The value of k shall indicate the maximum number of sequentially numbered I frames that the DTE or DCE may have outstanding (i.e. unacknowledged) at any given time. The value of k shall never exceed seven for modulo 8 operation, or one hundred and twenty-seven for modulo 128 operation. All networks (DCEs) shall support a value of seven. Other values of k (less than and greater than seven) may also be supported by networks (DCEs).

2.5 *Multilink procedure (MLP) (Subscription-time selectable option)*

The multilink procedure (MLP) exists as an added upper sublayer of the Data Link Layer, operating between the Packet Layer and a multiplicity of single data link protocol functions (SLPs) in the Data Link Layer (see Figure 1/X.25).

A multilink procedure (MLP) must perform the functions of accepting packets from the Packet Layer, distributing those packets across the available DCE or DTE SLPs for transmission to the DTE or DCE SLPs, respectively, and resequencing the packets received from the DTE or DCE SLPs for delivery to the DTE or DCE Packet Layer, respectively.

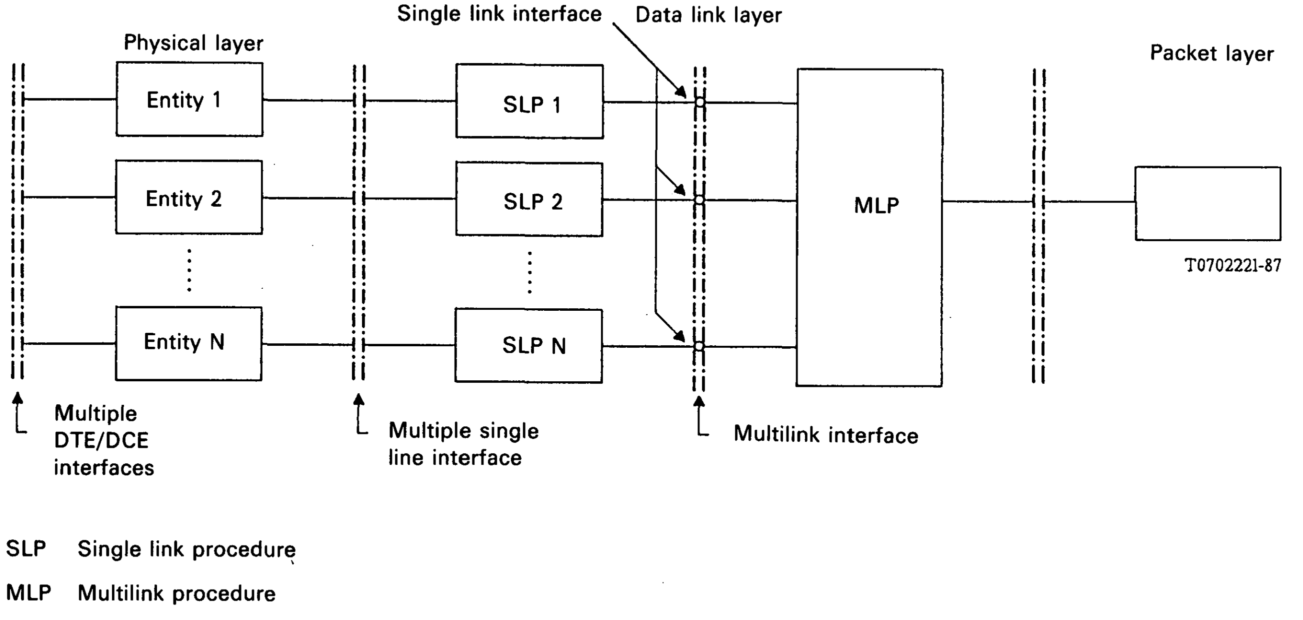


FIGURE 1/X.25

Multilink functional organization

2.5.1 *Field of application*

The optional multilink procedure (MLP) described below is used for data interchange over one or more single link procedures (SLPs), each conforming to the description in §§ 2.2, 2.3 and 2.4, in parallel between a DCE and a DTE. The multilink procedure provides the following general features:

a) achieve economy and reliability of service by providing multiple SLPs between DCE and a DTE;

b) permit addition and deletion of SLPs without interrupting the service provided by the multiple SLPs;

c) optimize bandwidth utilization of a group of SLPs through load sharing;

d) achieve graceful degradation of service when an SLP(s) fails;

e) provide each multiple SLP group with a single logical Data Link Layer appearance to the Packet Layer; and

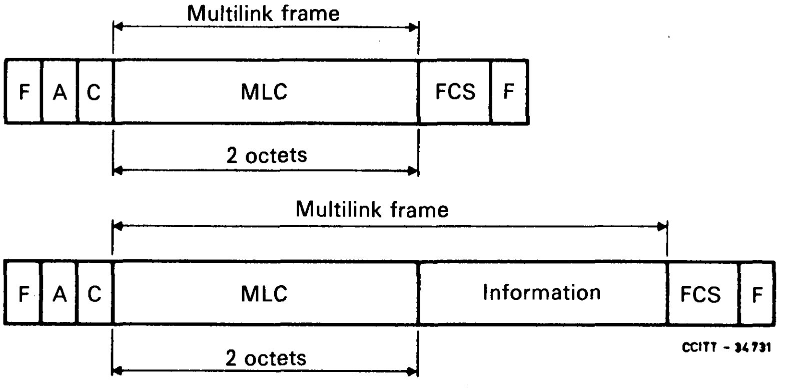
f) provide resequencing of the received packets prior to delivering them to the Packet Layer.

2.5.2 *Multilink frame structure*

All information transfers over an SLP are in multilink frames conforming to one of the formats shown in Table 9/X.25.

TABLE 9/X.25

Multilink frame formats



2.5.2.1 *Multilink control field*

The multilink control field (MLC) consists of two octets, and its contents are described in § 2.5.3.

2.5.2.2 *Multilink information field*

The information field of a multilink frame, when present, follows the MLC. See §§ 2.5.3.2.3 and 2.5.3.2.4 for the various codings and groupings of bits in the multilink information field.

2.5.3 *Multilink control field format and parameters*

2.5.3.1 *Multilink control field format*

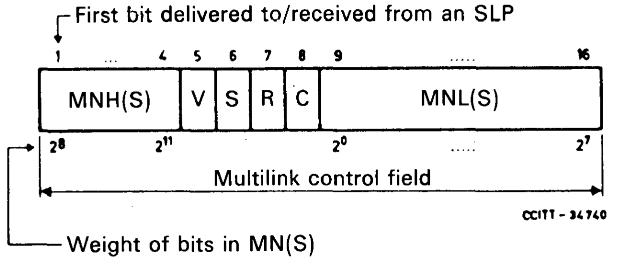
The relationship shown in Table 10/X.25 exists between the order of bits delivered to/received from an SLP and the coding of the fields in the multilink control field.

2.5.3.2 *Multilink control field parameters*

The various parameters associated with the multilink control field format are described below. See Table 10/X.25 and Figure 2/X.25.

TABLE 10/X.25

Multilink control field format



MNH(S)	Bits 9-12 of 12-bit multilink send sequence number MN(S)
MNL(S)	Bits 1-8 of 12-bit multilink send sequence number MN(S)
V	Void sequencing bit
S	Sequence check option bit
R	MLP reset request bit
C	MLP reset confirmation bit

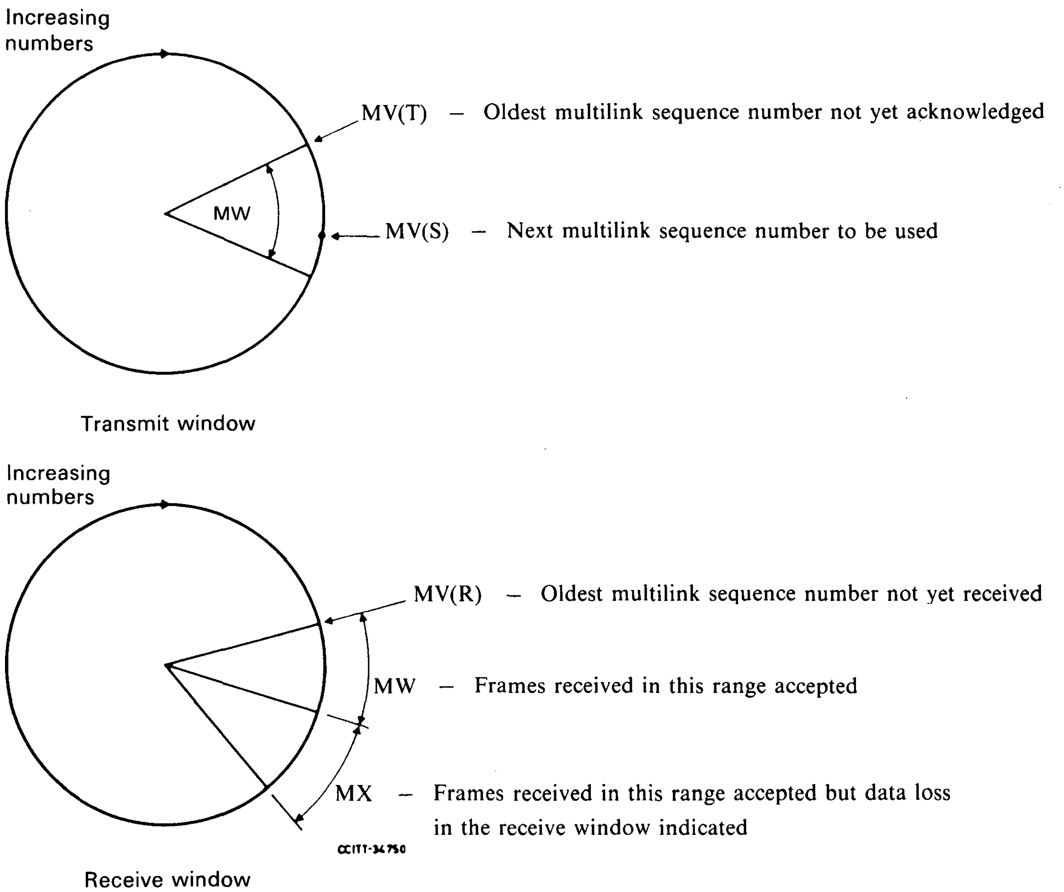


FIGURE 2/X.25

Parameters

2.5.3.2.1 *Void sequencing bit (V)*

The void sequencing bit (V) indicates if a received multilink frame shall be subjected to sequencing constraints. V set to 1 means sequencing shall not be required. V set to 0 means sequencing shall be required.

Note – For purposes of this Recommendation, this bit shall be set to 0.

2.5.3.2.2 *Sequence check option bit (S)*

The sequence check option bit (S) is only significant when V is set to 1 (indicating that sequencing of received multilink frames shall not be required). S set to 1 shall mean no MN(S) number has been assigned. S set to 0 shall mean an MN(S) number has been assigned, so that although sequencing shall not be required, a duplicate multilink frame check may be made, as well as a missing multilink frame identified.

Note – For purposes of this Recommendation, this bit shall be set to 0.

2.5.3.2.3 *MLP reset request bit (R)*

The MLP reset request bit (R) is used to request a multilink reset (see § 2.5.4.2). R set to 0 is used in normal communication, i.e. no request for a multilink reset. R set to 1 is used by the DCE MLP or DTE MLP to request the reset of the DTE MLP or DCE MLP state variables, respectively. In this R = 1 case, the multilink information field does not contain Packet Layer information, but may contain an optional 8 bit Cause Field that incorporates the reason for the reset.

Note – The encoding of the Cause Field is a subject for further study.

2.5.3.2.4 *MLP reset confirmation bit (C)*

The MLP reset confirmation bit (C) is used in reply to an R bit set to 1 (see § 2.5.3.2.3) to confirm the resetting of the multilink state variables (see § 2.5.4.2). C set to 0 is used in normal communications, i.e. no multilink reset request has been activated. C set to 1 is used by the DCE MLP or DTE MLP in reply to a DTE MLP or DCE MLP multilink frame, respectively, with R set to 1, and indicates that the DCE MLP or DTE MLP state variable reset process has been completed by the DCE or DTE, respectively. In this C = 1 case, the multilink frame is used without an information field.

2.5.3.2.5 *Multilink send state variable MV(S)*

The multilink send state variable MV(S) denotes the sequence number of the next in-sequence multilink frame to be assigned to an SLP. This variable can take on the value 0 through 4095 (modulo 4096). The value of MV(S) is incremented by 1 with each successive multilink frame assignment.

2.5.3.2.6 *Multilink sequence number MN(S)*

Multilink frames contain the multilink sequence number MN(S). Prior to the assignment of an in-sequence multilink frame to an available SLP, the value of MN(S) is set equal to the value of the multilink send state variable MV(S). The multilink sequence number is used to resequence and to detect missing and duplicate multilink frames at the receiver before the contents of a multilink frame information field is delivered to the Packet Layer.

2.5.3.2.7 *Transmitted multilink frame acknowledged state variable MV(T)*

MV(T) is the state variable at the transmitting DCE MLP or DTE MLP denoting the oldest multilink frame which is awaiting an indication that a DCE SLP or DTE SLP has received an acknowledgement from its remote DTE SLP or DCE SLP, respectively. This variable can take on the value 0 through 4095 (modulo 4096). Some multilink frames with sequence numbers higher than MV(T) may already have been acknowledged.

2.5.3.2.8 *Multilink receive state variable MV(R)*

The multilink receive state variable MV(R) denotes the sequence number at the receiving DCE MLP or DTE MLP of the next in-sequence multilink frame to be received and delivered to the Packet Layer. This variable can take on the value 0 through 4095 (modulo 4096). The value of MV(R) is updated as described in § 2.5.4.3.2 below. Multilink frames with higher sequence numbers in the DCE MLP or DTE MLP receive window may already have been received.

2.5.3.2.9 *Multilink window size MW*

MW is the maximum number of sequentially numbered multilink frames that the DCE MLP or DTE MLP may transfer to its SLPs beyond the lowest numbered multilink frame which has not yet been acknowledged. MW is a system parameter which can never exceed 4095 – MX. The value of MW shall be agreed for a period of time with the Administration and shall have the same value for both the DCE MLP and the DTE MLP for a given direction of information transfer.

Note – Factors which will affect the value of parameter MW include, but are not limited to, single link transmission and propagation delays, the number of links, the range of multilink frame lengths, and SLP parameters N2, T1, and k.

The MLP transmit window contains the sequence numbers MV(T) to MV(T) + MW – 1 inclusive.

The MLP receive window contains the sequence numbers MV(R) to MV(R) + MW – 1 inclusive. Any multilink frame received within this window shall be delivered to the Packet Layer when its MN(S) becomes the same as MV(R).

2.5.3.2.10 *Receive MLP window guard region MX*

MX is a system parameter which defines a guard region of multilink sequence numbers of fixed size beginning at MV(R) + MW. The range of MX shall be large enough for the receiving MLP to recognize the highest MN(S) outside of its receive window that it may legitimately receive after a multilink frame loss has occurred.

A multilink frame with sequence number MN(S) = Y received in this guard region indicates that those missing multilink frame(s) in the range MV(R) to Y – MW has(have) been lost. MV(R) is then updated to Y – MW + 1.

Note – A number of methods may be selected in calculating a value for the guard region MX:

a) In a system where the transmitting MLP assigns h_i in-sequence contiguous multilink frames at a time to the ith SLP, MX should be greater than or equal to the sum of the $h_i + 1 - h_{min}$, where h_{min} equals the smallest h_i encountered. Where there are L SLPs in the multilink group, MX should be greater than or equal to:

$$\sum_{i=1}^{L} h_i + 1 = h_{min}; \text{ or}$$

b) In a system where the transmitting MLP assigns on a rotation basis h in-sequence contiguous multilink frames at a time to each SLP, MX at the receiving MLP should be greater than or equal to $h(L - 1) + 1$, where L is the number of SLPs in the multilink group; or

c) MX should be no larger than MW.

Additional methods of selecting MX values are for further study.

2.5.4 *Description of multilink procedure (MLP)*

The procedure below is presented from the perspective of the transmitter and receiver of multilink frames.

The arithmetic is performed modulo 4096.

2.5.4.1 *Initialization*

The DCE or DTE will perform an MLP initialization by first resetting MV(S), MV(T) and MV(R) to zero and then initializing each of its SLPs. Upon successful initialization of at least one of the SLPs, the DCE shall, and the DTE should, perform the multilink resetting procedure as described in § 2.5.4.2. An SLP initialization is performed according to § 2.4.4.1 of this Recommendation.

Note – An SLP that cannot be initialized should be declared out of service and appropriate recovery action should be taken.

2.5.4.2 *Multilink resetting procedure*

The multilink resetting procedure provides the mechanism for synchronizing the sending and receiving MLPs in both the DCE and the DTE, when deemed necessary by either the DCE or the DTE. Exact cases where the MLP resetting procedures are invoked is for further study. Following a successful multilink resetting procedure, the multilink sequence numbering in each direction begins with the value 0. Appendix III provides examples of the multilink resetting procedures when initiated by either the DCE or the DTE, or by both the DCE and the DTE simultaneously.

A multilink frame with R = 1 is used to request multilink reset, and a multilink frame with C = 1 confirms that the multilink reset process has been completed. An MLP resets MV(S) and MV(T) to zero on transfer of a multilink frame with R = 1; and resets MV(R) to zero on receipt of a multilink frame with R = 1.

When the DCE MLP or DTE MLP initiates the resetting procedure, it removes all of the unacknowledged multilink frames that are held in that MLP and its associated SLPs, and retains control of those frames. Hereafter, the initiating MLP does not transfer a multilink frame with R = C = 0 until the reset process is completed. (One method to remove multilink frames in the SLP is to disconnect the data link of that SLP.) The initiating MLP then resets its multilink send state variable MV(S) and its transmitted multilink frame acknowledged state variable MV(T) to zero. The initiating MLP then transfers a multilink frame with R = 1 as a reset request on one of its SLPs and starts Timer MT3. The value of the MN(S) field in the R = 1 frame may be any value, since when R = 1 the MN(S) field is ignored by the receiving MLP. The initiating MLP continues to receive and process multilink frames from the remote MLP, in accordance with the procedures as described in § 2.5.4.4 below until it receives a multilink frame with R = 1 from the remote MLP.

An MLP which has received a multilink frame with R = 1 (reset request) in the normal communication status from an initiating MLP starts the operation as described above; the MLP should receive no multilink frame with R = C = 0 from the other MLP until the reset process is completed. Any such multilink frame received is discarded. When an MLP has already initiated its own multilink resetting procedure and has transferred the multilink frame with R = 1 to one of its SLPs for transmission, that MLP does not repeat the above operation upon receipt of a multilink frame with R = 1 from the other MLP.

Receipt of a frame with R = 1 (reset request) causes the receiving MLP to deliver to the Packet Layer those packets already received and to identify those multilink frames assigned to SLPs but unacknowledged. The Packet Layer may be informed of the packet loss at the original value of MV(R) and at any subsequent value(s) of MV(R) for which there has been no multilink frame received up to and including the highest numbered multilink frame received. The receiving MLP then resets its multilink receive state variable MV(R) to zero.

After an MLP assigns a multilink frame with R = 1 to one of its SLPs, it shall receive indication of successful or unsuccessful transmission from that SLP as one of the conditions before transferring a multilink frame with C = 1; when the initiating MLP then receives a multilink frame with R = 1, and has completed the multilink state variable resetting operation described above, the initiating MLP transfers a multilink frame with C = 1 (reset confirmation) to the other MLP. When an MLP has:

(1) received a multilink frame with R = 1,

(2) transferred a multilink frame with R = 1 on one of its SLPs, and

(3) completed the multilink state variable resetting operation above,

that MLP then transfers a multilink frame with C = 1 (reset confirmation) to the other MLP as soon as possible, given that indication of the successful or unsuccessful transmission of the R = 1 multilink frame has been received from that MLP's SLP. The C = 1 multilink frame is a reply to the multilink frame with R = 1. The value of the MN(S) field in the above C = 1 frame may be any value, since when C = 1 the MN(S) field is ignored by the receiving MLP. The multilink sequence number MN(S) received in each direction following multilink reset will begin with the value zero.

When an MLP uses only one SLP to transmit the multilink frame with R = 1 and the multilink frame with C = 1, the MLP can transfer the multilink frame with C = 1 immediately after the multilink frame with R = 1 without waiting for SLP indication of transmission completion. An MLP shall not retransmit a multilink frame with R = 1 or a multilink frame with C = 1 unless Timer MT3 (see § 2.5.5.3 below) runs out. An MLP may use two different SLPs as long as one is used for transmitting the multilink frame with R = 1 and the other is used for transmitting the multilink frame with C = 1 following receipt of the SLP indication of successful or unsuccessful transmission of the R = 1 multilink frame. A multilink frame with R = C = 1 is never used.

When an MLP receives the multilink frame with C = 1, the MLP stops its Timer MT3. The transmission of the multilink frame with C = 1 to a remote SLP and the reception of a multilink frame with C = 1 from the remote MLP completes the multilink resetting procedure for an MLP. The first multilink frame transferred with R = C = 0 shall have a multilink sequence number MN(S) value of zero. After an MLP transfers a multilink frame with C = 1 to an SLP, the MLP may receive one or more multilink frames with R = C = 0. After an MLP receives a multilink frame with C = 1, the MLP may transfer one or more multilink frames with R = C = 0 to its SLPs.

When an MLP additionally receives one or more multilink frames with R = 1 between receiving a multilink frame with R = 1 and transferring a multilink frame with C = 1, the MLP shall discard the extra multilink frames with R = 1. When an MLP receives a multilink frame with C = 1, which is not a reply to a multilink frame with R = 1, the MLP shall discard the multilink frame with C = 1.

After an MLP transfers a multilink frame with C = 1 on one of its SLPs, the MLP may receive a multilink frame with R = 1 from the other MLP. The MLP shall regard the multilink frame with R = 1 as a new reset request and shall start the multilink resetting procedure from the beginning. When an MLP which has not received a multilink frame with R = 1, transfers a multilink frame with R = 1, and therefore receives a multilink frame with C = 1, the MLP shall restart the resetting procedure from the beginning.

When Timer MT3 runs out, the MLP restarts the multilink resetting procedure from the beginning. The value of Timer MT3 shall be large enough to include the transmission, retransmission and propagation delays in the SLPs, and the operation time of the MLP that receives a multilink frame with R = 1 and responds with a multilink frame with C = 1.

2.5.4.3 *Transmitting multilink frames*

2.5.4.3.1 *General*

The transmitting DCE or DTE MLP shall be responsible for controlling the flow of packets from the Packet Layer into multilink frames and then to the SLPs for transmission to the receiving DTE or DCE MLP, respectively.

The functions of the transmitting DCE or DTE MLP shall be to:

a) accept packets from the Packet Layer;

b) allocate multilink control fields, containing the appropriate sequence number MN(S), to the packets;

c) assure that MN(S) is not assigned outside the MLP transmit window (MW);

d) pass the resultant multilink frames to the SLPs for transmission;

e) accept indications of successful transmission acknowledgements from the SLPs;

f) monitor and recover from transmission failures or difficulties that occur at the SLP sublayer; and

g) accept flow control indications from the SLPs and take appropriate actions.

2.5.4.3.2 *Transmission of multilink frames*

When the transmitting DCE MLP accepts a packet from the Packet Layer, it shall place the packet in a multilink frame, set the MN(S) equal to MV(S), assure that MN(S) is not assigned outside the transmit window (MW), set V, S, R and C to 0, and then increment MV(S) by 1.

In the following, incrementing send and receive state variables is in reference to a continuously repeated sequence series, i.e. 4095 is 1 higher than 4094, and 0 is 1 higher than 4095 for modulo 4096 series.

If the MN(S) is less than MV(T) + MW, and the DTE has not indicated a busy condition on all available DCE SLPs, the transmitting DCE MLP may then assign the new multilink frame to an available DCE SLP. The transmitting DCE MLP shall always assign the lowest MN(S) unassigned multilink frame first. Also, the transmitting DCE MLP may assign a multilink frame to more than one DCE SLP. When the DCE SLP successfully completes the transmission of (a) multilink frame(s) by receiving an acknowledgement from the DTE SLP, it shall indicate this to the transmitting DCE MLP. The transmitting DCE MLP may then discard the acknowledged multilink frame(s). As the transmitting DCE receives new indications of acknowledgements from the DCE SLPs, MV(T) shall be advanced to denote the lowest numbered multilink frame not yet acknowledged.

Whenever a DCE SLP indicates that it has attempted to transmit a multilink frame N2 times, the DCE MLP will then assign the multilink frame to the same or one or more other DCE SLPs unless the MN(S) has been acknowledged on some previous DCE SLP. The DCE MLP shall always assign the lowest MN(S) multilink frame first.

Note – If a DCE MLP implementation is such that a multilink frame is assigned to more than one DCE SLP (e.g. to increase the probability of successful delivery) there is a possibility that one of these multilink frames (i.e. a duplicate) may be delivered to the remote DTE MLP after an earlier one has been acknowledged [the earlier multilink frame would have resulted in the receiving DTE MLP having incremented its MV(R) and the transmitting DCE MLP having incremented its MV(T)]. To ensure that an old duplicate multilink frame is not mistaken for a new frame by the receiving DTE MLP, it is required that the transmitting DCE MLP shall never assign to a DCE SLP a new multilink frame with MN(S) equal to MN(S)′ – MW – MX, where MN(S)′ is associated with a duplicate multilink frame that was earlier assigned to other DCE SLPs, until all DCE SLPs have either successfully transmitted the multilink frame MN(S)′ or have attempted the transmission the maximum number of times. Alternatively, the incrementing of MV(T) may be withheld until all DCE SLPs that were assigned the multilink frame MN(S)′ have either successfully transferred the multilink frame MN(S)′ or have attempted the transmission the maximum number of times. These and other alternatives are for further study.

Flow control is achieved by the window size parameter MW, and through busy conditions being indicated by the DTE SLPs.

The DCE MLP will not assign a multilink frame with an MN(S) greater than MV(T) + MW – 1. At the point where the next DCE multilink frame to be assigned has an MN(S) = MV(T) + MW, the DCE MLP shall hold this and subsequent multilink frames until an indication of an acknowledgement that advances MV(T) is received from the DCE SLPs.

The DTE MLP may exercise flow control of the DCE MLP by indicating a busy condition over one or more DTE SLPs. The number of SLPs made busy will determine the degree of DCE MLP flow control realized. When the DCE MLP receives an indication of a DTE SLP busy condition from one or more of its DCE SLPs, the DCE MLP may reassign any unacknowledged multilink frames that were assigned to those DCE SLPs. The DCE MLP will assign the multilink frames containing the lowest MN(S) to an available DCE SLP as specified above.

Note 1 – The action to be taken on the receipt of an RNR frame by the DCE SLP whose unacknowledged multilink frames have been reassigned is for further study.

In the event of a circuit failure, a DCE SLP reset, or a DCE SLP or DTE SLP disconnection, all DCE MLP multilink frames that were unacknowledged on the affected DCE SLPs shall be reassigned to an operational DCE SLP(s) which is(are) not in the busy condition.

Note 2 – The means of detecting transmitting DCE MLP malfunctions (e.g. sending more than MW multilink frames) and the actions to be taken are for further study.

2.5.4.4 *Receiving multilink frames*

Any multilink frame less than two octets in length shall be discarded by the receiving DCE MLP.

Note – The procedures to be followed by the receiving DCE MLP when V and/or S is equal to 1 are for further study. The procedures to be followed by the receiving DCE MLP when R or C is equal to 1 are described in § 2.5.4.2 above.

When the DCE MLP receives multilink frames from one of the DCE SLPs, the DCE MLP will compare the multilink sequence number MN(S) of the received multilink frame to its multilink receive state variable MV(R), and act on the multilink frame as follows:

a) If the received MN(S) is equal to the current value of MV(R), i.e. is the next expected in-sequence multilink frame, the DCE MLP delivers the packet to the Packet Layer.

b) If the MN(S) is greater than the current value of MV(R) but less than MV(R) + MW + MX, the DCE MLP keeps the received multilink frame until condition a) is met, or discards it if it is a duplicate.

c) If the MN(S) is other than in a) and b) above, the multilink frame is discarded.

Note – In case c) above, the recovery from desynchronization greater than MX between the local and the remote MLP, i.e., the value of MN(S) reassigned to new multilink frames at the remote MLP is higher than MV(R) + MW + MX at the local MLP, is for further study.

On receipt of each multilink frame, MV(R) is incremented by the DCE MLP in the following way:

i) If MN(S) is equal to the current value of MV(R), the MV(R) is incremented by the number of consecutive in-sequence multilink frames that have been received. If additional multilink frames are awaiting delivery pending receipt of a multilink frame with MN(S) equal to the updated MV(R), then Timer MT1 (see § 2.5.5.1 below) is restarted; otherwise Timer MT1 is stopped.

ii) If MN(S) is greater than the current value of MV(R) but less than MV(R) + MW, MV(R) remains unchanged. Timer MT1 is started, if not already running.

iii) If MN(S) is ⩾ MV(R) + MW but < MV(R) + MW + MX, MV(R) is incremented to MN(S) − MW + 1 and then the Packet Layer may be informed of the packet loss at the original value of MV(R). As MV(R) is being incremented, if any multilink frame with MN(S) = MV(R) has not yet been received, the Packet Layer may be informed of that packet loss also; if the multilink frame with MN(S) = MV(R) has been received, it is delivered to the Packet Layer. After MV(R) reaches MN(S) − MW + 1, it will then be incremented further (as in i) above) until the first unacknowledged MN(S) is encountered. See Figure 3/X.25.

iv) If the MN(S) is other than that in i), ii) and iii) above, MV(R) remains unchanged.

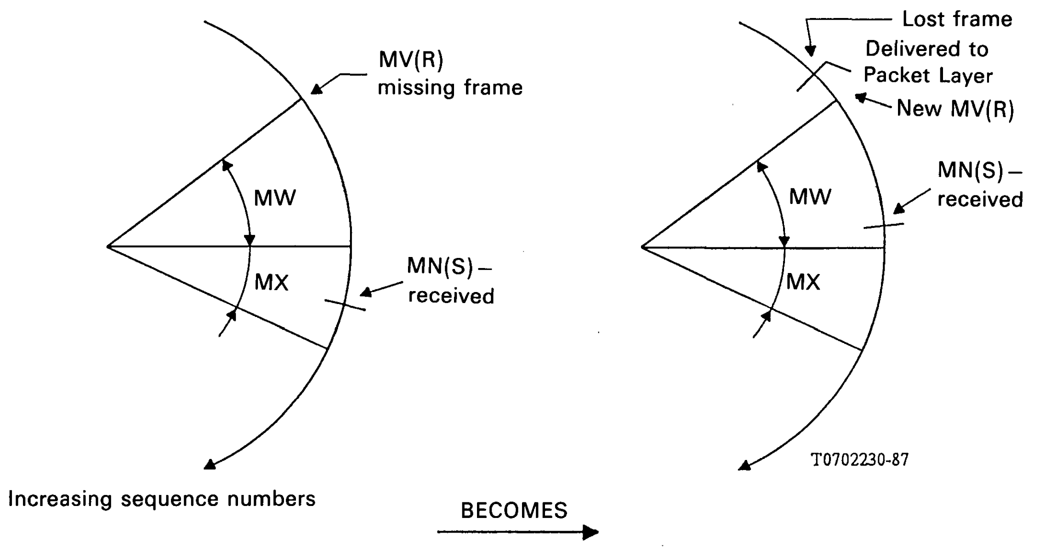


FIGURE 3/X.25

Detecting lost multilink frames

If Timer MT1 runs out, MV(R) is incremented to the MN(S) of the next multilink frame awaiting delivery to the Packet Layer and then the Packet Layer may be informed of the packet loss at the original MV(R). The procedure follows a) and i) above as long as there are consecutive in-sequence multilink frames which have been received.

When flow control of the DTE MLP is desired, one or more DCE SLP(s) may be made to indicate a busy condition. The number of DCE SLPs made busy determines the degree of flow control realized.

If the DCE MLP can exhaust its receive buffer capacity before resequencing can be completed, Timer MT2 (see § 2.5.5.2 below) may be implemented. Whenever a busy condition is indicated by the DCE MLP on all DCE SLPs, and multilink frames at the DCE MLP are awaiting resequencing, Timer MT2 shall be started. When the busy condition is cleared on one or more DCE SLPs by the DCE MLP, Timer MT2 shall be stopped.

If Timer MT2 runs out, the multilink frame with MN(S) = MV(R) is blocked and shall be considered lost. MV(R) shall be incremented to the next sequence number not yet received, and the packets contained in multilink frames with intervening multilink sequence numbers are delivered to the Packet Layer. Timer MT2 shall be restarted if the busy condition remains in effect on all DCE SLPs and more multilink frames are awaiting resequencing.

2.5.4.5 *Taking an SLP out of service*

A DCE SLP may be taken out of service for maintenance, traffic, or performance considerations.

A DCE SLP is taken out of service by disconnecting at the Physical Layer or the Data Link Layer. Any outstanding DCE MLP multilink frames will be reassigned to one or more other DCE SLPs, unless the MN(S) has been previously acknowledged on some other DCE SLP. The usual procedure for taking a DCE SLP out of service at the Data Link Layer would be to flow control the DTE SLP with an RNR frame, and then logically disconnect the DCE SLP (see § 2.4.4.3 above).

If the DCE SLP Timer T1 has run out N2 times and the DCE SLP data link resetting procedure is unsuccessful, then the DCE SLP will enter the disconnected phase, taking the DCE SLP out of service (see §§ 2.4.5.8 and 2.4.7.2 above).

Note – In the case where all SLPs are out of service, the recovery mechanism is based on initiating the multilink resetting procedures. Other recovery procedures are for further study.

2.5.5 *List of multilink system parameters*

2.5.5.1 *Lost-frame Timer MT1 (multilink)*

Timer MT1 is used at a receiving DCE MLP to provide a means to identify during low traffic periods that the multilink frame with MN(S) equal to MV(R) is lost.

2.5.5.2 *Group busy Timer MT2 (multilink)*

Timer MT2 is provided at a receiving DCE MLP to identify a "blocked" multilink frame condition (e.g. a buffer exhaust situation) that occurs before required resequencing can be accomplished. Timer MT2 is started when all DCE SLPs are busy and there are multilink frames awaiting resequencing. If Timer MT2 runs out before the "blocked" multilink frame MV(R) is received, the "blocked" multilink frame(s) is(are) declared lost. MV(R) is incremented to the value of the next in-sequence multilink frame to be received, and any packets in intervening multilink frames are delivered to the Packet Layer.

Note – Timer MT2 may be set to infinity; e.g. when the receiving DCE always has sufficient storage capacity.

2.5.5.3 *MLP reset confirmation Timer MT3 (multilink)*

Timer MT3 is used by the DCE MLP to provide a means of identifying that the DTE MLP multilink frame with the C bit set to 1 that is expected following the transmission of the DCE MLP multilink frame with R bit set to 1, has not been received.

2.6 *LAP elements of procedure*

2.6.1 The LAP elements of procedure are defined in terms of actions that occur on receipt of frames at the DCE or DTE.

The elements of procedure specified below contain the selection of commands and responses relevant to the LAP data link and system configurations described in § 2.1 above. Together, §§ 2.2 and 2.6 form the general requirements for the proper management of a LAP access data link.

2.6.2 *LAP control field formats and parameters*

2.6.2.1 *Control field formats*

The control field contains a command or a response, and sequence numbers where applicable.

Three types of control field formats (see Table 11/X.25) are used to perform numbered information transfer (I format), numbered supervisory functions (S format) and unnumbered control functions (U format).

TABLE 11/X.25

LAP control field formats (modulo 8)

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

N(S) Transmitter send sequence number (bit 2 = low-order bit)

N(R) Transmitter receive sequence number (bit 6 = low-order bit)

S Supervisory function bit

M Modifier function bit

P/F Poll bit when issued as a command, final bit when issued as a response. (1 = Poll/Final)

P Poll bit (1 = Poll)

2.6.2.1.1 *Information transfer format – I*

The I format is used to perform an information transfer. The functions of N(S), N(R) and P are independent, i.e. each I frame has an N(S), an N(R) which may or may not acknowledge additional I frames received by the DCE or DTE, and a P bit that may be set to 0 or 1.

2.6.2.1.2 *Supervisory format – S*

The S format is used to perform data link supervisory control functions such as acknowledge I frames, request retransmission of I frames, and to request a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent, i.e. each supervisory frame has an N(R) which may or may not acknowledge additional I frames received by the DCE or DTE, and a P/F bit that may be set to 0 or 1.

2.6.2.1.3 *Unnumbered format – U*

The U format is used to provide additional data link control functions. This format contains no sequence numbers, but does include a P/F bit that may be set to 0 or 1.

2.6.2.2 *Control field parameters*

The various parameters associated with the control field formats are described below.

2.6.2.2.1 *Modulus*

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

2.6.2.2.2 *Send state variable V(S)*

The send state variable V(S) denotes the sequence number of the next in-sequence I frame to be transmitted. V(S) can take on the value 0 through modulus minus 1. The value of V(S) is incremented by 1 with each successive I frame transmission, but cannot exceed N(R) of the last received I or supervisory frame by more than the maximum number of outstanding I frames (k). The value of k is defined in § 2.7.7.6 below.

2.6.2.2.3 *Send sequence number N(S)*

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

2.6.2.2.4 *Receive state variable V(R)*

The receive state variable V(R) denotes the sequence number of the next in-sequence I frame expected to be received. V(R) can take on the values 0 through modulus minus 1. The value of V(R) is incremented by 1 with the receipt of an error free, in-sequence I frame whose send sequence number N(S) equals the receive state variable V(R).

2.6.2.2.5 *Receive sequence number N(R)*

All I frames and supervisory frames contain N(R), the expected send sequence number of the next received I frame. At the time that a frame of the above types is designed for transmission, the value of N(R) is set equal to the current value of the receive state variable V(R). N(R) indicates that the DCE or DTE transmitting the N(R) has received correctly all I frames numbered up to and including N(R) – 1.

2.6.2.2.6 *Poll/Final bit P/F*

All frames contain P/F, the Poll/Final bit. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit.

2.6.3 *Functions of the Poll/Final bit*

The Poll bit set to 1 is used by the DCE or DTE to solicit (poll) a response from the DTE or DCE, respectively. The Final bit set to 1 is used by the DCE or DTE to indicate the response frame transmitted by the DTE or DCE, respectively, as a result of the soliciting (poll) command.

The use of the P/F bit is described in § 2.7.2 below.

2.6.4 *Commands and responses*

The commands and responses represented in Table 12/X.25 will be supported by the DCE and the DTE.

For purposes of the LAP procedures, the supervisory function bit encoding "11" and those encodings of the modifier function bits in Table 11/X.25 not identified in Table 12/X.25 are identified as "undefined or not implemented" command and response control fields.

TABLE 12/X.25

LAP commands and responses

Format	Command	Response	Encoding							
			1	2	3	4	5	6	7	8
Information transfer	I (information)		0	N(S)			P	N(R)		
Supervisory	RR (receive ready)	RR (receive ready)	1	0	0	0	P/F	N(R)		
	RNR (receive not ready)	RNR (receive not ready)	1	0	1	0	P/F	N(R)		
	REJ (reject)	REJ (reject)	1	0	0	1	P/F	N(R)		
Unnumbered	SARM (set asynchronous response mode)		1	1	1	1	P	0	0	0
	DISC (disconnect)		1	1	0	0	P	0	1	0
		CMDR (command reject)	1	1	1	0	F	0	0	1
		UA (unnumbered acknowledgement)	1	1	0	0	F	1	1	0

Note – RR, RNR and REJ supervisory commands are transmitted by the DCE.

The commands and responses in Table 12/X.25 are defined as follows:

2.6.4.1 *Information (I) command*

The function of the information (I) command is to transfer across a data link a sequentially numbered frame containing an information field.

2.6.4.2 *Receive ready (RR) command and response*

The receive ready (RR) supervisory frame is used by the DCE or DTE to:

1) indicate it is ready to receive an I frame; and
2) acknowledge previously received I frames numbered up to and including N(R) – 1.

An RR frame may be used to indicate the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). The RR command with the P bit set to 1 may be used by the DTE to ask for the status of the DCE.

2.6.4.3 *Reject (REJ) command and response*

The reject (REJ) supervisory frame is used by the DCE or DTE to request transmission of I frames starting with the frame numbered N(R). I frames numbered N(R) – 1 and below are acknowledged. Additional I frames pending initial transmission may be transmitted following the retransmitted I frame(s).

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

An REJ frame may be used to indicate the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). The REJ command with the P bit set to 1 may be used by the DTE to ask for the status of the DCE.

2.6.4.4 *Receive not ready (RNR) command and response*

The receive not ready (RNR) supervisory frame is used by the DCE or DTE to indicate a busy condition, i.e. temporary inability to accept additional incoming I frames. I frames numbered up to and including N(R) − 1 are acknowledged. I frame N(R) and any subsequent I frames received, if any, are not acknowledged; the acceptance status of these I frames will be indicated in subsequent exchanges.

The RNR command with the P bit set to 1 may be used by the DTE to ask for the status of the DCE.

2.6.4.5 *Set asynchronous response mode (SARM) command*

The SARM unnumbered command is used to place the addressed DCE or DTE in the asynchronous response mode (ARM) information transfer phase, where all command/response control fields will be one octet in length.

No information field is permitted with the SARM command. A DCE or DTE confirms acceptance of an SARM command by the transmission at the first opportunity of a UA response. Upon acceptance of this command, the DCE or DTE receive state variable V(R) is set to 0.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher layer (e.g. Packet Layer) to recover from the possible loss of the contents (packets) of such I frames.

2.6.4.6 *Disconnect (DISC) command*

The DISC unnumbered command is used to terminate the mode previously set. It is used to inform the DCE or DTE receiving the DISC that the DTE or DCE sending the DISC command is suspending operation. No information field is permitted with the DISC command. Prior to actioning the DISC command, the DCE or DTE receiving the DISC command confirms the acceptance of the DISC command by the transmission of a UA response. The DTE or DCE sending the DISC command enters the disconnected phase when it receives the acknowledging UA response.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher layer (e.g. Packet Layer) to recover from the possible loss of the contents (packets) of such I frames.

2.6.4.7 *Unnumbered acknowledgement (UA) response*

The UA unnumbered response is used by the DCE or DTE to acknowledge the receipt and acceptance of the mode-setting commands. Received mode-setting commands are not actioned until the UA response is transmitted. The UA response is transmitted as directed by the received U format command. No information field is permitted with the UA response.

2.6.4.8 *Command reject (CMDR) response*

The CMDR unnumbered response is used by the DCE or DTE to report an error condition not recoverable by retransmission of the identical frame, i.e. at least one of the following conditions, which results from the receipt of a valid command frame:

1) the receipt of a command control field that is undefined or not implemented;
2) the receipt of an I frame with an information field which exceeds the maximum established length;
3) the receipt of an invalid N(R) (see § 2.7.5.1), or
4) the receipt of a frame with an information field which is not permitted or the receipt of a supervisory or unnumbered frame with incorrect length.

An undefined or not implemented control field is any of the control field encodings that are not identified in Table 12/X.25.

An invalid N(R) is defined as one which points to an I frame which has previously been transmitted and acknowledged or to an I frame which has not been transmitted and is not the next sequential I frame awaiting transmission.

An information field which immediately follows the control field, and consists of 3 octets, is returned with this response and provides the reason for the CMDR response. This format is given in Table 13/X.25.

TABLE 13/X.25

LAP CMDR information field format

Information field bits

1 2 3 4 5 6 7 8	9	10 11 12	13	14 15 16	17	18	19	20	21	22	23	24
Rejected command control field	0	V(S)	0	V(R)	W	X	Y	Z	0	0	0	0

– Rejected command control field is the control field of the received command which caused the command reject.

– V(S) is the current send state variable value at the DCE or DTE reporting the rejection condition (bit 10 = low-order bit).

– V(R) is the current receive state variable value at the DCE or DTE reporting the rejection condition (bit 14 = low-order bit).

– W set to 1 indicates that the control field received and returned in bits 1 through 8 was undefined or not implemented.

– X set to 1 indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this frame or is a supervisory or unnumbered frame with an incorrect length. Bit W must be set to 1 conjunction with this bit.

– Y set to 1 indicates that the information field received exceeded the maximum established capacity of the DCE or DTE reporting the rejection condition.

– Z set to 1 indicates the control field received and returned in bits 1 through 8 contained an invalid N(R).

Note – Bits 9, 13 and 21 to 24 shall be set to 0.

2.6.5 *Exception condition reporting and recovery*

The error recovery procedures which are available to effect recovery following the detection/occurrence of an exception condition at the Data Link Layer are described below. Exception conditions described are those situations which may occur as the result of transmission errors, DCE or DTE malfunction, or operational situations.

2.6.5.1 *Busy condition*

The busy condition results when the DCE or DTE is temporarily unable to continue to receive I frames due to internal constraints, e.g. receive buffering limitations. In this case an RNR frame is transmitted from the busy DCE or DTE. I frames pending transmission may be transmitted from the busy DCE or DTE prior to or following the RNR frame.

An indication that the busy condition has cleared is communicated by the transmission of a UA (only in response to a SARM command), RR, REJ or SARM frame.

2.6.5.2 *N(S) sequence error condition*

The information field of all I frames received whose N(S) does not equal the receive state variable V(R) will be discarded.

An N(S) sequence error exception condition occurs in the receiver when an I frame received contains an N(S) which is not equal to the receive state variable V(R) at the receiver. The receiver does not acknowledge (increment its receive state variable) the I frame causing the sequence error, or any I frames which may follow, until an I frame with the correct N(S) is received.

A DCE or DTE which receives one or more valid I frames having sequence errors but otherwise errorless shall accept the control information contained in the N(R) field and the P bit to perform data link control functions, e.g. to receive acknowledgement of previously transmitted I frames and to cause the DCE or DTE to respond (P bit set to 1). Therefore, the retransmitted frame may contain an N(R) and a P bit that are updated from, and therefore different from, those contained in the originally transmitted I frame.

The methods specified in §§ 2.6.5.2.1 and 2.6.5.2.2 shall be available for initiating the retransmission of lost of errored I frames following the occurrence of an N(S) sequence error condition.

2.6.5.2.1 *REJ recovery*

The REJ frame is used by a receiving DCE or DTE to initiate a recovery (retransmission) following the detection of an N(S) sequence error.

With respect to each direction of transmission on the data link, only one "sent REJ" exception condition from a DCE or DTE, to a DTE or DCE, is established at a time. A "sent REJ" exception condition is cleared when the requested I frame is received.

A DCE or DTE receiving an REJ frame initiates sequential (re)transmission of I frames starting with the I frame indicated by the N(R) obtained in the REJ frame.

2.6.5.2.2 *Time-out recovery*

If a DCE or DTE, due to a transmission error, does not receive (or receives and discards) a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an N(S) sequence error condition and, therefore, will not transmit an REJ frame. The DTE or DCE, which transmitted the unacknowledged I frame(s) shall, following the completion of a system specified time-out period (see §§ 2.7.4.8 and 2.7.7.1 below), take appropriate recovery action to determine at which I frame retransmission must begin.

2.6.5.3 *Invalid frame condition*

Any frame which is invalid will be discarded, and no action will be taken as the result of that frame. An invalid frame is defined as one which:

a) is not properly bounded by two flags;

b) contains fewer than 32 bits between flags;

c) contains a Frame Check Sequence (FCS) error; or

d) contains an address other than A or B.

For those networks that are octet-aligned, a detection of non-octet alignment may be made at the Data Link Layer by adding a frame validity check that requires the number of bits between the opening flag and the closing flag, excluding bits inserted for transparency, to be an integral number of octets in length. Otherwise the frame is considered invalid.

2.6.5.4 *Command rejection condition*

A command rejection condition is established upon the receipt of an error-free command frame with one of the conditions listed in § 2.6.4.8 above.

At the DCE or DTE, this command rejection exception condition is reported by a CMDR response for appropriate DTE or DCE action, respectively. Once a DCE has established such an exception condition, no additional I frames are accepted until the condition is reset by the DTE, except for examination of the P bit. The CMDR response may be repeated at each opportunity, as specified in § 2.7.6.5, until recovery is effected by the DTE, or until the DCE initiates its own recovery.

2.6.5.5 *Excessive idle channel state condition on the incoming channel*

Upon detection of an idle channel state condition (see § 2.2.12.2 above) on the incoming channel, the DCE shall not take any action for a period T3 (see § 2.7.7.3 below), while waiting for detection of a return to the active channel state (i.e. detection of at least one flag sequence). After the period T3, the DCE shall notify the Packet Layer of the excessive idle channel state condition, but shall not take any action that would preclude the DTE from establishing the data link by normal data link set-up procedures.

Note – Other actions to be taken by the DCE at the Data Link Layer upon expiration of period T3 is a subject for further study.

2.7 *Description of the LAP procedure*

2.7.1 *LAP procedure for addressing*

The address field identifies a frame as either a command or a response. A command frame contains the address of the DCE or DTE to which the command is being sent. A response frame contains the address of the DCE or DTE sending the frame.

Frames containing commands transferred from the DCE to the DTE will contain the address A.

Frames containing responses transferred from the DCE to the DTE will contain the address B.

Frames containing commands transferred from the DTE to the DCE shall contain the address B.

Frames containing responses transferred from the DTE to the DCE shall contain the address A.

A and B addresses are coded as follows:

Address	1 2 3 4 5 6 7 8
A	1 1 0 0 0 0 0 0
B	1 0 0 0 0 0 0 0

Note – The DCE will discard all frames received with an address other than A or B; the DTE should do the same.

2.7.2 *LAP procedure for the use of the P/F bit*

The DCE or DTE receiving an SARM, DISC, supervisory command or I frame with the P bit set to 1 will set the F bit to 1 in the next response frame it transmits.

The response frame returned by the DCE to an SARM or DISC command with the P bit set to 1 will be a UA response with the F bit set to 1. The response frame returned by the DCE to an I frame with the P bit set to 1, received during the information transfer phase, will be an RR, REJ, RNR or CMDR response with the F bit set to 1. The response frame returned by the DCE to a supervisory command frame with the P bit set to 1, received during the information transfer phase, will be an RR, RNR, REJ or CMDR response with the F bit set to 1.

The P bit may be used by the DCE in conjunction with the timer recovery condition (see § 2.7.4.8 below).

Note – Other use of the P bit by the DCE is a subject for further study.

2.7.3 *LAP procedures for data link set-up and disconnection*

2.7.3.1 *Data link set-up*

The DCE will indicate that it is able to set up the data link by transmitting contiguous flags (active channel state).

The DTE shall indicate a request for setting up the data link by transmitting an SARM command to the DCE. Whenever receiving an SARM command, the DCE will return a UA response to the DTE and set its receive state variable V(R) to 0.

Should the DCE wish to indicate a request for setting up the data link, or after transmission of a UA response to a first SARM command from the DTE as a request for setting up the data link, the DCE will transmit an SARM command to the DTE and start Timer T1 in order to determine when too much time has elapsed waiting for a reply (see § 2.7.7.1 below). The DTE will confirm the reception of the SARM command by transmitting a UA response. When receiving the UA response the DCE will set its send state variable to 0 and stop its Timer T1.

If Timer T1 runs out before the UA response is received by the DCE, the DCE will retransmit an SARM command and restart Timer T1. After transmission of the SARM command N2 times by the DCE, appropriate recovery action will be initiated. The value of N2 is defined in § 2.7.7.4 below.

2.7.3.2 *Information transfer phase*

After having both transmitted the UA response to a received SARM command and having received the UA response to a transmitted SARM command, the DCE will accept and transmit I and supervisory frames according to the procedures described in § 2.7.4 below.

When receiving an SARM command, the DCE will conform to the data link resetting procedure described in § 2.7.6 below. The DTE may also receive an SARM command while in the information transfer phase.

2.7.3.3 *Data link disconnection*

During the information transfer phase the DTE shall indicate a request for disconnecting the data link by transmitting a DISC command to the DCE. Whenever receiving a DISC command, the DCE will return a UA response to the DTE.

During an information transfer phase, should the DCE wish to indicate a request for disconnecting the data link, or when receiving from the DTE a first DISC command as a request for disconnecting the data link, the DCE will transmit a DISC command to the DTE and start Timer T1 (see § 2.7.7.1 below). The DTE will confirm reception of the DISC command by returning a UA response. After transmitting an SARM command, the DCE will not transmit a DISC command until a UA response is received for this SARM command or until Timer T1 runs out. When receiving a UA response to the DISC command, the DCE will stop its Timer T1.

If Timer T1 runs out before a UA response is received by the DCE, the DCE will retransmit a DISC command and restart Timer T1. After transmission of the DISC command N2 times by the DCE, appropriate recovery action will be initiated. The value of N2 is defined in § 2.7.7.4 below.

2.7.4 *LAP procedures for information transfer*

The procedures which apply to the transmission of I frames in each direction during the information transfer phase are described below.

In the following, "number 1 higher" is in reference to a continuously repeated sequence series, i.e. 7 is 1 higher than 6, and 0 is 1 higher than 7 for modulo 8 series.

2.7.4.1 *Sending I frames*

When the DCE has an I frame to transmit (i.e. an I frame not already transmitted, or having to be retransmitted as described in § 2.7.4.5 below), it will transmit it with an N(S) equal to its current send state variable V(S), and an N(R) equal to its current receive state variable V(R). At the end of the transmission of the I frame, the DCE will increment its send state variable V(S) by 1.

If Timer T1 is not running at the time of transmission of an I frame, it will be started.

If the send state variable V(S) is equal to the last value of N(R) received plus k (where k is the maximum number of outstanding I frames – see § 2.7.7.6 below), the DCE will not transmit any new I frames, but may retransmit an I frame as described in § 2.7.4.6 or § 2.7.4.9 below.

When the DCE is in the busy condition, it may still transmit I frames provided that the DTE is not busy. When the DCE is in the command rejection condition, it may still transmit I frames.

2.7.4.2 *Receiving an I frame*

2.7.4.2.1 When the DCE is not in a busy condition and receives a valid I frame whose send sequence number N(S) is equal to the DCE receive state variable V(R), the DCE will accept the information field of this frame, increment by 1 its receive state variable V(R), and act as follows:

i) If an I frame is available for transmission by the DCE, it may act as in § 2.7.4.1 above and acknowledge the received I frame by setting N(R) in the control field of the next transmitted I frame to the value of the DCE receive state variable V(R). Alternatively the DCE may acknowledge the received I frame by transmitting an RR response with the N(R) equal to the value of the DCE receive state variable V(R).

ii) If no I frame is available for transmission by the DCE, it will transmit an RR response with N(R) equal to the value of the DCE receive state variable V(R).

2.7.4.2.2 When the DCE is in a busy condition, it may ignore the information field contained in any received I frame.

2.7.4.3 *Reception of invalid frames*

When the DCE receives an invalid frame (see § 2.6.5.3), this frame will be discarded.

2.7.4.4 *Reception of out-of-sequence I frames*

When the DCE receives a valid I frame whose FCS is correct, but whose send sequence number N(S) is incorrect, i.e. not equal to the current DCE receive state variable V(R), it will discard the information field of the I frame and transmit an REJ response with the N(R) set to one higher than the N(S) of the last correctly received I frame. The DCE will then discard the information field of all I frames received until the expected I frame is correctly received. When receiving the expected I frame, the DCE will then acknowledge the I frame as described in § 2.7.4.2 above. The DCE will use the N(R) and P bit information in the discarded I frames as described in § 2.6.5.2 above.

2.7.4.5 *Receiving acknowledgement*

When correctly receiving an I frame or a supervisory frame (RR, RNR or REJ), even in the busy condition, the DCE will consider the N(R) contained in this frame as an acknowledgement for all I frames it has transmitted with an N(S) up to and including the received N(R) – 1. The DCE will stop Timer T1 when it correctly receives an I frame or a supervisory frame with the N(R) higher than the last received N(R) (actually acknowledging some I frames) or an REJ frame with an N(R) equal to the last received N(R).

If Timer T1 has been stopped and if there are outstanding I frames still unacknowledged, the DCE will restart Timer T1. If Timer T1 then runs out, the DCE will follow the recovery procedure (in §§ 2.7.4.6 and 2.7.4.9 below) with respect to the unacknowledged I frames.

2.7.4.6 *Receiving an REJ frame*

When receiving an REJ frame, the DCE will set its send state variable V(S) to the value of the N(R) received in the REJ control field. It will transmit the corresponding I frame as soon as it is available or retransmit it in accordance with the procedures described in § 2.7.4.1 above. (Re)transmission will conform to the following:

i) If the DCE is transmitting a supervisory or unnumbered command or response when it receives the REJ frame, it will complete that transmission before commencing transmission of the requested I frame.

ii) If the DCE is transmitting an I frame when the REJ frame is received, it may abort the I frame and commence transmission of the requested I frame immediately after abortion.

iii) If the DCE is not transmitting any frame when the REJ frame is received, it will commence transmission of the requested I frame immediately.

In all cases, if other unacknowledged I frames have already been transmitted following the one indicated in the REJ frame, then those I frames will be retransmitted by the DCE following the retransmission of the requested I frame. Other I frames not yet transmitted may be transmitted following the retransmitted I frames.

If the REJ frame was received from the DTE as a command with the P bit set to 1, the DCE will transmit an RR or RNR response with the F bit set to 1 before transmitting or retransmitting the corresponding I frame.

2.7.4.7 *Receiving an RNR frame*

After receiving an RNR frame, the DCE may transmit or retransmit the I frame with the send sequence number equal to the N(R) indicated in the RNR frame. If Timer T1 runs out after the reception of the RNR frame, the DCE will follow the procedure described in § 2.7.4.9 below. In any case, the DCE will not transmit any other I frames before receiving an RR or REJ frame, or before the completion of a data link resetting procedure.

2.7.4.8 *DCE busy condition*

When the DCE enters a busy condition, it will transmit an RNR response at the earliest opportunity. While in the busy condition, the DCE will accept and process supervisory frames, will accept and process the contents of the N(R) fields of I frames, and will return an RNR response with the F bit set to 1 if it receives a supervisory command or I command frame with the P bit set to 1. To clear the busy condition, the DCE will transmit either an REJ response or an RR response, with N(R) set to the current receive state variable V(R), depending on whether or not it discarded information fields of correctly received I frames.

Note – The DTE when encountering a DCE busy condition, may send supervisory command frames with the P bit set to 1. In the event that the DTE has not implemented supervisory commands, it may follow the procedures of the DCE (see § 2.7.4.7).

2.7.4.9 *Waiting acknowledgement*

The DCE maintains an internal transmission attempt variable which is set to 0 when the DCE sends a UA response, when the DCE receives a UA response or an RNR command or response, or when the DCE correctly receives an I frame or supervisory frame with the N(R) higher than the last received N(R) (actually acknowledging some outstanding I frames).

If Timer T1 runs out waiting for the acknowledgement from the DTE for an I frame transmitted, the DCE will enter the timer recovery condition, add one to its transmission attempt variable and set an internal variable x to the current value of its send state variable V(S).

The DCE will restart Timer T1, set its send state variable V(S) to the last N(R) received from the DTE, and retransmit the corresponding I frame with the P bit set to 1.

The timer recovery condition is cleared when the DCE receives a valid supervisory frame from the DTE, with the F bit set to 1.

If, while in the timer recovery condition, the DCE correctly receives a supervisory frame with the F bit set to 1 and with an N(R) within the range from its current send state variable V(S) to x included, it will clear the timer recovery condition (including stopping Timer T1) and set its send state variable V(S) to the received N(R), and may then resume with I frame transmission or retransmission, as appropriate.

If, while in the timer recovery condition, the DCE correctly receives an I or supervisory frame with the P/F bit set to 0 and with N(R) within the range from its current send state variable V(S) to x included, it will not clear the timer recovery condition. The value of the received N(R) may be used to update the send state variable V(S). However, the DCE may decide to keep the last transmitted I frame in store (even if it is acknowledged) in order to be able to retransmit it with the P bit set to 1 when Timer T1 runs out at a later time.

If Timer T1 runs out in the timer recovery condition, the DCE will add one to its transmission attempt variable, restart Timer T1, and retransmit the I frame sent with the P bit set to 1.

If the transmission attempt variable is equal to N2, the DCE will initiate a data link resetting procedure for the direction of transmission from the DCE as described in § 2.7.6.3 below. N2 is a system parameter (see § 2.7.7.4 below).

Note – Although the DCE may implement the internal variable *x*, other mechanisms do exist that achieve the identical function. Therefore, the internal variable *x* is not necessarily implemented in the DTE.

2.7.5 *LAP command rejection conditions*

2.7.5.1 *Rejection conditions causing a data link resetting of the transmission of information from the DCE*

The DCE will initiate a data link resetting procedure as described in § 2.7.6.3 below when receiving a frame which is not invalid (see § 2.6.5.3) with the address A (coded 11000000) and with one of the following conditions:

- the frame type is unknown as one of the responses supported;
- the information field is invalid;
- the N(R) contained in the control field is invalid; or
- the response contains an F bit set to 1 except during a timer recovery condition as described in § 2.7.4.9 above.

The DCE will also initiate a data link resetting procedure as described in § 2.7.6.3 below when receiving an I or supervisory frame which is not invalid (see § 2.6.5.3) with the address B (coded 10000000) and with an invalid N(R) contained in the control field.

A valid N(R) must be within the range from the lowest send sequence number N(S) of the still unacknowledged frame(s) to the current DCE send state variable V(S) included, even if the DCE is in a rejection condition, but not if the DCE is in the timer recovery condition (see § 2.7.4.9 above).

2.7.5.2 *Rejection conditions causing the DCE to request a data link resetting of the transmission of information from the DTE*

The DCE will enter the command rejection condition as described in § 2.7.6.5 below when receiving a frame which is not invalid (see § 2.6.5.3) with the address B (coded 10000000) and with one of the following conditions:

- the frame type is unknown as one of the commands supported; or
- the information field is invalid.

2.7.6 *LAP procedures for data link resetting*

2.7.6.1 The data link resetting procedure is used to reinitialize one direction of information transfer according to the procedure described below. The data link resetting procedures only apply during the information transfer phase.

2.7.6.2 The DTE will indicate a data link resetting of the information transmission from the DTE by transmitting an SARM command to the DCE. When receiving an SARM command correctly, the DCE will return, at the earliest opportunity, a UA response to the DTE and set its receive state variables V(R) to zero. This also indicates a clearance of a DCE and/or DTE busy condition, if present.

2.7.6.3 The DCE will indicate a data link resetting of the information transmitted from the DCE by transmitting an SARM command to the DTE and will start Timer T1 (see § 2.7.7.1 below). The DTE will confirm reception of the SARM command by returning a UA response to the DCE. When receiving this UA response to the SARM command, the DCE will set its send state variable V(S) to 0 and stop its Timer T1. If Timer T1 runs out before the UA response is received by the DCE, the DCE will retransmit an SARM command and restart Timer T1. After transmission of the SARM command N2 times, appropriate higher layer recovery action will be initiated. The value of N2 is defined in § 2.7.7.4 below.

The DCE will not act on any received response frame which arrives before the UA response command. The value of N(R) contained in any correctly received I command frame arriving before the UA response will also be ignored.

2.7.6.4 When receiving a CMDR response from the DTE, the DCE will initiate a data link resetting of the information transmission from the DCE as described in § 2.7.6.3 above.

2.7.6.5 If the DCE transmits a CMDR response, it enters the command rejection condition. The command rejection condition is cleared when the DCE receives an SARM or DISC command. Any other command received while in the command rejection condition will cause the DCE to retransmit the CMDR response. The coding of the CMDR response will be as described in § 2.6.4.8 above.

2.7.7 *List of LAP system parameters*

The DCE and DTE system parameters are as follows:

2.7.7.1 *Timer T1*

The value of the DTE Timer T1 system parameter may be different than the value of the DCE Timer T1 system parameter. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The period of Timer T1, at the end of which retransmission of a frame may be initiated (see §§ 2.7.4 and 2.7.5 above for the DCE), shall take into account whether T1 is started at the beginning or the end of the transmission of a frame.

The proper operation of the procedure requires that the transmitter's (DCE or DTE) Timer T1 be greater than the maximum time between transmission of a frame (SARM, DISC, I, or supervisory command, or CMDR response) and the reception of the corresponding frame returned as an answer to that frame (UA or acknowledging frame). Therefore, the receiver (DCE or DTE) should not delay the response or acknowledging frame returned to one of the above frames by more than a value T2, where T2 is a system parameter (see § 2.7.7.2).

The DCE will not delay the response or acknowledging frame returned to one of the above DTE frames by more than a period T2.

2.7.7.2 *Parameter T2*

The value of the DTE parameter T2 may be different than the value of the DCE parameter T2. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The period of parameter T2 shall indicate the amount of time available at the DCE or DTE before the acknowledging frame must be initiated in order to ensure its receipt by the DTE or DCE, respectively, prior to Timer T1 running out at the DTE or DCE (parameter T2 < Timer T1).

Note – The period of parameter T2 shall take into account the following timing factors: the transmission time of the acknowledging frame, the propagation time over the access data link, the state processing times at the DCE and the DTE, and the time to complete the transmission of the frames in the DCE or DTE transmit queue that are neither displaceable or modifiable in an orderly manner.

Given a value for Timer T1 for the DTE or DCE, the value of parameter T2 at the DCE or DTE, respectively, must be no larger than T1 minus 2 times the propagation time over the access data link, minus the frame processing time at the DCE, minus the frame processing time at the DTE, and minus the transmission time of the acknowledging frame by the DCE or DTE, respectively.

2.7.7.3 *Timer T3*

The DCE shall support a Timer T3 system parameter, the value of which shall be made known to the DTE.

The period of Timer T3, at the end of which an indication of an observed excessively long idle link channel state condition is passed to the Packet Layer, shall be sufficiently greater than the period of the DCE Timer T1 (i.e. T3 > T1) so that the expiration of T3 provides the desired level of assurance that the data link channel is in a non-active, non-operational state, and is in need of data link set-up before normal data link operation can resume.

2.7.7.4 *Maximum number of attempts to complete a transmission N2*

The value of the DTE N2 system parameter may be different than the value of the DCE N2 system parameter. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The value of N2 shall indicate the maximum number of attempts made by the DCE or DTE to complete the successful transmission of a frame to the DTE or DCE, respectively.

2.7.7.5 *Maximum number of bits in an I frame N1*

The value of the DTE N1 system parameter may be different than the value of the DCE N1 system parameter. These values shall be made known to both the DTE and the DCE.

The values of N1 shall indicate the maximum number of bits in an I frame (excluding flags and 0 bits inserted for transparency) that the DCE or DTE is willing to accept from the DTE or DCE, respectively.

In order to allow for universal operation, a DTE should support a value of DTE N1 which is not less than 1080 bits (135 octets). DTEs should be aware that the network may transmit longer packets (see § 5.2), that may result in a data link layer problem.

All networks shall offer to a DTE which requires it, a value of DCE N1 which is greater than or equal to 2072 bits (259 octets) plus the length of the address, control and FCS fields at the DTE/DCE interface, and greater than or equal to the maximum length of the data packets which may cross the DTE/DCE interface plus the length of the address, control and FCS fields at the DTE/DCE interface.

2.7.7.6 *Maximum number of outstanding I frames k*

The value of the DTE k system parameter shall be the same as the value of the DCE k system parameter. This value shall be agreed to for a period of time by both the DTE and the DCE.

The value of k shall indicate the maximum number of sequentially numbered I frames that the DTE of DCE may have outstanding (i.e. unacknowledged) at any given time. The value of k shall never exceed seven. All networks (DCEs) shall support a value of seven. Other values of k (less than seven) may also be supported by networks (DCEs).

3 Description of the packet layer DTE/DCE interface

This and subsequent sections of the Recommendation relate to the transfer of packets at the DTE/DCE interface. The procedures apply to packets which are successfully transferred across the DTE/DCE interface.

Each packet to be transferred across the DTE/DCE interface shall be contained within the data link layer information field which will delimit its length, and only one packet shall be contained in the information field.

Note – Some networks require the data fields of packets to contain an integral number of octets. The transmission by the DTE of data fields not containing an integral number of octets to the network may cause a loss of data integrity. DTEs wishing universal operation on all networks should transmit all packets with data fields containing only an integral number of octets. Full data integrity can only be assured by exchange of octet-oriented data fields in both directions of transmission.

This section covers a description of the packet layer interface for virtual call and permanent virtual circuit services.

Procedures for the virtual circuit service (i.e., virtual call and permanent virtual circuit services) are specified in § 4. Packet formats are specified in § 5. Procedures and formats for optional user facilities are specified in §§ 6 and 7.

3.1 *Logical channels*

To enable simultaneous virtual calls and/or permanent virtual circuits, logical channels are used. Each virtual call or permanent virtual circuit is assigned a logical channel group number (less than or equal to 15) and a logical channel number (less than or equal to 255). For virtual calls, a logical channel group number and a logical channel number are assigned during the call set-up phase. The range of logical channels used for virtual calls is agreed with the Administration at the time of subscription to the service (see Annex A). For permanent virtual circuits, logical channel group numbers and logical channel numbers are assigned in agreement with the Administration at the time of subscription to the service (see Annex A).

3.2 *Basic structure of packets*

Every packet transferred across the DTE/DCE interface consists of at least three octets. These three octets contain a general format identifier, a logical channel identifier and a packet type identifier. Other packet fields are appended as required (see § 5).

Packet types and their use in association with various services are given in Table 14/X.25.

TABLE 14/X.25

Packet types and their use in various services

Packet type		Service	
From DCE to DTE	From DTE to DCE	VC	PVC
Call set-up and clearing (see Note 1)			
Incoming call	Call request	X	
Call connected	Call accepted	X	
Clear indication	Clear request	X	
DCE clear confirmation	DTE clear confirmation	X	
Data and interrupt (see Note 2)			
DCE data	DTE data	X	X
DCE interrupt	DTE interrupt	X	X
DCE interrupt confirmation	DTE interrupt confirmation	X	X
Flow control and reset (see Note 3)			
DCE RR	DTE RR	X	X
DCE RNR	DTE RNR	X	X
	DTE REJ [a)]	X	X
Reset indication	Reset request	X	X
DCE reset confirmation	DTE reset confirmation	X	X
Restart (see Note 4)			
Restart indication	Restart request	X	X
DCE restart confirmation	DTE restart confirmation	X	X
Diagnostic (see Note 5)			
Diagnostic [a)]		X	X
Registration [a)] (see Note 6)			
Registration Confirmation		X	X
	Registration Request	X	X

[a)] Not necessarily available on all networks.

VC Virtual call
PVC Permanent virtual circuit

Note 1 – See §§ 4.1 and 6.16 for procedures, § 5.2 for formats.

Note 2 – See § 4.3 for procedures and § 5.3 for formats.

Note 3 – See §§ 4.4 and 6.4 for procedures, §§ 5.4 and 5.7.1 for formats.

Note 4 – See § 3.3 for procedures and § 5.5 for formats.

Note 5 – See § 3.4 for procedures and § 5.6 for formats.

Note 6 – See § 6.1 for procedures and § 5.7.2 for formats.

3.3 *Procedure for restart*

The restart procedure is used to initialize or reinitialize the packet layer DTE/DCE interface. The restart procedure simultaneously clears all the virtual calls and resets all the permanent virtual circuits at the DTE/DCE interface (see § 4.5).

Figure B-1/X.25 gives the state diagram which defines the logical relationships of events related to the restart procedure.

Table C-2/X.25 specifies actions taken by the DCE on the receipt of packets from the DTE for the restart procedure.

3.3.1 *Restart by the DTE*

The DTE may at any time request a restart by transferring across the DTE/DCE interface a *restart request* packet. The interface for each logical channel is then in the *DTE restart request* state (r2).

The DCE will confirm the restart by transferring a *DCE restart confirmation packet* and placing the logical channels used for virtual calls in the *ready* state (p1), and the logical channels used for permanent virtual circuits in the *flow control ready* state (d1).

Note – States p1 and d1 are specified in § 4.

The *DCE restart confirmation* packet can only be interpreted universally as having local significance. The time spent in the *DTE restart request* state (r2) will not exceed time-limit T20 (see Annex D).

3.3.2 *Restart by the DCE*

The DCE may indicate a restart by transferring across the DTE/DCE interface a *restart indication* packet. The interface for each logical channel is then in the *DCE restart indication* state (r3). In this state of the DTE/DCE interface, the DCE will ignore all packets except for *restart request* and *DTE restart confirmation.*

The DTE will confirm the restart by transferring a *DTE restart confirmation* packet and placing the logical channels used for virtual calls in the *ready* state (p1), and the logical channels used for permanent virtual circuits in the *flow control ready* state (d1).

The action taken by the DCE when the DTE does not confirm the restart within time-out T10 is given in Annex D.

3.3.3 *Restart collision*

Restart collision occurs when a DTE and a DCE simultaneously transfer a *restart request* and a *restart indication* packet. Under these circumstances, the DCE will consider that the restart is completed. The DCE will not expect a *DTE restart confirmation* packet and will not transfer a *DCE restart confirmation* packet. This places the logical channels used for virtual calls in the *ready* state (p1), and the logical channels used for permanent virtual circuits in the *flow control ready* state (d1).

3.4 *Error handling*

Table C-1/X.25 specifies the reaction of the DCE when special error conditions are encountered. Other error conditions are discussed in § 4.

3.4.1 *Diagnostic packet*

The *diagnostic* packet is used by some networks to indicate error conditions under circumstances where the usual methods of indication (i.e. *reset*, *clear* and *restart* with cause and diagnostic) are inappropriate (see Tables C-1/X.25 and D-1/X.25). The *diagnostic* packet from the DCE supplies information on error situations which are considered unrecoverable at the packet layer of Recommendation X.25; the information provided permits an analysis of the error and recovery by higher layers at the DTE if desired or possible.

A *diagnostic* packet is issued only once per particular instance of an error condition. No confirmation is required to be issued by the DTE on receipt of a *diagnostic* packet.

4 Procedures for virtual circuit services

4.1 *Procedures for virtual call service*

Figures B-1/X.25, B-2/X.25 and B-3/X.25 show the state diagrams which define the events at the packet layer DTE/DCE interface for each logical channel used for virtual calls.

Annex C gives details of the action taken by the DCE on receipt of packets in each state shown in Annex B.

The call set-up and clearing procedures described in the following points apply independently to each logical channel assigned to the virtual call service at the DTE/DCE interface.

4.1.1 *Ready state*

If there is no call in existence, a logical channel is in the ready state (p1).

4.1.2 *Call request packet*

The calling DTE shall indicate a call request by transferring a *call request* packet across the DTE/DCE interface. The logical channel selected by the DTE is then in the *DTE waiting* state (p2). The *call request* packet includes the called DTE address.

Note 1 – A DTE address may be a DTE network address or any other DTE identification agreed for a period of time between the DTE and the DCE.

Note 2 – The call request packet should use the logical channel in the *ready* state with the highest number in the range which has been agreed with the Administration (see Annex A). Thus the risk of call collision is minimized.

4.1.3 *Incoming call packet*

The DCE will indicate that there is an incoming call by transferring across the DTE/DCE interface an *incoming call* packet. This places the logical channel in the *DCE waiting* state (p3).

The *incoming call* packet will use the logical channel in the *ready* state with the lowest number (see Annex A). The *incoming call* packet includes the calling DTE address.

Note – A DTE address may be a DTE network address or any other DTE identification agreed for a period of time between the DTE and the DCE.

4.1.4 *Call accepted packet*

The called DTE shall indicate its acceptance of the call by transferring across the DTE/DCE interface a *call accepted* packet specifying the same logical channel as that of the *incoming call* packet. This places the specified logical channel in the *data transfer* state (p4).

If the called DTE does not accept the call by a *call accepted* packet or does not reject it by a *clear request* packet as described in § 4.1.7 within time-out T11 (see Annex D), the DCE will consider it as a procedure error from the called DTE and will clear the virtual call according to the procedure described in § 4.1.8.

4.1.5 *Call connected packet*

The receipt of a *call connected* packet by the calling DTE specifying the same logical channel as that specified in the *call request* packet indicates that the call has been accepted by the called DTE by means of a *call accepted* packet. This places the specified logical channel in the *data transfer* state (p4).

The time spent in the *DTE waiting* state (p2) will not exceed time-limit T21 (see Annex D).

4.1.6 *Call collision*

Call collision occurs when a DTE and DCE simultaneously transfer a *call request* packet and an *incoming call* packet specifying the same logical channel. The DCE will proceed with the *call request* and cancel the *incoming call.*

4.1.7 *Clearing by the DTE*

At any time, the DTE may indicate clearing by transferring across the DTE/DCE interface a *clear request* packet (see § 4.5). The logical channel is then in the *DTE clear request* state (p6). When the DCE is prepared to free the logical channel, the DCE will transfer across the DTE/DCE interface a *DCE clear confirmation* packet specifying the logical channel. The logical channel is then in the *ready* state (p1).

The *DCE clear confirmation* packet can only be interpreted universally as having local significance; however, within some Administrations' networks, clear confirmation may have end-to-end significance. In all cases, the time spent in the *DTE clear request* state (p6) will not exceed time-limit T23 (see Annex D).

It is possible that subsequent to transferring a *clear request* packet the DTE will receive other types of packets, depending upon the state of the logical channel, before receiving a *DCE clear confirmation* packet.

Note – The calling DTE may abort a call by clearing it before it has received a *call connected* or *clear indication* packet.

The called DTE may refuse an incoming call by clearing it as described in this point rather than transmitting a *call accepted* packet as described in § 4.1.4.

4.1.8 *Clearing by the DCE*

The DCE will indicate clearing by transferring across the DTE/DCE interface a *clear indication* packet (see § 4.5). The logical channel is then in the *DCE clear indication* state (p7). The DTE shall respond by transferring across the DTE/DCE interface a *DTE clear confirmation packet.* The logical channel is then in the *ready* state (p1).

The action taken by the DCE when the DTE does not confirm clearing within time-out T13 is given in Annex D.

4.1.9 *Clear collision*

Clear collision occurs when a DTE and DCE simultaneously transfer a *clear request* packet and a *clear indication* packet specifying the same logical channel. Under these circumstances the DCE will consider that the clearing is completed. The DCE will not expect a *DTE clear confirmation* packet and will not transfer a *DCE clear confirmation* packet. This places the logical channel in the *ready* state (p1).

4.1.10 *Unsuccessful call*

If a call cannot be established, the DCE will transfer a *clear indication* packet specifying the logical channel indicated in the *call request* packet.

4.1.11 *Call progress signals*

The DCE will be capable of transferring to the DTE *clearing call progress* signals as specified in Recommendation X.96.

Clearing call progress signals will be carried in *clear indication* packets which will terminate the call to which the packet refers. The method of coding *clear indication* packets containing *call progress* signals is detailed in § 5.2.3.

4.1.12 *Data transfer state*

The procedures for the control of packets between DTE and DCE while in the *data transfer* state are contained in § 4.3.

4.2 *Procedures for permanent virtual circuit service*

Figures B-1/X.25 and B-3/X.25 show the state diagrams which give a definition of events at the packet layer DTE/DCE interface for logical channels assigned for permanent virtual circuits.

Annex C gives details of the action taken by the DCE on receipt of packets in each state shown in Annex B.

For permanent virtual circuits there is no call set-up or clearing. The procedures for the control of packets between DTE and DCE while in the *data transfer* state are contained in § 4.3.

If a momentary failure occurs within the network, the DCE will reset the permanent virtual circuit as described in § 4.4.3, with the cause "Network congestion", and then will continue to handle data traffic.

If the network has a temporary inability to handle data traffic, the DCE will reset the permanent virtual circuit with the cause "Network out of order". When the network is again able to handle data traffic, the DCE should reset the permanent virtual circuit with the cause "Network operational".

4.3 *Procedures for data and interrupt transfer*

The data transfer and interrupt procedures described in this section apply independently to each logical channel assigned for virtual calls or permanent virtual circuits existing at the DTE/DCE interface.

Normal network operation dictates that user data in *data* and *interrupt* packets are all passed transparently, unaltered through the network in the case of packet DTE to packet DTE communications. The order of bits in *data* and *interrupt* packets is preserved. Packet sequences are delivered as complete packet sequences. DTE diagnostic codes are treated as described in §§ 5.2.4, 5.4.3 and 5.5.1.

4.3.1 *States for data transfer*

A virtual call logical channel is in the *data transfer* state (p4) after completion of call establishment and prior to a clearing or a restart procedure. A permanent virtual circuit logical channel is continually in the *data transfer* state (p4) except during the restart procedure. *Data, interrupt, flow control* and *reset* packets may be transmitted and received by a DTE in the *data transfer* state of a logical channel at the DTE/DCE interface. In this state, the flow control and reset procedures described in § 4.4 apply to data transmission on that logical channel to and from the DTE.

When a virtual call is cleared, *data* and *interrupt* packets may be discarded by the network (see § 4.5). In addition, *data, interrupt, flow control* and *reset* packets transmitted by a DTE will be ignored by the DCE when the logical channel is in the *DCE clear indication* state (p7). Hence it is left to the DTE to define DTE to DTE protocols able to cope with the various possible situations that may occur.

4.3.2 *User data field length of data packets*

The standard maximum user data field length is 128 octets.

In addition, other maximum user data field lengths may be offered by Administrations from the following list: 16, 32, 64, 256, 512, 1024, 2048 and 4096 octets. An optional maximum user data field length may be selected for a period of time as the default maximum user data field length common to all virtual calls at the DTE/DCE interface (see § 6.9). A value other than the default may be selected for a period of time for each permanent virtual circuit (see § 6.9). Negotiation of maximum user data field lengths on a per call basis may be made with the *flow control parameter negotiation* facility (see § 6.12).

The user data field of *data* packets transmitted by a DTE or DCE may contain any number of bits up to the agreed maximum.

Note – Some networks require the user data field to contain an integral number of octets (see the note in § 3).

If the user data field in a *data* packet exceeds the locally permitted maximum user data field length, then the DCE will reset the virtual call or permanent virtual circuit with the resetting cause "Local procedure error".

4.3.3 *Delivery Confirmation bit*

The setting of the Delivery Confirmation bit (D bit) is used to indicate whether or not the DTE wishes to receive an end-to-end acknowledgement of delivery, for data it is transmitting, by means of the packet receive sequence number P(R) (see § 4.4).

Note – The use of the D bit procedure does not obviate the need for a higher layer protocol agreed between the communicating DTEs which may be used with or without the D bit procedure to recover from user or network generated resets and clearings.

The calling DTE may, during call establishment, ascertain that the D bit procedure can be used for the call by setting bit 7 in the General Format Identifier of the *call request* packet to 1 (see § 5.1.1). Every network or part of the international network will pass this bit transparently. If the remote DTE is able to handle the D bit procedure, it should not regard this bit being set to 1 in the *incoming call* packet as invalid.

Similarly, the called DTE can set bit 7 in the General Format Identifier of the *call accepted* packet to 1. Every network or part of the international network will pass this bit transparently. If the calling DTE is able to handle the D bit procedure, it should not regard this bit being set to 1 in the *call connected* packet as invalid.

The use by DTEs of the above mechanism in the *call request* and *call accepted* packets is recommended but is not mandatory for using the D bit procedure during the virtual call.

4.3.4 *More Data mark*

If a DTE or DCE wishes to indicate a sequence of more than one packet, it uses a more data mark (M bit) as defined below.

The M bit can be set to 1 in any *data* packet. When it is set to 1 in a full *data* packet or in a partially full *data* packet also carrying the D bit set to 1, it indicates that more data is to follow. Recombination with the following *data* packet may only be performed within the network when the M bit is set to 1 in a full *data* packet which also has the D bit set to 0.

A sequence of *data* packets with every M bit set to 1 except for the last one will be delivered as a sequence of *data* packets with the M bit set to 1 except for the last one when the original packets having the M bit set to 1 are either full (irrespective of the setting of the D bit) or partially full but have the D bit set to 1.

Two categories of *data* packets, A and B, have been defined as shown in Table 15/X.25. Table 15/X.25 also illustrates the network's treatment of the M and D bits at both ends of a virtual call or permanent virtual circuit.

4.3.5 *Complete packet sequence*

A complete packet sequence is defined as being composed of a single *category B* packet and all contiguous preceding *category A* packets (if any). *Category A* packets have the exact maximum user data field length with the M bit set to 1 and the D bit set to 0. All other *data* packets are *category B* packets.

When transmitted by a source DTE, a complete packet sequence is always delivered to the destination DTE as a single complete packet sequence.

Thus, if the receiving end has a larger maximum user data field length than the transmitting end, then packets within a complete packet sequence will be combined within the network. They will be delivered in a complete packet sequence where each packet, except the last one, has the exact maximum user data field length, the M bit set to 1, and the D bit set to 0. The user data field of the last packet of the sequence may have less than the maximum length and the M and D bits are set as described in Table 15/X.25.

TABLE 15/X.25

Definition of two categories of data packets and network treatment of the M and D bits

Data packet sent by source DTE				Combining with subsequent packet(s) is performed by the network when possible	*Data* packet [a] received by destination DTE	
Category	M	D	Full		M	D
B	0 or 1	0	No	No	0 (see Note 1)	0
B	0	1	No	No	0	1
B	1	1	No	No	1	1
B	0	0	Yes	No	0	0
B	0	1	Yes	No	0	1
A	1	0	Yes	Yes (see Note 2)	1	0
B	1	1	Yes	No	1	1

[a] Refers to the delivered *data* packet whose last bit of user data corresponds to the last bit of user data, if any, that was present in the *data* packet sent by the source DTE.

Note 1 – The originating network will force the M bit to 0.

Note 2 – If the *data* packet sent by the source DTE is combined with other packets, up to and including a *category B* packet, the M and D bit settings in the *data* packet received by the destination DTE will be according to that given in the two right hand columns for the last *data* packet sent by the source DTE that was part of the combination.

If the maximum user data field length is the same at both ends, then user data fields of *data* packets are delivered to the receiving DTE exactly as they have been received by the network, except as follows. If a full packet with the M bit set to 1 and D bit set to 0 is followed by an empty packet, then the two packets may be merged so as to become a single *category B* full packet. If the last packet of a complete packet sequence transmitted by the source DTE has a data field less than the maximum length, the M bit set to 1 and the D bit set to 0, then the last packet of the complete packet sequence delivered to the receiving DTE will have the M bit set to 0.

If the receiving end has a smaller maximum user data field length than the transmitting end, the packets will be segmented within the network, and the M and D bits will be set by the network as described to maintain complete packet sequences.

4.3.6 *Qualifier bit*

In some cases, an indicator may be needed with the user data field to distinguish between two types of information. It may be necessary to differentiate, for example, between user data and control information. An example of such a case is contained in Recommendation X.29.

If such a mechanism is needed, an indicator in the data packet header called the Qualifier bit (Q bit) may be used.

The use of the Q bit is optional. If this mechanism is not needed, the Q bit is always set to 0. If the Q bit mechanism is used, the transmitting DTE should set the Q bit so as to have the same value (i.e. 0 or 1) in all *data* packets of the same complete packet sequence. A complete packet sequence transferred by the DTE to the DCE in this fashion will be delivered to the distant DTE as a complete packet sequence having the Q bit set in all packets to the value assigned by the transmitting DTE.

If the Q bit is not set by the DTE to the same value in all the *data* packets of a complete packet sequence, the value of the Q bit in any of the *data* packets of the corresponding packet sequence transferred to the distant DTE is not guaranteed by the network. Moreover, some networks may reset the virtual call or permanent virtual circuit as described in Annex C/X.25.

Successive *data* packets are numbered consecutively (see § 4.4.1.1) regardless of the value of the Q bit.

4.3.7 *Interrupt procedure*

The interrupt procedure allows a DTE to transmit data to the remote DTE, without following the flow control procedure applying to *data* packets (see § 4.4). The interrupt procedure can only apply in the *flow control ready* state (d1) within the *data transfer* state (p4).

The interrupt procedure has no effect on the transfer and flow control procedures applying to the *data* packets on the virtual call or permanent virtual circuit.

To transmit an interrupt, a DTE transfers across the DTE/DCE interface a *DTE interrupt* packet. The DTE should not transmit a second *DTE interrupt* packet until the first one is confirmed with a *DCE interrupt confirmation* packet (see Table C-4/X.25). The DCE, after the interrupt procedure is completed at the remote end, will confirm the receipt of the interrupt by transferring a *DCE interrupt confirmation* packet. The receipt of a *DCE interrupt confirmation* packet indicates that the interrupt has been confirmed by the remote DTE by means of a *DTE interrupt confirmation* packet.

The DCE indicates an interrupt from the remote DTE by transferring across the DTE/DCE interface a *DCE interrupt* packet containing the same data field as in the *DTE interrupt* packet transmitted by the remote DTE. A *DCE interrupt* packet is delivered at or before the point in the stream of *data* packets at which the *DTE interrupt* packet was generated. The DTE will confirm the receipt of the *DCE interrupt* packet by transferring a *DTE interrupt confirmation* packet.

4.3.8 *Transit delay of data packets*

Transit delay is an inherent characteristic of a virtual call or a permanent virtual circuit, common to the two directions of transmission.

This transit delay is the *data* packet transfer delay as defined in § 3.1/X.135, measured between boundaries B_2 and B_{n-1}, as defined in Figure 2/X.135 (that means, excluding the access lines), with the conditions given in § 3.2/X.135, and is expressed in terms of a mean value.

Selection of transit delay on a per call basis, and indication to both the calling and called DTEs of the value of transit delay applying for a given virtual call, may be made by the means of the *transit delay selection and indication* facility (see § 6.27).

4.4 *Procedures for flow control*

Paragraph 4.4 only applies to the *data transfer* state (p4) and specifies the procedures covering flow control of *data* packets and reset on each logical channel used for a virtual call or a permanent virtual circuit.

4.4.1 *Flow control*

At the DTE/DCE interface of a logical channel used for a virtual call or permanent virtual circuit, the transmission of *data* packets is controlled separately for each direction and is based on authorizations from the receiver.

On a virtual call or permanent virtual circuit, flow control also allows a DTE to limit the rate at which it accepts packets across the DTE/DCE interface, noting that there is a network-dependent limit on the number of *data* packets which may be in the network on the virtual call or permanent virtual circuit.

4.4.1.1 *Numbering of data packets*

Each *data* packet transmitted at the DTE/DCE interface for each direction of transmission in a virtual call or permanent virtual circuit is sequentially numbered.

The sequence numbering scheme of the packets is performed modulo 8. The packet sequence numbers cycle through the entire range 0 to 7. Some Administrations will provide the *extended packet sequence numbering* facility (see § 6.2) which, if selected, provides a sequence numbering scheme for packets being performed modulo 128. In this case, packet sequence numbers cycle through the entire range 0 to 127. The packet sequence numbering scheme, modulo 8 or 128, is the same for both directions of transmission and is common for all logical channels at the DTE/DCE interface.

Only *data* packets contain this sequence number called the packet send sequence number P(S).

The first *data* packet to be transmitted across the DTE/DCE interface for a given direction of data transmission, when the logical channel has just entered the *flow control ready* state (d1), has a packet send sequence number equal to 0.

4.4.1.2 *Window description*

At the DTE/DCE interface, a window is defined for each direction of data transmission of a logical channel used for a virtual call or permanent virtual circuit. The window is the ordered set of W consecutive packet send sequence numbers of the *data* packets authorized to cross the interface.

The lowest sequence number in the window is referred to as the lower window edge. When a virtual call or permanent virtual circuit at the DTE/DCE interface has just entered the *flow control ready* state (d1), the window related to each direction of data transmission has a lower window edge equal to 0.

The packet send sequence number of the first *data* packet not authorized to cross the interface is the value of the lower window edge plus W (modulo 8, or 128 when extended).

The standard window size W is 2 for each direction of data transmission at the DTE/DCE interface. In addition, other window sizes may be offered by Administrations. An optional window size may be selected for a period of time as the default window size common to all virtual calls at the DTE/DCE interface (see § 6.10). A value other than the default may be selected for a period of time for each permanent virtual circuit (see § 6.10). Negotiation of window sizes on a per call basis may be made with the *flow control parameter negotiation* facility (see § 6.12).

4.4.1.3 *Flow control principles*

When the sequence number P(S) of the next *data* packet to be transmitted by the DCE is within the window, the DCE is authorized to transmit this *data* packet to the DTE. When the sequence number P(S) of the next data packet to be transmitted by the DCE is outside of the window, the DCE will not transmit a *data* packet to the DTE. The DTE should follow the same procedure.

When the sequence number P(S) of the *data* packet received by the DCE is the next in sequence and is within the window, the DCE will accept this *data* packet. A received *data* packet containing a P(S) that is out of sequence (i.e., there is a duplicate or a gap in the P(S) numbering), outside the window, or not equal to 0 for the first *data* packet after entering the *flow control ready* state (d1) is considered by the DCE as a local procedure error. The DCE will reset the virtual call or permanent virtual circuit (see § 4.4.3). The DTE should follow the same procedure.

A number (modulo 8, or 128 when extended), referred to as a packet receive sequence number P(R), conveys across the DTE/DCE interface information from the receiver for the transmission of *data* packets. When transmitted across the DTE/DCE interface, a P(R) becomes the lower window edge. In this way, additional *data* packets may be authorized by the receiver to cross the DTE/DCE interface.

The packet receive sequence number, P(R), is conveyed in *data*, *receive ready* (RR) and *receive not ready* (RNR) packets.

The value of a P(R) received by the DCE must be within the range from the last P(R) received by the DCE up to and including the packet send sequence number of the next *data* packet to be transmitted by the DCE. Otherwise, the DCE will consider the receipt of this P(R) as a procedure error and will reset the virtual call or permanent virtual circuit. The DTE should follow the same procedure.

The receive sequence number P(R) is less than or equal to the sequence number of the next expected *data* packet and implies that the DTE or DCE transmitting P(R) has accepted at least all *data* packets numbered up to and including P(R) − 1.

4.4.1.4 *Delivery confirmation*

When the D bit is set to 0 in a *data* packet having P(S) = p, the significance of the returned P(R) corresponding to that *data* packet [i.e., P(R) ⩾ p + 1] is a local updating of the window across the packet level interface so that the achievable throughput is not constrained by the DTE to DTE round trip delay across the network(s).

When the D bit is set to 0 in a *data* packet, the returned P(R) corresponding to that *data* packet does not signify that a P(R) has been received from the remote DTE.

When the D bit is set to 1 in a *data* packet having P(S) = p, the significance of the returned P(R) corresponding to that *data* packet [i.e. P(R) ⩾ p + 1] is an indication that a P(R) has been received from the remote DTE for all data bits in the *data* packet in which the D bit had originally been set to 1.

Note 1 – A DTE, on receiving a *data* packet with the D bit set to 1, should transmit the corresponding P(R) as soon as possible in order to avoid the possibility of deadlocks (e.g. without waiting for further *data* packets). A *data*, *RR* or *RNR* packet may be used to convey the P(R) (see Note to § 4.4.1.6). Likewise, the DCE is required to send P(R) to the DTE as soon as possible from when the P(R) is received from the remote DTE. When the DTE is not currently operating the D bit procedure, the receipt of a *data* packet with the D bit set to 1 may be treated by the DTE as an error condition.

Note 2 – If a P(R) for a *data* packet with the D bit set to 1 is outstanding, local updating of the window will be deferred for subsequent *data* packets with the D bit set to 0. Some networks may also defer updating the window for previous *data* packets (within the window) with the D bit set to 0 until the corresponding P(R) for the packet with the outstanding D bit set to 1 is transmitted to the DTE.

Note 3 – P(R) values corresponding to the data contained in *data* packets with the D bit set to 1 need not be the same at the DTE/DCE interfaces at each end of a virtual call or a permanent virtual circuit.

Note 4 – If the DTE has sent *data* packets with the D bit set to 0, the DTE does not have to wait for local updating of the window by the DCE before initiating a resetting or clearing procedure.

4.4.1.5 *DTE and DCE receive ready (RR) packets*

RR packets are used by the DTE or DCE to indicate that it is ready to receive the W *data* packets within the window starting with P(R), where P(R) is indicated in the *RR* packet.

4.4.1.6 *DTE and DCE receive not ready (RNR) packets*

RNR packets are used by the DTE or DCE to indicate a temporary inability to accept additional *data* packets for a given virtual call or permanent virtual circuit. A DTE or DCE receiving an *RNR* packet shall stop transmitting *data* packets on the indicated logical channel, but the window is updated by the P(R) value of the *RNR* packet. The receive not ready situation indicated by the transmission of an *RNR* packet is cleared by the transmission in the same direction of an *RR* packet or by the initiation of a reset procedure.

The transmission of an *RR* packet after an *RNR* packet at the packet level is not to be taken as a demand for retransmission of packets which have already been transmitted.

Note – The *RNR* packet may be used to convey across the DTE/DCE interface the P(R) value corresponding to a *data* packet which had the D bit set to 1 in the case that additional *data* packets cannot be accepted.

4.4.2 *Throughput characteristics and throughput classes*

The definitions of throughput and steady state throughput are given in § 4 of Recommendation X.135.

A throughput class for one direction of transmission is an inherent characteristic of the virtual call or permanent virtual circuit related to the amount of resources allocated to this virtual call or permanent virtual circuit. It is a measure of the steady state throughput that can be provided under optimal conditions on a virtual call or permanent virtual circuit. However, due to the statistical sharing of transmission and switching resources, it is not guaranteed that the throughput class can be reached 100% of the time.

The relations between throughput class and the throughput parameters and objectives described in Recommendation X.135 require further study. The complete definition of the optimal conditions where the measure of the steady state throughput in relation to throughput class is meaningful also requires further study. Pending the results of these further studies, it cannot be guaranteed or verified that a network supporting a given throughput class value (64 kbit/s for instance) offers better performance to its users than a network not supporting that throughput class. However, a network may offer a guarantee to its users on a contractual basis .

The optimal conditions for measurement include the following:

1) the access line characteristics of the local and remote DTEs do not constrain the throughput class;

   Note – In particular, because of the overhead due to the frame and packet headers, when the throughput class corresponding to the user class of service of the DTE is applicable to a virtual call or permanent virtual circuit, a steady state throughput equal to that throughput class can never be reached.

2) the window sizes at the local and remote DTE/DCE interfaces do not constrain the throughput;

3) the traffic characteristics of other logical channels at local and remote DTE/DCE interfaces do not constrain the throughput;

4) the receiving DTE is not flow controlling the DCE such that the throughput class is not attainable;

5) the transmitting DTE sends only *data* packets which have the maximum data field length;

6) the D bit is not set to 1.

The throughput class is expressed in bits per second. The maximum data field length is specified for a virtual call or permanent virtual circuit, and thus the throughput class can be interpreted by the DTE as the number of full *data* packets/second that the DTE/DCE interface.

In the absence of the *default throughput classes assignment* facility (see § 6.11), the default throughput classes for both directions of transmission correspond to the user class of service of the DTE (see § 7.2.2.2) but do not exceed the maximum throughput class supported by the network. Negotiation of throughput classes on a per call basis may be made with the *throughput class negotiation* facility (see § 6.13).

Note – The sum of the throughput classes of all virtual calls and permanent virtual circuits supported at a DTE/DCE interface may be greater than the data transmission rate of the access line.

4.4.3 *Procedure for reset*

The reset procedure is used to reinitialize the virtual call or permanent virtual circuit and in so doing removes in each direction all *data* and *interrupt* packets which may be in the network (see § 4.5). When a virtual call or permanent virtual circuit at the DTE/DCE interface has just been reset, the window related to each direction of data transmission has a lower window edge equal to 0, and the numbering of subsequent *data* packets to cross the DTE/DCE interface for each direction of data transmission shall start from 0.

The reset procedure can only apply in the *data transfer* state (p4) of the DTE/DCE interface. In any other state of the DTE/DCE interface, the reset procedure is abandoned. For example, when a clearing or restarting procedure is initiated, *reset request* and *reset indication* packets can be left unconfirmed.

For flow control, there are three states d1, d2 and d3 within the *data transfer* state (p4). There are *flow control ready* (d1), *DTE reset request* (d2), and *DCE reset indication* (d3) as shown in the state diagram in Figure B-3/X.25. When entering state p4, the logical channel is placed in state d1. Table C-4/X.25 specifies actions taken by the DCE on the receipt of packets from the DTE.

4.4.3.1 *Reset request packet*

The DTE shall indicate a request for reset by transmitting a *reset request* packet specifying the logical channel to be reset. This places the logical channel in the *DTE reset request* state (d2).

4.4.3.2 *Reset indication packet*

The DCE will indicate a reset by transmitting to the DTE a *reset indication* packet specifying the logical channel being reset and the reason for the resetting. This places the logical channel in the *DCE reset indication* state (d3). In this state, the DCE will ignore *data, interrupt, RR* and *RNR* packets.

4.4.3.3 *Reset collision*

Reset collision occurs when a DTE and a DCE simultaneously transmit a *reset request* packet and a *reset indication* packet specifying the same logical channel. Under these circumstances the DCE will consider that the reset is completed. The DCE will not expect a *DTE reset confirmation* packet and will not transfer a *DCE reset confirmation* packet. This places the logical channel in the *flow control ready* state (d1).

4.4.3.4 *Reset confirmation packets*

When the logical channel is in the *DTE reset request* state (d2), the DCE will confirm reset by transmitting to the DTE a *DCE reset confirmation* packet. This places the logical channel in the *flow control ready* state (d1).

The *DCE reset confirmation* packet can only be interpreted universally as having local significance; however, within some Administrations' networks, *reset confirmation* may have end-to-end significance. In all cases the time spent in the *DTE reset request* state (d2) will not exceed time-limit T22 (see Annex D).

When the logical channel is in the *DCE reset indication* state (d3), the DTE will confirm reset by transmitting to the DCE a *DTE reset confirmation* packet. This places the logical channel in the *flow control ready* state (d1). The action taken by the DCE when the DTE does not confirm the reset within time-out T12 is given in Annex D.

4.5 *Effects of clear, reset and restart procedures on the transfer of packets*

All *data* and *interrupt* packets generated by a DTE (or the network) before initiation by the DTE or the DCE of a clear, reset or restart procedure at the local interface will either be delivered to the remote DTE before the DCE transmits the corresponding indication on the remote interface, or be discarded by the network.

No *data* or *interrupt* packets generated by a DTE (or the network) after the completion of a reset (or for permanent virtual circuits also a restart) procedure at the local interface will be delivered to the remote DTE before the completion of the corresponding reset procedure at the remote interface.

When a DTE initiates a clear, reset or restart procedure at its local interface, all *data* and *interrupt* packets which were generated by the remote DTE (or the network) before the corresponding indication is transmitted to the remote DTE will be either delivered to the initiating DTE before DCE confirmation of the initial clear, reset or restart request, or be discarded by the network.

Note – The maximum number of packets which may be discarded is a function of network end-to-end delay and throughput characteristics and, in general, has no relation to the local window size. For virtual calls and permanent virtual circuits on which all *data* packets are transferred with the D bit set to 1, the maximum number of packets which may be discarded in one direction of transmission is not larger than the window size of the direction of transmission.

4.6 *Effects of the physical layer and the data link layer on the packet layer*

4.6.1 *General principles*

In general, if a problem is detected in one layer (physical, data link or packet layer) and can be solved in this layer according to the DCE error recovery procedures provided in this Recommendation without loss or duplication of data, the adjacent layers are not involved in the error recovery.

If an error recovery by the DCE implies a possible loss or duplication of data, then the higher layer is informed.

The reinitialization of one layer by the DCE is only performed if a problem cannot be solved in this layer.

Changes of operational states of the physical layer and the data link layer of the DTE/DCE do not implicitly change the state of each logical channel at the packet layer. Such changes when they occur are explicitly indicated at the packet layer by the use of restart, clear or reset procedures as appropriate.

4.6.2 *Definition of an out of order condition*

In the case of a single link procedure, there is an out of order condition when:

- a failure on the physical and/or data link layer is detected: such a failure is defined as a condition in which the DCE cannot transmit or cannot receive any frame because of abnormal conditions caused by, for instance, a line default between DTE and DCE;

  Note – Short physical layer outages (e.g. loss of carrier) are not considered as physical layer failures by the DCE and the data link layer and packet layer are not informed.

- the DCE has received or transmitted a DISC command.

There may be other out of order network-dependent conditions such as: reset of the data link layer, expiration of T3 timer (see § 2.4.5.3), receipt or transmission of a DM response, ... etc.

In the case of the Multilink procedure, an out of order condition is considered as having occured when it is present at the same time for every single link procedure of the DTE/DCE interface. There may be other out of order network-dependent conditions such as the performance by DTE or DCE of the multilink resetting procedure (see § 2.5.4.2), loss of multilink frame(s) (see § 2.5.4.4), etc.

4.6.3 *Actions on the packet layer when an out of order condition is detected*

When an out of order condition is detected, the DCE will transmit to the remote end:

1) a reset with the cause "Out of order" for each permanent virtual circuit; and
2) a clear with the cause "Out of order" for each existing virtual call.

4.6.4 *Actions on the packet layer during an out of order condition*

During an out of order condition:

1) the DCE will clear any incoming virtual call with the cause "Out of order";
2) for any *data* or *interrupt* packet received from the remote DTE on a permanent virtual circuit, the DCE will reset the permanent virtual circuit with the cause "Out of order";
3) a *reset* packet received from the remote DTE on a permanent virtual circuit will be confirmed to the remote DTE by either *reset confirmation* or *reset indication* packet.

4.6.5 *Actions on the packet layer when the out of order condition is recovered*

When the out of order condition is recovered:

1) the DCE will send a *restart indication* packet with the cause "Network operational" to the local DTE;
2) a reset with the cause "Remote DTE operational" will be transmitted to the remote end of each permanent virtual circuit.

5 Packet formats

5.1 *General*

The possible extension of packet formats by the addition of new fields is for further study.

Note – Any such field:

a) would only be provided as an addition following all previously defined fields, and not as an insertion between any of the previously defined fields;

b) would be transmitted to a DTE only when either the DCE has been informed that the DTE is able to interpret this field and act upon it, or when the DTE can ignore the field without adversely affecting the operation of the DTE/DCE interface (including charging);

c) would not contain any information pertaining to a user facility to which the DTE has not subscribed, unless the DTE can ignore the facility without adversely affecting the operation of the DTE/DCE interface (including charging).

Bits of an octet are numbered 8 to 1 where bit 1 is the low order bit and is transmitted first. Octets of a packet are consecutively numbered starting from 1 and are transmitted in this order.

5.1.1 *General format identifier*

The general format identifier field is a four bit binary coded field which is provided to indicate the general format of the rest of the header. The general format identifier field is located in bit positions 8, 7, 6 and 5 of octet 1, and bit 5 is the low order bit (see Table 16/X.25).

TABLE 16/X.25

General format identifier

General format identifier		Octet 1 Bits 8	7	6	5
Call set-up packets	Sequence numbering scheme modulo 8	X	X	0	1
	Sequence numbering scheme modulo 128	X	X	1	0
Clearing packets	Sequence numbering scheme modulo 8	X	0	0	1
	Sequence numbering scheme modulo 128	X	0	1	0
Flow control, interrupt, reset, restart, registration and *diagnostic* packets	Sequence numbering scheme modulo 8	0	0	0	1
	Sequence numbering scheme modulo 128	0	0	1	0
Data packets	Sequence numbering scheme modulo 8	X	X	0	1
	Sequence numbering scheme modulo 128	X	X	1	0
General format identifier extension		0	0	1	1
Reserved for other applications		*	*	0	0

* Undefined.

Note – A bit which is indicated as "X" may be set to either 0 or 1, as indicated in the text.

Bit 8 of the general format identifier is used for the Qualifier bit in *data* packets, for the Address bit in call set-up and clearing packets, and is set to 0 in all other packets.

Bit 7 of the general format identifier is used for the delivery confirmation procedure in *data* and *call set-up* packets and is set to 0 in all other packets.

Bits 6 and 5 are encoded for four possible indications. Two of the codes are used to distinguish packets using modulo 8 sequence numbering from packets using modulo 128 sequence numbering. The third code is used to indicate an extension to an expanded format for a family of general format identifier codes which are a subject of further study. The fourth code is reserved for other applications.

Note 1 – The DTE must encode the GFI to be consistent with whether or not it has subscribed to the *extended packet sequence numbering* facility (see § 6.2).

Note 2 – It is envisaged that other general format identifier codes could identify alternative packet formats.

5.1.2 *Logical channel group number*

The logical channel group number appears in every packet except *restart*, *diagnostic* and *registration* packets in bit position 4, 3, 2 and 1 of octet 1. For each logical channel, this number has local significance at the DTE/DCE interface.

This field is binary coded and bit 1 is the low order bit of the logical channel group number. In *restart*, *diagnostic* and *registration* packets, this field is coded all zeros.

5.1.3 *Logical channel number*

The logical channel number appears in every packet except *restart*, *diagnostic* and *registration* packets in all bit positions of octet 2. For each logical channel, this number has local significance at the DTE/DCE interface.

This field is binary coded and bit 1 is the low order bit of the logical channel number. In *restart*, *diagnostic* and *registration* packets, this field is coded all zeros.

5.1.4 *Packet type identifier*

Each packet shall be identified in octet 3 of the packet according to Table 17/X.25.

5.2 *Call set-up and clearing packets*

5.2.1 *Address block format*

The call set-up and clearing packets contain an address block. This address block has two possible formats: a non-TOA/NPI address format and a TOA/NPI address format. These two formats are distinguished by bit 8 of the general format identifier (A bit). When the A bit is set to 0, the non-TOA/NPI address format is used. When the A bit is set to 1, the TOA/NPI address format is used.

The non-TOA/NPI address format is supported by all networks. The TOA/NPI address format may be supported by some networks, in particular by those networks wishing to communicate with ISDNs for which the non-TOA/NPI address format provides insufficient addressing capacity.

Note – Prior to 1997, packet-mode DTEs operating according to case B of Recommendation X.31 (ISDN virtual circuit bearer service) will be addressed by a maximum 12 digit address from the E.164 numbering plan. After 1996, such a packet-mode DTE may have 15 digit E.164 address TOA/NPI address procedures will be required to address these DTEs. Recommendations E.165 and E.166 provide further guidance.

When transmitting a call set-up or clearing packet, a DCE will use the TOA/NPI address format if the DTE has subscribed to the TOA/NPI *address subscription* facility (see § 6.28), the non TOA/NPI address format if it has not.

TABLE 17/X.25

Packet type identifier

Packet type		Octet 3 Bits							
From DCE to DTE	From DTE to DCE	8	7	6	5	4	3	2	1
	Call set-up and clearing								
Incoming call	Call request	0	0	0	0	1	0	1	1
Call connected	Call accepted	0	0	0	0	1	1	1	1
Clear indication	Clear request	0	0	0	1	0	0	1	1
DCE clear confirmation	DTE clear confirmation	0	0	0	1	0	1	1	1
	Data and interrupt								
DCE data	DTE data	X	X	X	X	X	X	X	0
DCE interrupt	DTE interrupt	0	0	1	0	0	0	1	1
DCE interrupt confirmation	DTE interrupt confirmation	0	0	1	0	0	1	1	1
	Flow control and reset								
DCE RR (modulo 8)	DTE RR (modulo 8)	X	X	X	0	0	0	0	1
DCE RR (modulo 128) [a)]	DTE RR (modulo 128) [a)]	0	0	0	0	0	0	0	1
DCE RNR (modulo 8)	DTE RNR (modulo 8)	X	X	X	0	0	1	0	1
DCE RNR (modulo 128) [a)]	DTE RNR (modulo 128) [a)]	0	0	0	0	0	1	0	1
	DTE REJ (modulo 8) [a)]	X	X	X	0	1	0	0	1
	DTE REJ (modulo 128) [a)]	0	0	0	0	1	0	0	1
Reset indication	Reset request	0	0	0	1	1	0	1	1
DCE reset confirmation	DTE reset confirmation	0	0	0	1	1	1	1	1
	Restart								
Restart indication	Restart request	1	1	1	1	1	0	1	1
DCE restart confirmation	DTE restart confirmation	1	1	1	1	1	1	1	1
	Diagnostic								
Diagnostic [a)]		1	1	1	1	0	0	0	1
	Registration [a)]								
	Registration request	1	1	1	1	0	0	1	1
Registration confirmation		1	1	1	1	0	1	1	1

[a)] Not necessarily available on every network.

Note – A bit which is indicated as "X" may be set to either 0 or 1 as indicated in the text.

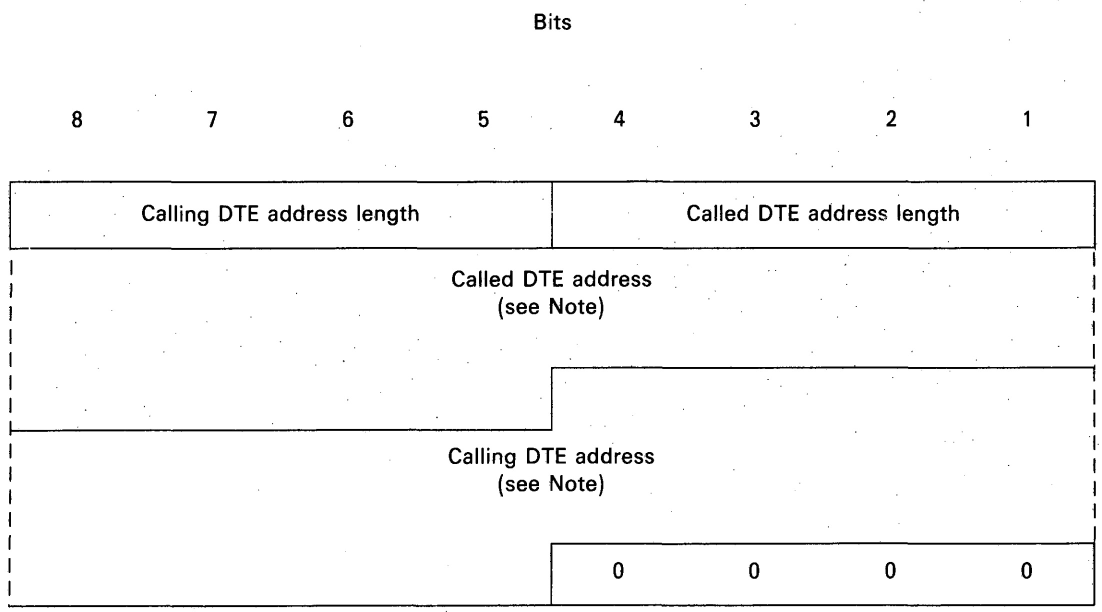
Note – The *TOA/NPI address subscription* facility is designated in Recommendation X.2 for further study (FS). In addition, there are several technical items associated with this TOA/NPI address format which are for further study.

When transmitting a call set-up or clearing packet, a DTE will use the TOA/NPI address format if the DTE has subscribed to the *TOA/NPI address subscription* facility, the non-TOA/NPI address format if it has not.

When the address format used by one DTE in a call set-up or clearing packet is different from the address format used by the remote DTE, the network (if it supports the TOA/NPI address format) converts from one address format to the other (see § 6.2.8).

5.2.1.1 *Format of the address block when the A bit is set to 0 (non-TOA/NPI address)*

Figure 4/X.25 illustrates the format of the address block when the A bit is set to 0.



Note – The figure is drawn assuming the number of address digits present in the called DTE address field is odd and the number of address digits present in the calling DTE address field is even.

FIGURE 4/X.25

Format of the address block when the A bit is set to 0

5.2.1.1.1 *Calling and called DTE address length fields*

These fields are four bits long each and consist of field length indicators for the called and calling DTE addresses. Bits 4, 3, 2 and 1 indicate the length of the called DTE address in semi-octets. Bits 8, 7, 6 and 5 indicate the length of the calling DTE address in semi-octets. Each DTE address length indicator is binary coded and bit 1 or 5 is the low order bit of the indicator.

5.2.1.1.2 *Called and calling DTE address fields*

Each digit of an address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low order bit of the digit.

Starting from the high order digit, a DTE address is coded in consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

When present, the calling DTE address field starts on the first semi-octet following the end of the called DTE address field. Consequently, when the number of digits of the called DTE address field is odd, the beginning of the calling DTE address field, when present, is not octet aligned.

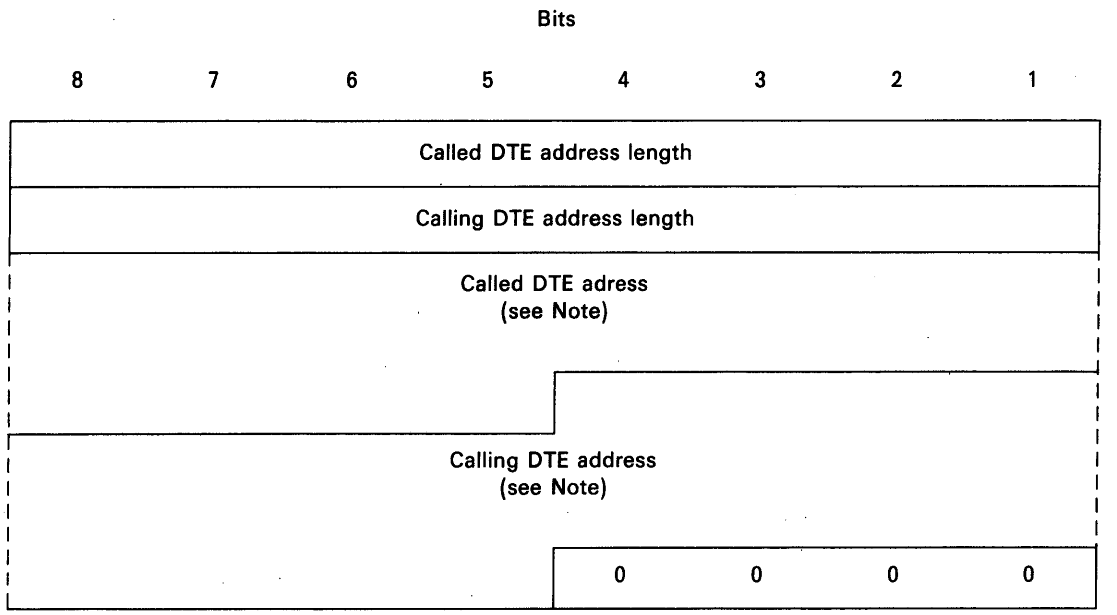
When the total number of digits in the called and calling DTE address fields is odd, a semi-octet with zeros in bits 4, 3, 2 and 1 will be inserted after the calling DTE address field in order to maintain octet alignment.

Further information on the coding of called and calling DTE address fields is given in Appendix IV.

Note – These fields may be used for optional addressing facilities such as abbreviated addressing. The optional addressing facilities employed as well as the coding of those facilities are for further study.

5.2.1.2 *Format of the address block when the A bit is set to 1 (TOA/NPI address)*

Figure 5/X.25 illustrates the format of the address block when the A bit is set to 1.



Note – The figure is drawn assuming the number of semi-octets present in the called DTE address field is odd and the number of semi-octets present in the calling DTE address field is even.

FIGURE 5/X.25

Format of the address block when the A bit is set to 1

5.2.1.2.1 *Called and calling DTE address length fields*

These fields are one octet long each and consist of field length indicators for the called and calling DTE addresses. They indicate the length of the called DTE address and the calling DTE address, respectively, in semi-octets. Each DTE address length indicator is binary coded and bit 1 is the low order bit of the indicator.

The maximum value of a DTE address field length indicator is 17.

5.2.1.2.2 *Called and calling DTE address fields*

These fields respectively consist of the called DTE address when present, and the calling DTE address when present.

Each DTE address field, when present, has three subfields: type of address subfield (TOA), numbering plan identification subfield (NPI), address digits subfield. The first two subfields are at the beginning of the address and are binary coded with the values indicated in Tables 18/X.25 and 19/X.25.

Note 1 – Currently, no non-BCD encodable values have been allocated for type of address and numbering plan identification subfields.

Note 2 – A DTE address containing type of address and numbering plan identification subfields but no address digits subfield is invalid.

TABLE 18/X.25

Coding of the type of address subfield

Bits: or Bits: (see Note 1)	8 7 6 5 4 3 2 1	Type of address
	0 0 0 0	Network-dependent number (see Note 2)
	0 0 0 1	International number (see Note 3)
	0 0 1 0	National number (see Note 3)
	to be defined	Complementary address alone (see Note 4)
	other values	Reserved

Note 1 – The type of address subfield of the called DTE address field uses bits 8, 7, 6 and 5. The type of address subfield of the calling DTE address field uses bits 4, 3, 2 and 1 if the called DTE address field does *not* end on an octet boundary; otherwise, it uses bits 8, 7, 6 and 5.

Note 2 – In this case, the address digits subfield present after the type of address and numbering plan identification subfields are organized according to the network numbering plan, e.g., prefix or escape code might be present. This case is equivalent to the use of the same code point in Q.931, where it is called "unknown".

Note 3 – As for Q.931, prefix or escape code shall not be included in the address digits subfield.

Note 4 – See Appendix IV for the definition of a complementary address.

TABLE 19/X.25

Coding of the numbering plan identification subfield

Bits: or Bits: (see Note 1)	8 7 6 5 4 3 2 1	Numbering plan
	0 0 1 1	X.121 (see Note 2)
	to be defined	Network-dependent (see Note 3)
	other values	Reserved (see Note 4)

Note 1 – The numbering plan identification subfield of the called DTE address field uses bits 4, 3, 2 and 1. The numbering plan identification subfield of the calling DTE address field uses bits 8, 7, 6 and 5 if the called DTE address does *not* end on an octet boundary; otherwise, it uses bits 4, 3, 2 and 1.

Note 2 – A mechanism equivalent to that provided by escape digits, as defined in Recommendation X.121, is not yet defined for use in conjunction whith the TOA/NPI capability; such a mechanism will not use the numbering plan identification subfield. Until the availability of such a mechanism (potentially, an optional user facility), only the code point for X.121 shall be used. The X.121 escape codes shall apply and, when they are used, the type of address subfield shall indicate network-dependent number.

Note 3 – In this case, the address digits subfield present after the type of address and numbering plan identification subfields are organized according to the network numbering plan, e.g., prefix or escape code might be present.

Note 4 – Included among the reserved values are those corresponding to numbering plan identifiers in Q.931 (e.g., F.69, E.164).

The other semi-octets of a DTE address are digits, coded in binary coded decimal with bit 5 or 1 being the low order bit of the digit. Starting from the high order digit, the address digits are coded in consecutive semi-octets. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

When present, the calling DTE address field starts on the first semi-octet following the end of the called DTE address field. Consequently, when the number of semi-octets of the called DTE address field is odd, the beginning of the calling DTE address field, when present, is not octet aligned.

When the total number of semi-octets in the called and calling DTE address fields is odd, a semi-octet with zeros in bits 4, 3, 2 and 1 will be inserted after the calling DTE address field in order to maintain octet alignment.

Further information on the coding of called and calling DTE address fields is given in Appendix IV.

Note – These fields may be used for optional addressing facilities such as abbreviated addressing. The optional addressing facilities employed as well as the coding of those facilities are for further study.

5.2.2 *Call request and incoming call packets*

Figure 6/X.25 illustrates the format of *call request* and *incoming call* packets.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	0	1	0	1	1
4	Address block (see § 5.2.1)							
	Facility length							
	Facilities							
	Call user data							

Note – Coded XX01 (modulo 8) or XX10 (modulo 128).

FIGURE 6/X.25

Call request and incoming call packet format

5.2.2.1 *General format identifier*

Bit 8 of octet 1 (A bit) should be set as described in § 5.2.1.

Bit 7 of octet 1 should be set to 0 unless the mechanism defined in § 4.3.3 is used.

5.2.2.2 *Address block*

The address block is described in § 5.2.1.

5.2.2.3 *Facility length field*

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.2.2.4 *Facility field*

The facility field is present only when the DTE is using an optional user facility requiring some indication in the *call request* and *incoming call* packets.

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note – It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.2.2.5 *Call user data field*

Following the facility field, the call user data field may be present and has a maximum length of 128 octets when used in conjunction with the *fast select* facility described in § 6.16, 16 octets in the other case.

Note – Some networks require the call user data field to contain an integral number of octets (see the note in § 3).

When the virtual call is being established between two packet-mode DTEs, the network does not act on any part of the call user data field. In other circumstances, see Recommendation X.244.

5.2.3 *Call accepted and call connected packets*

Figure 7/X.25 illustrates the format of the *call accepted* and *call connected* packets in the basic or extended format.

5.2.3.1 *Basic format*

5.2.3.1.1 *General format identifier*

Bit 8 of octet 1 (A bit) should be set as described in § 5.2.1

Bit 7 of octet 1 should be set to 0 unless the mechanism defined in § 4.3.3 is used.

5.2.3.1.2 *Address block*

The address block is described in § 5.2.1.

The use of the called and calling DTE address length fields in *call accepted* packets is only mandatory when the called DTE address field, the calling DTE address field or the facility length field is present.

5.2.3.1.3 *Facility length field*

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

The use of the facility length field in *call accepted* packets is only mandatory when the facility field is present.

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	0	1	1	1	1
4	Address block [a] (see § 5.2.1)							
	Facility length [a]							
	Facilities [a]							
	Called user data [b]							

[a] These fields are not mandatory in the basic format of *call accepted* packets (see § 5.2.3.1).

[b] This field may be present only in the extended format (see § 5.2.3.2).

Note – Coded XX01 (modulo 8) or XX10 (modulo 128).

FIGURE 7/X.25

Call accepted and call connected packet format

5.2.3.1.4 *Facility field*

The facility field is present only when the DTE is using an optional user facility requiring some indication in the *call accepted* and *call connected* packets.

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note – It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.2.3.2 *Extended format*

The extended format may be used only in conjunction with the *fast select* facility described in § 6.16. In this case, the called user data field may be present and has a maximum length of 128 octets.

The calling and called DTE address length fields and the facility length field must be present when the called user data field is present.

Note – Some networks require the called user data field to contain an integral number of octets (see the note in § 3).

When the virtual call is being established between two packet-mode DTEs, the network does not act on any part of the called user data field. See Recommendation X.244.

5.2.4 *Clear request and clear indication packets*

Figure 8/X.25 illustrates the format of *clear request* and *clear indication* packets, in basic and extended formats.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	0	0	1	1
4	Clearing cause							
5	Diagnostic code [a]							
4	Address block [b] (see § 5.2.1)							
	Facility length [b]							
	Facilites [b]							
	Clear user data [b]							

[a] This field is not mandatory in the basic format of *clear request* packets (see § 5.2.4.1).

[b] Used only in the extended format (see § 5.2.4.2).

Note – Coded X001 (modulo 8) or X010 (modulo 128).

FIGURE 8/X.25

Clear request and clear indication packet format

5.2.4.1 *Basic format*

5.2.4.1.1 *Clearing cause field*

Octet 4 is the clearing cause field and contains the reason for the clearing of the call.

In the *clear request* packets, the clearing cause field should be set by the DTE to one of the following values:

bits:	8 7 6 5 4 3 2 1
value:	0 0 0 0 0 0 0 0
or:	1 X X X X X X X

where each X may be independently set to 0 or 1 by the DTE.

The DCE will prevent values of the clearing cause field other than those shown above from reaching the other end of the call by either accepting the *clear request* packet and forcing the clearing cause field to all zeros in the corresponding *clear indication* packet, or considering the *clear request* as an error and following the procedure described in Annex C.

The coding of the clearing cause field in *clear indication* packets is given in Table 20/X.25.

TABLE 20/X.25

Coding of clearing cause field in clear indication packet

	Bits							
	8	7	6	5	4	3	2	1
DTE originated	0	0	0	0	0	0	0	0
DTE originated [a]	1	X	X	X	X	X	X	X
Number busy	0	0	0	0	0	0	0	1
Out of order	0	0	0	0	1	0	0	1
Remote procedure error	0	0	0	1	0	0	0	1
Reverse charging acceptance not subscribed [b]	0	0	0	1	1	0	0	1
Incompatible destination	0	0	1	0	0	0	0	1
Fast select acceptance not subscribed [b]	0	0	1	0	1	0	0	1
Ship absent [c]	0	0	1	1	1	0	0	1
Invalid facility request	0	0	0	0	0	0	1	1
Acces barred	0	0	0	0	1	0	1	1
Local procedure error	0	0	0	1	0	0	1	1
Network congestion	0	0	0	0	0	1	0	1
Not obtainable	0	0	0	0	1	1	0	1
RPOA out of order [b]	0	0	0	1	0	1	0	1

[a] When bit 8 is set to 1, the bits represented by Xs are those included by the remote DTE in the clearing or restarting cause field of the *clear* or *restart request* packet respectively.

[b] May be received only if the corresponding optional user facility is used.

[c] Used in the conjunction with mobile maritime service.

5.2.4.1.2 *Diagnostic code*

Octet 5 is the diagnostic code and contains additional information on the reason for the clearing of the call.

In a *clear request* packet, the diagnostic code is not mandatory.

In a *clear indication* packet, if the clearing cause field indicates "DTE originated", the diagnostic code is passed unchanged from the clearing DTE. If the clearing DTE has not provided a diagnostic code in its *clear request* packet, then the bits of the diagnostic code in the resulting *clear indication* packet will all be zero.

When a *clear indication* packet results from a *restart request* packet, the value of the diagnostic code will be that specified in the *restart request* packet, or all zeros in the case where no diagnostic code has been specified in the *restart request* packet.

When the clearing cause field does not indicate "DTE originated", the diagnostic code in a *clear indication* packet is network generated. Annex E lists the codings for network generated diagnostics. The bits of the diagnostic code are all set to 0 when no specific additional information for the clearing is supplied.

Note – The contents of the diagnostic code field do not alter the meaning of the cause field. A DTE is not required to undertake any action on the contents of the diagnostic code field. Unspecified code combinations in the diagnostic code field shall not cause the DTE to refuse the cause field.

5.2.4.2 *Extended format*

The extended format is used for *clear request* and *clear indication* packets only when the DTE or the DCE need to use the called and/or calling DTE address fields, the facility field and/or the clear user data field in conjunction with one or several optional user facilities described in §§ 6 and 7. The called DTE address field is used only when the *called line address modified notification* facility is used in clearing, in response to an *incoming call* or *call request* packet.

When the extended format is used, the diagnostic code field, the DTE address length fields and the facility length field must be present. Optionally, the clear user data field may also be present.

5.2.4.2.1 *Address block*

The address block is described in § 5.2.1.

5.2.4.2.2 *Facility length field*

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.2.4.2.3 *Facility field*

The facility field is present in the *clear request* or the *clear indication* packet only in conjunction with one or several optional user facilities requiring some indication in this packet.

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note – It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.2.4.2.4 *Clear user data field*

This field may be present only in conjunction with the *fast select* facility (see § 6.16) or the *call deflection selection* facility (see § 6.25.2.2). It has a maximum length of 128 octets in the first case, of 16 or 128 octets in the second case: whether the maximum length is 16 or 128 octets when using the *call deflection selection* facility is specified in § 6.25.2.2.

Note 1 – Some networks require the clear user data field to contain an integral number of octets (see the note in § 3).

Note 2 – The network does not act on any part of the clear user data field. See Recommendation X.244.

5.2.5 *DTE and DCE clear confirmation packets*

Figure 9/X.25 illustrates the format of the *DTE* and *DCE clear confirmation* packets, in the basic or extended format.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	0	1	1	1
4	Address block [a)] (see § 5.2.1)							
	Facility length [a)]							
	Facilities [a)]							

a) Used only in the extended format of *DCE clear confirmation* packets.

Note – Coded X001 (modulo 8) or X010 (modulo 128).

FIGURE 9/X.25

DTE and DCE clear confirmation packet format

The extended format may be used for *DCE clear confirmation* packets only in conjunction with the *charging information* facility described in § 6.22. It is not used for *DTE clear confirmation* packet.

5.2.5.1 *Address block*

The address block is described in § 5.2.1.

The calling and called DTE address length fields are coded with all zeros and the called and calling DTE address fields are not present.

5.2.5.2 *Facility length field*

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.2.5.3 *Facility field*

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note – It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.3 *Data and interrupt packets*

5.3.1 *DTE and DCE data packets*

Figure 10/X.25 illustrates the format of the *DTE* and *DCE data* packets.

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier Q	D	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			M	P(S)			0
	User data							

(Modulo 8)

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier Q	D	1	0	Logical channel group number			
2	Logical channel number							
3	P(S)							0
4	P(R)							M
	User data							

(When extended to modulo 128)

D Delivery confirmation bit
M More data bit
Q Qualifier bit

FIGURE 10/X.25

DTE and DCE data packet format

5.3.1.1 *Qualifier (Q) bit*

Bit 8 of octet 1 is the qualifier (Q) bit.

5.3.1.2 *Delivery confirmation (D) bit*

Bit 7 of octet 1 is the delivery confirmation (D) bit.

5.3.1.3 *Packet receive sequence number*

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.3.1.4 *More Data bit*

Bit 5 in octet 3, or bit 1 in octet 4 when extended, is used for the More Data mark (M bit): 0 for no more data and 1 for more data.

5.3.1.5 *Packet send sequence number*

Bits 4, 3 and 2 of octet 3, or bits 8 through 2 of octet 3 when extended, are used for indicating the packet send sequence number P(S). P(S) is binary coded and bit 2 is the low order bit.

5.3.1.6 *User data field*

Bits following octet 3, or octet 4 when extended, contain user data.

Note – Some networks require the user data field to contain an integral number of octets (see the note in § 3).

5.3.2 *DTE and DCE interrupt packets*

Figure 11/X.25 illustrates the format of the *DTE* and *DCE interrupt* packets.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	1	0	0	0	1	1
4	Interrupt user data							

Note – Coded 0001 (modulo 8) or 0010 (modulo 128).

FIGURE 11/X.25

DTE and DCE interrupt packet format

5.3.2.1 *Interrupt user data field*

Octet 4 and any following octets contain the interrupt user data. This field may contain from 1 to 32 octets.

Note – Some networks require the interrupt user data field to contain an integral number of octets (see the note in § 3).

5.3.3 *DTE and DCE interrupt confirmation packets*

Figure 12/X.25 illustrates the format of the *DTE* and *DCE interrupt confirmation* packets.

	Bits							
Octets	8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	1	0	0	1	1	1

Note – Coded 0001 (modulo 8) or 0010 (modulo 128).

FIGURE 12/X.25

DTE and DCE interrupt confirmation packet format

5.4 *Flow control and reset packets*

5.4.1 *DTE and DCE receive ready (RR) packets*

Figure 13/X.25 illustrates the format of the *DTE* and *DCE RR* packets.

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier 0	0	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			Packet type identifier 0	0	0	0	1

(Modulo 8)

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier 0	0	1	0	Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	0	0	0	0	1
4	P(R)							0

(When extended to modulo 128)

FIGURE 13/X.25

DTE and DCE RR packet format

5.4.1.1 *Packet receive sequence number*

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.4.2 *DTE and DCE receive not ready (RNR) packets*

Figure 14/X.25 illustrates the format of the *DTE* and *DCE RNR* packets.

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier 0	0	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			Packet type identifier 0	0	1	0	1

(Modulo 8)

Bits

Octets	8	7	6	5	4	3	2	1
1	General format identifier 0	0	1	0	Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	0	0	1	0	1
4	P(R)							0

(When extended to modulo 128)

FIGURE 14/X.25

DTE and DCE RNR packet format

5.4.2.1 *Packet receive sequence number*

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.4.3 *Reset request and reset indication packets*

Figure 15/X.25 illustrates the format of the *reset request* and *reset indication* packets.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	1	0	1	1
4	Resetting cause							
5	Diagnostic code [a]							

[a] This field is not mandatory in *reset request* packets.

Note – Coded 0001 (modulo 8) or 0010 (modulo 128).

FIGURE 15/X.25

Reset request and reset indication packet format

5.4.3.1 *Resetting cause field*

Octet 4 is the resetting cause field and contains the reason for the reset.

In *reset request* packets, the resetting cause field should be set by the DTE to one of the following values:

bits:	8 7 6 5 4 3 2 1
value:	0 0 0 0 0 0 0 0
or:	1 X X X X X X X

where each X may be independently set to 0 or 1 by the DTE.

The DCE will prevent values of the resetting cause field, other than those shown above, from reaching the other end of the virtual call or permanent virtual circuit by either accepting the *reset request* packet and forcing the resetting cause field to all zeros in the corresponding *reset indication* packet, or considering the reset request as an error and following the procedure described in Annex C.

The coding of the resetting cause field in a *reset indication* packet is given in Table 21/X.25.

TABLE 21/X.25

Coding of resetting cause field in reset indication packet

	Bits							
	8	7	6	5	4	3	2	1
DTE originated	0	0	0	0	0	0	0	0
DTE originated [a]	1	X	X	X	X	X	X	X
Out or order [b]	0	0	0	0	0	0	0	1
Remote procedure error	0	0	0	0	0	0	1	1
Local procedure error	0	0	0	0	0	1	0	1
Network congestion	0	0	0	0	0	1	1	1
Remote DTE operational [b]	0	0	0	0	1	0	0	1
Network operational [b]	0	0	0	0	1	1	1	1
Incompatible destination	0	0	0	1	0	0	0	1
Network out of order [b]	0	0	0	1	1	1	0	1

[a] When bit 8 is set to 1, the bits represented by Xs are those indicated by the remote DTE in the resetting cause field (virtual calls and permanent virtual circuits) or the restarting cause field (permanent virtual circuits only) of the *reset* or *restart request* packet, respectively.

[b] Applicable to permanent virtual circuits only.

5.4.3.2 *Diagnostic code*

Octet 5 is the diagnostic code and contains additional information on the reason for the reset.

In a *reset request* packet the diagnostic code is not mandatory.

In a *reset indication* packet, if the resetting cause field indicates "DTE originated", the diagnostic code has been passed unchanged from the resetting DTE. If the DTE requesting a reset has not provided a diagnostic code in its *reset request* packet, then the bits of the diagnostic code in the resulting *reset indication* packet will all be zeros.

When a *reset indication* packet results from a *restart request* packet, the value of the diagnostic code will be that specified in the *restart request* packet, or all zeros in the case where no diagnostic code has been specified in the *restart request* packet.

When the resetting cause field does not indicate "DTE originated", the diagnostic code in a *reset indication* packet is network generated. Annex E lists the codings for network generated diagnostics. The bits of the diagnostic code are all set to 0 when no specific additional information for the reset is supplied.

Note – The contents of the diagnostic code field do not alter the meaning of the cause field. A DTE is not required to undertake any action on the contents of the diagnostic code field. Unspecified code combinations in the diagnostic code field shall not cause the DTE to not accept the cause field.

5.4.4 *DTE and DCE reset confirmation packets*

Figure 16/X.25 illustrates the format of the *DTE* and *DCE reset confirmation* packets.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				Logical channel group number			
2	Logical channel number							
3	Packet type identifier							
	0	0	0	1	1	1	1	1

Note – Coded 0001 (modulo 8) or 0010 (modulo 128).

FIGURE 16/X.25

DTE and DCE reset confirmation packet format

5.5 *Restart packets*

5.5.1 *Restart request and restart indication packets*

Figure 17/X.25 illustrates the format of the *restart request* and *restart indication* packets.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				0	0	0	0
2	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	1	0	1	1
4	Restarting cause							
5	Diagnostic code [a]							

[a] This field is not mandatory in *restart request* packets.

Note – Coded 0001 (modulo 8) or 0010 (modulo 128).

FIGURE 17/X.25

Restart request and restart indication packet format

5.5.1.1 *Restarting cause field*

Octet 4 is the restarting cause field and contains the reason for the restart.

In *restart request* packets, the restarting cause field should be set by the DTE to one of the following values:

bits:	8 7 6 5 4 3 2 1
value:	0 0 0 0 0 0 0 0
or:	1 X X X X X X X

where each X may be independently set to 0 or 1 by the DTE.

The DCE will prevent values of the restarting cause field, other than those shown above, from reaching the other end of the virtual calls and/or permanent virtual circuits by either accepting the *restart request* packet and forcing the clearing or resetting cause field to all zeros in the corresponding *clear* and/or *reset indication* packets, or considering the restart request as an error and following the procedure described in Annex C.

The coding of the restarting cause field in the *restart indication* packets is given in Table 22/X.25.

TABLE 22/X.25

Coding of restarting cause field in restart indication packet

	Bits							
	8	7	6	5	4	3	2	1
Local procedure error	0	0	0	0	0	0	0	1
Network congestion	0	0	0	0	0	0	1	1
Network operational	0	0	0	0	0	1	1	1
Registration/cancellation confirmed [a]	0	1	1	1	1	1	1	1

[a] May be received only if the optional *on-line facility registration* facility is used.

5.5.1.2 *Diagnostic code*

Octet 5 is the diagnostic code and contains additional information on the reason for the restart.

In a *restart request* packet, the diagnostic code is not mandatory. The diagnostic code, if specified, is passed to the corresponding DTEs as the diagnostic code of a *reset indication* packet for permanent virtual circuits or a *clear indication* packet for virtual calls.

The coding of the diagnostic code field in a *restart indication* packet is given in Annex E. The bits of the diagnostic code are all set to zero when no specific additional information for the restart is supplied.

Note – The contents of the diagnostic code field do not alter the meaning of the cause field. A DTE is not required to undertake any action on the contents of the diagnostic code field. Unspecified code combinations in the diagnostic code field shall not cause the DTE to not accept the cause field.

5.5.2 *DTE and DCE restart confirmation packets*

Figure 18/X.25 illustrates the format of the *DTE* and *DCE restart confirmation* packets.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note)				0	0	0	0
2	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	1	1	1	1

Note – Coded 0001 (modulo 8) or 0010 (modulo 128).

FIGURE 18/X.25

DTE and DCE restart confirmation packet format

5.6 *Diagnostic packet*

Figure 19/X.25 illustrates the format of the *diagnostic* packet.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note 1)				0	0	0	0
2	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	0	0	0	1
4	Diagnostic code							
5	Diagnostic explanation (see Note 2)							

Note 1 – Coded 0001 (modulo 8) or 0010 (modulo 128).

Note 2 – The figure is drawn assuming the diagnostic explanation field is an integral number of octets in length.

FIGURE 19/X.25

Diagnostic packet format

5.6.1 *Diagnostic code field*

Octet 4 is the diagnostic code and contains information on the error condition which resulted in the transmission of the *diagnostic* packet. The coding of the diagnostic code field is given in Annex E.

5.6.2 *Diagnostic explanation field*

When the *diagnostic* packet is issued as a result of the reception of an erroneous packet from the DTE (see Tables C-1/X.25 and C-2/X.25), this field contains the first three octets of header information from the erroneous DTE packet. If the packet contains less than 3 octets, this field contains whatever bits were received.

When the *diagnostic* packet is issued as a result of a DCE time-out (see Table D-1/X.25), the diagnostic explanation field contains 2 octets coded as follows:

- bits 8, 7, 6 and 5 of the first octet contain the general format identifier for the interface;
- bits 4 to 1 of the first octet and bits 8 to 1 of the second octet are all 0 for expiration of time-out T10 and give the number of the logical channel on which the time-out occurred for expiration of time-out T12 or T13.

5.7 *Packets required for optional user facilities*

5.7.1 *DTE reject (REJ) packet for the packet retransmission facility*

Figure 20/X.25 illustrates the format of the *DTE REJ* packet, used in conjunction with the *packet retransmission* facility described in § 6.4.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier 0	0	0	1	Logical channel group number			
2	Logical channel number							
3	P(R)			Packet type identifier 0	1	0	0	1

(Modulo 8)

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier 0	0	1	0	Logical channel group number			
2	Logical channel number							
3	Packet type identifier 0	0	0	0	1	0	0	1
4	P(R)							0

(When extended to modulo 128)

FIGURE 20/X.25

DTE REJ packet format

5.7.1.1 *Packet receive sequence number*

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.7.2 *Registration packets for the on-line facility registration facility*

5.7.2.1 *Registration request packet*

Figure 21/X.25 illustrates the format of the *registration request* packet.

Octets \ Bits	8	7	6	5	4	3	2	1
1	General format identifier (see Note 1)				0	0	0	0
2	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	0	0	1	1
4	DTE address length				DCE address length			
	DCE and DTE address(es) (see Note 2)							
					0	0	0	0
	Registration length							
	Registration							

Note 1 – Coded 0001 (modulo 8) or 0010 (modulo 128).

Note 2 – The figure is drawn assuming the total number of address digits present is odd.

FIGURE 21/X.25

Registration request packet format

5.7.2.1.1 *Address length fields*

Octet 4 consists of the field length indicators for the DTE and DCE addresses. Bits 4, 3, 2 and 1 indicate the length of the DCE address in semi-octets. Bits 8, 7, 6 and 5 indicate the length of the DTE address in semi-octets. Each address length indicator is binary coded and bit 1 or 5 is the low order bit of the indicator.

These fields are coded with all zeros under the procedures in this Recommendation.

5.7.2.1.2 *Address field*

Octet 5 and the following octets consist of the DCE address, when present, and the DTE address, when present.

Each digit of an address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low order bit of the digit.

Starting from the high order digit, the address is coded in octet 5 and consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

The address field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field when necessary.

This field is not present under the procedures in this Recommendation.

5.7.2.1.3 *Registration length field*

The octet following the address field indicates the length of the registration field in octets. The registration length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.7.2.1.4 *Registration field*

The registration field is present only when the DTE wishes to request the DCE to agree to, or to stop a previous agreement for, an optional user facility.

The coding of the registration field is defined in § 7.3.

The registration field contains an integral number of octets. The actual maximum length of this field depends on the network. However, this maximum does not exceed 109 octets.

5.7.2.2 *Registration confirmation packet*

Figure 18/X.25 illustrates the format of the *registration confirmation* packet.

Octets	Bits 8	7	6	5	4	3	2	1
1	General format identifier (see Note 1)				0	0	0	0
2	0	0	0	0	0	0	0	0
3	Packet type identifier							
	1	1	1	1	0	1	1	1
4	Cause							
5	Diagnostic							
6	DTE address length				DCE address length			
7	DCE and DTE adress(es) (see Note 2)							
					0	0	0	0
	Registration length							
	Registration							

Note 1 – Coded 0001 (modulo 8) or 0010 (modulo 128).

Note 2 – The figure is drawn assuming the total number of address digits present is odd.

FIGURE 22/X.25

Registration confirmation packet format

5.7.2.2.1 *Cause field*

Octet 4 is the cause field and contains the cause of any failure in negotiation of facilities or an indication that the registration field was verified by the DCE.

The coding of the cause field in the *registration confirmation* packet is shown in Table 23/X.25.

TABLE 23/X.25

Coding of cause field in registration confirmation packet

	Bits							
	8	7	6	5	4	3	2	1
Registration/cancellation confirmed	0	1	1	1	1	1	1	1
Invalid facility request	0	0	0	0	0	0	1	1
Local procedure error	0	0	0	1	0	0	1	1
Network congestion	0	0	0	0	0	1	0	1

5.7.2.2.2 *Diagnostic code*

Octet 5 is the diagnostic code and contains additional information on the reason for failure of facilities negotiation.

Annex E lists the coding for diagnostics. The bits of the diagnostic code are all set to 0 when negotiation is successful, or when no additional information is supplied.

5.7.2.2.3 *Address length fields*

Octet 6 consists of the field length indicators for the DTE and DCE addresses. Bits 4, 3, 2 and 1 indicate the length of the DCE address in semi-octets. Bits 8, 7, 6 and 5 indicate the length of the DTE address in semi-octets. Each address length indicator is binary coded and bit 1 or 5 is the low order bit of the indicator.

These fields are coded with all zeros under the procedures in this Recommendation.

5.7.2.2.4 *Address field*

Octet 7 and the following octets consist of the DCE address, when present, and the DTE address, when present.

Each digit of an address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low order bit of the digit.

Starting from the high order digit, the address is coded in octet 7 and consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

The address field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field when necessary.

This field is not present under the procedures in this Recommendation.

5.7.2.2.5 *Registration length field*

The octet following the address field indicates the length of the registration field, in octets. The registration length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.7.2.2.6 *Registration field*

The registration field is used to indicate which optional user facilities are available, and which are currently in effect.

The coding of the registration field is defined in § 7.3.

The registration field contains an integral number of octets. The actual maximum length of this field depends on the network. However, this maximum does not exceed 109 octets.

6 Procedures for optional user facilities (packet layer)

6.1 *On-line facility registration*

On-line facility registration is an optional user facility agreed for a period of time. This facility, if subscribed to, permits the DTE at any time to request registration of facilities, or obtain current values of facilities as understood by the DCE, by transferring across the DTE/DCE interface a *registration request* packet.

The DCE will, in response to a *registration packet,* report the current value of all facilities applicable to the DTE/DCE interface, by transferring a *registration confirmation* packet across the DTE/DCE interface. Optional facilities which are not offered by the network will not be reported in the *registration confirmation* packet. To avoid requesting facilities that are not available in a particular network, or values that are not allowed, the DTE may transfer a *registration request* packet across the DTE/DCE interface containing no optional facilities. It may then modify any negotiable facilities reported in the corresponding *registration confirmation* packet by transferring a second *registration request* packet across the DTE/DCE interface.

When the DCE returns the *registration confirmation* packet, the facilities values shown are in effect for any subsequent virtual calls. The values of the *extended packet sequence numbering, packet retransmission,* and *D bit modification* facilities and the allocation of logical channel type ranges can be modified only when there are no virtual calls (i.e., all logical channels used for virtual calls are in state p1). When these facilities take effect and when there is one or more logical channels assigned to permanent virtual circuits, the network restarts the interface with the cause "Registration/cancellation confirmed" and the diagnostic "No additional information" in order to change the values of the permanent virtual circuits at the interface. At the remote end of each permanent virtual circuit, the corresponding *reset indication* packet is sent with the cause "Remote DTE operational" and the diagnostic "No additional information".

If a requested value of a particular facility is not allowed, the DCE shall report in the *registration confirmation* packet:

a) if the facility has a boolean value, the value allowed;

b) if the value is greater than the maximum allowed value of that facility, the maximum allowed value; or

c) if the value is less than the minimum allowed value of that facility, the minimum allowed value.

The *registration confirmation* packet shall also contain an appropriate cause code. The DTE may choose to accept the value reported by the DCE or to attempt to negotiate another value for the requested facilities.

If the DCE cannot make all the modifications requested in a *registration request* packet, it will not alter the values of some facilities. Circumstances in which the DCE can not make all of the modifications requested include:

a) conflict in facilities settings, and

b) when the interface has at least one virtual call established when attempting to negotiate those facilities that require all virtual call logical channels to be in state p1 (including the collision of an *incoming call* packet and a *registration request* packet).

The DTE should wait for the *registration confirmation* packet before sending a *call request* packet, or sending a packet on a permanent virtual circuit.

For every optional user facility, Annex F indicates:

- if the value of the facility may be negotiated;
- if the *registration confirmation* packets indicate whether or not the facility is supported by the DCE;
- if the value of the facility may be altered by the DTE either only when every logical channel used for virtual calls is in state p1, or in any packet layer state.

Indication in *registration confirmation* packet of whether the *NUI override* facility is supported by the network is for further study.

A fault condition within the network may affect the facilities previously negotiated by means of *registration* packets. In this situation, the DCE initiates the restart procedure to inform the DTE of the failure.

A restart procedure initiated by the DTE does not affect the facilities values. When the DCE initiates the restart procedure with the cause "Local procedure error", the facilities values are not affected. When the DCE initiates the restart procedure with the cause "Network congestion" or "Network operational", the values of facilities previously negotiated may be affected. When the DCE initiates the restart procedure with the cause "Registration/cancellation confirmed", the facilities values are as set by the related registration procedure.

6.2 *Extended packet sequence numbering*

Extended packet sequence numbering is an optional user facility agreed for a period of time. It is common to all logical channels at the DTE/DCE interface.

This user facility, if subscribed to, provides sequence numbering of packets performed modulo 128. In the absence of this facility, the sequence numbering of packets is performed modulo 8.

6.3 *D bit modification*

D bit modification is an optional user facility agreed for a period of time. This facility applies to all virtual calls and permanent virtual circuits at the DTE/DCE interface. This facility is only intended for use by those DTEs implemented prior to the introduction of the D bit procedure which were designed for operation on public data networks that support end-to-end P(R) significance. It allows these DTEs to continue to operate with end-to-end P(R) significance within a national network.

For communication within the national network, this facility, when subscribed to:

a) will change from 0 to 1 the value of bit 7 of the GFI in all *call request* and *call accepted* packets and the value of the D bit in all *DTE data* packets received from the DTE, and

b) will set to 0 the value of bit 7 of the GFI in all *incoming call* and *call connected* packets, and the value of the D bit in all *DCE data* packets transmitted to the DTE.

For international operation, conversion b) above applies and conversion a) above does not apply. Other conversion rules for international operation are for bilateral agreement between Administrations.

6.4 *Packet retransmission*

Packet retransmission is an optional user facility agreed for a period of time. It is common to all logical channels at the DTE/DCE interface.

This user facility, if subscribed to, allows a DTE to request retransmission of one or several consecutive *DCE data* packets from the DCE by transferring across the DTE/DCE interface a *DTE reject* packet specifying a logical channel number and a sequence number P(R). The value of this P(R) should be within the range from the last P(R) received by the DCE up to, but not including, the P(S) of the next *DCE data* packet to be transmitted by the DCE. If the P(R) is outside this range, the DCE will initiate the reset procedure with the cause "Local procedure error" and diagnostic # 2.

When receiving a *DTE reject* packet, the DCE initiates on the specified logical channel retransmission of the *DCE data* packets, the packet send sequence numbers of which are starting from P(R), where P(R) is indicated in the *DTE reject* packet. Until the DCE transfers across the DTE/DCE interface a *DCE data* packet with a packet send sequence number equal to the P(R) indicated in the *DTE reject* packet, the DCE will consider the receipt of another *DTE reject* packet as a procedure error and reset the logical channel.

Additional *DCE data* packets pending initial transmission may follow the retransmitted packet(s).

A *DTE receive not ready* situation indicated by the transmission of an *RNR* packet is cleared by the transmission of a *DTE reject* packet.

The conditions under which the DCE ignores a *DTE reject* packet, or considers it as a procedure error, are those described for *flow control* packets (see Annex C).

6.5 *Incoming calls barred*

Incoming calls barred is an optional user facility agreed for a period of time. This facility applies to all logical channels used at the DTE/DCE interface for virtual calls.

This user facility, if subscribed to, prevents incoming virtual calls from being presented to the DTE. The DTE may originate outgoing virtual calls.

Note 1 – Logical channels used for virtual calls retain their full duplex capability.

Note 2 – Some Administrations may provide a capability that allows a virtual call to be presented to the DTE only in cases where the called DTE address is the address of the calling DTE.

6.6 *Outgoing calls barred*

Outgoing calls barred is an optional user facility agreed for a period of time. This facility applies to all logical channels used at the DTE/DCE interface for virtual calls.

This user facility, if subscribed to, prevents the DCE from accepting outgoing virtual calls from the DTE. The DTE may receive incoming virtual calls.

Note – Logical channels used for virtual calls retain their full duplex capability.

6.7 *One-way logical channel outgoing*

One-way logical channel outgoing is an optional user facility agreed for a period of time. This user facility, if subscribed to, restricts the logical channel use to originating outgoing virtual calls only.

Note – A logical channel used for virtual calls retains its full duplex capability.

The rules according to which logical channel group numbers and logical channel numbers can be assigned to one-way outgoing logical channels for virtual calls are given in Annex A.

Note – If all the logical channels for virtual calls are one-way outgoing at a DTE/DCE interface, the effect is equivalent to the *incoming calls barred* facility (see § 6.5, particularly Note 2).

6.8 *One-way logical channel incoming*

One-way logical channel incoming is an optional user facility agreed for a period of time. This user facility, if subscribed to, restricts the logical channel use to receiving incoming virtual calls only.

Note – A logical channel used for virtual calls retains its full duplex capability.

The rules according to which logical channel group numbers and logical channel numbers can be assigned to one-way incoming logical channels for virtual calls are given in Annex A.

Note – If all the logical channels for virtual calls are one-way incoming at a DTE/DCE interface, the effect is equivalent to the *outgoing calls barred* facility (see § 6.6).

6.9 *Non-standard default packet sizes*

Non-standard default packet sizes is an optional user facility agreed for a period of time. This facility, if subscribed to, provides for the selection of default packet sizes from the list of packet sizes supported by the Administration. Some networks may constrain the packet sizes to be the same for each direction of data transmission across the DTE/DCE interface. In the absence of this facility, the default packet sizes are 128 octets.

Note – In this section, the term "packet sizes" refers to the maximum user data field lengths of*DCE data* and *DTE data* packets.

Values other than the default packet sizes may be negotiated for a virtual call by means of the *flow control parameter negotiation* facility (see § 6.12). Values other than the default packet sizes may be agreed for a period of time for each permanent virtual circuit.

6.10 *Non-standard default window sizes*

Non-standard default window sizes is an optional user facility agreed for a period of time. This facility, if subscribed to, provides for the selection of default window sizes from the list of window sizes supported by the Administration. Some networks may constrain the default window sizes to be the same for each direction of data transmission across the DTE/DCE interface. In the absence of this facility, the default windonw sizes are 2.

Values other than the default window sizes may be negotiated for a virtual call by means of the *flow control parameter negotiation* facility (see § 12). Values other than the default window sizes may be agreed for a period of time for each permanent virtual circuit.

6.11 *Default throughput classes assignment*

Default throughput classes assignment is an optional user facility agreed for a period of time. This facility, if subscribed to, provides for the selection of default throughput classes from the list of throughput classes supported by the Administration. Some networks may constrain the default throughput classes to be the same for each direction of data transmission. In the absence of this facility, the default throughput classes correspond to the user class of service of the DTE (see § 7.2.2.2) but do not exceed the maximum throughput class supported by the network.

The default throughput classes are the maximum throughput classes which may be associated with any virtual call at the DTE/DCE interface. Values other than the default throughput classes may be negotiated for a virtual call by means of the *throughput class negotiation* facility (see § 6.13). Values other than the default throughput classes may be agreed for a period of time for each permanent virtual circuit.

Note – Throughput characteristics and throughput class are described in § 4.4.2.

6.12 *Flow control parameter negotiation*

Flow control parameter negotiation is an optional user facility agreed for a period of time which can be used by a DTE for virtual calls. This facility, if subscribed to, permits negotiation on a per call basis of the flow control parameters. The flow control parameters considered are the packet and window sizes at the DTE/DCE interface for each direction of data transmission.

Note – In this section, the term "packet sizes" refers to the maximum user data field lengths of *DCE data* and *DTE data* packets.

In the absence of the *flow control parameter negotiation* facility, the flow control parameters to be used at a particular DTE/DCE interface are the default packet sizes (see § 6.9) and the default window sizes (see § 6.10).

When the calling DTE has subscribed to the *flow control parameter negotiation* facility, it may request packet sizes and/or window sizes for both direction of data transmission (see §§ 7.2.1 and 7.2.2.1). If particular window sizes are not explicitly requested in a*call request* packet, the DCE will assume that the default window sizes were requested for both directions of data transmission. If particular packet sizes are not explicitly requested, the DCE will assume that the default packet sizes were requested for both directions of data transmission.

When a called DTE has subscribed to the *flow control parameter negotiation* facility, each *incoming call* packet will indicate the packet and window sizes from which DTE negotiation can start. No relationship needs to exist between the packet sizes (P) and window sizes (W) requested in the *call request* packet and those indicated in the *incoming call* packet. The called DTE may request window and packet sizes with facility in the *call accepted* packet. The only valid facility requests in the *call accepted* packet, as a function of the facility indications in the *incoming call* packet, are given in Table 24/X.25. If the facility request is not made in the *call accepted* packet, the DTE is assumed to have accepted the indicated values (regardless of the default values) for both directions of data transmission.

TABLE 24/X.25

Valid facility requests in call accepted packets in response to facility indications in incoming call packets

Facility indication	Valid facility request
W(indicated) $\geqslant$ 2	W(indicated) $\geqslant$ W(requested) $\geqslant$ 2
W(indicated) = 1	W(requested) = 1 or 2
P(indicated) $\geqslant$ 128	P(indicated) $\geqslant$ P(requested) $\geqslant$ 128
P(indicated) < 128	128 $\geqslant$ P(requested) $\geqslant$ P(indicated)

When the calling DTE has subscribed to the *flow control parameter negotiation* facility, every *call connected* packet will indicate the packet and window sizes to be used at the DTE/DCE interface for the call. The only valid facility indications in the *call connected* packet, as a function of the facility requests in the *call request* packet, are given in Table 25/X.25.

TABLE 25/X.25

Valid facility indications in call connected packets in response to facility requests in call request packets

Facility indication	Valid facility request
W(requested) $\geqslant$ 2	W(requested) $\geqslant$ W(indicated) $\geqslant$ 2
W(requested) = 1	W(indicated) = 1 or 2
P(requested) $\geqslant$ 128	P(requested) $\geqslant$ P(indicated) $\geqslant$ 128
P(requested) < 128	128 $\geqslant$ P(indicated) $\geqslant$ P(requested)

The network may have constraints requiring the flow control parameters used for a call to be modified before indicating them to the DTE in the *incoming call* packet or *call connected* packet; e.g., the ranges of parameter values available on various networks may differ.

Window and packet sizes need not be the same at each end of a virtual call.

The role of the DCE in negotiating the flow control parameters may be network dependent.

6.13 *Throughput class negotiation*

Throughput class negotiation is an optional user facility agreed for a period of time which can be used by a DTE for virtual calls. This facility, if subscribed to, permits negotiation on a per call basis of the throughput classes. The throughput classes are considered independently for each direction of data transmission.

Default values are agreed between the DTE and the Administration (see § 6.11). The default values correspond to the maximum throughput classes which may be associated with any virtual call at the DTE/DCE interface.

When the calling DTE has subscribed to the *throughput class* negotiation facility, it may request the throughput classes of the virtual call in the *call request* packet for both directions of data transmission (see §§ 7.2.1 and 7.2.2.2). If particular throughput classes are not explicitly requested, the DCE will assume that the default values were requested for both directions of data transmission.

When a called DTE has subscribed to the *throughput class negotiation* facility, each *incoming call* packet will indicate the throughput classes from which DTE negotiation may start. These throughput classes are lower or equal to the ones selected at the calling DTE/DCE interface, either explicitly, or by default if the calling DTE has not subscribed to the *throughput class negotiation* facility or not explicitly requested throughput class values in the *call request* packet. These throughput classes indicated to the called DTE will also not be higher than the default throughput classes, respectively for each direction of data transmission, at the calling and the called DTE/DCE interfaces. They may be further constrained by internal limitations of the network.

The called DTE may request with a facility in the *call accepted* packet throughput classes that should finally apply to the virtual call. The only valid throughput classes in the *call accepted* packet are lower than or equal to the ones (respectively) indicated in the *incoming call* packet. If the called DTE does not make any throughput class facility request in the *call accepted* packet, the throughput classes finally applying to the virtual call will be the ones indicated in the *incoming call* packet.

If the called DTE has not subscribed to the *throughput class negotiation* facility, the throughput classes finally applying to the virtual call are less than or equal to the ones selected at the calling DTE/DCE interface, and less than or equal to the default values defined at the called DTE/DCE interface.

When the calling DTE has subscribed to the *throughput class negotiation* facility, every *call connected* packet will indicate the throughput classes finally applying to the virtual call.

When neither the calling DTE nor the called DTE has subscribed to the *throughput class negotiation* facility, the throughput classes applying to the virtual call will not be higher than the ones agreed as defaults at the calling and called DTE/DCE interfaces. They may be further constrained to lower values by the network, e.g., for international service.

Note 1 – Since both *throughput class negotiation* and *flow control parameter negotiation* (see § 6.12) facilities can be applied to a single call, the achievable throughput will depend on how users manipulate the D bit.

Note 2 – Users are cautioned that the choice of too small a window and packet size of a DTE/DCE interface (made by use of the *flow control parameter negotiation* facility may adversely affect the attainable throughput class of a virtual call. This is likewise true of flow control mechanisms adopted by the DTE to control data transmission from the DCE.

6.14 *Closed user group related facilities*

A set of closed user group (CUG) optional user facilities enables users to form groups of DTEs to and/or from which access is restricted. Different combinations of access restrictions to and/or from DTEs having one or more of these facilities result in various combinations of accessibility.

A DTE may belong to one or more CUGs. Each DTE belonging to at least one CUG has either the *closed user group* facility (see § 6.14.1) or one or both of the *closed user group with outgoing access* and the *closed user group with incoming access* facilities (see §§ 6.14.2 and 6.14.3). For each CUG to which a DTE belongs, either none of the *incoming calls barred within a closed user group* or the *outgoing calls barred within a closed user group* facilities (see §§ 6.14.4 and 6.14.5) may apply for that DTE. Different combinations of CUG facilities may apply for different DTEs belonging to the same CUG.

When a DTE belonging to one or more CUGs places a virtual call, the DTE may explicitly indicate in the *call request* packet the CUG selected by using the *closed user group selection* facility (see § 6.14.6) or the *closed user group with outgoing access selection* facility (see § 6.14.7) (see Note). When a DTE belonging to one or more CUGs receives a virtual call, the CUG selected may be explicitly indicated in the *incoming call* packet through the use of the *closed user group selection* facility or the *closed user group with outgoing access selection* facility.

Note – For a given virtual call, only one of the above-mentioned selection facilities can be present.

The number of CUGs to which a DTE can belong is network dependent.

6.14.1 *Closed user group*

Closed user group is an optional user facility agreed for a period of time for virtual calls. This user facility, if subscribed to, enables the DTE to belong to one or more closed user groups. A closed user group permits the DTEs belonging to the group to communicate with each other but precludes communication with all other DTEs.

When the DTE belongs to more than one closed user group, a preferential closed user group must be specified.

6.14.2 *Closed user group with outgoing access*

Closed user group with outgoing access is an optional user facility agreed for a period of time for virtual calls. This user facility, if subscribed to, enables the DTE to belong to one or more closed user groups (as in § 6.14.1) and to originate virtual calls to DTEs in the open part of the network (i.e., DTEs not belonging to any closed user group) and to DTEs belonging to other CUGs with the incoming access capability.

When the *closed user group with outgoing access* facility is subscribed to and the DTE has a preferential CUG, then only the *closed user group selection* facility (as in § 6.14.6) is applicable for use at the interface.

When the *closed user group with outgoing access* facility is subscribed to and the network offers to the DTE the capability of choosing whether or not to have a preferential CUG (i.e., the *closed user group with outgoing access selection* facility (see § 6.14.7) is offered by the network), and the DTE has no preferential CUG, then both the *closed user group selection* and the *closed user group with outgoing access selection* facilities are applicable for use at the interface.

6.14.3 *Closed user group with incoming access*

Closed user group with incoming access is an optional user facility agreed for a period of time for virtual calls. This user facility, if subscribed to, enables the DTE to belong to one or more closed user groups (as in § 6.14.1) and to receive incoming calls from DTEs in the open part part of the network (i.e., DTEs not belonging to any closed user group) and from DTEs belonging to other CUGs with the outgoing access capability.

When the *closed user group with incoming access* facility is subscribed to and the DTE has a preferential CUG, then only the *closed user group selection* facility is applicable for use at the interface.

When the *closed user group with incoming access* facility is subscribed to and the network offers to the DTE the capability of choosing whether or not to have a preferential CUG (i.e., the *closed user group with outgoing access selection* facility is offered by the network), and the DTE has no preferential CUG, then both the *closed user group selection* and the *closed user group with outgoing access selection* facilities are applicable for use at the interface.

6.14.4 *Incoming calls barred within a closed user group*

Incoming calls barred within a closed user group is an optional user facility agreed for a period of time. This user facility, if subscribed to for a given closed user group, permits the DTE to originate virtual calls to DTEs in this closed user group, but precludes the reception of incoming calls from DTEs in this closed user group.

6.14.5 *Outgoing calls barred within a closed user group*

Outgoing calls barred within a closed user group is an optional user facility agreed for a period of time. This user facility, if subscribed for a given closed user group, permits the DTE to receive virtual calls from DTEs in this closed user group, but prevents the DTE from originating virtual calls to DTEs in this closed user group.

6.14.6 *Closed user group selection*

Closed user group selection is an optional user facility which may be used on a per virtual call basis. This facility may be requested or received by a DTE only if it has subscribed to the *closed user group* facility, or the *closed user group with outgoing access* facility and/or the *closed user group with incoming access* facility.

The *closed user group selection* facility (see §§ 7.2.1 and 7.2.2.3) may be used by the calling DTE in the *call request* packet to specify the closed user group selected for a virtual call.

The *closed user group selection* facility is used in the *incoming call* packet to indicate to the called DTE the closed user group selected for a virtual call.

The number of closed user groups to which a DTE can belong is network dependent. If the maximum value of the index assigned for use by the DTE to select the closed user group is 99 or less, the basic format of the *closed user group selection* facility must be used. If the maximum value of the index assigned is between 100 and 9999, the extended format of the *closed user group selection* facility must be used.

Some networks may permit a DTE to use either the basic or extended format of the *closed user group selection* facility when the index is 99 or less.

Note – When a DTE subscribes to less than 101 closed user groups, the network should be able to agree on a maximum value of the index smaller than 100 if requested by the DTE.

The appearance in a *call request* packet of both formats, or a format inconsistent with the number of CUGs subscribed to, will be treated as a facility code not allowed.

The significance of the *closed user group selection* facility in *call request* packets is given in Table 26/X.25 and in *incoming call* packets is given in Table 27/X.25.

6.14.7 *Closed user group with outgoing access selection*

Closed user group with outgoing access selection is an optional user facility which may be used on a per virtual call basis. This facility may be requested by a DTE only if the network supports it and the DTE has subscribed to the *closed user group with outgoing access* facility or to both the *closed user group with outgoing access* and *closed user group with incoming access* facilities. This facility may be received by a DTE only if the network supports it and the DTE has subscribed to the *closed user group with incoming access* facility or to both the *closed user group with incoming access* and *closed user group with outgoing access* facilities.

The *closed user group with outgoing access selection* facility (see §§ 7.2.1 and 7.2.2.4) may be used by the calling DTE in the *call request* packet to specify the closed user group selected for a virtual call and to indicate that outgoing access is also desired.

TABLE 26/X.25

Meaning of closed user group facilities in call request packets

Closed user group subscription of the calling DTE (see Note 1) \ Contents of *call request* packet (see Note 2)	*Closed user group selection* facility	*Closed user group with outgoing access selection* facility	Neither *closed user group selection* nor *closed user group with outgoing access selection* facility
CUG with preferential (see Note 3)	CUG specified (see Note 4)	Not allowed (call cleared)	Preferential or only CUG (see Note 4)
CUG/IA with preferential	CUG specified (see Note 4)	Not allowed (call cleared)	Preferential or only CUG (see Note 4)
CUG/OA with preferential	CUG specified + outgoing access (see Note 4)	Not allowed (call cleared)	Preferential or only CUG + outgoing access (see Notes 5, 6)
CUG/IA/OA with preferential	CUG specified + outgoing access (see Note 4)	Not allowed (call cleared)	Preferential or only CUG + outgoing access (see Notes 5, 6)
CUG/IA without preferential	CUG specified (see Note 4)	Not allowed (call cleared)	Not allowed (call cleared)
CUG/OA without preferential	CUG specified (see Note 4)	CUG specified + outgoing access (see Notes 5, 6)	Outgoing access
CUG/IA/OA without preferential	CUG specified (see Note 4)	CUG specified + outgoing access (see Notes 5, 6)	Outgoing access
No CUG	Not allowed (call cleared)	Not allowed (call cleared)	Outgoing access

OA: Outgoing access
IA: Incoming access

Note 1 – The order of subscription types is different from that in Table 27/X.25.

Note 2 – The inclusion of both the *closed user group selection* facility and the *closed user group with outgoing access selection* facility is not allowed in the *call request* packet.

Note 3 – CUG without preferential is not allowed.

Note 4 – If outgoing calls are barred within the specified CUG or within the preferential or only CUG, then the call is cleared.

Note 5 – If outgoing calls are barred within the specified CUG or within the preferential or only CUG, then only outgoing access applies.

Note 6 – For international calls, if the destination network does not support the *closed user group with outgoing access selection* facility, the call may be cleared even if the called DTE belongs to the specified closed user group or to the open world or has incoming access.

TABLE 27/X.25

Meaning of closed user group facilities in incoming call packets

Closed user group subscription of the called DTE (see Note 1) \ Contents of *incoming call* packet	*Closed user group selection* facility	*Closed user group with outgoing access selection* facility	Neither *closed user group selection* nor *closed user group with outgoing access selection* facility
CUG with preferential (see Note 2)	CUG specified (see Note 3)	Not applicable	Preferential or only CUG (see Note 3)
CUG/OA with preferential	CUG specified (see Note 3)	Not applicable	Preferential or only CUG (see Note 3)
CUG/IA with preferential	CUG specified + incoming access (see Note 4)	Not applicable	Preferential or only CUG + incoming access (see Note 5)
CUG/IA/OA with preferential	CUG specified + incoming access (see Note 4)	Not applicable	Preferential or only CUG + incoming access (see Note 5)
CUG/OA without preferential	CUG specified (see Note 3)	Not applicable	Not applicable
CUG/IA without preferential	CUG specified (see Note 3)	CUG specified + incoming access (see Note 4)	Incoming access
CUG/IA/OA without preferential	CUG specified (see Note 3)	CUG specified + incoming access (see Note 4)	Incoming access
No CUG	Not applicable	Not applicable	Incoming access

OA: Outgoing access
IA: Incoming access

Note 1 – The order of subscription types is different from that in Table 26/X.25.

Note 2 – CUG without preferential is not allowed.

Note 3 – When incoming calls are barred within this CUG, the call is blocked; there is no incoming call.

Note 4 – When incoming calls are barred within this CUG, only incoming access applies and the *incoming call* packet carries neither the *closed user group selection* nor the *closed user group with outgoing access selection* facility.

Note 5 – When incoming calls are barred within this CUG, only incoming access applies.

The *closed user group with outgoing access selection* facility is used in the *incoming call* packet to indicate to the called DTE the closed user group selected for a virtual call and that outgoing access had applied at the calling DTE.

The *closed user group with outgoing access selection* facility can only be present in the facility field of *call set-up* packets if the DTE does not have a preferential closed user group.

The number of closed user groups to which a DTE can belong is network dependent. If the maximum value of the index assigned for use by the DTE to select the closed user group is 99 or less, the basic format of the *closed user group with outgoing access selection* facility must be used. If the maximum value of the index assigned is between 100 and 9999, the extended format of the *closed user group with outgoing access selection* facility must be used.

Some networks may permit a DTE to use either the basic or extended format of the *closed user group with outgoing access selection* facility when the index is 99 or less.

Note – When a DTE subscribes to less than 101 closed user groups, the network should be able to agree to a maximum value of the index smaller than 100 if requested by the DTE.

The appearance in a *call request* packet of both formats or a format inconsistent with the number of CUGs subscribed to will be treated as a facility code not allowed.

The significance of the presence of the *closed user group with outgoing access selection* facility in *call request* packets is given in Table 26/X.25 and in *incoming call* packets is given in Table 27/X.25.

6.14.8 *Absence of both CUG selection facilities*

The significance of the absence of both the *closed user group selection* facility and the *closed user group with outgoing access selection* facility in call request packets is given in Table 26/X.25 and in *incoming call* packets is given in Table 27/X.25.

6.15 *Bilateral closed user group related facilities*

The set of bilateral closed user group (BCUG) optional user facilities enables pairs of DTEs to form bilateral relations allowing access between each other while excluding access to or from other DTEs with which such a relation has not been formed. Different combinations of access restrictions for DTEs having these facilities result in various combinations of accessibility.

A DTE may belong to one or more BCUGs. Each DTE belonging to at least one BCUG has either the *bilateral closed user group* facility (see § 6.15.1) or the *bilateral closed user group with outgoing access* facility (see § 6.15.2). For a given BCUG, it is permissible for one DTE to subscribe to the *bilateral closed user group* facility while the other DTE subscribes to the *bilateral closed user group with outgoing access* facility.

When a DTE belonging to one or more BCUGs places a virtual call, the DTE should indicate in the *call request* packet the BCUG selected by using the *bilateral closed user group selection* facility (see § 6.15.3). When a DTE belonging to one or more BCUGs receives a virtual call, the BCUG selected will be indicated in the *incoming call* packet through the use of the *bilateral closed user group selection* facility.

The number of BCUGs to which a DTE can belong is network dependent.

6.15.1 *Bilateral closed user group*

Bilateral closed user group is an optional user facility agreed for a period of time for virtual calls. This facility, if subscribed to, enables the DTE to belong to one or more bilateral closed user groups. A bilateral closed user group permits a pair of DTEs who bilaterally agree to communicate with each other to do so, but precludes communication with all other DTEs.

6.15.2 *Bilateral closed user group with outgoing access*

Bilateral closed user group with outgoing access is an optional user facility agreed for a period of time for virtual calls. This facility, if subscribed to, enables the DTE to belong to one or more bilateral closed user groups (as in § 6.15.1) and to originate virtual calls to DTEs in the open part of the network (i.e., DTEs not belonging to any bilateral closed user group).

6.15.3 *Bilateral closed user group selection*

Bilateral closed user group selection is an optional user facility which may be used on a per virtual call basis. This facility should be requested or will only be received by a DTE if it has subscribed to the *bilateral closed user group* facility (see § 6.15.1), or the *bilateral closed user group with outgoing access* facility (see § 6.15.2).

The *bilateral closed user group selection* facility (see §§ 7.2.1 and 7.2.2.5) is used by the calling DTE in the *call request* packet to specify the bilateral closed user group selected for a virtual call. The called DTE address length shall be coded all zeros.

The *bilateral closed user group selection* facility is used in the *incoming call* packet to indicate to the called DTE, the bilateral closed user group selected for a virtual call. The calling DTE address length will be coded all zeros.

6.16 *Fast select*

Fast select is an optional user facility which may be requested by a DTE for a given virtual call.

DTEs can request the *fast select* facility on a per call basis by means of an appropriate facility request (see §§ 7.2.1 and 7.2.2.6) in a *call request* packet using any logical channel which has been assigned to virtual calls.

The *fast select* facility, if requested in the *call request* packet and if it indicates no restriction on response, allows this packet to contain a call user data field of up to 128 octets, authorizes the DCE to transmit to the DTE, during the *DTE waiting* state, a *call connected* or *clear indication* packet with a called or clear user data field respectively of up to 128 octets, and authorizes the DTE and the DCE to transmit after the call is connected, a *clear request* or a *clear indication* packet, respectively, with a clear user data field of up to 128 octets.

The *fast select* facility, if requested in the *call request* packet and if it indicates restriction on response, allows this packet to contain a call user data field of up to 128 octets and authorizes the DCE to transmit to the DTE, during the *DTE waiting* state, a *clear indication* packet with a clear user data field of up to 128 octets; the DCE would not be authorized to transmit a *call connected* packet.

When a DTE requests the *fast select* facility in a *call request* packet, the *incoming call* packet should only be delivered to the called DTE if that DTE has subscribed to the *fast select acceptance* facility (see § 6.17).

If the called DTE has subscribed to the *fast select acceptance* facility, it will be advised that the *fast select* facility, and an indication of whether or not there is a restriction on the response, has been requested through the inclusion of the appropriate facility (see §§ 7.2.1 and 7.2.2.6) in the *incoming call* packet.

If the called DTE has not subscribed to the *fast select acceptance* facility, an *incoming call* packet with the *fast select* facility requested will not be transmitted and a *clear indication* packet with the cause "Fast select acceptance not subscribed" will be returned to the calling DTE.

The presence of the *fast select* facility indicating no restriction on response in an *incoming call* packet permits the DTE to issue as a direct response to this packet a *call accepted* or *clear request* packet with a called or clear user data field, respectively, of up to 128 octets. If the call is connected, the DTE and the DCE are then authorized to transmit a *clear request* or a *clear indication* packet, respectively, with a clear user data field of up to 128 octets.

The presence of the *fast select* facility indicating restriction on response in an *incoming call* packet permits the DTE to issue as a direct response to this packet a *clear request* packet with a clear user data field of up to 128 octets; the DTE would not be authorized to send a *call accepted* packet.

Note – The call user data field, the called user data field and the clear user data field will not be fragmented for delivery across the DTE/DCE interface.

The significance of the *call connected* packet or the *clear indication* packet with the cause "DTE originated" as a direct response to the *call request* packet with the *fast select* facility is that the *call request* packet with the data field has been received by the called DTE.

All other procedures of a call in which the *fast select* facility has been requested are the same as those of a virtual call.

6.17 *Fast select acceptance*

Fast select acceptance is an optional user facility agreed for a period of time. This user facility, if subscribed to, authorizes the DCE to transmit to the DTE incoming calls which request the *fast select* facility. In the absence of this facility, the DCE will not transmit to the DTE incoming calls which request the *fast select* facility.

6.18 *Reverse charging*

Reverse charging is an optional user facility which may be requested by a DTE for a given virtual call (see §§ 7.2.1 and 7.2.2.6).

6.19 *Reverse charging acceptance*

Reverse charging acceptance is an optional user facility agreed for a period of time for virtual calls. This user facility, if subscribed to, authorizes the DCE to transmit to the DTE incoming calls which request the *reverse charging* facility. In the absence of this facility, the DCE will not transmit to the DTE incoming calls which request the *reverse charging* facility.

6.20 *Local charging prevention*

Local charging prevention is an optional user facility agreed for a period of time for virtual calls. This user facility, when subscribed to, authorizes the DCE to prevent the establishment of virtual calls which the subscriber must pay for by:

a) not transmitting to the DTE incoming calls which request the *reverse charging* facility, and

b) ensuring that the charges are made to another party whenever a call is requested by the DTE. This other party can be determined by using any of a number of actions, both procedural and administrative. The procedural methods include:

   – the user of reverse charging,

   – identification of a third party using *NUI subscription* facility (see § 6.21.1) and *NUI selection* facility (see § 6.21.3).

When the party to be charged has not been established for a call request, the DCE that receives the *call request* packet will apply reverse charging to this call.

Note – For an interim period of time, some networks may choose to enforce local charging prevention by clearing the call when the party to be charged has not been established.

6.21 *Network user identification (NUI) related facilities*

The set of network user identification (NUI) related facilities enables the DTE to provide information to the network for purposes of billing, security, network management, or to invoke subscribed facilities.

This set is composed of three optional user facilities, *NUI subscription* facility (see § 6.21.1) and *NUI override* facility (see § 6.21.2) may be agreed for a period of time for virtual calls. A DTE may subscribe to one or both of these facilities. When one or both of these facilities are subscribed to, one or several network user identifiers are also agreed for a period of time. A given network user identifier may be either specific or common to *NUI subscription* facility and *NUI override* facility. The network user identifier is transmitted by the DTE to the DCE in the *NUI selection* facility (see § 6.21.3).

Network user identifier is never transmitted to the remote DTE. The calling DTE address transmitted to the remote DTE in the calling DTE address field should not be inferred from the network user identifier transmitted by the DTE in the *NUI selection* facility in the *call request* packet.

6.21.1 *NUI subscription*

NUI subscription is an optional user facility agreed for a period of time for virtual calls. This facility, if subscribed to, enables the DTE to provide information to the network for billing, security or network management purposes on a per call basis. This information may be provided by the DTE in the *call request* packet or in the *call accepted* packet by using the *NUI selection* facility (see § 6.21.3). It may be used whether or not the DTE has also subscribed to the *local charging prevention* facility (see § 6.20). If the DCE determines that the network user identifier is invalid or that the *NUI selection* facility is not present when required by the network, it will clear the call as described in Annex C.

6.21.2 *NUI override*

NUI override is an optional user facility agreed for a period of time for virtual calls. When this facility is subscribed to, one or more network user identifiers are also agreed for a period of time. Associated with each network user identifier is a set of subscription-time optional user facilities. When one of these network user identifiers is provided in a *call request* packet by means of the *NUI selection* facility (see § 6.21.3), the set of subscription-time optional user facilities associated with it overrides the facilities which apply to the interface. This override does not apply to other existing calls or subsequent calls on the interface. It remains in effect for the duration of the particular call to which it applies.

The optional user facilities that may be associated with a network user identifier when the *NUI override* facility has been subscribed to are specified in Annex H. The optional user facilities which have been agreed for a period of time for the interface and which are not overriden by using the *NUI override* facility remain in effect.

6.21.3 *NUI selection*

NUI selection is an optional user facility which may be requested by a DTE for a given virtual call (see §§ 7.2.1 and 7.2.2.7). This user facility may be requested by a DTE only if it has subscribed to the *NUI subscription* facility (see § 6.21.1) and/or the *NUI override* facility. *NUI selection* facility permits the DTE to specify which network user identifier is to be used in conjunction with the *NUI subscription* facility and/or the *NUI override* facility.

NUI selection may be requested in a *call request* packet if the selected network user identifier has been agreed in conjunction with the *NUI subscription* facility or the *NUI override* facility. *NUI selection* may be requested in the *call accepted* packet if the selected network user identifier has been agreed in conjunction with the *NUI subscription* facility.

Some networks may require that the *NUI selection* facility be requested by the DTE in every *call request* packet and, possibly, in every *call accepted* packet transmitted on a given DTE/DCE interface, when the *NUI subscription* facility has been agreed for a period of time for the interface.

If the network determines that the network user identifier is invalid or that any of the optional user facilities requested in the *call request* packet are not allowed for the DTE, it will clear the call.

6.22 *Charging information*

Charging information is an optional user facility which may be either agreed for a period of time or requested by a DTE for a given virtual call.

If the DTE is the DTE to be charged, the DTE can request the *charging information* facility on a per call basis by means of an appropriate facility request (see §§ 7.2.1 and 7.2.2.8.1) in a *call request* packet or *call accepted* packet.

If a DTE subscribes to the *charging information* for a contractual period, the facility is in effect for the DTE, whenever the DTE is the DTE to be charged, without sending the facility request in *call request* or *call accepted* packets.

Using the *clear indication* or *DCE clear confirmation* packet, the DCE will send to the DTE information about the charge for that call and/or other information which makes it possible for the user to calculate the charge.

6.23 *RPOA related facilities*

The set of RPOA optional user facilities provides for the calling DTEs designation of a sequence of one or more RPOA transit network(s) within the originating country through which the call is to be routed when more than one RPOA transit network exists at a sequence of one or more gateways. In the case of international calls, this capability includes the selection of an international RPOA in the originating country.

6.23.1 *RPOA subscription*

RPOA subscription is an optional user facility agreed for a period of time for virtual calls. This user facility, if subscribed to, applies (unless overriden for a single virtual call by the *RPOA selection* facility) to all virtual calls where more than one RPOA transit network exist at a sequence of one or more gateways. The *RPOA subscription* facility provides a sequence of RPOA transit networks through which calls are to be routed. In the absence of both the *RPOA subscription* facility and the *RPOA selection* facility (see § 6.23.2), no user designation of RPOA transit networks is in effect.

6.23.2 *RPOA selection*

RPOA selection is an optional user facility which may be requested by a DTE for a given virtual call (see §§ 7.2.1 and 7.2.2.9). It is not necessary to subscribe to the *RPOA subscription* facility in order to use this facility. This facility, when used for a given virtual call, applies for this virtual call only where more than one RPOA transit network exist at a sequence of one or more gateways. The *RPOA selection* facility provides a sequence of RPOA transit networks through which the call is to be routed. The presence of this facility in a call request packet completely overrides the sequence of RPOA transit networks that may have been specified by the *RPOA subscription* facility (see § 6.23.1).

If the DTE selects only one RPOA transit network, either the basic or extended format of the *RPOA selection* facility may be used. If the DTE selects more than one RPOA transit network, the extended format of the *RPOA selection* facility is used. The appearance of both formats in a *call request* packet will be treated as a facility code not allowed.

6.24 *Hunt group*

Hunt group is an optional user facility agreed for a period of time. This user facility, if subscribed to, distributes incoming calls having an address associated with the hunt group across a designated grouping of DTE/DCE interfaces.

Selection is performed for an incoming virtual call if there is at least one idle logical channel, excluding one-way outgoing logical channels, available for virtual calls on any of the DTE/DCE interfaces in the group. Once a virtual call is assigned to a DTE/DCE interface, it is treated as a regular call.

When virtual calls are placed to a hunt group address in the case that specific addresses have also been assigned to the individual DTE/DCE interfaces, the *clear indication* packet (when no *call accepted* packet has been transmitted) or the *call connected* packet transferred to the calling DTE optionally will contain the called DTE address of the selected DTE/DCE interface and the *called line address modified notification* facility (see § 6.26) indicating the reason why the called DTE address is different from the one originally requested.

Virtual calls may be originated by the DTEs on DTE/DCE interfaces belonging to the hunt group; these are handled in the normal manner. In particular, the calling DTE address transferred to the remote DTE in the *incoming call* packet is the hunt group address unless the DTE/DCE interface has a specific address assigned. Permanent virtual circuits may be assigned to DTE/DCE interfaces belonging to the hunt group. These permanent virtual circuits are independent of the operation of the hunt group. Some networks may apply virtual call subscription time user facilities in common to all DTE/DCE interfaces in the hunt group, place a limit on the number of DTE/DCE interfaces in the hunt group, and/or constrain the size of the geographic region that can be served by a single hunt group.

6.25 *Call redirection and call deflection related facilities*

The set of call redirection and call deflection optional user facilities enables the redirection or the deflection of calls destined to one DTE (the "originally called DTE") to another DTE ("the alternative DTE"). The *call redirection* facility (see § 6.25.1) allows the DCE, in specific circumstances, to redirect calls destined to the originally called DTE; no *incoming call* packet is transmitted to the originally called DTE when such a redirection is performed. The call deflection related facilities (see § 6.25.2) allow the originally called DTE to deflect individual incoming virtual calls after reception of the *incoming call* packet by this originally called DTE. A DTE may subscribe to the *call redirection* facility, to the *call deflection subscription* facility, or to both.

When a call to which the *call redirection* or *call deflection* facilities are applied is cleared, the clearing cause shall be that generated during the last attempt to reach a called DTE/DCE interface.

Call redirection or call deflection is limited to the network of the DTE originally called.

The basic service is limited to one call redirection or call deflection. In addition, some networks may permit a chaining of several call redirections or call deflections. In all cases, networks will ensure that loops are avoided and that the connection establishment phase has a limited duration, consistent with the DTE time limit T21 (see Table D-2/X.25).

When the virtual call is redirected or deflected, the *clear indication* packet, when no *call accepted* packet has been transmitted by any DTE, or the *call connected* packet transferred to the calling DTE will contain the called address of the alternative DTE and the *called line address modified notification* facility (see § 6.26), indicating the reason why the called address is different from the one originally requested.

When the virtual call is redirected or deflected, some networks may indicate to the alternative DTE that the call was redirected or deflected, the reason for redirection or deflection, and the address of the originally called DTE, using the *call redirection or call deflection notification* facility (see § 6.25.3) in the *incoming call* packet.

Further information on the coding of the alternative DTE address is given in Appendix IV/X.25.

6.25.1 *Call redirection*

Call redirection is an optional user facility agreed for a period of time. This user facility, if subscribed to, redirects calls destined to this DTE when:

1) the DTE is out of order, or

2) the DTE is busy.

Some networks may provide call redirection only in case of 1). Some networks may offer, in addition:

3) systematic call redirection due to a prior request by the subscriber according to criteria other than 1) and 2) above, agreed to between the network and the subscriber.

In addition to the basic service, some networks may offer either one of the following (mutually exclusive) capabilities:

1) a list of alternative DTEs (C1, C2, . . .) is stored by the network of the originally called DTE (DTE B). Consecutive attempts of call redirection are tried to each of these addresses, in the order of the list, up to the completion of the call;

2) call redirections may be logically chained; if DTE C has subscribed to call redirection to DTE D, a call redirected from DTE B to DTE C may be redirected to DTE D; call redirections and call deflections may also be chained.

The order of call set-up processing at the originally called DCE as well as the alternative DCE will be according to the sequence of *call progress* signals in Table 1/X.96. For those networks that provide systematic call redirection due to a prior request by the subscriber, the systematic call redirection request will have the highest priority in the call set-up processing sequence at the originally called DCE.

6.25.2 *Call deflection related facilities*

6.25.2.1 *Call deflection subscription*

Call deflection subscription is an optional user facility agreed for a period of time. This facility, if subscribed to, enables the DTE to request, by using the *call deflection selection* facility (see § 6.25.2.2), that an individual call presented to it by transmission of an *incoming call* packet be deflected to an alternative DTE.

The DCE may use a network timer, with a value agreed to with the subscriber, to limit the time between the transmission to the originally called DTE or an *incoming call* packet and the request by this originally called DTE of deflecting the call. Once this timer has expired, the originally called DTE will no longer be permitted to use the *call deflection selection* facility to deflect the call. If the originally called DTE tries to deflect the call after the expiration of this internal timer, the network clears the call.

6.25.2.2 *Call deflection selection*

Call deflection selection is an optional user facility which may be used on a per virtual call basis. This facility may be requested by a DTE only if it has subscribed to the *call deflection subscription* facility (see § 6.25.2.1).

The *call deflection selection* facility (see §§ 7.2.1 and 7.2.2.10) may be used by the called DTE in the *clear request* packet only in direct response to an *incoming call* packet to specify the alternative DTE address to which the call is to be deflected. If the *call deflection selection* facility is used in the *clear request* packet, then the DTE must also include any CCITT- specified DTE facilities and user data to be sent to the alternative DTE. Up to 16 octets of user data may be included in the *clear request* packet in this case, if the original call was established without fast select; up to 128 octets of user data may be included in the *clear request* packet if the original call was established with fast select. If no CCITT-specified DTE facilities are included in the clear request packet, then there will be none in the incoming call packet to the alternative DTE. If no clear user data is included in the clear request packet, then no call user data will be included in the incoming call packet to the alternative DTE. When requested for a given virtual call, the network deflects the call to the alternative DTE and does not respond to the calling DTE as a result of the clearing of the originally called DTE/DCE interface. The X.25 facilities that are present in the *incoming call* packet transmitted to the alternative DTE are those that would have been present in the *incoming call* packet if the call was a direct call from the calling DTE to the alternative DTE; moreover, the *call redirection or call deflection notification* facility (see § 6.25.3) may also be present, if supported by the network.

Note – For an interim period, some networks may not allow a deflected *incoming call* packet's contents to be modified, in which case a deflecting DTE is not permitted to use any user data or CCITT-defined DTE facilities in the *clear request* packet.

The bit 7 of the General Format Identifier (see § 4.3.3) in the *incoming call* packet transmitted to the originally called DTE or the alternative DTE has the same value as the same bit in the *call request* packet.

If the network offers only the basic service and if a call redirection or call deflection has already been performed, the DCE clears the call as indicated in Annex C when the *call deflection selection* facility is used.

6.25.3 *Call redirection or call deflection notification*

Call redirection or call deflection notification is a user facility used by the DCE in the *incoming call* packet to inform the alternative DTE that the call has been redirected or deflected, why the call was redirected or deflected, and the address of the originally called DTE.

The following reasons can be indicated with the use of the *call redirection or call deflection notification* facility (see § 7.2.1 and 7.2.2.11):

1) call redirection due to originally called DTE out of order,

2) call redirection due to originally called DTE busy,

3) call redirection due to prior request from the originally called DTE for systematic call redirection,

4) call deflection by the originally called DTE.

Some networks may also use the following reason in network-dependent cases not described in this Recommendation:

5) call distribution within a hunt group.

6.26 *Called line address modified notification*

Called line address modified notification is an optional user facility used by the DCE in the *call connected* or *clear indication* packets (see §§ 7.2.1 and 7.2.2.12) to inform the calling DTE why the called DTE address in the packet is different from that specified in the *call request* packet.

When more than one address applies to a DTE/DCE interface, the *called line address modified notification* facility may be used by the DTE in the *clear request* packet (when no *call accepted* packet has been transmitted) or the *call accepted* packet, when the called DTE address is present in the packet and different from that specified in the *incoming call* packet. When this facility is received from the DTE, the DCE will clear the call if the called DTE address is not one of those applying to the interface.

Note – The DTE should be aware that a modification of any part of the called DTE address field, without notification by the *called line address modified notification* facility, may cause the call to be cleared.

The following reasons can be indicated with the use of the *called line address modified notification* facility in *call connected* or *clear indication* packets transmitted to the calling DTE:

1) call distribution within a Hunt Group,

2) call redirection due to originally called DTE out of order,

3) call redirection due to originally called DTE busy,

4) call redirection due to a prior request from the originally called DTE according to criteria agreed to between the network and the subscriber,

5) called DTE originated,

6) call deflection by the originally called DTE.

In *call accepted* or *clear request* packets, the reason indicated in conjunction with the use of the *called line address modified notification* facility should be "Called DTE originated".

When several reasons could apply to a same call, the reason to be indicated by the network in the *call connected* or the *clear indication* packet by means of the *called line address modified notification* facility is as specified below:

1) the indication of a call redirection or call deflection in the network has precedence over the indication of distribution within a hunt group or over a called DTE originated indication,
2) the called DTE originated indication has precedence over the indication of distribution within a hunt group,
3) when several call redirections or call deflections have been performed, the first one has precedence over the others.

The called DTE address indicated in the *call connected* or the *clear indication* packets should correspond to the last DTE which has been reached or attempted.

6.27 *Transit delay selection and indication*

Transit delay selection and indication is an optional user facility which may be requested by a DTE for a given virtual call. This facility permits selection and indication, on a per call basis, of the transit delay applicable to that virtual call as defined in § 4.3.8.

A DTE wishing to specify a desired transit delay in the *call request* packet for a virtual call indicates the desired value (see §§ 7.2.1 and 7.2.2.13).

The network, when able to do so, should allocate resources and route the virtual call in a manner such that the transit delay applicable to that call does not exceed the desired transit delay.

The *incoming call* packet transmitted to the called DTE and the *call connected* packet transmitted to the calling DTE, will both contain the indication of the transit delay applicable to the virtual call. This transit delay may be smaller than, equal to, or greater than the desired transit delay requested in the *call request* packet.

Note – During the interim period when this optional user facility is not yet supported by all networks, the indication of the transit delay applicable to the virtual call will not be provided in the *incoming call* packet transmitted to the called DTE, if either a transit network or the destination network does not support this facility.

6.28 TOA/NPI *address subscription*

TOA/NPI his facility is designated in Recommendation X.2 for further study (FS).

TOA/NPI *address subscription* is an optional user facility agreed for a period of time for virtual calls.

When this facility is subscribed to, the DCE and the DTE shall always use the TOA/NPI address format of the call set-up and clearing packets transmitted between the DCE and the DTE (see § 5.2.1).

When the DCE needs to transmit an *incoming call* packet to a DTE which has not been subscribed to this facility, and the calling DTE address to be transmitted in this packet cannot be contained in the non-TOA/NPI address format of the address block, the DCE will include no calling DTE address.

Note – Some Administrations may provide a subscription-time option of the TOA/NPI *address subscription* facility, allowing the user to indicate that the DCE shall clear the call with cause "incompatible destination" and a specific diagnostic in the case described in that last paragraph above, rather than include no calling DTE address.

7 Formats for facility fields and registration fields

7.1 *General*

The facility field is present only when a DTE is using an optional user facility requiring some indication in the *call request, incoming call, call accepted, call connected, clear request, clear indication* or *DCE clear confirmation* packet.

The registration field is present in a *registration request* packet only when the DTE wishes to request the DCE to agree or to stop a previous agreement for an optional user facility and is present in a *registration confirmation* packet when the DCE whishes to indicate which optional user facilities are available or which optional user facilities are currently in effect.

The facility/registration field contains one or more facility/registration elements. The first octet of each facility/registration element contains a facility/registration code to indicate the facility or facilities requested/negociated.

The facility/registration codes are divided into four classes, by making use of bits 8 and 7 of the facility/registration code field, in order to specify facility/registration parameters consisting of 1, 2, 3 or a variable number of octets. The general class coding of the facility/registration code field is shown in Table 28/X.25.

TABLE 28/X.25

General class coding for facility/registration code fields

Bits	8	7	6	5	4	3	2	1	
Class A	0	0	X	X	X	X	X	X	for single octet parameter field
Class B	0	1	X	X	X	X	X	X	for double octet parameter field
Class C	1	0	X	X	X	X	X	X	for triple octet parameter field
Class D	1	1	X	X	X	X	X	X	for variable length parameter field

For class D the octet following the facility/registration code indicates the length, in octets, of the facility/registration parameter field. The facility/registration parameter field length is binary coded and bit 1 is the low order bit of this indicator.

The formats for the four classes are shown in Figure 23/X.25.

The facility/registration code field is binary coded and, without extension, provides for a maximum of 64 facility/registration codes for classes A, B and C and 63 facility/registration codes for class D giving a total of 255 facility/registration codes.

Facility/registration code 11111111 is reserved for extension of the facility/registration code. The octet following this octet indicates an extended facility/registration code having the format A, B, C and D as defined above. Repetition of facility/registration code 11111111 is permitted and additional extensions thus result.

The coding of the facility/registration parameter field is dependent on the facility being requested/negociated.

A facility/registration code may be assigned to identify a number of specific facilities, each having a bit in the parameter field indicating facility requested/facility not requested. In this situation, the parameter field is binary encoded with each bit position relating to a specific facility. A 0 indicates that the facility related to the particular bit is not requested and a 1 indicates that the facility related to the particular bit is requested. Parameter bit positions not assigned to a spectific facility are set to zero. If none of the facilities represented by the facility/registration code are requested for a virtual call or for on-line facility registration, the facility/registration code and its associated parameter field need not be present.

In addition to the facility/registration codes defined in § 7, other codes may be used for:

– non-X.25 facilities which may be provided by some network(s) (*call set-up* and *registration* packets);

– CCITT-specified DTE facilities as described in Annex G of this Recommendation (*call set-up, clear request* and *clear indication* packets).

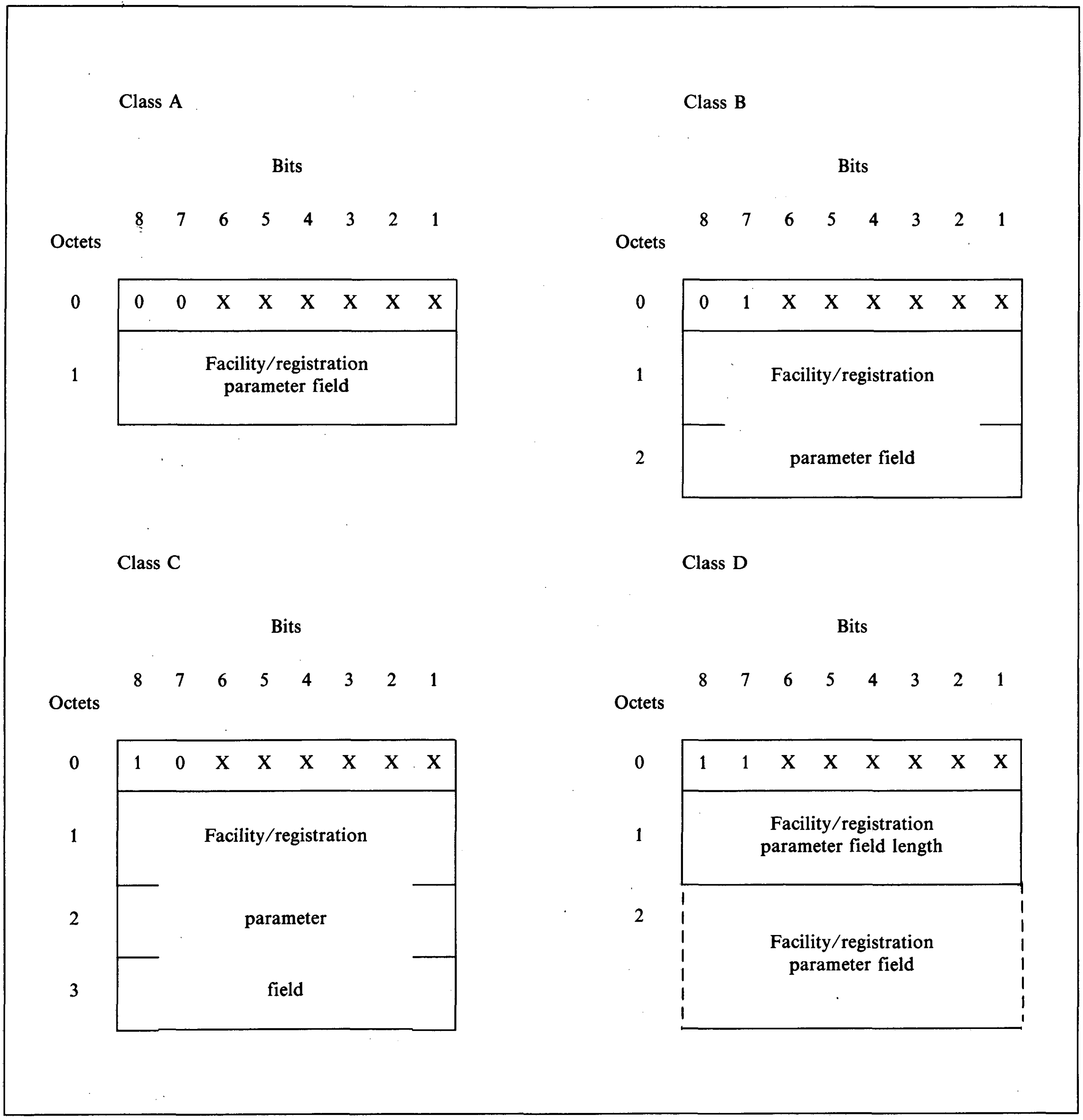


FIGURE 23/X.25

Facility/registration element general formats

Facility/registration markers, consisting of a single octet pair, are used to separate requests for X.25 facilities as defined in §§ 6 and 7 from other categories as defined above, and, when several categories of facilities are simultaneously present, to separate these categories from each other.

The first octet of the marker is a facility/registration code field and is set to zero. The second octet is a facility/registration parameter field.

The facility/registration parameter field of a marker is set to zero when the marker precedes requests for:

- registration codes specific to the local network (*registration* packets);
- non-X.25 facilities provided by the network in case of intranetwork calls (*call set-up* packets);
- non-X.25 facilities provided by the network to which the calling DTE is connected, in case of internetwork calls (*call set-up* packets).

The facility parameter field of a marker is set to all ones when the marker precedes requests for non-X.25 facilities provided by the network to which the called DTE is connected, in case of internetwork calls (*call set-up* packets).

The facility parameter field of a marker is set to 00001111 when the marker precedes requests for CCITT-specfied DTE facilities.

All networks will support the facility markers with a facility parameter field set to all ones or to 00001111.

DTEs should not use a facility marker with a facility parameter field set to all ones in case of intranetwork calls. However, if a DTE uses such a marker in an intranetwork call, the DCE is not obliged to clear the call, and the marker, with the corresponding facility requests, may be transmitted to the remote DTE.

Facility/registration codes for X.25 facilities and for the other categories of facilities may be simultaneously present. However, requests for X.25 facilities must precede the other requests, and requests for CCITT-specified DTE facilities must follow the other requests.

The coding of CCITT-specified DTE facilities should comply with the description in Annex G. However, the DCE is not required to verify that compliance. If the network verifies that compliance and finds an error, it may clear the call with the cause "Invalid facility request". The CCITT-specified DTE facilities are passed unchanged by public data networks between the two packet-mode DTEs.

7.2 *Coding of facility field in call set-up and clearing packets*

The coding of the facility code field and the format of the facility parameter field are the same in the various *call set-up* and *clearing* packets in which they are used.

7.2.1 *Coding of the facility code fields*

Table 29/X.25 gives the coding of the facility code fields and the packet types in which they may be present.

7.2.2 *Coding of the facility parameter fields*

7.2.2.1 *Flow control parameter negotiation facility*

7.2.2.1.1 *Packet size*

The packet size for the direction of transmission from the called DTE is indicated in bits 4, 3, 2 and 1 of the first octet of the facility parameter field. The packet size for the direction of transmission from the calling DTE is indicated in bits 4, 3, 2 and 1 of the second octet. Bits 8, 7, 6 and 5 of each octet must be zero.

The four bits indicating each packet size are binary coded and express the logarithm base 2 of the number of octets of the maximum packet size.

Networks may offer values from 4 to 12, corresponding to packet sizes of 16, 32, 64, 126, 256, 512, 1024, 2048 or 4096, or a contiguous subset of these values. All Administrations will provide a packet size of 128.

7.2.2.1.2 *Window size*

The window size for the direction of transmission from the called DTE is indicated in bits 7 to 1 of the first octet of the facility parameter field. The window size for the direction of transmission from the calling DTE is indicated in bits 7 to 1 of the second octet. Bit 8 of each octet must be zero.

The bits indicating each window size are binary coded and express the size of the window. A value of zero is not allowed.

TABLE 29/X.25

Coding of the facility code field

Facility	Packet types in which it may be used							Facility code bits
	Call request	Incoming call	Call accepted	Call connected	Clear request	Clear indication	DCE clear confirmation	8 7 6 5 4 3 2 1
Flow control parameter negotiation: – packet size – window size	X	X	X	X				 0 1 0 0 0 0 1 0 0 1 0 0 0 0 1 1
Throughput class negotiation	X	X	X	X				0 0 0 0 0 0 1 0
Closed user group selection: – basic format – extended format	X	X						 0 0 0 0 0 0 1 1 0 1 0 0 0 1 1 1
Closed user group with outgoing access selection: – basic format – extented format	X	X						 0 0 0 0 1 0 0 1 0 1 0 0 1 0 0 0
Bilateral closed user group selection	X	X						0 1 0 0 0 0 0 1
Reverse charging	X	X						0 0 0 0 0 0 0 1 (see Note 1)
Fast select	X	X						
NUI selection	X		X (see Note 2)					1 1 0 0 0 1 1 0

TABLE 29/X.25 *(cont.)*

Facility	Packet types in which it may be used							Facility code bits							
	Call request	Incoming call	Call accepted	Call connected	Clear request	Clear indication	DCE clear confirmation	8	7	6	5	4	3	2	1
Charging information:															
– requesting service	X		X					0	0	0	0	0	1	0	0
– receiving information:						X	X								
i) monetary unit								1	1	0	0	0	1	0	1
ii) segment count								1	1	0	0	0	0	1	0
iii) call duration								1	1	0	0	0	0	0	1
RPOA selection:	X														
– basic format								0	1	0	0	0	1	0	0
– extended format								1	1	0	0	0	1	0	0
Call deflection selection					X (see Note 4)			1	1	0	1	0	0	0	1
Call redirection or deflection notification		X						1	1	0	0	0	0	1	1
Called line address modified notification			X (see Note 3)	X	X (see Notes 3 and 4)	X		0	0	0	0	1	0	0	0
Transit delay selection and indication	X	X		X				0	1	0	0	1	0	0	1
Marker (see § 7.1)	X	X	X	X	X	X		0	0	0	0	0	0	0	0
Reserved for extension								1	1	1	1	1	1	1	1

Note 1 – This facility code and associated facility parameter will be present in the *incoming call* packet if either or both of *reverse charging* (if *reverse charging acceptance* is subscribed to) or *fast select* (if *fast select acceptance* is subscribed to) is indicated. They may, but need not, be present if neither *reverse charging acceptance* nor *fast select acceptance* are subscribed to.

Note 2 – This facility code and associated facility parameter may be present in *call accepted* packet only in conjunction with the *NUI subscription* facility (see § 6.21.3).

Note 3 – Only when the reason "Called DTE originated" is used in the parameter field (see §§ 6.26 and 7.2.2.12).

Note 4 – The DTE is not allowed to use both *call deflection selection* and *called line address modified notification* facilities in the same *clear request* packet.

Window sizes of 8 to 127 are only valid if extended sequence numbering is used (see § 6.2). The ranges of contiguous values allowed by a network for calls with normal numbering and extended numbering are network dependent. All Administrations will provide a window size of 2.

7.2.2.2 *Throughput class negotiation facility*

The throughput class for the direction of data transmission from the called DTE is indicated in bits 8, 7, 6 and 5. The throughput class for the direction of data transmission from the calling DTE is indicated in bits 4, 3, 2 and 1.

The four bits indicating each throughput class are binary coded and correspond to throughput classes as indicated in Table 30/X.25.

TABLE 30/X.25

Coding of throughput classes

Bits: or Bits:	4 / 8	3 / 7	2 / 6	1 / 5	Throughput class (bit/s)
	0	0	0	0	Reserved
	0	0	0	1	Reserved
	0	0	1	0	Reserved
	0	0	1	1	75
	0	1	0	0	150
	0	1	0	1	300
	0	1	1	0	600
	0	1	1	1	1 200
	1	0	0	0	2 400
	1	0	0	1	4 800
	1	0	1	0	9 600
	1	0	1	1	19 200
	1	1	0	0	48 000
	1	1	0	1	64 000
	1	1	1	0	Reserved
	1	1	1	1	Reserved

7.2.2.3 *Closed user group selection facility*

7.2.2.3.1 *Basic format*

The index to the closed user group selected for the virtual call is in the form of two decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 being the low order bit of the first digit and bit 1 being the low order bit of the second digit.

Indexes to the same closed user group at different DTE/DCE interfaces may be different.

7.2.2.3.2 *Extended format*

The index to the closed user group selected for the virtual call is in the form of four decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 of the first octet being the low order bit of the first digit, bit 1 of the first octet being the low order bit of the second digit, bit 5 of the second octet being the low order bit of the third digit and bit 1 of the second octet being the low order bit of the fourth digit.

Indexes to the same closed user group at different DTE/DCE interfaces may be different.

7.2.2.4 *Closed user group with outgoing access selection facility*

7.2.2.4.1 *Basic format*

The index to the closed user group selected for the virtual call is in the form of two decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 being the low order bit of the first digit and bit 1 being the low order bit of the second digit.

Indexes to the same closed user group at different DTE/DCE interfaces may be different.

7.2.2.4.2 *Extended format*

The index to the closed user group selected for the virtual call is in the form of four decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 of the first octet being the low order bit of the first digit, bit 1 of the first octet being the low order bit of the second digit, bit 5 of the second octet being the low order bit of the third digit, and bit 1 of the second octet being the low order bit of the fourth digit.

Indexes to the same closed user group at different DTE/DCE interfaces may be different.

7.2.2.5 *Bilateral closes user group selection facility*

The index to the bilateral closed user group selected for the virtual call is in the form of 4 decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 of the first octet being the low order bit of the first digit, bit 1 of the first octet being the low order bit of the second digit, bit 5 of the second octet being the low order bit of the third digit, and bit 1 of the second octet being the low order bit of the fourth digit.

Indexes to the same bilateral closed user group at different DTE/DCE interfaces may be different.

7.2.2.6 *Reverse charging and fast select facilities*

The coding of the facility parameter field is:

Bit 1 = 0 for reverse charging not requested

Bit 1 = 1 for reverse charging requested

Bit 8 = 0 and bit 7 = 0 or 1 for fast select not requested

Bit 8 = 1 and bit 7 = 0 for fast select requested with no restriction on response

Bit 8 = 1 and bit 7 = 1 for fast select requested with restriction on response

Note – Bits 6, 5, 4, 3 and 2 may be assigned to other facilities in the future; presently, they are set to 0.

7.2.2.7 *NUI selection facility*

The octet following the facility code field indicates the length, in octets, of the facility parameter field. The following octets contain the network user identifier, in a format determined by the network administration.

7.2.2.8 *Charging information facility*

7.2.2.8.1 *Parameter field for requesting service*

The coding of the facility parameter field is:

Bit 1 = 0 for charging information not requested

Bit 1 = 1 for charging information requested

Note – Bits 8, 7, 6, 5, 4, 3 and 2 may be assigned to other facilities in the future; presently, they are set to 0.

7.2.2.8.2 *Parameter field indicating monetary unit*

The octet following the facility code field indicates the length, in octets, of the facility parameter field.

The parameter field indicates the charging. The coding of the parameter is for further study.

7.2.2.8.3 *Parameter field indicating segment count*

The octet following the facility code field indicates the length, in octets, of the facility parameter field and has the value $n \times 8$ where n is the number of different tariff periods managed by the network.

For each tariff period, the first four octets of the facility parameter field indicate the number of segments sent to the DTE. The following four octets indicate the number of segments received from the DTE.

Each digit is coded in a semi-octet in binary coded decimal and bit 1 or bit 5 of each semi-octet is the low order bit of each digit and bits 4 to 1 of the last octet represent the lowest order digit of the segment count.

Segment size and the specific packet types to be counted are a matter of the Administration in the case of national calls and are specified in Recommendation D.12 for international calls.

Note – The relationship between a particular tariff period and its place in the parameter field is a national matter. The order is given by each Administration.

7.2.2.8.4 *Parameter field indicating call duration*

The octet following the facility code field indicates the length, in octets, of the facility parameter field and has the value $n \times 4$ where n is the number of different tariff periods managed by the network.

For each tariff period, the first octet of the facility parameter field indicates number of days, the second indicates number of hours, the third indicates number of minutes and the fourth indicates number of seconds. Each digit is coded in a semi-octet in binary coded decimal and bit 1 or bit 5 of each semi-octet is the low order bit of each digit. Bits 4 to 1 of each octet represent the low order digit.

Note – The relationship between a particular tariff period and its place in the parameter field is a national matter. The order is given by each Administration.

7.2.2.9 *RPOA selection facility*

7.2.2.9.1 *Basic format*

The parameter field contains the data network identification code for the requested initial RPOA transit network and is in the form of four decimal digits.

Each digit is coded in a semi-octet in binary coded decimal with bit 5 of the first octet being the low order bit of the first digit, bit 1 of the first octet being the low order bit of the second digit, bit 5 of the second octet being the low order bit of the third digit, and bit 1 of the second octet being the low order bit of the fourth digit.

7.2.2.9.2 *Extended format*

The octet following the facility code field indicates the length, in octets, of the facility parameter field and has the value $n \times 2$, where n is the number of RPOA transit networks selected.

Each RPOA transit network is indicated by a data network identification code, and is in the form of four decimal digits. Each digit is coded in a semi-octet in binary coded decimal with bit 5 of the first octet being the low order bit of the first digit, bit 1 of the first octet being the low order bit of the second digit, bit 5 of the second octet being the low order bit of the third digit, and bit 1 of the second octet being the low order of the fourth digit.

RPOA transit network should appear in the facility parameter field in the order that the calling DTE wishes them to be traversed.

7.2.2.10 *Call deflection selection facility*

The octet following the facility code indicates the length, in octets, of the facility parameter field and has the value $n + 2$, where n is the number of octets necessary to hold the called address of the DTE to which the call is to be deflected (the alternative DTE).

The first octet of the facility parameter field indicates the reason for the DTE deflecting the call. The coding of this octet is:

bits:	8 7 6 5 4 3 2 1
or	1 1 X X X X X X

Note – Each X may be independently set to 0 of 1 by the called DTE and is passed transparently to the DTE to which the call is deflected. If bits 8 and 7 are not set to 1 by the called DTE, they are forced to this value by the DCE.

The second octet indicates the number of semi-octets in the alternative DTE address. This address length indicator is binary coded and bit 1 is the low order bit. Its value is limited to 15 when the A bit is set to 0 (see § 5.2.1), to 17 when the A bit is set to 1.

The following octets contains the alternative DTE address, using coding which corresponds to the coding of the called DTE address field in the address block (see § 5.2.1). When the number of semi-octets of the alternative DTE address is odd, a semi-octet with zeros in bits 4, 3, 2 and 1 will be inserted after the last semi-octet in order to maintain octet alignment.

7.2.2.11 call redirection *or call deflection notification facility*

The octet following the facility code field indicates the length, in octets, of the facility parameter field and has the value $n + 2$, where n is the number of octets necessary to hold the originally called DTE address.

The first octet of the facility parameter field indicates the reason for the call redirection of call deflection. The coding of this octet is given in Table 31/X.25.

TABLE 31/X.25

Coding of the reason in the call redirection or call deflection notification facility parameter field

	Bits							
	8	7	6	5	4	3	2	1
Originally called DTE busy	0	0	0	0	0	0	0	1
Call distribution within a hunt group [a]	0	0	0	0	0	1	1	1
Originally called DTE out of order	0	0	0	0	1	0	0	1
Systematic call redirection	0	0	0	0	1	1	1	1
Call deflection by the originally called DTE [b]	1	1	X	X	X	X	X	X

[a] This value may be used by some networks for network-dependent reasons not described in this Recommendation.

[b] The Xs are those set by the originally called DTE in the *call deflection selection* facility (see § 7.2.2.10).

The second octet indicates the number of semi-octets in the originally called DTE address. This address length indicator is binary coded and bit 1 is the low order bit. Its value is limited to 15 when the A bit is set to 0 (see § 5.2.1), to 17 when the A bit is set to 1.

The following octets contain the originally called DTE address. When both the calling DTE and the alternative DTE have subscribed to the *TOA/NPI address subscription* facility (see § 6.2.8), or when none of them have subscribed to this facility, the originally called DTE address is coded identically to the called DTE address field in the *call request* packet. When these conditions are not satisfied, the network converts from one address format to the other (see § 5.2.1). When the number of semi-octets of the originally added DTE address is odd, a semi-octet with zeros in bits 4, 3, 2 and 1 will be inserted after the last semi-octet in order to maintain octet alignment.

7.2.2.12 *Called line address modified notification facility*

The coding of the facility parameter field for *called line address modified notification* is given in Table 32/X.25.

TABLE 32/X.25

Coding of the parameter field for called line address modified notification facility

	Bits							
	8	7	6	5	4	3	2	1
Call redirection due to originally called DTE busy	0	0	0	0	0	0	0	1
Call distribution within a hunt group	0	0	0	0	0	1	1	1
Call redirection due to originally called DTE out of order	0	0	0	0	1	0	0	1
Call redirection due to prior request from originally called DTE for systematic call redirection	0	0	0	0	1	1	1	1
Called DTE originated [a)]	1	0	X	X	X	X	X	X
Call deflection by the originally called DTE [b)]	1	1	X	X	X	X	X	X

[a)] Each X may be independently set to 0 or 1 by the called DTE and is passed transparently to the calling DTE. Bit 8, when received from the called DTE, and when it is not set to 1, is forced to 1 by the DCE.

[b)] The Xs are those set by the originally called DTE in the *call deflection selection* facility (see § 7.2.2.10).

7.2.2.13 *Transit delay selection and indication facility*

This parameter is two octets. Transit delay is expressed in milliseconds, binary coded, with bit 8 of octet 1 being the high order bit and bit 1 of octet 2 being the low order bit. The expressed transit delay may have a value from 0 to 65 534 (all bits set to 1 but the low order bit).

Note – During the interim period when this optional user facility is not yet supported by all networks, the transit delay indicated in the *call connected* packet transmitted to the calling DTE should have a value of 65 535 (all ones) when either a transit network involved in the virtual call or the destination network does not support this facility. So, this value should be interpreted by the calling DTE as an indication that the actual transit delay cannot be transmitted to it.

7.3 *Coding of the registration field of registration packets*

The coding of the registration code field and the format of the registration parameter field are the same in *registration request* packets and *registration confirmation* packets in which they are used.

7.3.1 *Coding of the registration code fields*

Table 33/X.25 gives the coding of the registration code field and the registration code field and the packet types in which they may be present.

TABLE 33/X.25

Coding of the registration code field

Facility	May be used in:		Registration code							
	registration request	registration confirmation	Bits							
			8	7	6	5	4	3	2	1
Facilities that may be negotiated only when all logical channels used for virtual calls are in state *p1*	X	X	0	0	0	0	0	1	0	1
Facilities that may be negotiated at any time	X	X	0	1	0	0	0	1	0	1
Availability of facilities		X	0	1	0	0	0	1	1	0
Non-negotiable facility values		X	0	0	0	0	0	1	1	0
Default throughput classes assignment	X	X	0	0	0	0	0	0	1	0
Non-standard default packet sizes	X	X	0	1	0	0	0	0	1	0
Non-standard default window sizes	X	X	0	1	0	0	0	0	1	1
Logical channel type ranges	X	X	1	1	0	0	1	0	0	0

Note – Whether or not the *call redirection* facility may be negotiated requires further study.

The absence of a registration code in a *registration request* packet means that the DTE does not want to modify the previous agreement for the concerned facility(ies).

The absence of a registration code in a *registration confirmation* packet means that the concerned facility(ies) is not supported by the DCE or is not permitted by the DCE to be negociated by the *on-line facility registration* facility.

DTEs and DCEs should discard registration elements with registration codes that they do not support or do not know.

7.3.2 *Coding of the registration parameter fields*

7.3.2.1 *Facilities that may be negotiated only when all logical channels used for virtual calls are in state p1*

Each one of the following bits of the registration parameter field corresponds to one facility that may be negotiated only when all logical channels for virtual calls are in state *p1* (see annex F), and that needs only a single bit value to indicate its value. The correspondence between bits and facilities is given in Table 34/X.25.

TABLE 34/X.25

Correspondence between bits and facilities for the registration parameter field corresponding to facilities that may be negotiated only when all logical channels used for virtual calls are in state p1

Bit number	Facility corresponding to the bit
8 7 6 5 4	Reserved for future use (see Note 1)
3	*D bit modification* facility
2	*Packet retransmission* facility
1	*Extended packet sequence numbering* facility (see Note 2)

Note 1 – Bits 8, 7, 6, 5 and 4 should be ignored when received and set to 0 when transmitted by DTE or DCE.

Note 2 – Further study is needed to determine the exact method to negotiate this facility.

A bit set to 1/0 in a *registration request* packet means that the DTE asks for the DCE to invoke/revoke the corresponding facility.

A bit set to 1/0 in a *registration confirmation* packet means that the corresponding facility is invoked/revoked by the DCE.

7.3.2.2 *Facilities that may be negotiated at any time*

Each one of the following bits of the registration parameter field corresponds to one facility that may be negotiated at any time (see Annex F). The correspondence between bits and facilities is given in Table 35/X.25.

A bit set to 1/0 in a *registration request* packet means that the DTE asks for the DCE to invoke/revoke the corresponding facility.

A bit set to 1/0 in a *registration confirmation* packet means that the corresponding facility is invoked/revoked by the DCE.

7.3.2.3 *Availability of facilities*

Each one of the following bits of the registration parameter field corresponds to one facility whose availability must be indicated to the DTE. The correspondence between bits and facilities is given in Table 36/X.25.

A bit set to 1/0 by the DCE in a *registration confirmation* packet means that the corresponding facility is available/not available for use by the DTE, or negotiable/not negotiable by the DTE.

7.3.2.4 *Non-negotiable facilities values*

Each one of the following bits of the registration parameter field corresponds to one facility which is not available for negotiation but whose value should be indicated to the DTE.

Bit 1: *Local charging prevention* facility

Note – Bits 8, 7, 6, 5, 4, 3 and 2 should be ignored when received by the DTE and set to 0 when transmitted by the DCE.

TABLE 35/X.25

Correspondence between bits and facilities for the registration parameter field corresponding to facilities that may be negotiated at any time

Octet number	Bit number	Facility corresponding to the bit
1	8	Reserved for future use (see Note)
	7	*Charging information* facility (per interface basis)
	6	*Throughput classe negotiation* facility
	5	*Flow control parameter negotiation* facility
	4	*Reverse charging acceptance* facility
	3	*Fast select acceptance* facility
	2	*Outgoing calls barred* facility
	1	*Incoming calls barred* facility
2	1 to 8	Reserved for future use (see Note)

Note – Bit 8 of octet 1 and bits 8, 7, 6, 5, 4, 3, 2 and 1 of octet 2 should be ignored when received and set to 0 when transmitted by the DTE or DCE.

TABLE 36/X.25

Correspondence between bits and facilities for the registration parameter field indicating availability of facilites

Octet number	Bit number	Facility corresponding to the bit
1	8	*Reverse charging* facility (see Note 1)
	7	*Reverse charging acceptance* facility
	6	*Charging information* facility (per call basis) (see Note 1)
	5	*Charging information* facility (per interface basis)
	4	*Called line address modified notification* facility (see Note 1)
	3	*D bit modification* facility
	2	*Packet retransmission* facility
	1	*Extended packet sequence numbering* facility
2	8 7 6	Reserved for future use (see Note 2)
	5	*RPOA selection* facility (see Note 1)
	4	*Logical channel type ranges* registration facility
	3	*Non-standard default packet size* registration facility
	2	*Non-standard default window size* registration facility
	1	*Default throughput classes assignment* registration facility

Note 1 – A bit set to 1/0 for the corresponding facility indicates that it is available for use by the DTE; no further negotiation is required for these facilities.

Note 2 – Bits 8, 7 and 6 of octet 2 should be ignored when received by the DTE and set to 0 when transmitted by the DCE.

A bit is set to 1/0 in a *registration confirmation* packet when the DCE has invoked/revoked the corresponding facility.

7.3.2.5 *Default throughput classes*

The throughput class for the direction of data transmission from the DTE is indicated in bits 8, 7, 6 and 5. The throughput class for the direction of data transmission from the DCE is indicated in bits 4, 3, 2 and 1.

The four bits indicating each throughput class are binary coded and correspond to throughput classes as indicated in Table 30/X.25 (see § 7.2.2.2).

Note – Registration applies only to facility values for virtual calls; it does not apply to facility values for permanent virtual circuits.

7.3.2.6 *Non-standard default packet sizes*

The packet size for the direction of data transmission from the DCE is indicated in bits 4, 3, 2 and 1 of the first octet. The packet size for the direction of data transmission from the DTE is indicated in bits 4, 3, 2 and 1 of the second octet. Bits 8, 7, 6 and 5 of each octet must be zero.

The four bits indicating each packet size are binary coded and express the logarithm base 2 of the number of octets of the maximum packet size.

Networks may offer values from 4 to 12, corresponding to packet sizes of 16, 32, 64, 128, 256, 512, 1024, 2048 or 4096, or a subset of these values. All Administrations will provide a packet size of 128.

Note – Registration applies only to facility values for virtual calls; it does not apply to facility values for permanent virtual circuits.

7.3.2.7 *Non-standard default window sizes*

The window size for the direction of data transmission from the DCE is indicated in bits 7 to 1 of the first octet. The window size for the direction of data transmission from the DTE is indicated in bits 7 to 1 of the second octet. Bit 8 of each octet must be zero.

The bits indicating each window size are binary coded and express the size of the window. A value of zero is not allowed.

Window sizes of 8 to 127 are only valid when extended sequence numbering is used. The ranges of values allowed by a network are network dependent. All Administrations will provide a window size of 2.

Note – Registration applies only to facility values for virtual calls; it does not apply to facility values for permanent virtual circuits.

7.3.2.8 *Logical channel types ranges*

The octet following the registration code field indicates the length, in octets, of the registration parameter field and shall indicate 14 octets.

Bits 4, 3, 2 and 1 of octets 1, 3, 5, 7, 9 and 11 of registration parameter field shall contain the logical channel group number for parameters LIC, HIC, LTC, HTC, LOC and HOC, respectively (see Annex A). Bits 8, 7, 6 and 5 of these octets must be set to zero.

Octets 2, 4, 6, 8, 10 and 12 of the registration parameter field shall contain the logical channel numbers for parameters LIC, HIC, LTC, HTC, LOC and HOC, respectively (see Annex A).

No one-way incoming logical channels is represented by LIC and HIC both equal to zero; no two-way logical channels is represented by LTC and HTC both equal to zero; and no one-way outgoing logical channels is represented by LOC and HOC both equal to zero.

Bits 4, 3, 2 and 1 of octet 13 of the registration parameter field shall contain the high order bits of the total number of logical channels to be used for virtual calls. Bits 8, 7, 6 and 5 of octet 13 must be set to zero. Octet 14 of the registration parameter field shall contain the low order bits of the total number of logical channels to be used for virtuals calls.

Note 1 – The inequalites of Annex A must apply to non-zero values of LIC, HIC, LTC, HTC, LOC and HOC.

Note 2 – The total number of logical channels to be used for virtual calls as indicated in octets 13 and 14 is equal to the sum of the number of one-way incoming logical channels, two-way logical channels and one-way outgoing logical channels.

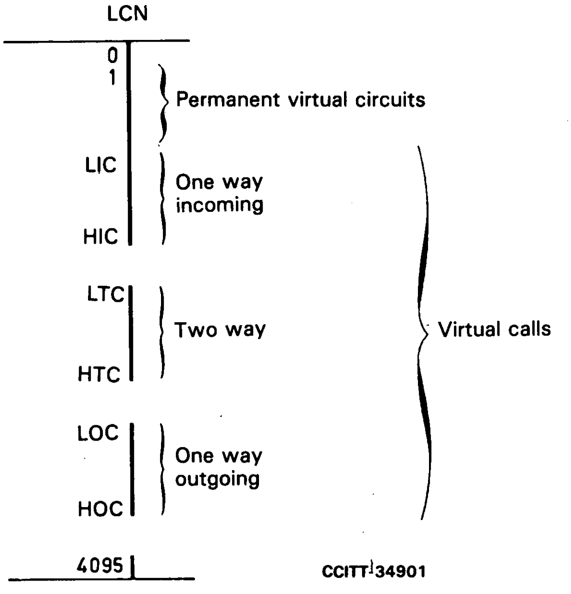
ANNEX A

(to Recommendation X.25)

Range of logical channels used for virtual calls and permanent virtual circuits

In the case of a single logical channel DTE, logical channel 1 will be used.

For each multiple logical channel DTE/DCE interface, a range of logical channels will be agreed upon with the Administration according to Figure A-1/X.25.



LCN Logical channel number
LIC Lowest incoming channel
HIC Highest incoming channel
LTC Lowest two-way channel
HTC Highest two-way channel
LOC Lowest outgoing channel
HOC Highest outgoing channel

Logical channels 1 to LIC-1: range of logical channels which may be assigned to permanent virtual circuits.
Logical channels LIC to HIC: range of logical channels which are assigned to one-way incoming logical channels for virtual calls (see § 6.8).
Logical channels LTC to HTC: range of logical channels which are assigned to two-way logical channels for virtual calls.
Logical channels LOC to HOC: range of logical channels which are assigned to one-way outgoing logical channels for virtual calls (see § 6.7).
Logical channels HIC + 1 to LTC − 1, HTC + 1 to LOC − 1, and HOC + 1 to 4095 are non-assigned logical channels.

Note 1 — The reference to the number of logical channels is made according to a set of contiguous numbers from 0 (lowest) to 4095 (highest) using 12 bits made up of the 4 bits of the logical channel group number (see § 5.1.2) and the 8 bits of the logical channel number (see § 5.1.3). The numbering is binary coded using bit positions 4 through 1 of octet 1 followed by bit positions 8 through 1 of octet 2 with bit 1 of octet 2 as the low order bit.

Note 2 – All logical channel boundaries are agreed with the Administration for a period of time.

Note 3 – In order to avoid frequent rearrangement of logical channels, not all logical channels within the range for permanent virtual circuits are necessarily assigned.

Note 4 — In the absence of permanent virtual circuits, logical channel 1 is available for LIC. In the absence of permanent virtual circuits and one-way incoming logical channels, logical channel 1 is available for LTC. In the absence of permanent virtual circuits, one-way incoming logical channels and two-way logical channels, logical channel 1 is available for LOC.

Note 5 — The DCE search algorithm for a logical channel for a new incoming call will be to use the lowest logical channel in the *ready* state in the range of LIC to HIC and LTC to HTC.

Note 6 – In order to minimize the risk of call collision, the DTE search algorithm is suggested to start with the highest numbered logical channel in the *ready* state. The DTE could start with the two-way logical channel or one-way outgoing logical channel ranges.

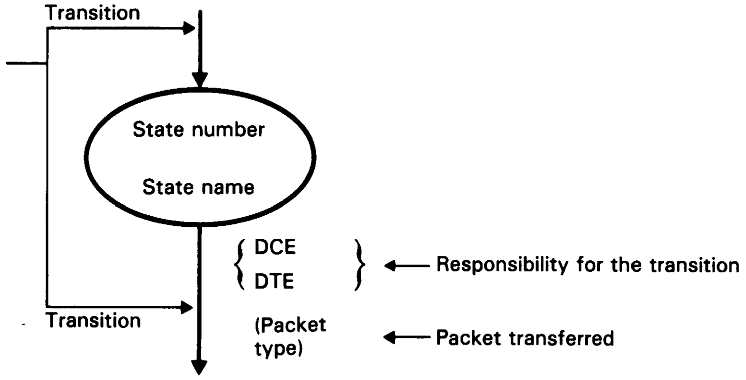
FIGURE A-1/X.25

ANNEX B

(to Recommendation X.25)

Packet layer DTE/DCE interface state diagrams

B.1 *Symbol definition of the state diagrams*



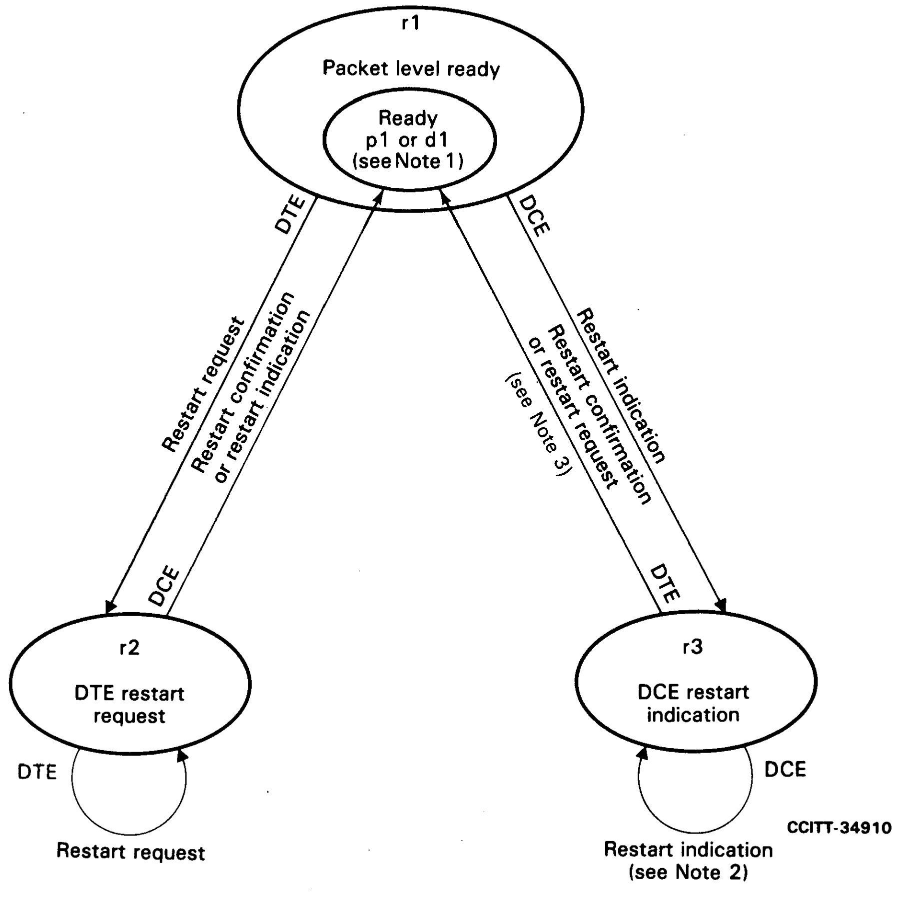
Note 1 – Each state is represented by an ellipse wherein the state name and number are indicated.

Note 2 – Each state transition is represented by an arrow. The responsibility for the transition (DTE or DCE) and the packet that has been transferred is indicated beside that arrow.

B.2 *Order definition of the state diagrams*

For the sake of clarity, the normal procedure at the interface is described in a number of small state diagrams. In order to describe the normal procedure fully, it is necessary to allocate a priority to the different figures and to relate a higher order diagram with a lower one. This has been done by the following means:

- The figures are arranged in order of priority with Figure B-1/X.25 (restart) having the highest priority and subsequent figures having lower priority. Priority means that when a packet belonging to a higher order diagram is transferred, that diagram is applicable and the lower order one is not.
- The relation with a state in a lower order diagram is given by including that state inside an ellipse in the higher order diagram.



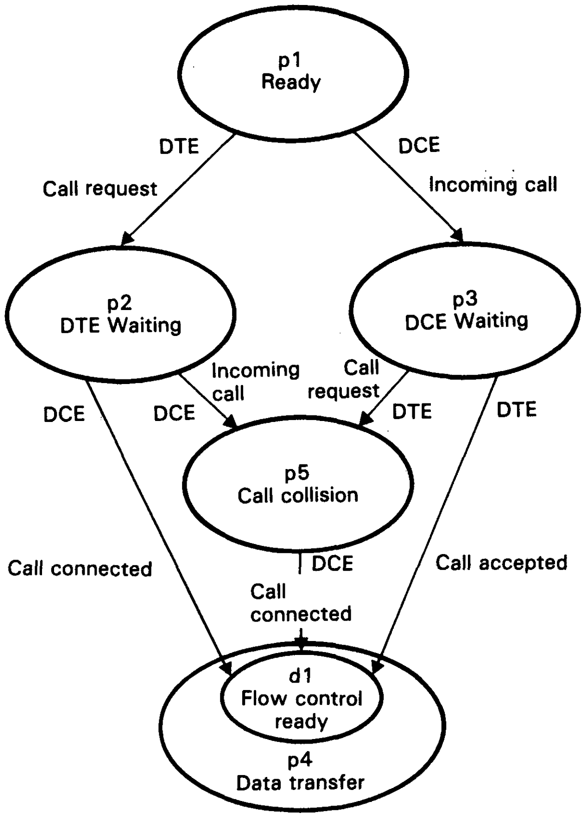
Note 1 – State p1 for virtual calls or state d1 for permanent virtual circuits.

Note 2 – This transition takes place after time-out T10 expires the first time.

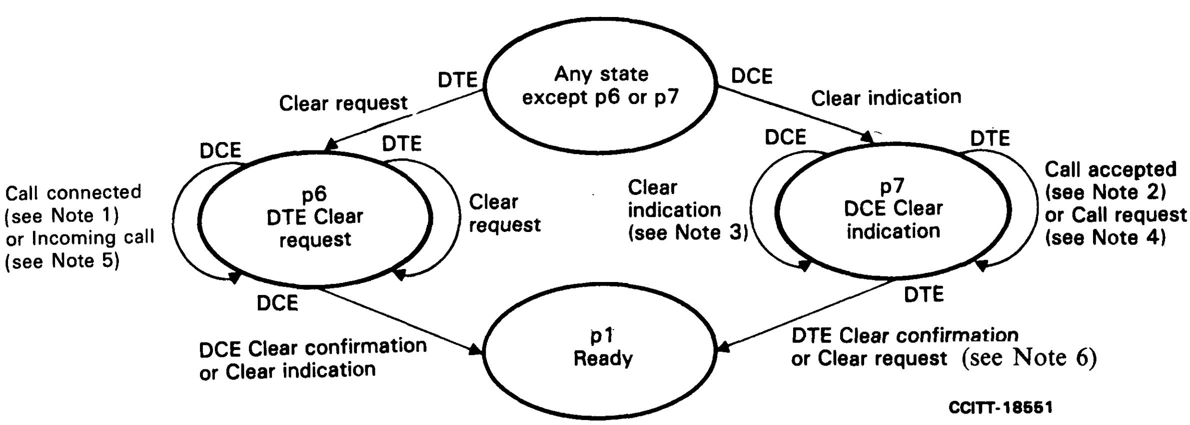
Note 3 – This transition also takes place after time-out T10 expires the second time (without transmission of any packet, except, possibly, a diagnostic packet).

FIGURE B-1/X.25

Diagram of states for the transfer of restart packets



a) *Call set-up phase*



b) *Call clearing phase*

Note 1 — This transition is possible only if the previous state was *DTE Waiting* (p2).

Note 2 — This transition is possible only if the previous state was *DCE Waiting* (p3).

Note 3 — This transition takes place after time-out T13 expires the first time.

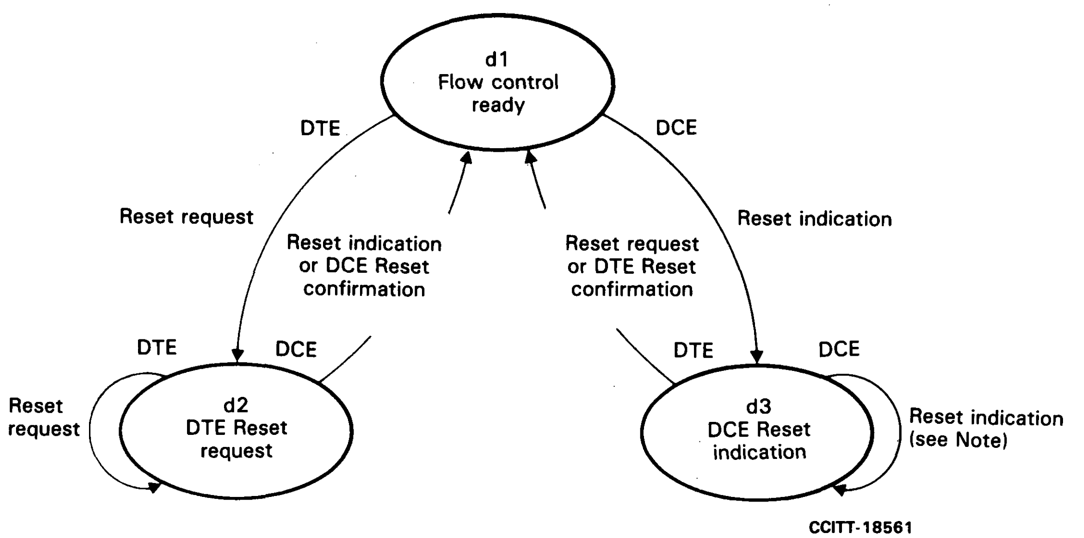
Note 4 — This transition is possible only if the previous state was *Ready* (p1) or *DCE Waiting* (p3).

Note 5 — This transition is possible only if the previous state was *Ready* (p1) or *DTE Waiting* (p2).

Note 6 — This transition also takes place after time-out T13 expires the second time (without transmission of any packet, except, possibly, a diagnostic packet).

FIGURE B-2/X.25

Diagram of states for the transfer of call set-up and call clearing packets within the packet level ready (r1) state



Note – This transition takes place after time-out T12 expires the first time.

FIGURE B-3/X.25

Diagram of states for the transfer of reset packets within the data transfer (p4) state

ANNEX C

(to Recommendation X.25)

Actions taken by the DCE on receipt of packets in a given state of the packet layer DTE/DCE interface as perceived by the DCE

Introduction

This annex specifies the actions taken by the DCE on receipt of packets in a given state of the packet layer DTE/DCE interface as perceived by the DCE.

It is presented as a succession of chained tables.

The following rules are valid for all these tables:

1) there may be more than one error associated with a packet. The network will stop normal processing of a packet when an error is encountered. Thus only one diagnostic code is associated with an error indication by the DCE. The order of packet decoding and checking on networks is not standardized;

2) for those networks which are octet aligned, the detection of a non-integral number of octets may be made at the data link or packet layer. In this annex, only those networks which are octet aligned and detect the non-integral number of octets at the packet layer are concerned with the considerations about octet alignment;

3) in each table, the actions taken by the DCE are indicated in the following way:
   - DISCARD: the DCE discards the received packet and takes no subsequent action as a direct result of receiving that packet; the DCE remains in the same state;
   - DIAG # x: the DCE discards the received packet and, for networks which implement the *diagnostic* packet, transmits to the DTE a *diagnostic* packet containing the diagnostic # x. The state of the interface is not changed;
   - NORMAL or ERROR: the corresponding action is specified after each table.

4) Annex E gives a list of the diagnostic codes which may be used.

TABLE C-1/X.25

Special cases

Packet from DTE	Any state
Any packet with packet length shorter than 2 octets, including data link layer valid I-frame containing no packet	DIAG # 38
Any packet with invalid general format identifier (GFI)	DIAG # 40
Any packet with unassigned logical channel	DIAG # 36
Any packet with correct GFI and assigned logical channel, or with correct GFI and bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to 0	(see Table C-2/X.25)

TABLE C-2/X.25

Action taken by the DCE on receipt of packets in a given state of the packet layer DTE/DCE interface as perceived by the DCE: restart and registration procedure

Packet from the DTE \ State of the interface as perceived by the DCE	Packet layer ready r1	DTE restart request r2	DCE restart indication r3
Restart request with bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to zero	NORMAL (r2)	DISCARD	NORMAL (r1)
DTE restart confirmation with bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to zero	ERROR (r3) # 17	ERROR (r3) # 18	NORMAL (r1)
Registration request (when supported by the DCE) with bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to zero	NORMAL (r1)	NORMAL (r2)	NORMAL (r3)
Packet supported by the DCE other than restart request, DTE restart confirmation and registration request (when supported by the DCE) with bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to zero	DIAG # 36	DIAG # 36	DIAG # 36
Packet having a packet type identifier which is shorter than 1 octet, with bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to zero	DIAG # 38	ERROR (r3) # 38	DISCARD
Packet having a packet type identifier which is undefined or not supported by the DCE (i.e., reject or registration packets), with bits 1 to 4 of octet 1 and bits 1 to 8 of octet 2 equal to zero	DIAG # 33	ERROR (r3) # 33	DISCARD
Data, interrupt, call set-up and clearing, flow control or reset, with assigned logical channel	See Table C-3/X.25 or C-4/X.25 (see Note)	ERROR (r3) # 18	DISCARD
Restart request, DTE restart confirmation or registration request (when supported by the network) with bits 1 to 4 of octet 1 or bits 1 to 8 of octet 2 unequal to zero	See Table C-3/X.25 or C-4/X.25 (see Note)	ERROR (r3) # 41	DISCARD
Packet having a packet type identifier which is shorter than 1 octet, with assigned logical channel	See Table C-3/X.25 or C-4/X.25 (see Note)	ERROR (r3) # 38	DISCARD
Packet having a packet type identifier which is undefined or not supported by the DCE (i.e., reject or registration packets), with assigned logical channel	See Table C-3/X.25 or C-4/X.25 (see Note)	ERROR (r3) # 33	DISCARD

Note – Table C-3/X.25 for logical channels assigned to virtual calls, Table C-4/X.25 for logical channels assigned to permanent virtual circuits.

ERROR (r3): # x — The DCE discards the received packet, indicates a restarting by transmitting to the DTE a *restart indication* packet, with the cause "Local procedure error" and the diagnostic # x, and enters state r3. If connected through a virtual call, the distant DTE is also informed of the restarting by a *clear indication* packet, with the cause "Remote procedure error" (same diagnostic). In the case of a permanent virtual circuit, the distant DTE will be informed by a *reset indication* packet, with the cause "Remote procedure error" (same diagnostic).

NORMAL (ri): Provided none of the following error conditions has occurred, the action taken by the DCE follows the procedure as defined in §§ 3 and 6.1 and DTE/DCE interface enters state ri:

a) If a *restart request* packet or *DTE restart confirmation* packet received in state r3, or a *registration request* packet received in state r2 or r3, exceeds the maximum permitted length, is too short or is not octet aligned (see rule 2 in the introduction of this annex), the DCE will invoke the ERROR # 39, # 38 or # 82 procedure, respectively.

   Note – In the case of a *registration request* packet received in state r2 or r3 with the error(s) as noted above, alternative behavior by the DCE is for further study.

   Some networks may invoke the ERROR # 81 procedure if the restarting cause field is not "DTE originated" in the *restart request* packet received in state r3.

b) If a *restart request* or a *registration request* packet received in state r1 exceeds the maximum permitted length, is too short or is not octet aligned (see rule 2 in the introduction of this annex), the DCE shall invoke the DIAG # 39, # 38 or # 82 procedure, respectively.

   Some networks may invoke the DIAG # 81 procedure if the restarting cause field is not "DTE originated" in the *restart request* packet received in state r1.

c) If a *registration request* packet is received from the DTE when the *on-line facility registration* facility is supported by the DCE but not subscribed by the DTE, the DCE shall transmit to the DTE a *registration confirmation* packet with the cause "Local procedure error", the diagnostic # 42, and no registration field. If a *registration request* packet modifying one or more of the facilities which can take effect only when all logical channels used for virtual calls are in state p1 (see Annex F), is received when it is possible to make the modification, the DCE shall transmit a *restart indication* packet with the cause "Registration/cancellation confirmed" and diagnostic # 0 and enter state r3, if there is one or more logical channels assigned to permanent virtual circuits. This action ensures that the permanent virtual circuits are reset so that all of the negotiated facilities can properly take effect.

TABLE C-3/X.25

Action taken by the DCE on receipt of packets in a given state of the packet layer DTE/DCE interface as perceived by the DCE: call set-up and clearing on logical channel assigned to virtual call (see Note 1)

State of the interface as perceived by the DCE / Packet from the DTE with logical channel assigned to virtual call	Packet layer ready r1						
	Ready p1	DTE waiting p2 (see Note 3)	DCE waiting p3 (see Note 2)	Data transfer p4	Call collision p5 (see Notes 2 and 3)	DTE clear request p6	DCE clear indication p7
Call request	NORMAL (p2)	ERROR (p7) # 21	NORMAL (p5)	ERROR (p7) # 23	ERROR (p7) # 24	ERROR (p7) # 25	DISCARD
Call accepted	ERROR (p7) # 20	ERROR (p7) # 21	NORMAL (p4)	ERROR (p7) # 23	ERROR (p7) # 24	ERROR (p7) # 25	DISCARD
Clear request	NORMAL (p6)	NORMAL (p6)	NORMAL (p6)	NORMAL (p6)	NORMAL (p6)	DISCARD	NORMAL (p1)
DTE clear confirmation	ERROR (p7) # 20	ERROR (p7) # 21	ERROR (p7) # 22	ERROR (p7) # 23	ERROR (p7) # 24	ERROR (p7) # 25	NORMAL (p1)
Data, interrupt, reset or flow control	ERROR (p7) # 20	ERROR (p7) # 21	ERROR (p7) # 22	See Table C-4/X.25	ERROR (p7) # 24	ERROR (p7) # 25	DISCARD
Restart request, DTE restart confirmation or registration request with bits 1 to 4 of octet 1 or bits 1 to 8 of octet 2 unequal to zero	ERROR (p7) # 41	ERROR (p7) # 41	ERROR (p7) # 41	See Table C-4/X.25	ERROR (p7) # 41	ERROR (p7) # 41	DISCARD
Packets having a packet type identifier which is shorter than one octet	ERROR (p7) # 38	ERROR (p7) # 38	ERROR (p7) # 38	See Table C-4/X.25	ERROR (p7) # 38	ERROR (p7) # 38	DISCARD
Packet having a packet type identifier which is undefined or not supported by the DCE (i.e., reject or registration packet)	ERROR (p7) # 33	ERROR (p7) # 33	ERROR (p7) # 33	See Table C-4/X.25	ERROR (p7) # 33	ERROR (p7) # 33	DISCARD

Note 1 – On permanent virtual circuit, only state p4 exists and the DCE takes no action except those specified in Table C-4/X.25.

Note 2 – This state does nos exist in the case of an outgoing one-way logical channel (as perceived by the DTE).

Note 3 – This state does not exist in the case of an incoming one-way logical channel (as perceived by the DTE).

ERROR (p7): # x — The DCE discards the received packet, indicates a clearing by transmitting to the DTE a *clear indication* packet, with the cause "Local procedure error" and the diagnostic # x, and enters state p7. If connected through a virtual call, the distant DTE is also informed of the clearing by a *clear indication* packet, with the cause "Remote procedure error" (same diagnostic).

NORMAL (pi): Provide none of the following error conditions has occurred, the action taken by the DCE follows the procedures as defined in § 4 and the DTE/DCE interface enters state pi. In all the cases specified hereunder, the DCE will transmit to the DTE a *clear indication* with the appropriate cause and diagnostic, and enter state p7. If connected through a virtual call, the distant DTE is also informed of the clearing by a *clear indication* packet with the cause "Remote procedure error" (same diagnostic).

a) *Call request packet*

Error condition	Cause	Specific diagnostics (see Note 3 of Annex E)
1. Packet not octet aligned (see rule 2 in the introduction of this annex)	Local procedure error	# 82
2. Packet too short	Local procedure error	# 38
3. Incoming one-way logical channel (as perceived by the DTE)	Local procedure error	# 34
4. Address length larger than remainder of packet	Local procedure error	# 38
5. Address contains a non-BCD digit	Local procedure error	# 67, # 68
6. Invalid calling DTE address (see Note)	Local procedure error	# 68
7. Invalid called DTE address (see Note)	Local procedure error or not obtainable	# 67

Note – Possible reasons for invalid address are:

- Prefix digit not supported;
- Invalid type of address/numbering plan identification informations (A bit set to 1);
- National address smaller than permitted by the national address format;
- National address larger than permitted by the national address format;
- DNIC less than four digits, etc.

Error condition	Cause	Specific diagnostics (see Note 3 of Annex E)
8. Value of the facility length field greater than 109'	Local procedure error	# 69
9. No combination of facilities could equal facility length	Local procedure error	# 69
10. Facility length larger than remainder of packet	Local procedure error	# 38
11. Facility code not allowed	Invalid facility request	# 65
12. Facility value not allowed or invalid	Invalid facility request	# 66
13. Class coding of the facility corresponding to a length of parameter larger than remainder of packet	Local procedure error	# 69
14. Facility code repeated	Local procedure error	# 73
15. Invalid network user identifier	Invalid facility request	# 84
16. *NUI selection* facility expected by the DCE and not provided by the DTE	Local procedure error	# 84
17. Invalid/unsupported NUI value or missing NUI detected at inter-network interface	Access barred	# 84
18. RPOA selection required	RPOA out of order	# 76
19. Facility values conflicts (e.g., a particular combination not supported)	Invalid facility request	# 66
20. CCITT-specified DTE facility code or parameter not allowed or invalid	Invalid facility request	# 77
21. Call user data larger than 16, or 128 in case of *fast select* facility	Local procedure error	# 39

If the virtual call cannot be established by the network, the DCE should use a *call progress* signal and diagnostic code among the following:

Error condition	Cause	Specific diagnostics (see Note 3 of Annex E)
22. Requested RPOA out of order	RPOA out of order	# 0
23. Requested RPOA invalid or not supported	RPOA out of order	# 119
24. Unknown number	Not obtainable	# 67
25. Incoming call barred	Access barred	# 70
26. Closed user group protection	Access barred	# 65
27. Ship absent	Ship absent	# 0
28. Reverse charging rejected	Reverse charging acceptance not subscribed	# 0
29. Fast select rejected	Fast select acceptance not subscribed	# 0
30. Called DTE out of order	Out of order	# 0 # greater than 127
31. No logical channel available	Number busy	# 71
32. Call collision	Number busy	# 71, # 72
33. The remote DTE/DCE interface or the transit network does not support a function or a facility requested	Incompatible destination	# 0

Note – Precise definition of error condition 30 necessitates further study, and should take into account the possible non-support of the virtual call service (only permanent virtual circuit) by the destination DTE.

Error condition	Cause	Specific diagnostics (see Note 3 of Annex E)
34. Procedure error at the remote DTE/DCE interface	Remote procedure error	[see b) and c) below and Annex D]
35. Temporary network congestion or fault condition within the network	Network congestion	# 0, # 122 or # greater than 127

b) *Call accepted packet*

Error condition	Cause	Specific diagnostics (see Note 3 of Annex E)
1. Packet not octet aligned (see rule 2 in the introduction of this annex)	Local procedure error	# 82
2. Address length larger than remainder of packet	Local procedure error	# 38
3. Address contains a non-BCD digit	Local procedure error	# 67, # 68
4. Invalid calling DTE address [see Note under a)]	Local procedure error	# 68
5. Invalid called DTE address [see Note under a)]	Local procedure error	# 67
6. Value of the facility length greater than 109	Local procedure error	# 69
7. No combination of facilities could equal facility length	Local procedure error	# 69
8. Facility length larger than remainder of packet	Local procedure error	# 38
9. Facility code not allowed	Invalid facility request	# 65
10. Facility value not allowed or invalid	Invalid facility request	# 66
11. Class coding of the facility corresponding to a length of parameter field larger than remainder of packet	Local procedure error	# 69
12. Facility code repeated	Local procedure error	# 73
13. Invalid network user identifier	Invalid facility request	# 84
14. *NUI selection* facility expected by the DCE and not provided by the DTE	Local procedure error	# 84
15. Invalid/unsupported NUI value or missing NUI detected at inter-network interface	Access barred	# 84
16. Facility value conflict (e.g., a particular combination not supported)	Invalid facility request	# 66
17. CCITT-specified DTE facility code or parameter not allowed or invalid	Invalid facility request	# 77
18. Call user data larger than 128 (if *fast select* facility requested)	Local procedure error	# 39
19. Call user data present (if *fast select* facility not requested)	Local procedure error	# 39
20. The *incoming call* packet indicated fast select with restriction on response	Local procedure error	# 42

Some networks may invoke the ERROR # 74 procedure if the calling and/or called DTE address length fields are not equal to 0 in the *call accepted* packet, except when the *called line address modified notification* facility is present in the facility field.

c) *Clear request packet*

Error condition	Cause	Specific diagnostics (see Note 3 of Annex E)
1. Packet not octet aligned (see rule 2 in the introduction of this annex)	Local procedure error	# 82
2. Packet too short	Local procedure error	# 38
3. Packet length incorrectly larger than 5 octets	Local procedure error	# 39
4. Calling DTE address length field not set to zero (at any time); called DTE address length field not set to zero except when the *called line address modified notification* facility is present in clearing a call in state p3	Local procedure error	# 74
5. Invalid called DTE address when the *called line address modified notification* facility is present in clearing a call in state p3 [see Note under a)]	Local procedure error	# 67
6. Value of the facility length field greater than 109	Local procedure error	# 69
7. No combination of facilities could equal facility length	Local procedure error	# 69
8. Facility length larger than remainder of packet	Local procedure error	# 38
9. Facility code not allowed	Invalid facility request	# 65
10. Facility value not allowed or invalid	Invalid facility request	# 66
11. Class coding of the facility corresponding to a parameter field length larger than remainder of packet	Local procedure error	# 69
12. Facility code repeated	Local procedure error	# 73
13. *Call deflection selection* facility requested when the maximum number of call redirections and call deflections is reached	Invalid facility request	# 78
14. *Call deflection selection* facility requested after timer expiration	Invalid facility request	# 53
15. Clear user data larger than 128 (if *fast select* facility requested)	Local procedure error	# 39
16. Clear user data present (if *fast select* facility and *call deflection selection* facility not requested)	Local procedure error	# 39
17. Clear user data larger than 16 (if *fast select* facility not requested and *call deflection selection* facility requested)	Local procedure error	# 39

Some networks may invoke the ERROR # 81 procedure if the clearing cause field is not "DTE originated" in the *clear request* packet.

d) *DTE clear confirmation packet*

Error condition	Cause	Specific diagnostics (see Note 3 of annex E)
1. Packet not octet aligned (see rule 2 in the introduction of this annex)	Local procedure error	# 82
2. Packet length greater than 3 octets	Local procedure error	# 39

TABLE C-4/X.25

Action taken by the DCE on receipt of packets in a given state of the packet layer DTE/DCE interface as perceived by the DCE: data transfer (flow control and reset) on assigned logical channels

State of the interface as perceived by the DCE / Packet from the DTE with assigned logical channel	Data transfer (p4)		
	Flow control ready (d1)	DTE reset request (d2)	DCE reset indication (d3)
Reset request	NORMAL (d2)	DISCARD	NORMAL (d1)
DTE reset confirmation	ERROR (d3) # 27	ERROR (d3) # 28	NORMAL (d1)
Data, interrupt or flow control	NORMAL (d1)	ERROR (d3) # 28	DISCARD
Restart request, DTE restart confirmation or registration request with bits 1 to 4 of octet 1 or bits 1 to 8 of octet 2 unequal to zero	ERROR (d3) # 41	ERROR (d3) # 41	DISCARD
Packet having a packet type identifier which is shorter than 1 octet	ERROR (d3) # 38	ERROR (d3) # 38	DISCARD
Packet having a packet type identifier which is undefined or not supported by the DCE (i.e., reject or registration packet)	ERROR (d3) # 33	ERROR (d3) # 33	DISCARD
Invalid packet type on a permanent virtual circuit	ERROR (d3) # 35	ERROR (d3) # 35	DISCARD
Reject packet not subscribed	ERROR (d3) # 37	ERROR (d3) # 37	DISCARD

ERROR (d3): # x — The DCE discards the received packet, indicates a reset by transmitting to the DTE a *reset indication* packet, with the cause "Local procedure error" and the diagnostic # x, and enter state d3. The distant DTE is also informed of the reset by a *reset indication* packet, with the cause "Remote procedure error" (same diagnostic).

NORMAL (di): Provided none of the following error conditions or special situations has occurred, the actions taken by the DCE follows the procedure as defined in § 4:

a) if the packet exceeds the maximum permitted length, is too short, is not octet aligned (see rule 2 in the introduction of this annex), the DCE will invoke the ERROR # 39, # 38 or # 82 procedure, respectively;

b) some networks may invoke the ERROR # 81 procedure if the resetting cause field in a *reset request* packet does not have the value "DTE originated";

c) some networks may invoke the ERROR # 83 procedure if the Q bit is not set to the same value within a complete packet sequence;

d) if the P(S) or the P(R) received is not valid, the DCE will invoke the ERROR # 1 or # 2 procedure respectively;

e) the DCE will consider the receipt of a *DTE interrupt confirmation* packet which does not correspond to a yet unconfirmed *DCE interrupt* packet as an error and will invoke the ERROR # 43 procedure. The DCE will consider a *DTE interrupt* packet received before a previous *DTE interrupt* packet has been confirmed as an error, and will invoke the ERROR # 44 procedure;

f) if the network has a temporary inability to handle data traffic for a permanent virtual circuit (see § 4.2), and if the packet is a *data, interrupt, flow control* or *reset request* packet received in state d1, the DCE shall transmit to the DTE a *reset indication* packet with the cause "Network out of order" and enter state d3 (*data, interrupt* or *flow control* packet) or d1 (*reset request* packet).

ANNEX D

(to Recommendation X.25)

Packet layer DCE time-outs and DTE time-limits

D.1 *DCE time-outs*

Under certain circumstances this Recommendation requires the DTE to respond to a packet issued from the DCE within a stated maximum time.

Table D-1/X.25 covers these circumstances and the actions that the DCE will initiate upon the expiration of that time.

The time-out values used by the DCE will never be less than those indicated in Table D-1/X.25.

D.2 *DTE time-limits*

Under certain circumstances, this Recommendation requires the DCE to respond to a packet from the DTE within a stated maximum time. Table D-2/X.25 gives these maximum times. The actual DCE response times should be well within the specified time-limits. The rare situation where a time-limit is exceeded should only occur when there is a fault condition.

To facilitate recovery from such fault conditions, the DTE may incorporate timers. The time-limits given in Table D-2/X.25 are the lower limits of the times a DTE should allow for proper operation. A time-limit longer than the values shown may be used. Suggestions on possible DTE actions upon expiration of the time-limits are given in Table D-2/X.25.

Note – A DTE may use a time shorter than the value given for T21 in Table D-2/X.25. This may be appropriate when the DTE knows the normal response time of the called DTE to an incoming call. In this case, the timer should account for the normal maximum response time of the called DTE and the estimated maximum call set-up time.

TABLE D-1/X.25

DCE time-outs

Time-out number	Time-out value	Started when	State of the logical channel	Normally terminated when	Actions to be taken the first time the time-out expires		Actions to be taken the second time the time-out expires	
					Local side	Remote side	Local side	Remote side
T10	60 s	DCE issues a *restart indication*	r3	DCE leaves the r3 state (i.e., the *restart confirmation* or *restart request* is received)	DCE remains in r3, signals a *restart indication* (local procedure error # 52) again, and restarts time-out T10	For permanent virtual circuits, DCE may enter the d3 state signalling a *reset indication* (remote procedure error # 52)	DCE enters the r1 state and may issue a *diagnostic* packet (# 52)	For permanent virtual circuits, DCE may enter the d3 state signalling a *reset indication* (remote procedure error # 52)
T11	180 s	DCE issues an *incoming call*	p3	DCE leaves the p3 state (e.g., the *call accepted*, *clear request* or *call request* is received)	DCE enters the p7 state signalling a *clear indication* (local procedure error # 49)	DCE enters the p7 state signalling a *clear indication* (remote procedure error # 49)		
T12	60 s	DCE issues a *reset indication*	d3	DCE leaves the d3 state (e.g., the *reset confirmation* or *reset request* is received)	DCE remains in d3, signals a *reset indication* (local procedure error # 51) again, and restarts time-out T12	DCE may enter the d3 state signalling a *reset indication* (remote procedure error # 51)	For virtual calls, DCE enters the p7 state signalling a *clear indication* (local procedure error # 51). For permanent virtual circuits, DCE enters the d1 state and may issue a *diagnostic* packet (# 51)	For virtual calls, DCE enters the p7 state signalling a *clear indication* (remote procedure error # 51). For permanent virtual circuits, DCE may enter the d3 state signalling a *reset indication* (remote procedure error # 51)
T13	60 s	DCE issues a *clear indication*	p7	DCE leaves the p7 state (e.g., the *clear confirmation* or *clear request* is received)	DCE remains in p7, signals a *clear indication* (local procedure error # 50) again, and restarts the time-out T13		DCE enters the p1 state and may issue a *diagnostic* packet (# 50)	

TABLE D-2/X.25

DTE Time-limits

Time-out number	Time-limit value	Started when	State of the logical channel	Normally terminated when	Preferred action to be taken when time-limit expires
T20	180 s	DTE issues a *restart request*	r2	DTE leaves the r2 state (i.e., the *restart confirmation* or *restart indication* is received)	To retransmit the *restart request* (see Note 1)
T21	200 s	DTE issues a *call request*	p2	DTE leaves the p2 state (e.g., the *call connected, clear indication* or *incoming call* is received)	To transmit a *clear request*
T22	180 s	DTE issues a *reset request*	d2	DTE leaves the d2 state (e.g., the *reset confirmation* or *reset indication* is received)	For virtual calls, to retransmit the *reset request* or to transmit a *clear request.* For virtual permanent call circuits, to retransmit the *reset request* (see Note 2)
T23	180 s	DTE issues a *clear request*	p6	DTE leaves the p6 state (e.g., the *clear confirmation* or *clear indication* is received)	To retransmit the *clear request* (see Note 2)
T28 (see Note 3)	300 s	DTE issues a *registration request*	any	DTE receives the *registration confirmation* or a *diagnostic* packet	May retransmit the *registration request,* but should at some point recognize that the *on-line facility registration* facility is not offered

Note 1 – After unsuccessful retries, recovery decisions should be taken at higher layers.

Note 2 – After unsuccessful retries, the logical channel should be considered out of order. The restart procedure should be invoked for recovery if reinitialization of all logical channels is acceptable.

Note 3 – The DTE timers T24 through T27 have been assigned by ISO in the specification of the packet layer for X.25 DTEs. To avoid ambiguity and confusion, the time-out number has therefore been assigned T28.

ANNEX E

(to Recommendation X.25)

Coding of X.25 network generated diagnostic fields in clear, reset and restart indication, registration confirmation and diagnostic packets

TABLE E-1/X.25

(see Notes 1, 2 and 3)

Diagnostics	Bits 8	7	6	5	4	3	2	1	Decimal
No additional information	0	0	0	0	0	0	0	0	0
Invalid P(S)	0	0	0	0	0	0	0	1	1
Invalid P(R)	0	0	0	0	0	0	1	0	2
	0	0	0	0	1	1	1	1	15
Packet type invalid	0	0	0	1	0	0	0	0	16
For state r1	0	0	0	1	0	0	0	1	17
For state r2	0	0	0	1	0	0	1	0	18
For state r3	0	0	0	1	0	0	1	1	19
For state p1	0	0	0	1	0	1	0	0	20
For state p2	0	0	0	1	0	1	0	1	21
For state p3	0	0	0	1	0	1	1	0	22
For state p4	0	0	0	1	0	1	1	1	23
For state p5	0	0	0	1	1	0	0	0	24
For state p6	0	0	0	1	1	0	0	1	25
For state p7	0	0	0	1	1	0	1	0	26
For state d1	0	0	0	1	1	0	1	1	27
For state d2	0	0	0	1	1	1	0	0	28
For state d3	0	0	0	1	1	1	0	1	29
	0	0	0	1	1	1	1	1	31
Packet not allowed	0	0	1	0	0	0	0	0	32
Unidentifiable packet	0	0	1	0	0	0	0	1	33
Call on one-way logical channel	0	0	1	0	0	0	1	0	34
Invalid packet type on a permanent virtual circuit	0	0	1	0	0	0	1	1	35
Packet on unassigned logical channel	0	0	1	0	0	1	0	0	36
Reject not subscribed to	0	0	1	0	0	1	0	1	37
Packet too short	0	0	1	0	0	1	1	0	38
Packet too long	0	0	1	0	0	1	1	1	39
Invalid general format identifier	0	0	1	0	1	0	0	0	40
Restart or registration packet with nonzero in bits 1 to 4 of octet 1, or bits 1 to 8 of octet 2	0	0	1	0	1	0	0	1	41
Packet type not compatible with facility	0	0	1	0	1	0	1	0	42
Unauthorized interrupt confirmation	0	0	1	0	1	0	1	1	43
Unauthorized interrupt	0	0	1	0	1	1	0	0	44
Unauthorized reject	0	0	1	0	1	1	0	1	45
	0	0	1	0	1	1	1	1	47
Time expired	0	0	1	1	0	0	0	0	48
For incoming call	0	0	1	1	0	0	0	1	49
For clear indication	0	0	1	1	0	0	1	0	50
For reset indication	0	0	1	1	0	0	1	1	51
For restart indication	0	0	1	1	0	1	0	0	52
For call deflection	0	0	1	1	0	1	0	1	53
	0	0	1	1	1	1	1	1	63

TABLE E-1/X.25 *(cont.)*

Diagnostics	Bits								Decimal
	8	7	6	5	4	3	2	1	
Call set-up, call clearing or registration problem	0	1	0	0	0	0	0	0	64
Facility/registration code not allowed	0	1	0	0	0	0	0	1	65
Facility parameter not allowed	0	1	0	0	0	0	1	0	66
Invalid called DTE address	0	1	0	0	0	0	1	1	67
Invalid calling DTE address	0	1	0	0	0	1	0	0	68
Invalid facility/registration length	0	1	0	0	0	1	0	1	69
Incoming call barred	0	1	0	0	0	1	1	0	70
No logical channel available	0	1	0	0	0	1	1	1	71
Call collision	0	1	0	0	1	0	0	0	72
Duplicate facility requested	0	1	0	0	1	0	0	1	73
Non zero address length	0	1	0	0	1	0	1	0	74
Non zero facility length	0	1	0	0	1	0	1	1	75
Facility not provided when expected	0	1	0	0	1	1	0	0	76
Invalid CCITT-specified DTE facility	0	1	0	0	1	1	0	1	77
Maximum number of call redirections or call deflections exceeded	0	1	0	0	1	1	1	0	78
	0	1	0	0	1	1	1	1	79
Miscellaneous	0	1	0	1	0	0	0	0	80
Improper cause code from DTE	0	1	0	1	0	0	0	1	81
Not aligned octet	0	1	0	1	0	0	1	0	82
Inconsistent Q bit setting	0	1	0	1	0	0	1	1	83
NUI problem	0	1	0	1	0	1	0	0	84
	0	1	0	1	1	1	1	1	95
Not assigned	0	1	1	0	0	0	0	0	96
	0	1	1	0	1	1	1	1	111
International problem	0	1	1	1	0	0	0	0	112
Remote network problem	0	1	1	1	0	0	0	1	113
International protocol problem	0	1	1	1	0	0	1	0	114
International link out of order	0	1	1	1	0	0	1	1	115
International link busy	0	1	1	1	0	1	0	0	116
Transit network facility problem	0	1	1	1	0	1	0	1	117
Remote network facility problem	0	1	1	1	0	1	1	0	118
International routing problem	0	1	1	1	0	1	1	1	119
Temporary routing problem	0	1	1	1	1	0	0	0	120
Unknown called DNIC	0	1	1	1	1	0	0	1	121
Maintenance action (see Note 4)	0	1	1	1	1	0	1	0	122
	0	1	1	1	1	1	1	1	127
Reserved for network specific diagnostic information	1	0	0	0	0	0	0	0	128
	1	1	1	1	1	1	1	1	255

Note 1 – Not all diagnostic codes need apply to a specific network, but those used are as coded in the table.

Note 2 – A given diagnostic need not apply to all packet types (i.e., *reset indication, clear indication, restart indication, registration confirmation* and *diagnostic* packets).

Note 3 – The first diagnostic in each grouping is a generic diagnostic and can be used in place of the more specific diagnostics within the grouping. The decimal 0 diagnostic code can be used in situations where no additional information is available.

Note 4 – This diagnostic may also apply to a maintenance action within a national network.

ANNEX F

(to Recommendation X.25)

Applicability of the on-line facility registration facility to other facilities

Name of facility or interface parameter	Reference to definition (§)	Negotiable in *registration request* and *registration confirmation* packets	Indication in *registration confirmation* packets whether the facility is supported by the DCE	Negotiable only when every logical channel used for virtual calls is in state p1
Extended packet sequence numbering	6.2	Yes (see Note 1)	Yes (see Note 1)	Yes
D bit modification	6.3	Yes	Yes	Yes
Packet retransmission	6.4	Yes	Yes	Yes
Incoming calls barred	6.5	Yes	No	No
Outgoing calls barred	6.6	Yes	No	No
One-way logical channel outgoing	6.7	(see Note 2)		
One-way logical channel incoming	6.8	(see Note 2)		
Non-standard default packet sizes	6.9	Yes	Yes	No
Non-standard default window sizes	6.10	Yes	Yes	No
Default throughput classes assignment	6.11	Yes	Yes	No
Flow control parameter negotiation	6.12	Yes	No	No
Throughput class negotiation	6.13	Yes	No	No
Closed user group related facilities	6.14	No	No	–
Bilateral closed user group related facilities	6.15	No	No	–
Fast select	6.16	No	No	–
Fast select acceptance	6.17	Yes	No	No
Reverse charging	6.18	No	Yes	–
Reverse charging acceptance	6.19	Yes	Yes	No
Local charging prevention	6.20	No	Yes	–
NUI related facilities	6.21	No	No	–
Charging information	6.22			
(per interface basis)		Yes	Yes	No
(per call basis)		No	Yes	–
RPOA related facilities				
RPOA subscription	6.23.1	(see Note 1)	(see Note 1)	(see Note 1)
RPOA selection	6.23.2	No	Yes	–
Hunt group	6.24	No	No	–
Call redirection	6.25.1	(see Note 1)	(see Note 1)	(see Note 1)
Call deflection related facilities	6.25.2	(see Note 1)	(see Note 1)	(see Note 1)
Call redirection or call deflection notification	6.25.3	No	No	–
Called line address modified notification	6.26	No	No	–
Transit delay selection and indication	6.27	No	Yes	–
Allocation of logical channel type range	Annex A	Yes	Yes	Yes

Note 1 – Further study is needed.

Note 2 – Negotiation of one-way logical channel ranges is accomplished by allocation of logical channel type ranges negotiation.

ANNEX G

(to Recommendation X.25)

CCITT-specified DTE facilities to support the OSI Network service

G.1 *Introduction*

The facilities described in this annex are intended to support end-to-end signalling required by the OSI Network service. They follow the CCITT-specified DTE facility marker defined in § 7.1. These facilities are passed unchanged between the two packet mode DTEs involved.

Procedures for use of these facilities by DTEs are specified in ISO 8208. Subsequent provision of X.25 facilities to be acted on by public data networks is for further study. Coding of the facilities in this annex is defined here in order to facilitate a consistent facility coding scheme in such future evolution.

G.2 *Coding of the facility code fields*

Table G-1/X.25 gives the coding of the facility code field for each CCITT-specified DTE facility and the packet types in which they may be present. These facilities are conveyed after the CCITT-specified DTE facility marker.

TABLE G-1/X.25

Coding of the facility code field

Facility	Packet types in which the facility may be used						Facility code							
	Call request	Incoming call	Call accepted	Call connected	Clear request	Clear indication	Bits 8	7	6	5	4	3	2	1
Calling address extension	X	X			X (see Note)		1	1	0	0	1	0	1	1
Called address extension	X	X	X	X	X	X	1	1	0	0	1	0	0	1
Quality of service negotiation:														
Minimum throughput class	X	X			X (see Note)		0	0	0	0	1	0	1	0
End-to-end transit delay	X	X	X	X	X (see Note)		1	1	0	0	1	0	1	0
Priority	X	X	X	X	X (see Note)		1	1	0	1	0	0	1	0
Protection	X	X	X	X	X (see Note)		1	1	0	1	0	0	1	1
Expedited data negotiation	X	X	X	X	X (see Note)		0	0	0	0	1	0	1	1

Note – Only when the *call deflection selection* facility is used (see § 6.25.2.2.).

G.3 *Coding of the facility parameter field*

G.3.1 *Calling address extension facility*

The octet following the facility code field indicates the length of the facility parameter field in octets. It has a value of $n + 1$, where n is the number of octets necessary to hold the calling address extension. The facility parameter field follows the length and contains the calling address extension.

The first octet of the facility parameter field indicates, in bits 8 and 7, the use of the calling address extension, as shown in Table G-2/X.25.

TABLE G-2/X.25

Coding of bits 8 and 7 in the first octet of the calling extension facility parameter field

Bits		Use of calling address extension
8	7	
0	0	To carry a calling address assigned according to Recommendation X.213/ISO 8348 AD2
0	1	Reserved
1	0	Other (to carry a calling address not assigned according to Recommendation X.213/ISO 8348 AD2)
1	1	Reserved

Bits 6, 5, 4, 3, 2 and 1 of this octet indicates the number of semi-octets (up to a maximum of 40) in the calling address extension. This address length indicator is binary coded, where bit 1 is the low-order bit.

The following octets contain the calling address extension.

If bits 8 and 7 of the first octet of the facility parameter field are coded "00", the following octets are encoded using the preferred binary encoding (PBE) defined in Recommendation X.213. Starting from the high-order digit of the Initial Domain Part (IDP), the address is coded in octet 2 and consecutive octets of the facility parameter field. Each digit, with padding digits applied as necessary, is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. In each octet, the higher-order bit is coded in bits 8, 7, 6 and 5. The Domain Specific Part (DSP) of the calling OSI NSAP follows the IDP and is coded in decimal of binary, according to the PBE. For example, if the syntax of the DSP is decimal, each digit is coded in binary coded decimal (with the same rules applying to the DSP as to the IDP above). If the syntax of the DSP is binary, each octet of the calling address extension contains an octet of the DSP.

If bits 8 and 7 of the first octet of the facility parameter field are coded "10", each digit of the calling address extension is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. Starting from the high-order digit, the address is coded in octet 2 and consecutive octets of the facility parameter field with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5. When necessary, the facility parameter field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field.

G.3.2 *Called address extension facility*

The octet following the facility code field indicates the length of the facility parameter field in octets. It has a value of $n + 1$, where n is the number of octets necessary to hold the called address extension. The facility parameter field follows the length and indicates the called address extension.

The first octet of the facility parameter field indicates, in bits 8 and 7, the use of the called address extension, as shown in Table G-3/X.25.

TABLE G-3/X.25

Coding of bits 8 and 7 in the first octet of the called extension facility parameter field

Bits		Use of called address extension
8	7	
0	0	To carry a called address assigned according to Recommendation X.213/ISO 8348 AD2
0	1	Reserved
1	0	Other (to carry a called address not assigned according to Recommendation X.213/ISO 8348 AD2)
1	1	Reserved

Bits 6, 5, 4, 3, 2 and 1 of this octet indicates the number of semi-octets (up to a maximum of 40) in the called address extension. This address length indicator is binary coded, where bit 1 is the low-order bit.

The following octets contain the called address extension.

If bits 8 and 7 of the first octet of the facility parameter field are coded "00", the following octets are encoded using the preferred binary encoding (PBE) defined in Recommendation X.213. Starting from the high-order digit of the Initial Domain Part (IDP), the address is coded in octet 2 and consecutive octets of the facility parameter field. Each digit, with padding digits applied as necessary, is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. In each octet, the higher-order bit is coded in bits 8, 7, 6 and 5. The Domain Specific Part (DSP) of the called OSI NSAP follows the IDP and is coded in decimal of binary, according to the PBE. For example, if the syntax of the DSP is decimal, each digit is coded in binary coded decimal (with the same rules applying to the DSP as to the IDP above). If the syntax of the DSP is binary, each octet of the called address extension contains an octet of the DSP.

If bits 8 and 7 of the first octet of the facility parameter field are coded "10", each digit of the called address extension is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. Starting from the high-order digit, the address is coded in octet 2 and consecutive octets of the facility parameter field with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5. When necessary, the facility parameter field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field.

G.3.3 *Quality of service negotiation facilities*

G.3.3.1 *Minimum throughput class facility*

The minimum throughput class for the direction of data transmission from the calling DTE is indicated in bits 4, 3, 2 and 1. The minimum throughput class for the direction of data transmission from the called DTE is indicated in bits 8, 7, 6 and 5.

The four bits indicating each throughput class are binary coded and correspond to throughput classes as indicated in Table 30/X.25.

G.3.3.2 *End-to-end transit delay facility*

The octet following the facility code field indicates the length in octets of the facility parameter field and has the value 2, 4 or 6.

The first and second octets of the facility parameter field contain the cumulative transit delay. The third and fourth octets are optional and, when present, contain the requested end-to-end transit delay. If the third and fourth octets are present, then the fifth and sixth octets are also optional. The fifth and sixth octets, when present, contain the maximum acceptable end-to-end transit delay. The optional octets are not present in *call accepted* and *call connected* packets.

Transit delay is expressed in milliseconds and is binary-coded, with bit 8 of the first of a pair of octets being the high-order bit and bit 1 of the second of a pair of octets being the low-order bit. The value of all ones for cumulative transit delay indicates that the cumulative transit delay is unknown or exceeds 65 534 milliseconds.

G.3.3.3 *Priority facility*

The octet following the facility code field indicates the length, in octets, of the facility parameter field. This may take the value 1, 2, 3, 4, 5 or 6.

The first, second and third octets of the facility parameter field contain the target (*call request* packet), available (*incoming call* packet) or selected (*call accepted* and *call connected* packets) values for the priority of data on connection, priority to gain a connection and priority to keep a connection, respectively. The fourth, fifth and sixth octets of the facility parameter field in *call request* and *incoming call* packets contain the lowest acceptable values for the priority of data on connection, priority to gain a connection and priority to keep a connection, respectively. When the facility is present in *call request* and *incoming call* packets, octet 2 through 6 of the facility parameter field are optional. For example, if the only values to be specified are the target and lowest acceptable values for priority to gain a connection, then the facility parameter field will contain at least 5 octets with octets 1, 3 and 4 containing the value "unspecified", and octets 2 and 5 containing the specified values. When the facility is present in the *call accepted* and *call connected* packets, octets 2 and 3 are optional.

The potential range of specified values for each sub-parameter is 0 (lowest priority) to 254 (highest priority). The value 255 (1111 1111) indicates "unspecified".

G.3.3.4 *Protection facility*

The octet following the facility code indicates the length, in octets, of the facility parameter field.

The two highest order bits of the first octet (i.e., bits 8 and 7) of the facility parameter field specify the protection format code as indicated in Table G-4/X.25.

TABLE G-4/X.25

Coding of the two highest order bits in the first octet of the protection format code

Bits		Protection format code
8	7	
0	0	Reserved
0	1	Source address specific
1	0	Destination address specific
1	1	Globally unique

The remaining six bits of the octet are reserved and must be set to zero.

The second octet of the facility parameter field specifies the length "n", in octets, of the target (*call request* packet), available (*incoming call* packet) or selected (*call accepted* and *call connected* packets) protection level. The actual value is placed in the following "n" octets. Optionally, the "n + 3" octet of the facility parameter field specifies the length "m", in octets, of the lowest acceptable protection level in *call request* and *incoming call* packets. The actual value is placed in the following "m" octets. The optional octets are not present in *call accepted* and *call connected* packets.

Note – The values of "n" and "m" are bounded firstly by the overall length of the facility (first octet), and secondly by each other.

G.3.4 *Expedited data negotiation facility*

The coding of the facility parameter field is:

bit 1 = 0 for no use of expedited data

bit 1 = 1 for use of expedited data

Note – Bits 8, 7, 6, 5, 4, 3 and 2 may be assigned to other facilities in the future; presently, they are set to zero.

ANNEX H

(to Recommendation X.25)

Subscription-time optional user facilities that may be associated with a network user identifier in conjunction with the NUI override facility
(see § 6.21.2)

Subscription-time optional user facility	May be associated with an NUI
On-line facility registration	No
Extended packet sequence numbering	No
D bit modification	No
Packet retransmission	No
Incoming calls barred	No
Outgoing calls barred	No
One-way logical channel outgoing	No
One-way logical channel incoming	No
Non-standard default packet sizes	Yes
Non-standard default window sizes	Yes
Default throughput classes assignment	Yes
Flow control parameter negotiation (subscription-time)	Yes
Throughput class negotiation (subscription-time)	Yes
Closed user group related facilities	
Closed user group	Yes
Closed user group with outgoing access	Yes
Closed user group with incoming access	No
Incoming calls barred within a closed user group	No
Outgoing calls barred within a closed user group	No
Bilateral closed user group related facilities	
Bilateral closed user group	Yes
Bilateral closed user group with outgoing access	Yes
Fast select acceptance	No
Reverse charging acceptance	No
Local charging prevention	No
Charging information (subscription-time)	Yes
RPOA subscription	Yes
Hunt group	No
Call redirection and call deflection related facilities	
Call redirection	No
Call deflection subscription	No
"TOA/NPI address" subscription	No

APPENDIX I

(to Recommendation X.25)

Examples of data link layer transmitted bit patterns by the DCE and the DTE

This appendix is provided for explanatory purposes and indicates the bit patterns that will exist in the physical layer for some of the unnumbered frames. It is included for the purpose of furthering the understanding of the transparency mechanism and the frame check sequence implementation.

I.1 The following are examples of the bit patterns that will be transmitted by a DCE for some unnumbered frames.

Example 1 : SABM command frame with address = A, P = 1

First bit transmitted ↓				Last bit transmitted ↓
0111 1110	1100 0000	1111 1(0 [3])100	1101 1010 0011 0111	0111 1110
Flag	Address = A	SABM(P = 1)	Frame check sequence	Flag

Example 2 : UA response frame with address = B, F = 1

First bit transmitted ↓				Last bit transmitted ↓
0111 1110	1000 0000	1100 1110	1100 0001 1110 1010	0111 1110
Flag	Address = B	UA(F = 1)	Frame check sequence	Flag

I.2 The following are examples of the bit patterns that should be transmitted by a DTE for some unnumbered frames:

Example 1 : SABM command frame with address = B, P = 1

First bit transmitted ↓				Last bit transmitted ↓
0111 1110	1000 0000	1111 1(0 [3])100	1101 0111 11(0 [3])11 1011	0111 1110
Flag	Address = B	SABM(P = 1)	Frame check sequence	Flag

Example 2 : UA response frame with address = A, F = 1

First bit transmitted ↓				Last bit transmitted ↓
0111 1110	1100 0000	1100 1110	1100 1100 0010 0110	0111 1110
Flag	Address = A	UA(F = 1)	Frame check sequence	Flag

---

3) Zero inserted for transparency.

APPENDIX II

(to Recommendation X.25)

An explanation of how the values for N1 in Section 2.4.8.5 are derived

Introduction

This appendix provides a description of how the values given for data link layer parameter N1 in § 2.4.8.5 are derived.

DTE N1

Section 2.4.8.5 states that for universal operation a DTE should support a value of DTE N1 which is not less than 1080 bits (135 octets).

For universal operation, a DTE must be capable of accepting at least the largest packet that can be transmitted across a DTE/DCE interface when no options apply. This implies that the DTE may choose not to support, for example, any optional facilities for universal operations, but must support, for example, a data packet using the standard default packet size. Therefore, the determining factor for the maximum value of N1 that a DTE must support is the standard default packet size of a data packet rather than the size of a call setup packet. Thus, for universal operation a DTE should support a value of DTE N1 which is not less than 135 octets, derived as shown in the following table.

TABLE II-1/X.25

Derivation of the maximum value of N1 for a DTE

Name of the field	Length of the field (octets)
Packet header (Layer 3)	3
User data (Layer 3)	128
Address (Layer 2)	1
Control (Layer 2)	1
FCS (Layer 2)	2
TOTAL	135

Note – A DTE will need to support larger values of N1 when optional facilities will apply.

DCE N1

Section 2.4.8.5 also states that all network shall offer to a DTE which requires it a value of DCE N1 which is greater than or equal to 2072 bits (259 octets) plus the length of the address field plus the length of the control field and plus the length of the FCS field.

When the maximum length of the data field of a data packet supported is less than or equal to the standard default value of 128 octets, the determining factor (for the value of DCE N1) is the clear request packet rather than the data packet. Therefore, the network shall offer to a DTE, a value of DCE N1 which is not less than 263 or 264 octets, derived as shown in the following table.

TABLE II-2/X.25

Derivation of the minimum value of N1 for a DCE

Name of the field	Length of the field (octets)
Header (Layer 3)	3
Clearing cause (Layer 3)	1
Diagnostic code (Layer 3)	1
DTE address length (Layer 3)	1
DTE address(es) (Layer 3)	15
Facility length (Layer 3)	1
Facilities (Layer 3)	109
Clear user data (Layer 3)	128
Layer 3 – TOTAL	259
Address (Layer 2)	1
Control (Layer 2)	1 or 2*
Multilink procedure	2**
FCS (Layer 2)	2
TOTAL	263 or 264* or 265** or 266*, **

* If level 2 modulo 128 is supported.

** Multilink procedures (MLP) are supported.

When the maximum length of the user data field of a data packet supported is greater than the standard default value of 128 octets, the determining factor (for the value of DCE N1) is the data packet rather than the clear request packet. Therefore, the network shall offer to a DTE, a value of DCE N1 which is greater than or equal to:

[the maximum length of the data packet +
the length of the address field (Layer 2) +
the length of the control field (Layer 2) +
the length of the FCS field (Layer 2)].

General DCE N1 calculations

The following table indicates the value of DCE N1 for each possible case. The table shows for each case, whether

a) Layer 2 Modulo 128 is used,
b) Multilink Procedures are used,
c) Layer 3 Modulo 128 is used, and/or
d) the maximum length of the data field (p) in a data packet is greater than or equal to 256 octets.

TABLE II-3/X.25

Various cases and corresponding minimum N1 values for a DCE

Layer 2 Modulo 128	MLP	Layer 3 Modulo 128	$p \geq 256$	DCE N1 (octets)
				259 + 4*
	X			259 + 4* + 2*****
			X	p + 3** + 4*
	X		X	p + 3** + 4* + 2*****
		X		259 + 4*
	X	X		259 + 4* + 2*****
		X	X	p + 3** + 1*** + 4*
	X	X	X	p + 3** + 1*** + 4* + 2*****
X				259 + 4* + 1****
X	X			259 + 4* + 1**** + 2*****
X			X	p + 3** + 1**** + 4*
X	X		X	p + 3** + 1**** + 4* + 2*****
X		X		259 + 4* + 1****
X	X	X		259 + 4* + 1**** + 2*****
X		X	X	p + 3** + 1*** + 4* + 1****
X	X	X	X	p + 3** + 1*** + 4* + 1**** + 2*****

* The number of octets for modulo 128 layer 2 frame fields.

** The number of octets for layer 3 packet header fields.

*** Additional octet for layer 3 modulo 128 operations.

**** Additional octet for layer 2 modulo 128 operations.

***** Additional octets for MLP support.

APPENDIX III

(to Recommendation X.25)

Examples of multilink resetting procedures

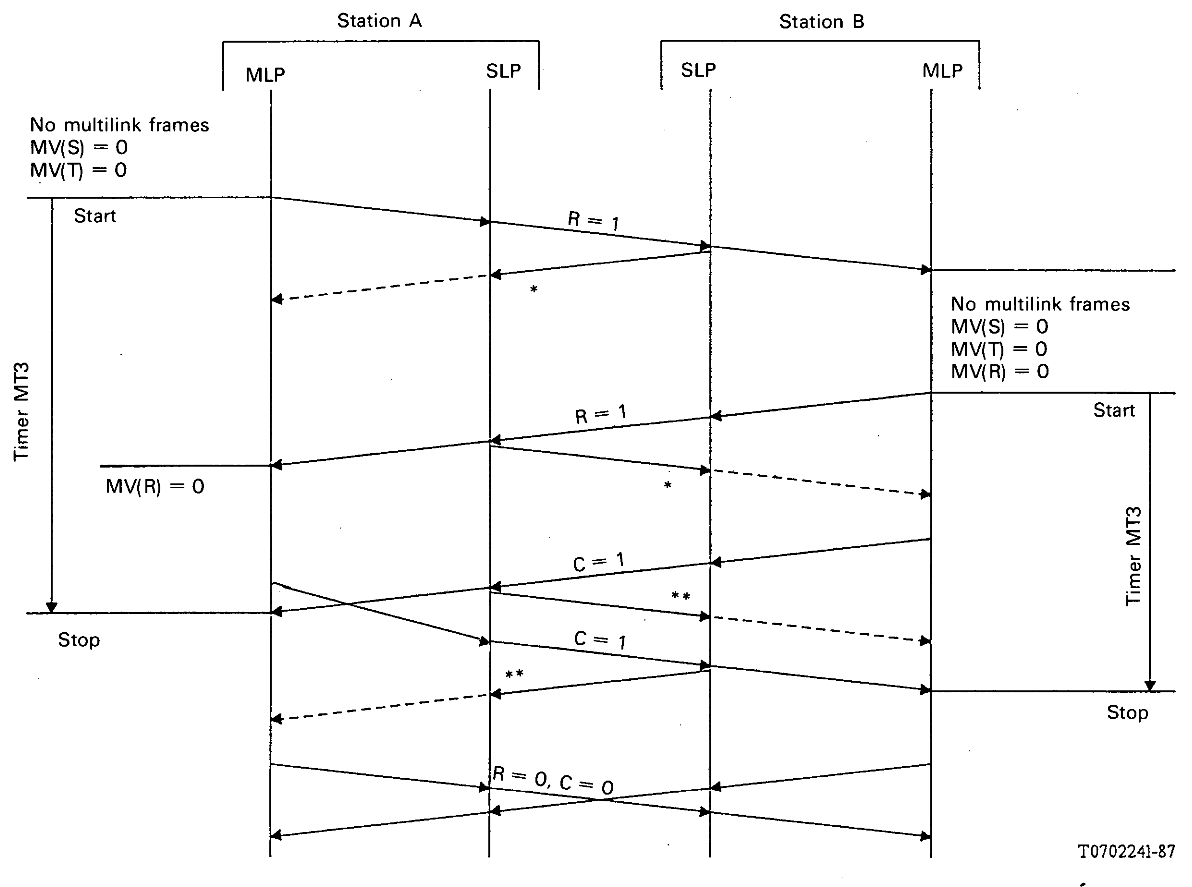
III.1 *Introduction*

The following examples illustrate application of the multilink resetting procedures in the case of:

a) MLP reset initiated by either the DCE or the DTE; and

b) MLP reset initiated by both the DCE and the DTE simultaneously.

III.2 *MLP reset initiated by either the DCE or the DTE*

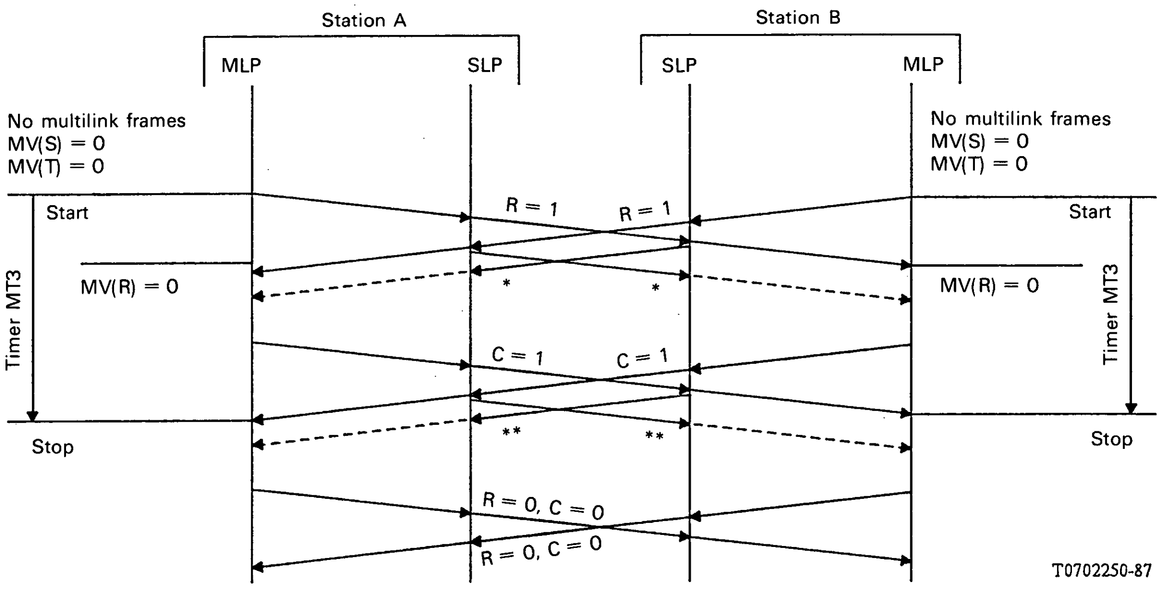


* The SLP frame that acknowledges delivery of the multilink frame with R = 1.

** The SLP frame that acknowledges delivery of the multilink frame with C = 1.

FIGURE III-1/X.25

III.3 *MLP reset initiated by both the DCE and the DTE simultaneously*



* The SLP frame that acknowledges delivery of the multilink frame with R = 1.

** The SLP frame that acknowledges delivery of the multilink frame with C = 1.

FIGURE III-2/X.25

APPENDIX IV

(to Recommendation X.25)

Information on addresses in call set-up and clearing packets

IV.1 *Main address and complementary address*

A DTE address may include two components: a main address and a complementary address.

IV.1.1 *Main address*

When the A bit is set to 0, the main address is conforming to formats described in Recommendations X.121 and X.301 (including possible prefixes and/or escape codes).

When the A bit is set to 1, the main address is as described in Figure IV-1/X.25.

Type of address	Numbering plan identification	Address digits

< – – – 1 semi-octet – – – > < – – – 1 semi-octet – – – >

FIGURE IV-1/X.25

Format of the main address when the A bit is set to 1

The possible values and the semantic of these subfields are described in § 5.2.1.2.2.

IV.1.2 *Complementary address*

A complementary address is an address information additional to that defined in X.121 (see § 6.8.1 of Recommendation X.301).

Some networks allow the DTE to include a complementary address. When a complementary address is permitted by the network, the DTE is not obliged to use this complementary address. The complementary address may be as long as possible in considering the maximum value of the DTE address length fields defined in §§ 5.2.1.1.1 and 5.2.1.2.1.

When a complementary address is contained in a DTE address field of a packet transmitted by the network to the DTE, this complementary address is always passed transparently from the remote DTE: it means that the network never creates a complementary address from itself.

When a complementary address is invoked in the following sections, it is supposed that the network supports the use of complementary addresses.

When the A bit is set to 1 and a complementary address is present alone (i.e., without main address) in DTE address field, it is preceded by the type of address and numbering plan identification subfields.

IV.2 *Addresses in call request packet*

In *call request* packet, the called DTE address should be provided by the DTE except when the *bilateral closed user group selection* is provided in the facility field (see § 6.15.3). Depending on the called network and the DTE, this called DTE address may be made of a main address then a complementary address, or of a main address alone.

Depending on the network, the DTE may have the following possibilities for the called DTE address:

i) The DTE may include either no calling DTE address, or a main address optionally followed by a complementary address. When a calling DTE address is provided by the DTE, the network is required to check its validity. If the calling DTE address is not valid, the network may either replace this invalid calling DTE address by a valid one, or clear the call. If the *hunt group* facility has been subscribed to by the calling DTE (see § 6.24) and a specific address has been assigned to the calling DTE/DCE interface, the main address provided by the calling DTE may be the hunt group address or the specific address.

   Note – In this later case, some networks do not allow the calling DTE to indicate the hunt group address, but only the specific address.

ii) The DTE may include either no calling DTE address, or a calling complementary address. In this last case, when the A bit is set to 1, this complementary address shall be preceded by the type of address and numbering plan identification subfields.

IV.3 *Addresses in incoming call packets*

In *incoming call* packet, the calling DTE address should be provided by the DCE except when the *bilateral closed user group selection* is provided in the facility field (see § 6.15.3) or in one case described in § 6.28. This calling DTE address always includes a main address. This main address is followed by a calling complementary address if such a complementary address had been provided by the calling DTE in the *call request* packet (see § IV.2), and the calling DTE address was considered as valid by the network at the calling DTE side. If the *hunt group* facility has been subscribed to by the calling DTE (see § 6.24) and a specific address has been assigned to the calling DTE/DCE interface, the main address indicated in the calling DTE address may be the hunt group address (only if the calling DTE had indicated either its hunt group address or no main address, in the calling DTE address field of the *call request* packet) or the specific address (regardless of the contents of the calling DTE address field in the *call request* packet).

Depending on the network, the called DTE address may be made of:

i) The main called address optionally followed by the called complementary address if this complementary address had been provided by the calling DTE. If the *hunt group* facility has been subscribed to by the called DTE (see § 6.24) and a specific address has been assigned to the called DTE/DCE interface, the main address indicated in the called DTE address field may be the hunt group address (only if the calling DTE had indicated this hunt group address or no main address, in the calling DTE address field of the *call request* packet) or the specific address (regardless of the contents of the calling DTE address field in the *call request* packet).

ii) The called complementary address alone when provided by the calling DTE, or nothing if the calling DTE had not provided this called complementary address. When a called complementary address is alone and the A bit is set to 1, the called complementary is preceded by the type of address and numbering plan identification subfields.

IV.4 *Addresses in call accepted packets*

Some networks do not allow any DTE addresses in *call accepted* packets except a called DTE address in conjunction with the *called line address modified notification* facility when supported by the network and provided by the DTE.

Some other networks allow the DTE to include in the *called accepted* packet none, one or both of the two DTE addresses. When provided by the DTE, the calling DTE address in the *call accepted* packet should be the same as the calling DTE address in the *incoming call* packet. When provided by the DTE, the called DTE address in the *called accepted* packet should be the same as the called DTE address in the *incoming call* packet, except if the *called line address modified notification* facility (when supported by the network) is also provided by the DTE.

When the *called line address modified notification* facility (when supported by the network) is provided by the DTE in the *call accepted* packet, the called DTE address may be made of one of the following exclusive network-dependent possibilities:

i) A main DTE address identical to that of the *incoming call* packet, followed by a called complementary address different from that of the *incoming call* packet, or another main DTE address valid for the DTE/DCE interface optionally followed by any complementary address.

ii) A called complementary address, different from that which was possibly present in the called DTE address of the *incoming call* packet. In this case, when the A bit is set to 1, the called complementary address shall be preceded by the type of address and numbering plan identification subfields.

IV.5 *Addresses in call connected packets*

Some networks do not provide any DTE address in *call connected* packets except a called DTE address in conjunction with the *called line address modified notification* facility.

Some other networks always provide both DTE addresses in *call connected* packets.

Some other networks provide a DTE address in a *call connected* packet only if this DTE address was present in the *call ccepted* packet or in conjunction with the *called line address modified notification* facility.

In any case, when an address is provided by the network in the *call connected* packet, this address should be the same as that in the *call request* packet except when the *called line address modified notification* facility is present in the facility field: in this case, the called DTE address contains always a main address optionally followed by a complementary address.

IV.6 *Addresses in clear request packets*

No DTE address is permitted in *clear request* packets except a called DTE address when the *called line address modified notification* facility (see § 6.26) is used in this packet. In this case, the *clear request* packet is transmitted as a direct response to the *incoming call* packet and the called DTE address may be made of one of the following network-dependent possibilities:

i) A main DTE address identical to that of the *incoming call* packet, followed by a called complementary address different from that of the *incoming call* packet, or another main DTE address valid for the DTE/DCE interface.

ii) A called complementary address, different from that which was possibly present in the called DTE address of the *incoming call* packet. In this case, when the A bit is set to 1, the called complementary address shall be preceded by the type of address and numbering plan identification subfields.

IV.7 *Addresses in clear indication packets*

No DTE address is permitted in *clear indication* packets except when the *called line address modified notification* facility (see § 6.26) is used in this packet. In this case, the *clear indication* packet is transmitted as a direct response to the *call request* packet and the called DTE address contains always a main address optionally followed by a complementary address.

IV.8 *Addresses in clear confirmation packets*

DTE addresses are not present in *clear confirmation* packets.

IV.9 *Addresses in call redirection and call deflection related facilities*

The alternative DTE address, indicated at subscription-time (for the *call redirection* facility) or in the *call deflection selection* facility of the *clear request* packet (see §§ 6.25.1 and 6.25.2), is composed of a main address optionally followed by a complementary address.

If a called complementary address was present in the *call request* packet, some networks may add this called complementary address after the alternative DTE address.

Recommendation X.26

ELECTRICAL CHARACTERISTICS FOR UNBALANCED DOUBLE-CURRENT INTERCHANGE CIRCUITS FOR GENERAL USE WITH INTEGRATED CIRCUIT EQUIPMENT IN THE FIELD OF DATA COMMUNICATIONS

(For the text of this Recommendation, see Recommendation V.10 for which Study Group XVII is responsible.)

Recommendation X.27

ELECTRICAL CHARACTERISTICS FOR BALANCED DOUBLE-CURRENT INTERCHANGE CIRCUITS FOR GENERAL USE WITH INTEGRATED CIRCUIT EQUIPMENT IN THE FIELD OF DATA COMMUNICATIONS

(For the text of this Recommendation, see Recommendation V.11 for which Study Group XVII is responsible.)

Recommendation 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

(provisional, Geneva, 1977; amended, Geneva, 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

CONTENTS

Preface

The establishment in various countries of public data networks providing packet-switched data transmission services creates a need to produce standards to facilitate access from the public telephone network, circuit-switched public data networks and leased circuits.

The CCITT,

considering

(a) that Recommendations X.1 and X.2 define user classes of service and user facilities provided by a public data network, and Recommendation X.96 defines call progress signals;

(b) that Recommendation X.29 defines procedures for a packet mode DTE to control the PAD and for interworking between PADs;

(c) that Recommendation X.3 defines the Packet Assembly/Disassembly (PAD) facility in a public data network;

(d) that the logical control links for packet-switched data transmission services are defined in Recommendation X.92;

(e) the need for defining an international Recommendation for the exchange of control information between a start-stop mode DTE and a PAD;

(f) that DTEs operating in the start-stop mode will send and receive network call control information and user information in the form of characters according to Recommendation T.50 or the *break* signal;

(g) that the necessary elements for an interface Recommendation should be defined independently as:

1) procedures for the establishment of a national access information path between a start-stop mode DTE and a PAD,
2) procedures for character interchange and service initialization between a start-stop mode DTE and a PAD,
3) procedures for the exchange of control information between a start-stop mode DTE and a PAD,
4) procedures for the exchange of user data between a start-stop mode DTE and a PAD.

unanimously declares

that start-stop mode DTE accessing the PAD should operate in accordance with this Recommendation.

1 Procedures for the establishment of a national access information path between a start-stop mode DTE and a PAD

1.1 *Access via a public switched telephone network or leased lines with V-Series interfaces*

1.1.1 *DTE/DCE interface*

The access information path will be provided by the use of modems standardized for use in the public switched telephone network or leased line operating:

i) at rates up to 300 bit/s in accordance with Recommendation V.21; or
ii) at the rate of 1200 bit/s in accordance with Recommendation V.22 alternative B, mode ii) or V.22 *bis* mode 4, and at the rates of 2400 bit/s in accordance with Recommendation V.22 *bis* mode 2, on the public switched telephone network or 2-wire leased circuit, or at the rates up to 1200 bit/s in accordance with Recommendation V.23 without backward channel on 4-wire leased circuits; or
iii) at the rate of 75/1200 bit/s (for the signal received by the DTE and 75 bit/s for the signal sent by the DTE on the backward channel) in accordance with Recommendation V.23.

The particular interchange circuits provided, and their operation, shall be in accordance with the relevant modem Recommendations, and clamping of circuit 104 shall be implemented in accordance with Recommendation V.24, § 4.3.

At rates of up to 300 bit/s or at 1200 bit/s or 2400 bit/s:

a) on the telephone network, the modem shall be set up for channel operation in accordance with Recommendation V.21, or with Recommendation V.22, or with Recommendation V.22 *bis*; or

b) on leased lines (2-wire), the channel operation will be determined by the same rule, the modem at the DTE side being considered as the one making the telephone call.

At the rate of 75/1200 bit/s: the modem shall be set up for channel operation in accordance with Recommendation V.23.

Note 1 – The interface requirements for other data signalling rates are for further study.

Note 2 – In some networks, references to modem characteristics do not apply (e.g. for leased lines).

1.1.2 *Electrical characteristics*

The electrical characteristics of the DTE/DCE interface shall be in accordance with Recommendation V.28.

1.1.3 *Procedure for setting up and disconnecting the access information path*

1.1.3.1 *Setting up the access information path by the DTE*

The access information path shall be established in accordance with Recommendation V.25 for a manual data station calling an automatic answering station.

The mechanism for echo suppressor disablement may not be implemented in some national networks where the access information path does not include echo suppressors.

Subsequent to the completion of the above, both the DTE and DCE shall transmit binary 1 on circuits 103 and 104.

1.1.3.2 *Disconnecting the access information path by the DTE*

The access information path shall be disconnected by:

i) reversion of the data circuit to the voice mode, or

ii) the DTE turning circuit 108/1 or 108/2 OFF for a period greater than Z. The value of Z is for further study.

1.1.3.3 *Setting up the access information path by the PAD*

The procedure for the PAD to establish an access information path shall be in accordance with Recommendation V.25 as far as it is perceived by the DTE.

1.1.3.4 *Disconnecting the access information path by the PAD*

Disconnection by the PAD will be indicated by the DCE turning circuits 106 and 109 OFF, while circuit 108 is ON.

Note – Access information path clear indication to the DTE is not signalled by circuit 107 OFF. Not all DTEs allow circuit 107 to be turned OFF if circuit 108 has not been turned OFF previously.

1.2 *Access via a public switched data network or via leased lines with X-Series interfaces*

1.2.1 *DTE/DCE interface designed for start-stop transmission services on public data networks (Recommendation X.20)*

1.2.1.1 *Physical characteristics*

The physical characteristics of the DTE/DCE interface are defined in § 2 of Recommendation X.20.

1.2.1.2 *Procedures for setting up and disconnecting the access information path (call control)*

The procedures and formats for call control of the public circuit-switched data network are described in §§ 3 and 4 of Recommendation X.20. The procedures for setting up a virtual call in a packet-switched network are those given in §§ 2, 3 and 4 of this Recommendation. The use of Recommendation X.20 procedures to establish a virtual call via a PAD is for further study.

1.2.2 *DTE/DCE interface designed for operation on telephone type networks (Recommendation X.20 bis)*

In the case of DTEs with interfaces designed for operation on telephone type networks (V-Series interfaces), the access information path will be established by the use of DCEs standardized for start-stop transmission services on public data networks according to Recommendation X.20 *bis*.

1.2.2.1 *Characteristics of interchange circuits*

The characteristics of the interchange circuits are described in § 2 of Recommendation X.20 *bis*.

1.2.2.2 *Operational requirements*

The requirements for the operation of the interchange circuits 106, 107, 108, 109 and 125 are described in § 3 of Recommendation X.20 *bis*.

1.2.2.3 *Operational requirements for disconnecting the access information path by the DTE*

The access information path shall be disconnected either

manually by depressing the clearing key of the DCE, or

automatically by the DTE turning OFF circuit 108/1 or 108/2 for a period longer than 210 ms.

1.2.2.4 *Indication of disconnection by the PAD*

Disconnection by the PAD, i.e. DCE clearing, will be indicated by the DCE by turning OFF circuits 106 and 109. The DTE should then perform clear confirmation by turning OFF circuit 108.

1.2.2.5 *Setting up the access information path by the PAD*

The procedure for the PAD to establish an access information path is for further study.

1.2.2.6 *Operational constraints for maintaining the access information path during information transfer*

The transmission of a *break* signal longer than 200 ms may cause clearing in a public switched data network. Therefore, the transmission of a *break* signal in either direction should either be avoided or the timer of the circuit generating a *break* signal should be adjusted to generate a signal length considerably shorter than 200 ms (see also § 3.1.2).

2 Procedures for character interchange and service initialization between a start-stop mode DTE and a PAD

2.1 *Format of characters used in the exchange of control information between start-stop mode DTE and a PAD*

2.1.1 The start-stop mode DTE shall generate and be capable of receiving characters in accordance with International Alphabet No. 5 as described in Recommendation T.50. The general structure of characters shall be in accordance with Recommendation X.4 except that the transmitted stop bits shall be as specified in § 2.1.2. The character format specified below applies to the procedures described in §§ 2 and 3.

2.1.2 The PAD will transmit and expect to receive 8-bit characters.

When the value of parameter 21 is set to 0, whenever the PAD has to interpret a received character for a specific action different from or additional to the transfer of this data character to the remote DTE, it will only inspect the first seven bits and will not take account of the eighth bit (the last bit preceding the stop element).

When the value of parameter 21 is set to 1, the PAD will treat the 8th bit of the characters received from the start-stop DTE as a parity bit and check this bit against the type of parity [even, odd, space ("0") or mark ("1")] used between the PAD and the start-stop mode DTE.

When the value of parameter 21 is set to 2, the PAD will replace the 8th bit of the characters to be sent to the start-stop mode DTE with the bit that corresponds to the type of parity used between the PAD and the start-stop mode DTE.

When the value of parameter 21 is set to 3, the PAD will both check the parity bit for characters received from the start-stop mode DTE and generate the parity bit for characters to be sent to the start-stop mode DTE, as described for values 1 and 2.

Whenever the PAD generates characters (e.g. *PAD service* signals), they will be transmitted by the PAD with even parity if parameter 21 is set to 0, and with the type of parity (even, odd, space or mark) used between the PAD and the start-stop mode DTE if parameter 21 is set to 1, 2 or 3 or if the parity is determined by alternate means.

When the value of parameter 21 is set to 1 or 3, if the PAD detects a parity error in the characters received from the start-stop mode DTE, the PAD will:

- if parameter 2 is set to 0 (no echo), and parameter 6 is set to 0 (no service signals), reset the virtual circuit;
- if parameter 2 is set to 1 (echo) and parameter 6 is set to 0 (no service signals), discard and not echo the character in error and transmit the character 0/7 (BEL) to the start-stop mode DTE;
- if parameter 2 is set to 1 (echo) and parameter 6 is set to 1 or greater (service signals) discard and not echo the character in error and transmit the character 0/7 (BEL) to the start-stop mode DTE; the PAD may also transmit the parity error *PAD service* signal. The action of the PAD when parameter 2 is set to 0 (no echo) and parameter 6 is set to 1 or greater (service signal) is for further study.

The PAD will accept characters which have a single stop element and will transmit characters with at least two stop elements if the start-stop mode DTE is operating at 110 bit/s. If the PAD is operating at any other speed, the PAD will transmit and accept characters with a single stop element.

2.2 *Procedures for initialization*

The references to states in the following procedures correspond to the state diagrams, see Figures 1/X.28, 2/X.28 and 3/X.28.

2.2.1 *Active link (state 1)*

After the access information path has been established, the start-stop mode DTE and the PAD exchange binary 1 across the start-stop mode DTE/DCE interface and the interface is in the *active link* state.

2.2.2 *Service request (state 2)*

If the interface is in the *active link* state, the DTE shall transmit a sequence of characters to indicate *service request* and to initialize the PAD. The *service request* signal enables the PAD to detect the data rate, the code and, optionally, the parity used by the DTE and to select the *initial profile* of the PAD. The parameters of CCITT *standard profiles* are summarized in Table 1/X.28.

The format of the *service request* signal to be transmitted by the DTE is given in § 3.5.16 below.

Some networks may allow state 2 to be bypassed. In case the start-stop mode DTE is connected to the PAD by a leased line or if the access information path is set up by the PAD, the PAD either knows the speed, code, and initial profile, required for the start-stop mode DTE or uses a default value. The default value is network dependent. In case the access information path is set up by the start-stop mode DTE, the access method chosen may be uniquely dedicated to a single combination of speed, code and initial profile.

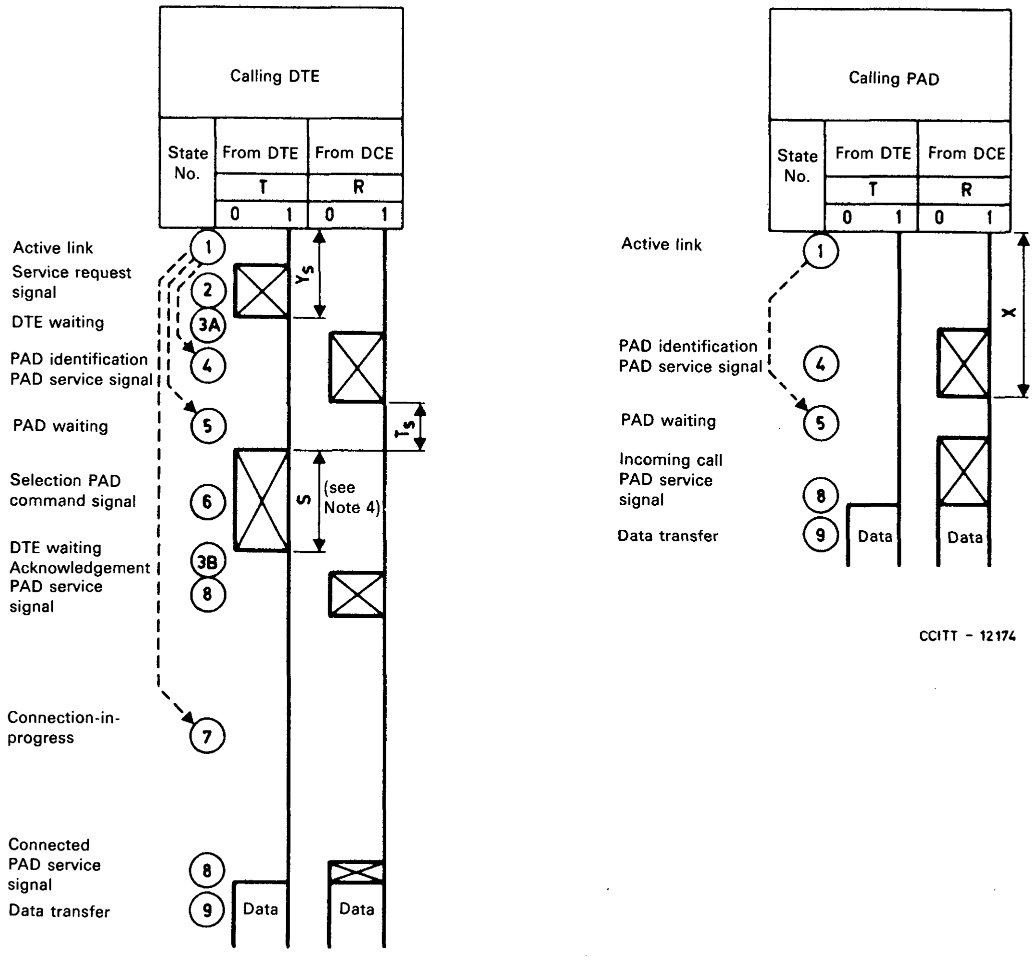
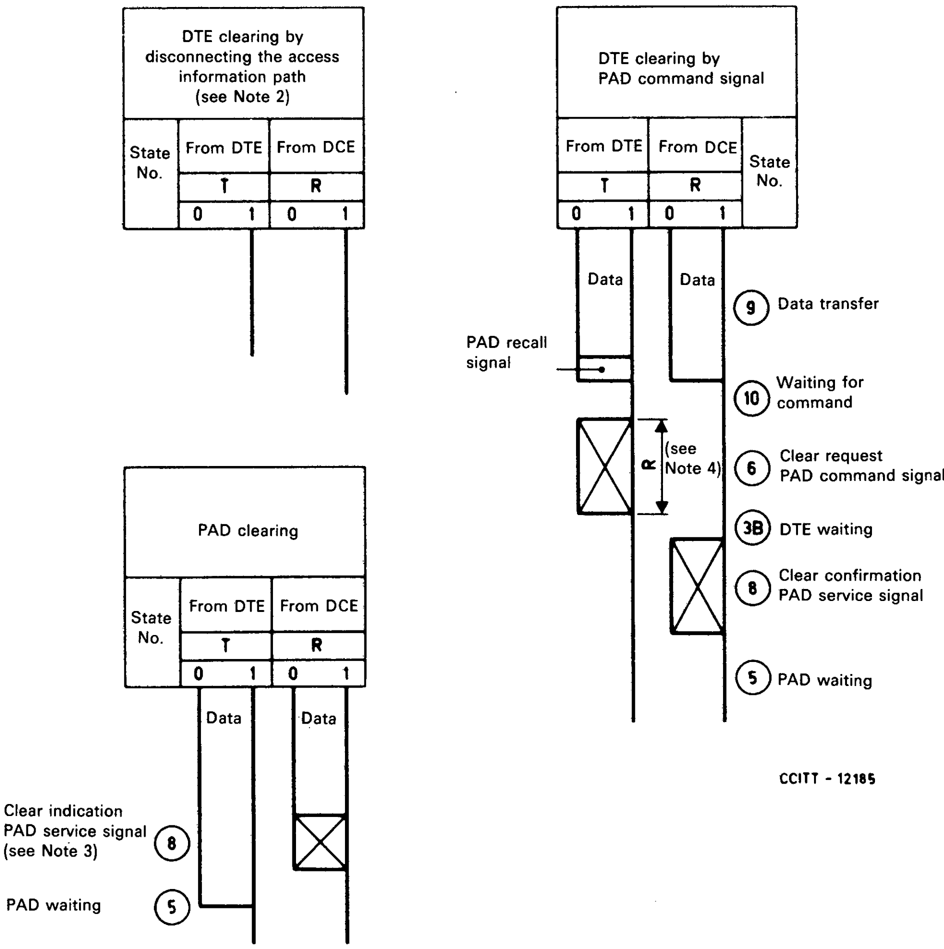


FIGURE 1a/X.28

Sequence of events at the interface: call establishment



Note 1 – Some networks may allow a direct state transition from state 1 to either state 4, 5 or 7.

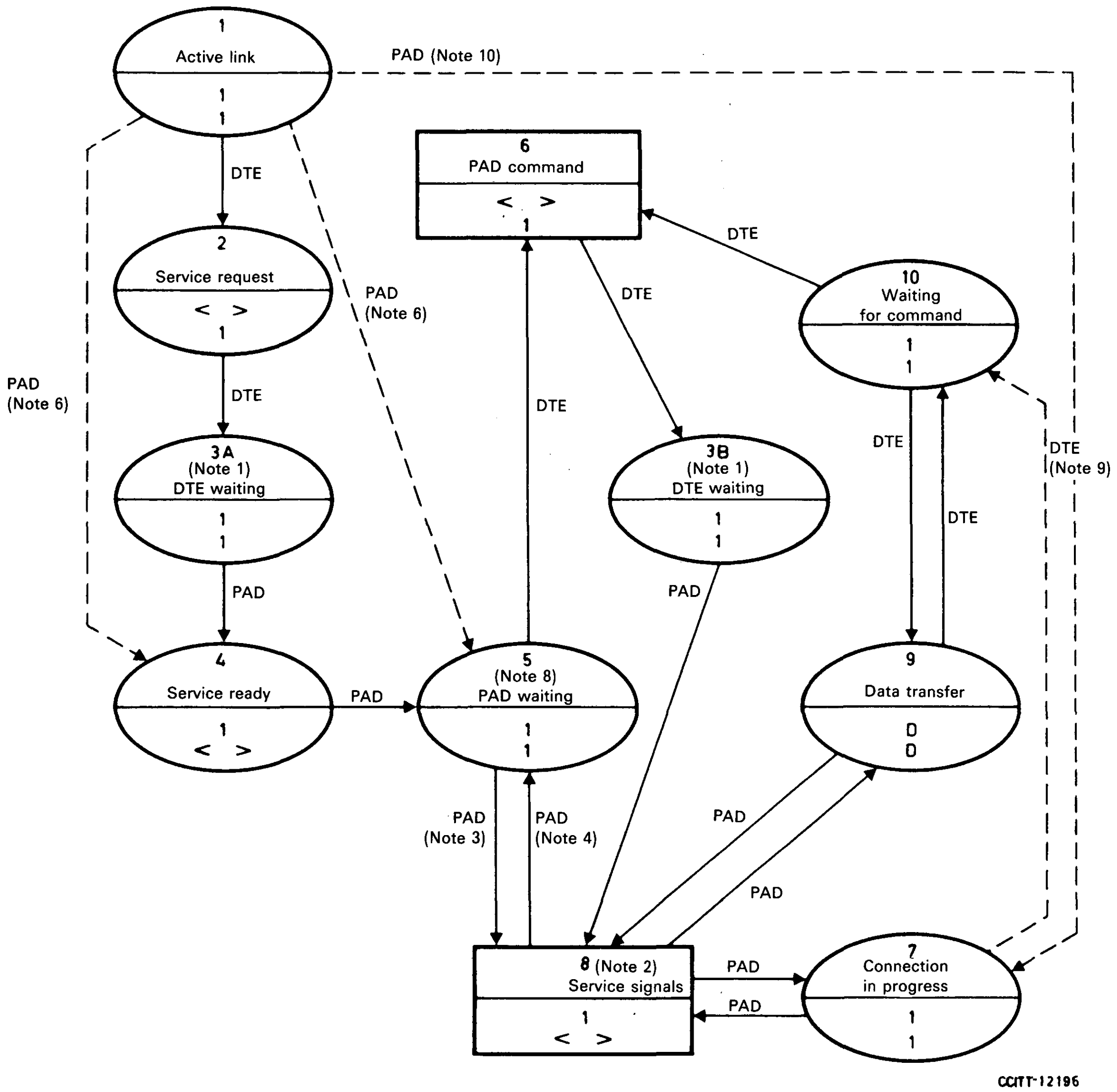
Note 2 – The *DTE clear* may be performed by disconnecting the access information path (see § 1 of this Recommendation). The response from the DCE is *PAD clearing* which also disconnects the access information path.

Note 3 – PAD clearing may also be performed by disconnecting the access information path (see § 1 of this Recommendation).

Note 4 – The time-outs S and R are not less than 60 s.

FIGURE 1b/X.28

Sequence of events at the interface: call clearing



Note 1 – States 3A and 3B are represented in Figure 2a/X.28 for convenience. They are functionally equivalent.

Note 2 – State 8 is used to represent a state during which all *PAD service* signals are transmitted (except for the *PAD identification* and *editing PAD service* signals).

Note 3 – The transition from state 5 to state 8 occurs only when the PAD receives a call destined for the start-stop mode DTE.

Note 4 – The PAD may permit entry to the *PAD waiting* state N times before performing PAD disconnection (see § 3.2.3.1.2).

Note 5 – Under certain circumstances *DTE clearing* is performed by disconnecting the access information path (see § 1 of the text).

Note 6 – Some networks may allow a direct state transition from state 1 to either state 4 or 5.

Note 7 – See Figure 3/X.28 for the symbol definitions of the state diagram.

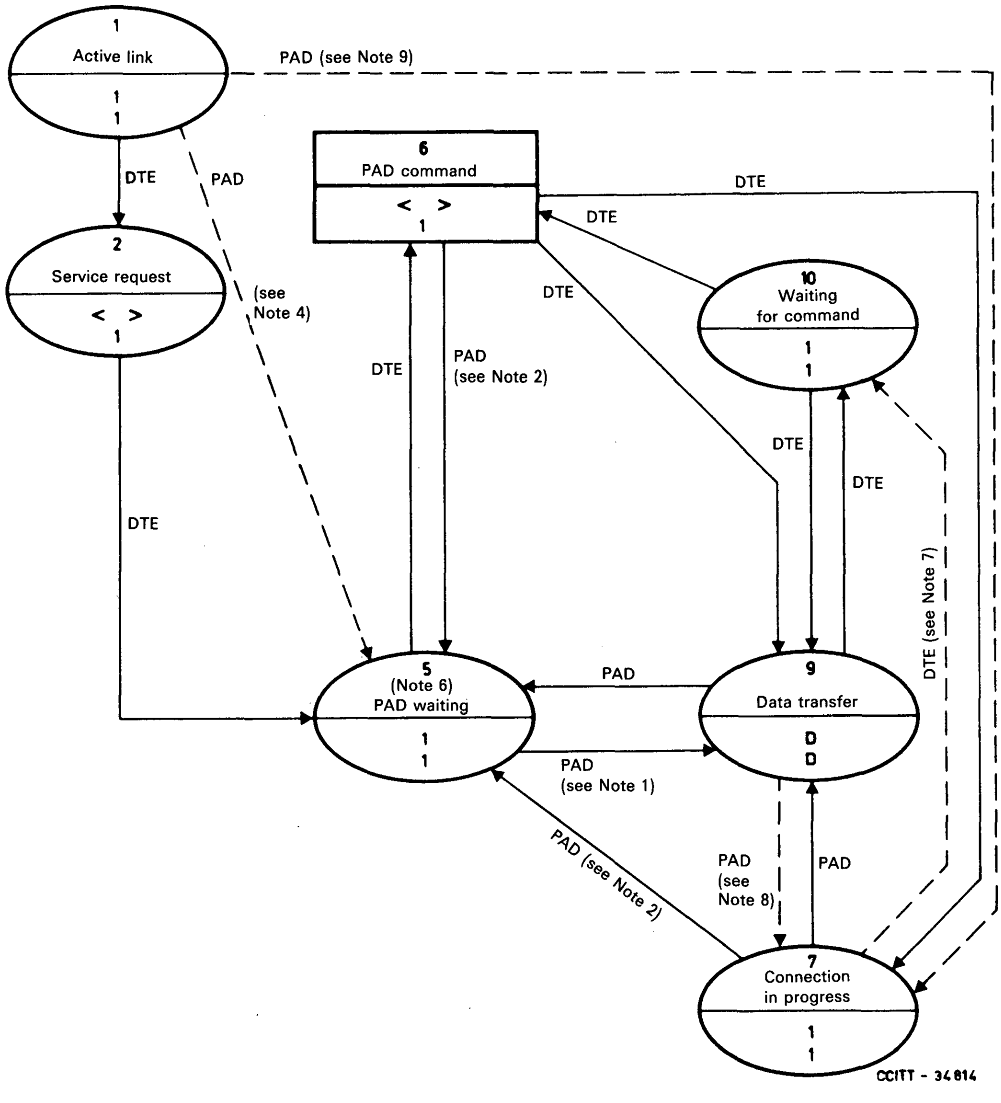
Note 8 – The condition of the interchange circuit 103 (Recommendations X.20 *bis* and V.21) or the T interchange circuit (Recommendation X.20) shown in state 5 is the preferred condition. It is recognized that the DTE may not have sufficient information to maintain this condition under all circumstances and consequently may transmit characters.

Note 9 – Some networks allow the transition from state 7 to state 10 for the purpose of accepting *PAD command* signals (e.g. *clear request PAD command* signal) as described in § 3.2.1.5.

Note 10 – In some networks, the transition from state 1 to state 7 occurs when the PAD establishes a virtual call without receiving the *service request* signal and *selection PAD command* signal. It is network dependent how the PAD knows the start-stop mode DTE characteristics relevant to the virtual call.

FIGURE 2a/X.28

State diagram of call establishment and call clearing by PAD command and service signals when parameter 6 is set to 1



Note 1 – The transition from state 5 to state 9 occurs only when the PAD receives a call destined for the start-stop mode DTE.

Note 2 – The PAD will permit entry to the *PAD waiting* state N times before performing PAD disconnection (see § 3.2.3.1.2).

Note 3 – Under certain circumstances *DTE clearing* is performed by disconnecting the access information path (see § 1 of the text).

Note 4 – Some networks may allow a direct state transition from state 1 to state 5.

Note 5 – See Figure 3/X.28 for the symbol definitions of the state diagram.

Note 6 – The condition of the interchange circuit 103 (Recommendations X.20 *bis* and V.21) or the T interchange circuit (Recommendation X.20) shown in state 5 is the preferred condition. It is recognized that the DTE may not have sufficient information to maintain this condition under all circumstances and consequently may transmit characters.

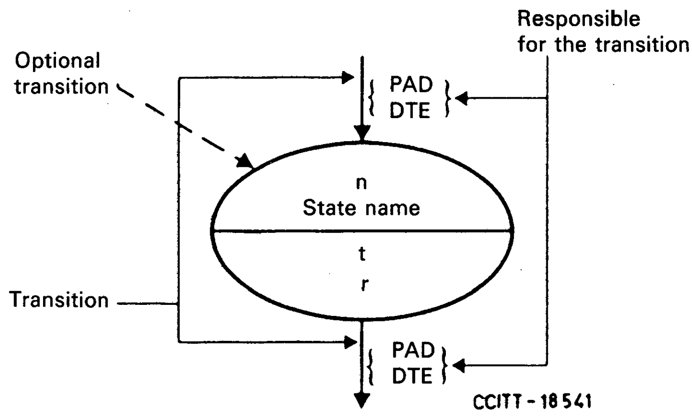
Note 7 – Some networks allow the transition from state 7 to state 10 for the purpose of accepting *PAD command* signals (e.g. *clear request PAD command* signal) as described in § 3.2.1.5.

Note 8 – Some networks allow the transition from state 9 to state 7 for the purpose of performing called DTE reselection.

Note 9 – In some networks, the transition from state 1 to state 7 occurs when the PAD establishes a virtual call without receiving the *service request* signal and *selection PAD command* signal. It is network dependent how the PAD knows the start-stop mode DTE characteristics relevant to the virtual call.

FIGURE 2b/X.28

State diagram of call establishment and call clearing by PAD command signals when parameter 6 is set to 0



n	State number
t	Value on interchange circuit 103 when access is via X.20 *bis* or V.21; or on T interchange circuit when access is via X.20
r	Value on interchange circuit 104 when access is via X.20 *bis* or V.21; or on R interchange circuit when access is via X.20
–	DTE to DTE data signal
0 and 1	Steady binary conditions
< >	An International Alphabet No. 5 character sequence

FIGURE 3/X.28

Symbol definitions of the state diagrams

2.2.3 *DTE waiting (state 3A)*

Following the transmission of the *service request* signal the DTE shall transmit binary 1 and the interface will be in the *DTE waiting* state.

When the value of parameter 6 is set to 0, the interface will directly enter the *PAD waiting* state following receipt of a valid *service request* signal.

2.2.4 *Service ready (state 4)*

When parameter 6 is not set to 0 the interface will enter the *service ready* state when the PAD transmits a *PAD identification PAD service* signal after receiving a *service request* signal. If the *PAD identification PAD service* signal is not received within V seconds, the DTE should retransmit the *service request* signal. Following transmission of the *service request* signal W times the user should report a fault to the appropriate point. The values of V and W are for further study.

The standard format of the *PAD identification PAD service* signal is given in § 3.5.18 below.

2.2.5 *Fault condition*

If a valid *service request* signal is not received by the PAD within Y seconds after the transmission of binary 1, it will perform PAD clearing by disconnecting the access information path.

The value of Y is for further study.

Note – Some networks may allow states 2 to 4 to be bypassed. In this case the condition described under § 2.2.4 does not apply.

TABLE 1/X.28

PAD parameter settings

The parameter references and values relate to Recommendation X.3 (see Note 1)

Parameter reference number (see Note 3)	Parameter description	Parameter setting for CCITT standard profile (see Note 2)	
		Transparent standard profile (see Note 4)	Simple standard profile (see Note 4)
1	PAD recall using a character	Set to *not possible* (value 0)	Set to *possible* (value 1)
2	Echo	Set to *no echo* (value 0)	Set to *echo* (value 1)
3	Selection of *data forwarding* signal	Set to *no data forwarding signal* (value 0)	Set to *all characters in columns 0 and 1 and character 7/15 (DEL)* of International Alphabet No. 5 (value 126)
4	Selection of *idle timer delay*	Set to *one second* (value 20)	Set to *no time out* (value 0)
5	Ancillary device	Set to *no use of X-ON and X-OFF* (value 0)	Set to *use of X-ON and X-OFF* (value 1)
6	Control of *PAD service* signals and *PAD command* signals	Set to *no service signals sent to the* start-stop mode DTE (value 0)	Set to *service signals are sent* (value 1)
7	Selection of operation of PAD on receipt of *break* signal from the start-stop mode DTE	Set to *reset* (value 2)	Set to *reset* (value 2)
8	Discard output	Set to *normal data delivery* (value 0)	Set to *normal data delivery* (value 0)
9	Padding after carriage return (CR)	Set to *no padding after CR* (value 0) (see Note 5)	Set to *no padding after CR* (value 0) (see Note 5)
10	Line folding	Set to *no line folding* (value 0)	Set to *no line folding* (value 0)
11 (read only)	Binary speed of start-stop mode DTE	Indicate speed of DTE	Indicate speed of DTE
12	Flow control of the PAD by the start-stop mode DTE	Set to *no use of X-ON and X-OFF* (value 0)	Set to *use of X-ON and X-OFF* (value 1)
13 (see Note 6)	Linefeed insertion after carriage return	Set to *no linefeed insertion* (value 0)	Set to *no linefeed insertion* (value 0)
14 (see Note 6)	Linefeed padding	Set to *no linefeed after LF* (value 0)	Set to *no linefeed after LF* (value 0)
15 (see Notes 6 and 7)	Editing	Set to no editing in *data transfer* state (value 0)	Set to no editing in *data transfer* state (value 0)

Parameter reference number (see Note 3)	Parameter description	Parameter setting for CCITT standard profile (see Note 2)	
		Transparent standard profile (see Note 4)	Simple standard profile (see Note 4)
16 (see Note 6)	Character delete	Set to character 7/15 (DEL) (value 127)	Set to character 7/15 (DEL) (value 127)
17 (see Note 6)	Line delete	Set to character 1/8 (CAN) (value 24)	Set to character 1/8 (CAN) (value 24)
18 (see Note 6)	Line display	Set to character 1/2 (DC2) (value 18)	Set to character 1/2 (DC2) (value 18)
19 (see Notes 6 and 7)	Editing *PAD service* signals	Set to editing *PAD service* signals for printing terminals (value 1)	Set to editing *PAD service* signals for printing terminals (value 1)
20 (see Notes 6 and 8)	Echo mask	Set to echo all characters (value 0)	Set to echo all characters (value 0)
21 (see Notes 6 and 9)	Parity Treatment	Set to no parity detection or generation (value 0)	Set to no parity detection or generation (value 0)
22 (see Note 6)	Page Wait	Set to page wait disabled (value 0)	Set to page wait disabled (value 0)

Note 1 – All parameters standardized by CCITT are listed in Table 1/X.3 including those which provide additional user facilities listed in Recommendation X.2.

Note 2 – In the case of a leased circuit access, the appropriate profile parameter values are specified at subscription time. In the case of access from public telephone networks or circuit switched public data networks, the definition of other CCITT standard profiles is for further study.

Note 3 – Parameter reference 0 is not used to define a PAD parameter. Specific use of the decimal value 0 in PAD messages to permit the existence of parameters not defined by CCITT is provided in Recommendation X.29. A similar use of this value in Recommendation X.28 is for further study.

Note 4 – The procedures for selecting *transparent standard* profile or *simple standard* profile by the start-stop mode DTE are currently defined by using the *service request* signal or *standard profile selection PAD command* signal.

Note 5 – There will be no padding except that *PAD service* signals will obtain a number of padding characters according to the data transmission rate of the start-stop mode DTE.

Note 6 – Parameter which provides additional user facilities available in some countries for international and national services (see Recommendation X.3). The implementation of this parameter in a PAD is a matter for national determination. When implemented, the values appropriate when a *standard* profile is selected are given in this table.

Note 7 – Editing functions apply during the *PAD command* state irrespective of the value of parameter 15. The default values of selectable values of parameters 16, 17, 18 and 19 apply for the functions.

Note 8 – This parameter does not apply if parameter 2 is set to 0.

Note 9 – Characters generated by the PAD itself (e.g. *PAD service* signals) have even parity when parameter 21 is set to zero unless the parity is set by alternate means.

3 Procedures for the exchange of control information between a start-stop mode DTE and a PAD

3.1 *General*

3.1.1 *PAD command signals and PAD service signals*

The operation of the PAD depends on the current values of internal PAD variables which are known as PAD parameters. Initially PAD parameter values depend on the initial standard profile applicable at the time of sending a service request signal or by previous arrangement with the Administration. The parameter values for the transparent and simple standard profile are given in Table 1/X.28.

PAD command signals (direction DTE to PAD) are provided for:

a) the establishment and clearing of a virtual call (see § 3.2 below);

b) the selection of a set of preset values of PAD parameters known as a *standard* profile, either CCITT or network defined (see § 3.3.1 below);

c) the selection of individual PAD parameter values (see § 3.3.2 below);

d) requesting the current values of PAD parameters to be transmitted by the PAD to the DTE (see § 3.4 below);

e) sending of an interrupt;

f) requesting the status of the circuit (see § 3.7 below);

g) resetting the virtual call.

PAD service signals (direction PAD to DTE) are provided to:

a) transmit *call progress* signals to the calling DTE;

b) acknowledge *PAD command* signals;

c) transmit information regarding the operation of the PAD to the start-stop mode DTE.

The formats of *PAD command* signals and the standard formats of *PAD service* signals are given in § 3.5 below. Some networks may also support the extended dialogue mode for *PAD command* signals and *PAD service* signals as defined in § 3.5 and § 5 below. Some networks may also support additional *PAD command* signals and *PAD service* signals as defined in § 5 below.

The information content of *PAD command* signals and *PAD service* signals are summarized in Annex A.

3.1.2 *Break signal*

The *break* signal is provided to allow the start-stop mode DTE to signal to the PAD without loss of character transparency. The *break* signal can also be transmitted by the PAD to the start-stop mode DTE.

The *break* signal is defined as the transmission of binary 0 for more than 135 ms. The maximum permitted duration shall depend upon the type of access information path used (see, for example, § 1.2.2.6 above).

A *break* signal shall be separated from any following start-stop character or other *break* signal by the transmission of binary 1 for more than 100 ms.

3.1.3 *Prompt PAD service signal*

If parameter 6 is set to 5 on entering the *PAD waiting* state or *waiting for command* state, the PAD will indicate its readiness to receive a *PAD command* signal by transmitting the *prompt PAD service* signal.

If the value of parameter 6 is set to 0 or 1, the PAD will not transmit the *prompt PAD service* signal to the start-stop mode DTE.

If the value of parameter 6 is set to 5, a *PAD command* signal transmitted before the *prompt PAD service* signal has been received from the PAD will be ignored.

If the value of parameter 6 is set to any of the values 8-15, the availability and format of a *prompt PAD service* signal is network dependent.

The standard format of the *prompt PAD service* signal is given in § 3.5.23.

3.2 *Procedures for virtual call control*

Figure 1/X.28 (Sequence of events at the interface) shows the procedures at the DTE/DCE interface during call establishment, data transfer and call clearing. Figure 2/X.28 shows the state diagram.

For details on the action expected of the start-stop mode DTE following receipt of a *PAD service* signal, refer to Recommendation X.96.

3.2.1 *Call establishment*

3.2.1.1 *PAD waiting (state 5)*

Following the transmission of a *PAD service* signal the interface will be in the *PAD waiting* state unless a virtual call is established or is being established. During the *PAD waiting* state the PAD will transmit binary 1.

If parameter 2 is set to 1, all characters are echoed.

Note – In some networks the *active link* state will either lead directly to the *PAD waiting* state, the *service ready* state or the *connection in progress* state.

3.2.1.2 *Network user identification (NUI)*

When required, for security, billing and/or network management purposes the network user shall transmit a *network user identification* signal. Some Administrations may not implement a *network user identification* signal. When implemented, the *network user identification* signal will be defined in the *facility request* block of a *selection PAD command* signal.

The format of the *facility request* block is defined in § 3.5.15.1.

The information content of the *network user identification* signal is network dependent.

When *network user identification* is not used and the calling DTE is not identified by other means, the *reverse charging* facility will be used.

3.2.1.3 *PAD command (state 6)*

The DTE may transmit a *PAD command* signal when the interface is in the *PAD waiting* state (state 5) and enters the *PAD command* state at the start of a *PAD command* signal.

The DTE may also transmit *PAD command* signals after escaping from the *data transfer* state or the *connection in progress* state (see § 4.9.1 below).

If parameter 2 is set to 1, characters in *PAD command* signals are echoed, except the characters following the character P in a *selection PAD command* signal, which are not echoed. If parameter 20 is implemented, the set of characters to be echoed is determined by the value of parameter 20.

If parameter 6 is not set to 0, the PAD will ignore all characters received from the DTE following the receipt of a *PAD command* signal until the associated *PAD service* signal or sequence of *PAD service* signals has been transmitted to the DTE by the PAD.

If parameter 6 is set to 0, the PAD will not transmit a *PAD service* signal. Therefore it is for the user to define the way in which information regarding the completion of the connection is signalled to the start-stop mode DTE.

The DTE may request the establishment of a virtual call by transmitting a *selection PAD command* signal.

The DTE may edit *PAD command* signals before they are actioned by the PAD by using the procedures in § 3.6 below.

The formats of *PAD command* signals are given in § 3.5 below. A summary of *PAD command* signals is given in Table 2/X.28.

3.2.1.4 *DTE waiting (state 3B)*

Following the transmission of a *PAD command* signal the DTE will transmit binary 1 and the interface will be in the *DTE waiting* state.

TABLE 2/X.28

Summary of PAD command signals

PAD command signals	Valid before virtual call set-up	Valid after escaping from *data transfer* state	Valid after escaping from *connection-in-progress* state
Selection (§ 3.2.1.3)	X		
Profile selection (§§ 3.3.1 and 4.9.2.5)	X	X	
Set (§§ 3.3.2 and 4.9.2.5)	X	X	
Set and read (§§ 3.3.2 and 4.9.2.5)	X	X	
Read (§§ 3.4 and 4.9.2.5)	X	X	
Clear request (§§ 3.2.1.5, 3.2.2.1 a) and 4.9.2.1)		X	X
Status (§§ 3.7 and 4.9.2.2)	X	X	
Reset (§ 4.9.2.3)		X	
Interrupt (§ 4.9.2.4)		X	
Remote set and read (§§ 3.3.4)		X	
Remote read (§ 3.4.2)		X	
Invitation to clear (§ 3.2.2)		X	
Extended dialogue mode			
Break (§ 5.1)		X	
Help (§ 5.4)	X	X	
Language (§ 5.3)	X	X	
NUI on (§ 5.2)	X		
NUI off (§ 5.2)	X		

3.2.1.5 *Connection-in-progress (state 7)*

If parameter 6 is not set to 0, on receipt of a valid *selection PAD command* signal the PAD will transmit an *acknowledgement PAD service* signal followed by binary 1 and the interface will enter the *connection-in-progress* state. The interface will enter the *PAD service signals* state as necessary and the PAD will transmit the *connected PAD service* signal or a *clear indication PAD service* signal to the DTE. During this period the PAD will not accept any *PAD command* signals. Characters are not echoed.

If the value of parameter 6 is 0, the PAD will not transmit *PAD service* signals to the start-stop mode DTE. Following the receipt of a valid *selection PAD command* signal, the interface shall remain in the *connection-in-progress* state until the virtual call has been established.

In some networks, during the *connection in progress* state, the start-stop mode DTE may escape from that state by transmitting a *PAD recall* signal to the PAD. On detection of the *PAD recall* signal, the interface will enter the *waiting for command* state.

If parameter 1 is set to 1, the PAD will recognize the character 1/0 (DLE) as the *PAD recall* signal from the start-stop mode DTE.

If parameter 1 is set to a decimal value from 32 to 126, the PAD will recognize the binary representation of the decimal value as the *PAD recall* signal from the start-stop mode DTE.

If parameter 7 is set to 8, the *break* signal may be used as the *PAD recall* signal from the *connection in progress* state, allowing for escape from the *connection in progress* state without loss of character transparency.

If parameter 6 is set to 5, the *prompt PAD service* will be transmitted by the PAD. At this time, the PAD may accept the *clear request PAD command* signal or another suitable command to be determined by further study.

On receipt of the next character from the start-stop mode DTE, the PAD will act in accordance with one of the following conditions:

a) if the character received is the *PAD recall* character or the *PAD command* signal delimiter [characters 2/11 (+) or 0/13 (CR)] the interface will return to the *connection in progress* state and no action will be taken with the character;

b) if the character received is in columns 2 to 7 of International Alphabet No. 5, excluding the characters 2/0 (SP), 2/11 (+) [see § 3.2.1.5.1 a) above], 7/15 (DEL) and the *PAD recall* character, the interface will enter the *PAD command* state, and the character will be placed in the editing buffer. Characters 2/0 (SP) and 7/15 (DEL) will be ignored;

c) if the character is not covered above, for example editing characters in columns 2 to 7 and characters in columns 0 and 1 of IA5, the action by the PAD is for further study.

If the first character of a *PAD command* signal is not received within P seconds of the interface entering the *waiting for command* state from the *connection in progress* state, the PAD will transmit an *error PAD service* signal, when parameter 6 is not set to 0. The interface will then enter the *connection in progress* state, irrespective of the value of parameter 6. The value of P is for further study but will not be less than 60 s.

If the *PAD command* signal delimiter is not received within Q seconds of the interface entering the *PAD command* state from the *connection in progress* state, or an invalid *PAD command* signal is received, the PAD will transmit an *error PAD service* signal, when parameter 6 is not set to 0, indicating that an error has occurred. The interface will then enter the *connection in progress* state, irrespective of the value of parameter 6. The value of Q is for further study but will not be less than 60 s.

If a valid *clear request PAD command* signal is received the procedure will be as described in § 3.2.2.1 a).

3.2.1.6 *PAD service signals (state 8)*

Following receipt by the DTE of a *PAD service* signal or a sequence of *PAD service* signals (in the case of call set-up) in response to a previously transmitted *PAD command* signal, the interface will be in either:

a) a *PAD waiting* state (state 5) if no virtual call is in progress, or

b) a *data transfer* state (state 9) if a virtual call is in progress.

Any *PAD service* signal arising from events within the packet network will not be transmitted until any *PAD service* signal outstanding from a previously received *PAD command* signal has been transmitted.

PAD service signals will not be transmitted if the value of parameter 6 is set to 0 and the *PAD service* signals state will be bypassed.

The standard format of *PAD service* signals is defined in § 3.5 below.

A summary of *PAD service* signals is given in Annex A.

3.2.1.7 *Incoming calls*

The PAD will indicate *incoming call* to the start-stop mode DTE only if the DTE/DCE interface is in the *PAD waiting* state (state 5). In any other case the PAD will only indicate incoming call if:

a) the PAD knows the speed and code of the start-stop mode DTE by previous agreement, or a default value is applicable;

b) the PAD waiting state (state 5) is reached by the setting up of an access information path within X seconds.

The value of X is for further study, but should not exceed 120 s.

The PAD will transmit to the start-stop mode DTE an *incoming call PAD service* signal.

The PAD will not expect a response to the *incoming call PAD service* signal from the start-stop mode DTE and will consider the interface to enter at once the *data transfer* state (state 9).

The standard format of the *incoming call PAD service* signal is given in § 3.5.22 below.

3.2.2 *Clearing*

3.2.2.1 *Clearing by the start-stop mode DTE*

3.2.2.1.1 *Clearing by the local PAD*

DTE clearing of the PAD to which the DTE is connected shall be indicated by either:

a) transmitting a *clear request PAD command* signal after escaping from the *data transfer* state during a virtual call (see § 4.9 below). The format of a *clear request PAD command* signal is given in § 3.5.8 below. The PAD will transmit a *clear confirmation PAD service* signal within B seconds. The value of B is for further study. The standard format of the *clear confirmation PAD service* signal is given in § 3.5.9 below. The interface will enter the *PAD waiting* state and the DTE will be allowed to make a follow-on call; or

b) disconnecting the access information path.

3.2.2.1.2 *Clearing of the remote PAD*

Note – This is an optional function which will not be supported on all PADs.

DTE clearing of a remote PAD shall be indicated by transmitting an *invitation to clear PAD command* signal after escaping from the data transfer state during a virtual call (see § 4.9 below). The format of an *invitation to clear PAD command* signal is given in § 3.5.8 below. The PAD to which the DTE issuing the invitation to clear is connected will transmit a *clear indication PAD service* signal to that DTE once indication of clearing has been received from the remote PAD. The format of the clear indication PAD service signal is given in § 3.5.17 below. The interface will enter the PAD waiting state and the DTE will be allowed to make a follow-on call or disconnect the access information path.

3.2.3 *Unsuccessful calls*

If a call is unsuccessful for any reason, the PAD will indicate the reason to the start-stop mode DTE by means of a *clear indication PAD service* signal. If parameter 6 is set to 0, a *PAD service* signal is not transmitted.

After transmission of the *clear indication PAD service* signal the PAD will be in the *PAD waiting* state.

3.2.3.1 *Fault conditions*

3.2.3.1.1 *Failure to receive a PAD command signal*

If the first character of a *PAD command* signal is not received within T seconds of the interface entering the *PAD waiting* state, the PAD will perform PAD clearing in accordance with § 3.2.2.2 above. The value of T is for further study.

This restriction does not apply to a DTE which accesses the PAD by a leased line.

If following the first character of a *PAD command* signal a *PAD command* signal delimiter is not received within S seconds, the PAD will transmit an *error PAD service* signal, if parameter 6 is not set to 0, indicating that an error has occurred (see § 3.5.19 below) and the interface will return to the *PAD waiting* state. The value of S is for further study but will not be less than 60 s.

If the PAD receives an unrecognized *PAD command* signal it will transmit an *error PAD service* signal, if parameter 6 is not set to 0, indicating that an error has occurred and the interface will return to the *PAD waiting* state.

The operation of the PAD when parameter 6 is set to 0 is for further study.

3.2.3.1.2 *Failure to establish a virtual call*

If the interface enters the *PAD waiting* state more than N times after setting up the access information path without a virtual call being established, the PAD will disconnect the access information path. This restriction does not apply to DTEs which access the PAD by leased lines.

The value of N is for further study.

3.2.3.1.3 *Invalid clear request PAD command signal*

If the PAD receives a *clear request PAD command* signal while the interface is in the *PAD waiting* state, the PAD will transmit a *clear indication PAD service* signal (local procedure error) if parameter 6 is not set to 0 and the interface will return to the *PAD waiting* state. The standard format of the relevant *clear indication PAD service* signal is given in § 3.5.17 e) below.

3.2.3.1.4 *Invalid facility request*

If the PAD receives an invalid facility request code the PAD will perform PAD clearing in accordance with §§ 3.2.2.1.1 or 3.2.2.1.2 above.

3.2.3.2 *Failure of the access information path*

If the access information path is disconnected for any reason, the call attempt or virtual call will be cleared by the PAD.

3.2.4 *Data transfer*

The procedures for data transfer are given in § 4 below.

3.2.5 *Called DTE reselection*

The called DTE reselection is provided as default condition by the PAD. The start-stop mode DTE is able to prevent the called DTE reselection by including the *called DTE reselection prevention facility* in the *selection PAD command* signal.

On receipt of a *reselection PAD* message the PAD will, if parameter 6 is not set to 0 and the *called DTE reselection prevention facility* has not been requested in the *selection PAD command* signal, send a *reselection PAD service* signal to the start-stop mode DTE.

The standard format of the *reselection PAD service* signal is given in § 3.5.29. The interface will enter *connection in progress* state, and the PAD will act as described in § 3.2.1.5 above.

Note – Some networks may not implement this procedure.

3.3 *Procedures for setting or changing the values of PAD parameters*

The procedures described in §§ 3.3.1 and 3.3.2 give details for setting or changing the values of PAD parameters by the start-stop mode DTE connected to that PAD. These procedures may be used before the *selection PAD command* signal is sent and also after escaping from the *data transfer* state.

The procedures described in § 3.3.3 below refer to the PAD behaviour about the current values of PAD parameters in the case of call clearing.

The procedures described in § 3.3.4 give details for setting or changing the values of remote PAD parameters by a start-stop mode DTE. These precedures may only be used after escaping the *data transfer* state.

Note – The procedure for setting or changing parameters in a remote PAD is optional and may not be supported by many PADs.

3.3.1 *Selection of a standard profile by the start-stop mode DTE*

The start-stop mode DTE may select a set of defined values of PAD parameters known as a *standard profile* [see § 3.1.1 b) above] by sending the *profile selection PAD command* signal which includes a profile identifier. This procedure is additional to the selecting of an *initial standard profile* by transmitting the *service request* signal. The start-stop mode DTE may select a set of parameter values as an initial profile at subscription time by agreement with the Administration.

The format of the *profile selection PAD command* signal is given in § 3.5.5 below.

A list of the parameter values associated with the *transparent* and *simple standard profiles* is given in Table 1/X.28. Other CCITT *standard profiles*, all corresponding parameter values and their identifiers are subjects for further study.

When parameter 6 is not set to 0, the PAD will acknowledge the *profile selection PAD command* signal by sending an *acknowledgement PAD service* signal to the start-stop mode DTE.

The standard format of the *acknowledgement PAD service* signal is defined in § 3.5.3 below.

3.3.2 *Procedures for setting or changing one or several parameters by the start-stop mode DTE*

The start-stop mode DTE may change the values of one or several parameters by sending a *set* or *set and read PAD command* signal including the parameter reference(s) and value(s). The format of *PAD command* signals is defined in § 3.5 below.

When parameter 6 is not set to 0, the PAD will respond to a valid *set and read PAD command* signal by transmitting a *parameter value PAD service* signal, showing the newly set parameter values. The PAD will respond to a valid *set PAD command* signal by transmitting an *acknowledgement PAD service* signal. If at least one of the requested PAD parameters is invalid, the PAD will send a *parameter value PAD service* signal to the start-stop mode DTE to identify the invalid parameters. In this case the valid parameters will be accepted and invoked. Valid parameter references and values are given in Table 1/X.3.

The format of the *parameter value PAD service* signal is defined in § 3.5.14 below.

When parameter 6 is set to 0, the PAD will accept and invoke valid parameters without advising the start-stop mode DTE of any invalid parameters or parameter values.

If the function of a character is duplicated by the selection of parameter values by use of the *set* or *set and read PAD command* signal, the PAD will consider these parameter changes as valid, and will respond as described above. After these changes are invoked, when the PAD receives from the start-stop mode DTE the character with the duplicated function, the PAD will perform the function of the character that has the highest priority among the functions that are duplicated. The priority assignment of the functions is as follows:

(Highest) 1) PAD recall character (parameter 1)
2) PAD command signal delimiter
3) X-ON, X-OFF (parameters 12 and 22)
4) Line Display (parameter 18)
5) Character delete (parameter 16)
6) Line delete (parameter 17)
(Lowest) 7) Data forwarding character (parameter 31).

3.3.3 *PAD procedures regarding the current values of PAD parameters*

The following situations are considered:

i) *Call establishment phase*

In any case if a *clear* condition, without disconnecting the access information path, occurs prior to the virtual call being set up, the current values of PAD parameters are left as they are.

ii) *Clear after call set up*

In the case where a *clear* condition, without disconnecting the access information path, occurs after set up of the virtual call, the PAD will reset the parameters to the values specified in the *initial profile.*

3.3.4 *Procedures for setting or changing one or several parameters of a remote PAD by the start-stop mode DTE*

Note – The function of being able to set or change parameters in the remote PAD is optional and may not be supported by many PADs.

The start-stop mode DTE may change the values of one or several parameters in a remote PAD by sending a remote *set and read PAD command* signal including the parameter reference(s) and value(s). The format of *PAD command* signals is defined in § 3.5 below.

When parameter 6 is not set to 0, the PAD will, in response to a valid remote *set and read PAD command* signal from the local DTE and following receipt of a *parameter indication PAD* message from the remote PAD, transmit a remote parameter value PAD service signal to the local DTE showing the newly set parameter values in the remote PAD.

3.4 *Procedures for reading the values of one or several parameters by the start-stop mode DTE*

This procedure may be used when parameter 6 is not set to 0. The PAD will ignore a *read PAD command* signal or a *remote read PAD command signal* if parameter 6 is set to 0.

3.4.1 *To read local PAD parameter values*

The start-stop mode DTE may enquire about the current values of one or several PAD parameters by sending the *read PAD command* signal and the references of the required parameters before the *selection PAD command* signal is sent and also after escaping from the *data transfer* state. The format of the *read PAD command* signal is defined in § 3.5.4 below.

The PAD will respond by sending a *parameter value PAD service* signal containing the requested parameter values. The standard format of the *parameter value PAD service* signal is defined in § 3.5.14 below.

3.4.2 *To read remote PAD parameter values*

The procedures used by the start-stop mode DTE to enquire about the current values of the remote PAD are similar to those in § 3.4.1 above. In this case the remote *read PAD command* signal and *remote parameter value PAD* signal are used, and the procedure may only be used after escaping from the *data transfer* state.

3.5 *Formats of PAD command signals and PAD service signals*

All characters in columns 2 to 7 of International Alphabet No. 5, excluding the characters 2/0 (SP), 7/15 (DEL), 2/11 (+) and the characters assigned to perform editing functions will be recognized by the PAD as forming part of a *PAD command* signal. The PAD will always recognize the characters 0/13 (CR) and 2/11 (+) as the *PAD command signal delimiter.* The *PAD command signal delimiter* is not part of the command. Characters 2/0 (SP) and 7/15 (DEL) are not considered as part of a *PAD command* signal and those characters will be ignored by the PAD if no other function is assigned to these characters. Characters from columns 0 to 7 may be assigned to perform editing functions and in this case the PAD will operate in accordance with § 3.6 below. Unassigned characters in columns 0 and 1 will be ignored by the PAD.

PAD command signals are defined in upper case characters in this Recommendation; however, in addition, lower case characters are acceptable. For an interim period, some networks may consider *PAD command* signals containing lower case characters as invalid.

All *PAD command* signals shall be terminated with the *PAD command signal delimiter.*

If the low order 4 bits or parameter 6 are set to a value of 1 or 5, *PAD service* signals will be sent in the standard format, as described below. If the low order 4 bits of parameter 6 are set to one of the values 8 to 15 *PAD service* signals are sent in a network dependent format.

If the high order 4 bits of parameter 6 are not all zero, the PAD will operate in the extended dialogue mode. The extended dialogue mode provides additional natural language text in *PAD service* signals. It provides a *help PAD command* signal for requesting explanatory information on *PAD command* signals, PAD parameters, standard profiles, etc. In the following definitions of standard formats for *PAD service* signals, the extended text, where shown, is to be sent only when the PAD is in the extended dialogue mode. In some networks the extended dialogue mode information may be provided in different languages. Additional *PAD command* signals may be provided as defined in § 5. Some networks may also provide the additional *PAD command* signals while the PAD is not in extended dialogue mode.

Note – The text for service signals in languages other than English is for further study. See Annex C.

Some networks may not permit the free use of character 2/0 (SP) anywhere in the command when operating in the extended dialogue mode. In particular this character may not be permitted within keywords. In addition, at least one such character may be required as a separator between keywords or between keywords and numeric values.

PAD service signals, other than the *acknowledgement, prompt, character deleted, line deleted* and *page wait PAD service* signals (see §§ 3.5.2, 3.5.23, 3.5.24, 3.5.25 and 3.5.26) will commence with and be followed by the *format effector.*

3.5.1 *Format of the PAD command signal delimiter*

The character 0/13 (CR) or character 2/11 (+) may be sent as a delimiter.

3.5.2 *Format of the format effector*

The characters 0/13 (CR) 0/10 (LF) will be sent by the PAD followed by, when parameter 9 is set to 0, two padding characters if the start-stop mode DTE operates at a data rate of 110 bit/s and four padding characters if the start-stop mode DTE operates at 200 bit/s, 300 bit/s, 1200 bit/s or 75/1200 bit/s.

If parameter 9 is not set to 0, then the number of padding characters transmitted after the character 0/10 (LF) will be equal to the current value of that parameter.

The format of the padding characters is given in § 3.5.20 below.

Note – The term "format effector" is used here slightly differently than in Recommendation T.50.

3.5.3 *Standard format of the acknowledgement PAD service signal*

The *format effector* will be sent.

3.5.4 *Format of read PAD command signal*

3.5.4.1 To read parameters of the local PAD to which the requesting DTE is connected, the characters 5/0 (P) 4/1 (A) 5/2 (R) 3/15 (?) shall be sent followed by the decimal reference of the parameter to be read.

Characters of International Alphabet No. 5 will be sent to represent both the parameter reference and parameter value, e.g. decimal value 12 would be sent as characters 3/1 (1) and 3/2 (2).

If no parameter reference number is indicated in the *read PAD command* signal then it applies implicitly to all parameters.

When more than one parameter is required to be read by sending the *read PAD command* signal, the character 2/12 (,) shall be sent between the decimal references of the parameters.

Example: PAR? 1, 3, 5

The format required to read national parameters is for further study.

3.5.4.2 If reading of remote PAD parameters is supported by the local PAD, the characters 5/2 (R) 5/0 (P) 4/1 (A) 5/2 (R) 3/15 (?) shall be sent followed by the reference of the parameter to be read.

Characters of International Alphabet No. 5 will be sent to represent both the parameter reference and parameter value, e.g. decimal value 12 would be sent as characters 3/1 (1) and 3/2 (2).

If no parameter reference number is indicated in the *remote read PAD command* signal then it applies implicitly to all parameters.

When more than one parameter is required to be read by sending the *remote read PAD command* signal, the character 2/12 (,) shall be sent between the decimal references of the parameters.

Example: RPAR ? 1, 3, 5

3.5.5 *Format of profile selection PAD command signal*

The characters 5/0 (P) 5/2 (R) 4/15 (O) 4/6 (F) shall be sent followed by a profile identifier. A profile identifier will consist of one or more alphanumeric characters. The profile identifiers 90-99 are reserved for CCITT defined profiles as defined in Tables 3/X.28. In addition, some networks may also assign other profile identifiers to CCITT defined profiles.

TABLE 3/X.28

CCITT standard profile identifiers

Profile identifier	CCITT standard profile
90	Simple standard profile
91	Transparent standard profile
92 to 99	Reserved for future use

3.5.6 *Format of set PAD command signal and the set and read PAD command signal*

3.5.6.1 To set or set and read parameters in the local PAD to which the DTE is connected:

The *set PAD command* signal will consist of the characters 5/3 (S) 4/5 (E) 5/4 (T) followed by the decimal reference of the parameter to be set, followed by character 3/10 (:) and the parameter value required.

The *set and read PAD command* signal will consist of the characters 5/3 (S) 4/5 (E) 5/4 (T) 3/15 (?) followed by the decimal reference of the parameter to be set and read, followed by the character 3/10 (:) and the parameter value required.

If more than one parameter is to be set or set and read by the *set and read PAD command* signal, the character 2/12 (,) shall be sent between a parameter value and the next parameter reference.

Example: SET 2:0, 3:2, 9:4

The format required to set national parameters is for further study.

3.5.6.2 *To set and read parameter in the remote PAD*

The local PAD may optionally support the setting and reading of the remote PAD parameters.

The *remote set and read PAD command* signal will consist of the characters 5/2 (R) 5/3 (S) 4/5 (E) 5/4 (T) 3/15(?) followed by the decimal reference of the parameter to set and read, followed by the character 3/10 (:) and the parameter value required.

If more than one parameter is to be set and read by the *remote set and read PAD command* signal, the character 2/12 (,) shall be sent between a parameter value and the next parameter reference.

Example: RSET 2:0, 3:2, 9:4

3.5.7 *Standard format of the reset PAD service signal*

The *reset PAD service* signal consists of the following elements:

<reset PAD service signal> ::= <RESET> <cause> <diagnostic> <text>

where

<RESET> ::= 5/2 (R) 4/5 (E) 5/3 (S) 4/5 (E) 5/4 (T) 2/0 (SP)

<cause> ::= as shown in Table 5/X.28

<diagnostic> ::= 1, 2 or 3 characters which represent the decimal value of the diagnostic code, as specified in Recommendation X.25.

<text> ::= 2/0 (SP) 2/13 (–) 2/0 (SP) followed by extended dialogue mode text as specified in Table 5/X.28.

3.5.8 *Format of the clear request PAD command signal and invitation to clear PAD command signal*

3.5.8.1 *Standard Format of the clear request PAD command signal*

The *clear request PAD command* signal will, in the following order, consist of the following elements:

– One mandatory field:

  The characters <4/3 (C) 4/12 (L) 5/2 (R)> shall be sent to cause the local PAD to clear the call, followed by <Formatting character>

– One optional field (only present in conjunction with the fast select facility):

  Up to 128 characters of clear user data that may only be present in conjunction with the fast select facility.

Note – the characters 0/13 (CR) and 2/11 (+) should not be included in the *clear user data* field because they will be treated as a *PAD command* signal delimiter and not transmitted to the remote packet mode DTE. The editing functions should not be included in the *clear user data* field as they will be treated as providing the editing function.

3.5.8.2 *Invitation to clear PAD command signal*

The local PAD may support the capability to generate an *invitation to clear* PAD message to the remote PAD to request the remote PAD to clear the call when all remaining data has been transmitted to the remote DTE.

The characters 4/9 (I) 4/3 (C) 4/12 (L) 5/2 (R) shall be sent to cause the local PAD to send an invitation to clear to the remote PAD.

3.5.9 *Standard format of the clear confirmation PAD service signal*

The *clear confirmation PAD service* signal consists of the following elements:

<clear confirmation> ::= <CLR> <CONF> <TEXT> <format effector> <optional facility block>

where

<CLR> ::= 4/3 (C) 4/12 (L) 5/2 (R) 2/0 (SP)

<CONF> ::= characters as specified in Table 7/X.28

<text> ::= 2/0 (SP) 2/13 (–) 2/0 (SP) followed by extended dialogue mode text as specified in Table 7/X.28.

<format effector> ::= see § 3.5.2

<optional facility block> ::= see § 3.5.17.3

If subscribed to or requested in the *selection PAD command* signal (see Table 4/X.28), the optional facility block will contain the charging information and will be transmitted by the PAD to the start-stop mode DTE. The format of the charging information is network dependent.

3.5.10 *Format of the status PAD command signal*

The characters 5/3 (S) 5/4 (T) 4/1 (A) 5/4 (T) shall be sent.

3.5.11 *Standard format of the status engaged and status free PAD service signals*

The *status engaged PAD service* signal consists of the following elements:

<status engaged> ::= <ENGAGED> <text>

where

<ENGAGED> ::= 4/5 (E) 4/14 (N) 4/7 (G) 4/1 (A) 4/7 (G) 4/5 (E) 4/4 (D)

<text> ::= 2/0 (SP) 2/13 (–) 2/0 (SP) followed by the extended dialogue mode text "Call Established"

Note – The inclusion of additional information (e.g. destination address) is for further study.

The *status free PAD service* signal consists of the following elements:

<status free> ::= <FREE> <text>

where

<FREE> ::= 4/6 (F) 5/2 (R) 4/5 (E) 4/5 (E)

<Text> ::= 2/0 (SP) 2/13 (–) 2/0 (SP) followed by the extended dialogue mode next "No Call Established"

Note – The inclusion of additional information, (e.g. see § 3.5.18) is for further study.

3.5.12 *Format of the reset PAD command signal*

The characters 5/2 (R) 4/5 (E) 5/3 (S) 4/5 (E) 5/4 (T) shall be sent.

3.5.13 *Format of the interrupt PAD command signal*

The characters 4/9 (I) 4/14 (N) 5/4 (T) shall be sent.

TABLE 4/X.28

Facility request/indication codes

Facility request/indication code	Facility	Remarks
4/2 (B)	Bilateral closed user group	Note 2
4/3 (C)	Charging information	Note 1
4/4 (D)	Throughput class negotiation	Note 2
4/5 (E) Address Extension String	Called Address extension	Note 1
4/6 (F)	Fast select with no restriction on response	Note 1
4/7 (G) CUG String	Closed user group	Note 1
4/13 (M)	Called line address modified notification	Note 2
4/14 (N) NUI String	Network user identification	Note 1
4/15 (O) CUG String	Closed user group with outgoing access	Note 1
5/0 (P)	Packet size negotiation	Note 2
5/1(Q)	Fast select with restriction on response	Note 1
5/2 (R)	Reverse charging	Note 1
5/3 (S)	Called DTE reselection prevention	Note 2
5/4 (T) RPOA string	RPOA transit network selection	Note 1
5/5 (U)	Call redirection notification	Note 2
5/7 (W)	Window size negotiation	Note 2

Note 1 – These codes may be currently used.

Note 2 – These codes are reserved for possible future use.

TABLE 5/X.28

Extended dialogue mode text for reset PAD service signal

<Cause>	<Text>
4/4 (D) 5/4 (T) 4/5 (E)	Reset by remote device, data may be lost
4/5 (E) 5/2 (R) 5/2 (R)	Reset by network, local procedure error, data may be lost
4/15 (N) 4/3 (C)	Reset due to temporary network problem, data may be lost
5/2 (R) 5/0 (P) 4/5 (E)	Reset by network, remote procedure error, data may be lost

3.5.14 *Standard format of parameter value PAD service signals*

The *parameter value PAD service* signal consists of the following elements:

< parameter value PAD service signal > :: = < PAR > < parameter list >

where

<PAR> :: =	5/0 (P) 4/1 (A) 5/2 (R) 2/0 (SP)

(Response from the local PAD to a request for parameter values)

5/2 (R) 5/0 (P) 4/1 (A) 5/2 (R) 2/0 (SP)

(Response from the remote PAD to a request for parameter values)

<parameter list> :: =	one or more of <parameter>
<parameter> :: =	<parameter reference> <parameter value> <text>
<parameter reference> :: =	decimal reference of the parameter followed by the character 3/10 (:)
<parameter value> :: =	decimal value of the parameter
<text> :: =	2/0 (SP) 2/13 (−) 2/0 (SP) followed by the extended dialogue mode text as specified in Table 8/X.28

If the requested parameter reference or value is invalid, the characters 4/9 (I) 4/14 (N) 5/6 (V) will be sent in place of the appropriate parameter value.

If more than one parameter value is contained in the parameter value *PAD service* signal the characters 2/12 (,) 2/0 (SP) will be sent before the next parameter reference.

In extended dialogue mode, if the length of the next parameter reference, value and text would cause the line length to exceed the value of PAD parameter 10 (if it is non-zero) then the character 2/12 (,) followed by the format effector may be used.

3.5.15 *Format of the selection PAD command signal*

A *selection PAD command* signal shall, in the following order, consist of a *facility request* block, or an *address* block, or both, optionally followed by *call user data* field.

3.5.15.1 *Format of facility request block*

Characters representing the *facility request* code shall be sent as defined in Table 4/X.28. When more than one *facility request* code is to be sent, the character 2/12 (,) shall be sent to separate the *facility request* codes. The character 2/13 (−) shall be sent at the end of the *facility request* block.

3.5.15.1.1 The format of the NUI *facility request* signal is as follows:

<facility request> :: = <N> <NUI string>

<N> :: = IA5 character 4/14 (N)

<string> :: = one or more characters in columns 2 to 7 of International Alphabet No. 5 (IA5), except 2/0 (SP) 7/15 (DEL), 2/13 (−), 2/12 (,) and 2/11 (+).

Note 1 – The recognition by the PAD of the presence of the *facility request* signal should turn off the echo, (irrespective of its parameter value) for the duration of the NUI *facility request.*

Note 2 – The length of the NUI string is network dependent.

Note 3 – Characters in columns 0 and 1, except 0/13 (CR), and characters 7/15 (DEL), and 2/0 (SP) may be included during the transmission of the NUI string but will not form part of the NUI string and will be discarded.

3.5.15.1.2 The format of the RPOA (transit network) selection *facility request* signal is *as* follows:

<RPOA facility request> :: = <T> <RPOA string>

<RPOA string> :: = The DNIC of the requested RPOA. In addition, some networks may also support graphic representations of the DNIC which may be used.

<T> :: = IA5 character 5/4 (T).

3.5.15.1.3 The format of the reverse charging *facility request* signal is as follows:

<reverse charging facility request> :: = <R>

<R> :: = IA5 character 4/2 (R).

3.5.15.1.4 *Formats for Closed User Group Signals*

When the user has subscribed to Closed User Groups (CUG), a preferential CUG must be chosen. In this case, only the *CUG facility request* signal may be used by the user.

When the user has subscribed to CUG and has outgoing access (CUGOA) and/or incoming access (CUGIA), the user may choose whether or not to have a preferential CUG. If a preferential has not been chosen, the user may signal the *CUG facility request* or the *CUGOA facility request* in a particular *PAD Selection Command* Signal. When the user has chosen a preferential CUG, only the *CUG facility request* signal may be used.

The *CUG facility request* and the *CUGOA facility request* shall not be used in the same *PAD Selection Command* Signal.

3.5.15.1.4.1 The format of the closed user group *facility request* signal is as follows:

<CUG facility request> :: = <G> <index>

<G> :: = IA5 character 4/7 (G)

<Optional index> :: = one or two decimal digits.

The PAD shall treat the absence of the index as an implicit request for the preferential CUG.

The PAD shall treat the absence of a *CUG facility request* as an implicit preferential CUG request if the user has subscribed to the CUG, CUGOA and/or CUGIA facility and has chosen a preferential.

3.5.15.1.4.2 The format of the closed user group with outgoing access facility is as follows:

<CUG with outgoing access facility request> :: = <O> <index>

<O> :: = IA5 character 4/15 (O)

<Optional index> :: = one or two decimal digits

3.5.15.1.5 The format of the charging information *facility request* signal is as follows.

<charging information facility request> :: = <C>

<C> :: = IA5 character4/3 (C).

3.5.15.1.6 The format of the called address extension *facility request* signal is as follows:

CAE facility request:

<CAE facility request> :: = <E> <CAE string>

<E> :: = IA5 character 4/5 (E)

<CAE> :: = The called address extension as a string of up to 40 characters from the set 3/0-3/9. Further, other representations of the called address extension are for further study.

The means to indicate the type of address present in the called address extension facility is for further study.

3.5.15.1.7 The format of the fast select with no restriction on response *facility request* signal is as follows:

<fast select with no restriction on response facility request> :: = <F>

<F> :: = IA5 character 4/6 (F)

3.5.15.1.8 The format of the called DTE reselection prevention *facility request* signal is as follows:

<called DTE reselection prevention facility request> :: = <S>

<S> :: = IA5 character 5/3 (S)

3.5.15.1.9 The format of the fast select with restriction on response *facility request* signal is as follows:

<fast select with restriction on response facility request> :: = <Q>

<Q> :: = IA5 character 5/1 (Q)

The formats of other *facility request* codes are for further study.

3.5.15.2 *Format of address block*

Characters representing a full address or an abbreviated address shall be sent. When an abbreviated address is sent, it shall be prefixed by character 2/14 (.). When more than one address, either full address or abbreviated address, is sent, the character 2/12 (,) is sent as a separator. When an abbreviated address is used, the call user data field shall be separated from the *abbreviated address* signal by the character 2/10 (*).

3.5.15.2.1 The format of the full address is as follows:

<full address> :: = one or more numeric characters of the International Alphabet No. 5 (IA5)

Note 1 – The numeric characters are those in the ranges 3/0 to 3/9.

3.5.15.2.2 The format of the abbreviated address is as follows:

<abbreviated address> :: = one or more characters in colums 2 to 7 of the International Alphabet No. 5, except 2/10 (*), 2/11 (+) 2/12 (,) and 7/15 (DEL). The first character shall not be from the set 0 . . 9 (3/0 . . 3/9).

Note 1 – The PAD shall translate the string into a full address

Note 2 – Recommendations for the translation of the character string to a full address are for further study.

Note 3 – This facility is optional.

3.5.15.3 *Format of call user data field*

The character 5/0 (P) or the character 4/4 (D) shall be sent, followed by up to 12 characters of user data or up to 124 characters of user data in conjunction with the fast select facility. Some networks may not make this field available to the user.

Note – The characters 0/13 (CR) and 2/11 (+) should not be included in the user data field because they will be treated as a *PAD command signal delimiter* and not transmitted to the remote packet mode DTE. The editing characters should not be included in the user data field as they will be treated as providing the editing function.

3.5.16 *Format of service request signal*

The format is for further study.

3.5.17 *Standard format of clear indication PAD service signal*

The *clear indication PAD service* signal will, in the following order, consist of the following elements:

- one mandatory field:

  <a sequence of alphabetic characters indicating the clear indication (see § 3.5.17.1)> <formatting character>

- the following optional fields:

  <called DTE address block (see § 3.5.17.2)> <formatting character>

  <optional facility block (see § 3.5.17.3)> <formatting character>

  <optional clear user data block (see § 3.5.17.4)> <formatting character>

3.5.17.1 *Standard format of the mandatory field*:

The mandatory field consists of the following elements:

<Mandatory field> :: =	<CLEAR> <cause> <cause code> <diagnostic> <text>
<CLEAR> :: =	4/3 (C) 4/12 (L) 5/2 (R) 2/0 (SP)
<cause> :: =	one of the causes shown in Table 6/X.28
<cause code> :: =	2/0 (SP) 4/3 (C) 3/10 (:) followed by 1, 2 or 3 characters which represent the decimal value of the cause code, as specified in Recommendation X.25.
<diagnostic> :: =	2/0 (SP) 4/4 (D) 3/10 (:) followed by 1, 2 or 3 characters which represent the decimal value of the diagnostic code, as specified in Recommendation X.25.
<text> :: =	2/0 (SP) 2/13 (–) 2/0 (SP) followed by extented dialogue mode text as specified for the corresponding <cause> in Table 6/X.28.

Note – The use of the <cause code> and <diagnostic> field is optional.

TABLE 6/X.28

Cause and extended dialogue mode text for clear PAD service signal

<Cause>	<Text>
4/15(O) 4/3(O) 4/3(C)	Call cleared, number busy
4/14(N) 4/3(C)	Call cleared, temporary network problem
4/9(I) 4/14(N) 5/6(V)	Call cleared, invalid facility requested
4/14(N) 4/1(A)	Call cleared, access to this number is barred
4/5(E) 5/2(R) 5/2(R)	Call cleared, network detected local procedure error
5/2(R) 5/0(P) 4/5(E)	Call cleared, network detected remote procedure error
4/14(N) 5/0(P)	Call cleared, number not assigned
4/4(D) 4/5(E) 5/2(R)	Call cleared, number out of order
5/0(P) 4/1(A) 4/4(D)	Call cleared, remote request
4/4(D) 5/4(T) 4/5(E)	Call cleared, by remote device, data may be lost
5/2(R) 4/14(N) 4/1(A)	Call cleared, reverse charging refused
4/9(I) 4/4(D)	Call cleared, incompatible destination
5/3(S) 4/1(A)	Call cleared, ship cannot be contacted
4/6(F) 4/14(N) 4/1(A)	Call cleared, fast select refused
5/2(R) 4/15(O) 4/15(O)	Call cleared, cannot be routed as requested

Note – For details see Recommendation X.96.

TABLE 7/X.28

Extended dialogue mode text for clear confirmation PAD service signal

<CONF>	<Text>
4/3(C) 4/15(O) 4/14(N) 4/6(F)	Call cleared, confirmed

TABLE 8/X.28

PAD parameter names for extended dialogue mode

Parameter reference number	Abbreviated parameter name (Note 1)	Parameter description (Note 2)
1	esc(ape)	PAD recall using a character
2	ech(o)	Echo
3	for(ward)	Selection of data forwarding characters
4	idl(e)	Selection of idle timer delay
5	dev(ice)	Ancillary device control
6	sig(nals)	Control of PAD service signals
7	bre(ak)	Operation on receipt of break signal
8	dis(card)	Discard output
9	CRp(ad)	Padding after carriage return
10	fol(ding)	Line folding
11	spe(ed)	Binary speed of start-stop mode DTE
12	flo(w)	Flow control of the PAD
13	LFi(nsert)	Linefeed insertion after carriage return
14	LFp(ad)	Padding after linefeed
15	Edi(t)	Editing
16	Cdel(ete)	Character delete
17	Ldel(ete)	Line delete
18	Ldis(play)	Line display
19	Esig(nals)	Editing PAD service signals
20	Mas(k)	Echo mask
21	par(ity)	Parity treatment
22	pag(e)	Page wait

Note 1 – These names are provisional. This name should appear in the *parameter value PAD service* signals. The name or abbreviation should be accepted in the *read, set,* or *set and read PAD command* signals.

Note 2 – In some networks this parameter description may appear in the *parameter value PAD service* signals. Alternative parameter descriptions are for further study.

3.5.17.2 *Format of the called DTE address block*

The need and the format of the called DTE address block is for further study.

3.5.17.3 *Format of the optional facility block*

If subscribed to, or requested in the *selection PAD command* signal (see Table 4/X.28), the optional facility block will contain the charging information and will be transmitted by the PAD to the start-stop mode DTE. The format of the charging information is network dependent.

3.5.17.4 *Format of the clear user data block*

The 128 or less characters from the clear user data field received from the remote DTE shall be sent. The clear user data field is only allowed in conjunction with the fast select facility.

3.5.18 *Standard format of the PAD identification PAD service signal*

The characters that will comprise this *PAD service* signal will be network dependent, but would probably indicate the PAD identity and port identity.

3.5.19 *Standard format of the error PAD service signal*

The characters 4/5 (E) 5/2 (R) 5/2 (R) will be sent, followed by other characters which are for further study.

3.5.20 *Format of padding characters*

The padding character will be 0/0 (NUL) or the equivalent duration of binary 1 according to the particular network.

3.5.21 *Standard format of the connected PAD service signal*

The *connected PAD service* signal will, in the following order, consist of the following elements:

– <optional called DTE address block> <formatting characters>
– <optional facility block> <formatting characters>
– <optional called user data field (see § 3.5.21.1)> <formatting characters>
– <character 4/3 (C) 4/15 (O) 4/13 (M)> <formatting characters>

The called DTE address block will consist of numeric characters from IA5. The optional facility block will be as given in § 3.5.22.2 below. It is for further study if the formatting characters will be 2/0 (SP) or the format effector.

3.5.21.1 *Standard format of the called user data field*

The 124 or less characters from the called user data field received from the remote DTE shall be sent. The called user data field is only allowed in conjunction with the fast select facility.

3.5.22 *Standard format of the incoming call PAD service signal*

The standard format of the *incoming call PAD service* signal will, in the following order, consist of the following elements:

– <calling DTE address block> <formatting characters>
– <optional facility block> <formatting character>
– <call data block> <formatting characters>
– <characters 4/3 (C) 4/15 (O) 4/13 (M)>

3.5.22.1 *Standard format of the calling DTE address block*

The standard format of the calling DTE address block is for further study.

3.5.22.2 *Standard format of the optional facility block*

The standard format of the facility block is as follows:

<facility block> :: = <FAC:> <facility string>

<FAC:> :: = <IA5 character 4/6 (F), 4/1 (A), 4/3 (C), 3/10 (:), 2/0 (SP)>

<facility string> :: = One or more facility indication codes separated by character 2/12 (,). For facility indication codes see Table 4/X.28 and § 3.5.15.1.

The facility block is supressed if no facilities are present in the incoming call.

3.5.22.3 *Standard format of the call data block*

The 12 or less characters, or 124 or less characters in conjunction with the fast select facility, from the call data field received from the remote DTE shall be sent.

3.5.23 *Standard format of the prompt PAD service signal*

The standard format of the *prompt PAD service* signal is the character 2/10 (*) following a *format effector.*

Note – For an interim period, other characters are permitted.

3.5.24 *Standard format of the character deleted PAD service signal*

Depending on the value of parameter 19, the following will apply:

Value 0:	no *PAD service* signal will be sent;
Value 1:	the character 5/12 (\) will be sent; see note
Value 2:	the characters 0/8 (BS) 2/0 (SP) 0/8 (BS) will be sent;
Value 8, 32-126:	one character from International Alphabet No. 5 will be sent.

Note – Alternatively the character 2/15 (/) may be used by some networks.

3.5.25 *Standard format of the line deleted PAD service signal*

Depending on the value of parameter 19, the following will apply:

Value 0:	no *PAD service* signal will be sent;
Value 1, 8, 32-126:	the characters 5/8 (X), 5/8 (X), 5/8 (X) will be sent followed by the format effector;
Value 2:	the characters 0/8 (BS), 2/0 (SP), 0/8 (BS) will be sent the number of times equal to the number of graphic characters being deleted from the buffer.

3.5.26 *Standard format of the parity error PAD service signal*

The standard format is for further study.

3.5.27 *Standard format of the page wait PAD service signal*

The characters 0/13 (CR) 5/0 (P) 4/1 (A) 4/7 (G) 4/5 (E) will be sent.

3.5.28 *Format of the page wait cancellation character*

The character X-ON will be sent.

3.5.29 *Standard format of the reselection PAD service signal*

The standard format of the *reselection PAD service* signal will, in the following order, consist of the following element:

- <character 5/4 (T) 5/2 (R) 4/1 (A) 4/14 (N) 5/3 (S) 4/9 (F) 4/5 (E) 5/2 (R) 2/0 (SP) 5/4 (T) 4/15 (O) 3/10 (:)> <formatting character>
- <reselected DTE address block> <formatting character>
- <optional facility block> <character> <note>

Note 1 – the optional facility block contains the facilities included by the PAD in the *Call Request Packet* sent to the reselected DTE. The format of the optional facility block is identical to the one of the *incoming call PAD service* signal.

Note 2 – if requested in the *selection PAD command* signal for the original call or in the *reselection PAD service* signal for the reselected call(s), the PAD will send the charging information before transmitting the *reselection PAD service* signal (see § 3.6. iii) of Recommendation X.29).

Note 3 – the format of charging information is network dependent (see § 3.5.17.2).

3.6 *Editing functions in the PAD*

The PAD provides functions for the start-stop mode DTE to edit characters input to the PAD in *PAD command* signals before being processed by the PAD. The functions provided are:

a) character delete,

b) line delete,

c) line display.

Optionally available in some PADs are identical functions for use by the start-stop mode DTE during the *data transfer* state. When the value of parameter 15 is set to 0 no editing is available during the *data transfer* state.

When the value of parameter 15 is set to 1 editing is provided during the *data transfer* state (see § 4.17).

The user may also have the ability in some PAD implementations to select the character used to effect each of the above functions by setting the value of parameters 16, 17 and 18 and to choose if and in what format the PAD will respond to the editing characters by setting the value of parameter 19 appropriately.

The procedures for editing described in this section apply to both *PAD command* and *data transfer* state (when provided).

3.6.1 *Editing buffer*

To perform the functions of editing, the PAD provides temporary storage of characters in an editing buffer.

3.6.1.1 *Editing buffer size in PAD command state*

In the *PAD command* state the size of the editing buffer will be sufficient to contain the longest mandatory *PAD command* signal permissible in this Recommendation.

3.6.1.2 *Editing buffer size in data transfer state*

In the *data transfer* state the size of the editing buffer is network dependent but will not be smaller than the full packet size and will not be smaller than the value of parameter 10 plus one. It should be noted however, that in some networks the size of the editing buffer may be limited to a maximum of 128 octets.

3.6.1.3 *Impact of editing on data forwarding conditions*

In the *data transfer* state, characters entered into the editing buffer will be forwarded in a complete packet sequence when any of the data forwarding conditions described in § 4.4 and Recommendation X.29, § 2.1 occurs, except that:

a) the PAD will not take account of the value of the idle time delay defined by the value of parameter 4;

b) data forwarding on full packet will be suspended.

Whenever more than enough data has been received to fill the editing buffer, one full packet will be forwarded. The remaining characters will be placed in the beginning of the editing buffer and editing of these characters remains possible.

Once a packet has been forwarded, characters included in it can no longer be edited by the start-stop mode DTE by use of the PAD editing functions.

3.6.2 *Procedures for editing*

The procedures for editing *PAD command* signals and user data (when this facility is provided) use PAD parameters as defined in Recommendation X.3.

3.6.2.1 *Procedure for character delete editing function*

The character delete editing function is performed when the PAD receives a *character delete* character or a series of *character delete* characters from the start-stop mode DTE. The receipt of each *character delete* character causes the last character currently in the editing buffer to be deleted.

Subsequently, if the value of parameter 6 is not set to 0, if the value of parameter 19 is set to 2 or 8 and a graphic character is removed from the editing buffer, or, if the value of parameter 19 is set to 1 or 32-126, and a character is removed from the editing buffer, the *character deleted PAD service* signal will be sent by the PAD. The standard format of the *character deleted PAD service* signal is given in § 3.5.24 above.

The *character delete* character when user selectable is determined by the value of parameter 16. The default value of parameter 16 or the *character delete* character when not user selectable is the character 7/15 (DEL).

3.6.2.2 *Procedure for line delete editing function*

The line delete editing function is performed when the PAD receives a *line delete* character from the start-stop mode DTE. The receipt of the *line delete* character causes the deletion of the current contents of the editing buffer.

The PAD will transmit, if parameter 6 and parameter 19 are not set to 0 and the editing buffer is not empty, a *line deleted PAD service* signal.

The *line delete* character when user selectable is determined by the value of parameter 17. The default value of parameter 17 or the *line delete* character when not user selectable is the character 1/8 (CAN).

3.6.2.3 *Procedure for line display editing function*

The line display editing function is performed when the PAD receives a *line display* character from the start-stop mode DTE.

The receipt of the *line display* character causes the PAD to transmit to the start-stop mode DTE a format effector followed by the characters currently stored in the editing buffer.

The *line display* character when user selectable is determined by the value of parameter 18. The default value of parameter 18 or the *line display* character when not user suitable is the character 1/2 (DC2).

3.7 *Procedure for request of status of the virtual call*

The start-stop mode DTE may, if parameter 6 is not set to 0, enquire whether a virtual call exists by sending the *status PAD* command signal to the PAD. The PAD will respond by sending the *status engaged* or *status free PAD* service signal to the DTE. The format of the PAD command signal and the standard format of the PAD service signals is given in §§ 3.5.10 and 3.5.11 respectively.

4 Procedures for the exchange of user data between a start-stop mode DTE and a PAD

The procedures described apply during the *data transfer* state of the interface to a start-stop mode DTE.

4.1 *Data transfer state*

After receipt of the *connected* or *incoming call PAD service* signal, the interface shall be in the *data transfer* state and will remain in that state, unless it escapes as described in § 4.9 below, until the virtual call is cleared by the PAD or by the start-stop mode DTE as described in § 3.2.2 above.

If parameters 1, 12, 15 and 22 when implemented are set to 0, during the *data transfer* state any character sequence may be transmitted by the start-stop mode DTE for delivery to the remote DTE. If parameter 1 is not set to 0, the PAD recall character selected by the value of parameter 1 can only be transferred by following the procedure described in § 4.9.1.1 below.

If parameter 12 is set to 1, characters 1/1 (DC1) and 1/3 (DC3) are unable to be transferred to the remote DTE, if parameter 15 is set to 1 the characters assigned for editing functions are unable to be transferred to the remote DTE; and if parameter 22 when implemented is not set to 0, the character 1/1 (DC1) is unable to be transferred to the remote DTE.

The values of other parameters may affect the characters which may be transferred during the *data transfer* state.

4.2 *Data from the start-stop mode DTE received by the PAD*

Characters received from the start-stop mode DTE are defined as consisting of all the bits received between, but not including, the start and stop bits. The action of the PAD with respect to the parity bit (bit 8) of all characters received is described in § 2.1 above.

4.3 *Delivery of user data to the start-stop mode DTE*

Data received by the PAD for delivery to the start-stop mode DTE will be treated as contiguous octets. Each octet will be transmitted to the start-stop mode DTE at the data signalling rate appropriate to the start-stop mode DTE. The action of the PAD with respect to bit 8 (parity) of all characters transmitted is described in § 2.1 above.

Start and stop bits will be added to the characters in accordance with Recommendation X.4, except that the number of stop bits will be as follows. If the PAD is operating at 110 bit/s, two stop bits will be transmitted. At any other speed, one stop bit will be transmitted.

The data will be transmitted to the start-stop mode DTE at the earliest opportunity permitted by the interleaving rules (see § 4.19).

4.4 *Data forwarding conditions*

A packet will be forwarded subject to flow control, whenever more than enough data has been received from the start-stop mode DTE to fill a packet after the last packet was forwarded if the value of parameter 15 is set to 0. A packet will also be forwarded when the maximum assembly timer delay period, which starts upon receipt by the PAD of the first character to be assembled into a packet, elapses. The value of the time-out, when implemented, is network dependent and will be greater than or equal to 15 minutes.

In addition, the start-stop mode DTE may indicate to the PAD that a packet should be forwarded, subject to flow control, whenever it performs any one, or more, of the following:

a) Allows the idle time delay period (see parameter 4 in Table 1/X.3), after the transmission of the previous character to the PAD, to elapse without sending a character. If, due to flow control constraints, the packet cannot be forwarded, characters from the start-stop mode DTE will continue to be added to the packet until flow control permits the packet to be forwarded or the packet becomes full. The start-stop mode DTE may be advised (see §§ 4.5 and 4.6 below) if this latter condition occurs. This forwarding condition does not apply if the value of parameter 15 is set to 1.

b) Transmits one of the data forwarding character (see parameter 3 in Table 1/X.3). The character will be included in the data field of the packet it delimits before the packet is forwarded. In case the forwarding character is the character 0/13 (CR) and the value of parameter 13 is set to 6 or 7, the character 0/10 (LF) will be included in the same complete packet sequence as the character 0/13 (CR) and will delimit it.

c) Transmits the *break* signal when parameter 7 is set to any value except 0.

d) Transmits the first character of a *PAD command* signal after the interface has entered a *waiting for command* state as described in § 4.9.1 below.

e) If the value of parameter 15 is set to one, data forwarding will take place as described in § 3.6.1.3.

4.5 *Procedure for the PAD to indicate to the start-stop mode DTE, by means of a PAD service signal, a temporary inability to accept additional information*

The procedure to enable the PAD to indicate a temporary inability to receive additional characters and to subsequently indicate that characters will be accepted, using PAD service signals, is for further study.

This procedure will not operate if parameter 6 is set to 0.

4.6 *Procedures for transmission of X-ON and X-OFF by the PAD*

4.6.1 If parameter 5 is set to 1, the following ancillary device control procedure applies:

The PAD will send the X-ON character to the DTE as soon as the interface enters the *data transfer* state. The character 1/1 (DC1) will be transmitted by the PAD as the X-ON character.

The PAD will send the X-OFF character to the start-stop mode DTE when it is incapable of receiving more than M characters from the ancillary device at the start-stop mode DTE and another character is received from the DTE. The PAD will also send the X-OFF character before the interface leaves the *data transfer* state. The character 1/3 (DC3) will be transmitted by the PAD as the X-OFF character.

When the PAD is again able to receive at least M + 1 characters from the start-stop mode DTE, it will send the X-ON character to that DTE.

4.6.2 If parameter 5 is set to 2, the following flow control procedure applies:

The PAD will send the X-ON character to DTE as soon as the interface enters the *PAD waiting* state (state 5), after link initialization.

The PAD will send the X-OFF character to the start-stop mode DTE, when it is incapable of receiving more than M characters from the start-stop mode DTE and another character is received from the DTE, in either state 5, 6, 7, 9 or 10.

When the PAD is again able to receive at least M + 1 characters from the start-stop mode DTE, it will send the X-ON character to that DTE.

The PAD will not send the X-OFF character to the start-stop mode DTE other than as specified in the above paragraph.

Note – Some networks may send the X-ON character to the start-stop mode DTE when the interface enters either state 5, 6, 7, 9 or 10 from any other state.

4.6.3 The value of M is for further study.

4.7 *Procedures for reset*

4.7.1 *Reset by the DTE*

The start-stop mode DTE shall send a *reset PAD command* signal to the PAD when it wishes to reset the virtual call.

a) The *break* signal (see § 3.1.2 above) will be recognized by the PAD as a *reset PAD command* signal if parameter 7 is set to 2.
b) Alternatively the start-stop mode DTE may request reset by escaping from the *data transfer* state and sending a *reset PAD command* signal according to the procedure of § 4.9.2.3 below.

4.7.2 *Indication of reset by the PAD*

If the virtual call is reset by the packet mode DTE, by the remote start-stop mode DTE connected via a PAD or by the network, the PAD will send a *reset PAD service* signal, if the value of parameter 6 is not set to 0, to the start-stop mode DTE. The *PAD service* signal will indicate the cause of the reset.

The following reset causes will be indicated to the start-stop mode DTE:

a) the remote DTE has reset the virtual call; the standard format is given in § 3.5.7 above;
b) a local procedure error has occurred; the standard format is given in § 3.5.7 above;
c) network congestion has occurred; the standard format is given in § 3.5.7 above.
d) a remote procedure error has occurred; the standard format is given in § 3.5.7 above.

When parameter 6 is set to 0 the PAD is unable to indicate to the start-stop mode DTE that a reset has occurred.

4.8 *Procedure for indication of break*

The PAD will inform the start-stop mode DTE that an incoming *indication of break PAD message* has been received by the PAD (see Recommendation X.29) by sending the *break* signal (see § 3.1.2 above).

4.9 *Escape from the data transfer state*

4.9.1 During the *data transfer* state, the start-stop mode DTE may escape from that state by transmitting a *PAD recall* signal to the PAD. On detection of the *PAD recall* signal, the interface will enter the *waiting for command* state. On entering the *waiting for command* state, delivery of any data characters to the start-stop mode DTE will be delayed until the interface returns to the *data transfer* state.

If parameter 1 is set to 1, the PAD will recognize the character 1/0 (DLE) as the *PAD recall* signal from the start-stop mode DTE.

If parameter 1 is set to a decimal value from 32 to 126, the PAD will recognize the binary representation of the decimal value as the *PAD recall* signal from the start-stop mode DTE.

If parameter 7 is set to 8, the *break* signal may be used as the *PAD recall* signal from the *data transfer* state, allowing for escape from the *data transfer* state without loss of character transparency.

If parameter 6 is set to 5 the *prompt PAD service* signal will be transmitted by the PAD.

On receipt of the next character from the start-stop mode DTE, the PAD will act in accordance with one of the following conditions:

a) If the character is the *PAD recall* character the interface will immediately return to the *data transfer* state. This character will be treated as user data.

b) If the character received is the *PAD command signal delimiter* [characters 2/11 (+) or 0/13 (CR)] the PAD will not transfer it and the interface will return to the *data transfer* state.

c) If the character received is in columns 2 to 7 of International Alphabet No. 5, excluding the characters 2/0 (SP), 2/11 (+) [see § 4.9.1 b) above], 7/15 (DEL) and the *PAD recall* character, the interface will enter the *PAD command* state. Characters 2/0 (SP) and 7/15 (DEL) will be ignored. Entering the *PAD command* state is a data forwarding condition and data will be sent to the packet mode DTE as described in § 4.4 above.

d) If the character is not covered above the action by the PAD is for further study.

If the *PAD command* signal delimiter is not received within R seconds of the interface entering the *PAD command* state, or an invalid *PAD command* signal is received, the PAD will transmit an *error PAD service* signal, when parameter 6 is not set to 0, indicating that an error has occurred. Following transmission of the *error PAD service* signal the interface will be in the *data transfer* state. The value of R is for further study but will not be less than 60 s.

If a valid *PAD command* signal is received the interface will, if parameter 6 is not set to 0, subsequently enter the *PAD service* signal state, and on transmission of the last character of the *PAD service* signal will enter the *PAD waiting* state or the *data transfer* state as appropriate. If parameter 6 is set to 0, the interface will enter the *PAD waiting* state or the *data transfer* state, as appropriate, following the transmission of a *PAD command* signal or following the time-out condition specified above.

4.9.2 The ability to escape from the *data transfer* state allows a start-stop mode DTE to use the following *PAD command* signals and procedures:

4.9.2.1 *Clearing*

The procedure for clearing of the virtual call by the start-stop mode DTE sending a *clear request PAD command* signal is described in § 3.2.2.1 a).

4.9.2.2 *Request for status of the virtual call*

The procedure for requesting the status of the virtual call by the start-stop mode DTE sending a *status PAD command* signal, is described in § 3.7.

4.9.2.3 *Reset*

The start-stop mode DTE may request a resetting of the virtual call by sending a *reset PAD command* signal to the PAD. The format of the *reset PAD command* signal is given in § 3.5.12 above.

The PAD will acknowledge the *reset PAD command* signal, if parameter 6 is not set to 0, by transmitting the *acknowledgement PAD service* signal.

4.9.2.4 *Interrupt*

The start-stop mode DTE may request that an *interrupt* packet (with the interrupt user data field appropriately coded, see Recommendation X.29) is sent by the PAD by sending an *interrupt PAD command* signal to the PAD. The format of the *interrupt PAD command signal* is given in § 3.5.13 above.

The PAD will acknowledge the *PAD command* signal, if parameter 6 is not set to 0, by transmitting the *acknowledgement PAD service* signal.

4.9.2.5 *Setting, setting and reading, and reading PAD parameter values after having entered the data transfer state*

The start-stop mode DTE shall be able to send the following *PAD command* signals to set, set and read, and read PAD parameter values:

a) *profile selection PAD command* signal;

b) *set PAD command* signal;

c) *set and read PAD command* signal;

d) *read PAD command* signal.

As an option, a PAD may enable the start-stop mode DTE to send the following *PAD command* signals to read or set and read the remote PAD parameter values:

b) *read remote PAD command* signal;

c) *set and read remote PAD command* signal.

The procedures for sending the above *PAD command* signals are described in §§ 3.3 and 3.4 above.

4.9.2.6 *Procedure when parameter 6 is set to 0*

In all cases of the procedures given, when parameter 6 is set to 0, the *PAD service* signal state (state 8) is bypassed and the interface will enter *PAD waiting* state or the *data transfer* state as appropriate.

4.10 *Echo*

If parameter 2 is set to 1, the following procedures will apply:

Received characters not masked by parameter 20 will be echoed to the start-stop mode DTE at the earliest opportunity permitted by the interleaving rules (see § 4.19).

In the case where the PAD cannot handle and ignores a data character coming from the start-stop mode DTE, e.g. because of flow control constraints, the PAD will not echo the characters.

Echoing of editing characters will not be masked if editing is not enabled.

4.11 *Selection of the procedure on receipt of the break signal from the start-stop mode DTE*

The start-stop mode DTE, by means of parameter 7, will be able to select the state of the interface and which procedure the PAD will perform when the PAD receives the *break* signal from the start-stop mode DTE. The start-stop mode DTE may select any one of the following:

a) If parameter 7 is set to 0, the state of the interface remains the same and no action is taken by the PAD.

b) If parameter 7 is set to 1, the state of the interface remains the same and the PAD causes an *interrupt* packet, (with the interrupt user data field appropriately coded) to be transmitted by the PAD (see Recommendation X.29).

c) If parameter 7 is set to 2, the state of the interface remains the same and the PAD causes the virtual call to be reset (see Recommendation X.29).

d) If parameter 7 is set to 21, the state of the interface remains the same, the PAD discards all data received for delivery to the start-stop mode DTE, and the PAD sends an *interrupt* packet (with the interrupt user data field appropriately coded) followed by an *indication of break PAD message* (see Recommendation X.29).

e) If parameter 7 is set to 8, the interface will escape from the *data transfer* state and will enter the *waiting for command* state.

f) If parameter 7 is set to 5, the state of the interface remains the same, the PAD sends an *interrupt* packet (with the interrupt user data field appropriately coded), followed by an *indication of break PAD* message.

Other procedures which may be selected by the start-stop mode DTE are for further study.

Note 1 – The receipt by the PAD of a *break* signal is a packet forwarding condition except when parameter 7 is set to 0.

Note 2 – The receipt of a *break* signal by the PAD when there is no virtual call established is ignored and the PAD takes no action.

4.12 *Selection of padding characters to be inserted after the character 0/13 (CR)*

The start-stop mode DTE, by means of parameter 9, will be able to select the number of padding characters that will be inserted after each character 0/13 (CR) transmitted or echoed to it. The value selected will also apply to the number of padding characters transmitted after the character 0/10 (LF) of the *format effector* as described in § 3.5.2 above.

Other padding sequences and other padding rules are for further study.

4.13 *Selection of line folding*

The start-stop mode DTE, by means of parameter 10, will be able to select line folding and specify the maximum number (L) of graphic characters that the PAD may send as a single line to the start-stop mode DTE.

When line folding is requested, the PAD will maintain a count (C) which is incremented by 1 subsequent to the transmission of a graphic character including echoed characters, to the start-stop mode DTE.

The graphic characters are those shown in columns 2 to 7 of International Alphabet No. 5, excluding the character 7/15 (DEL).

If the value of C is equal to the value of L, and the next character to be transmitted to the start-stop mode DTE is a graphic character, the PAD will transmit to the start-stop mode DTE a *format effector* (see § 3.5.2 above) and set the value of C to 0.

The PAD will set the value of C to 0 when the PAD transmits the character 0/13 (CR) to the start-stop mode DTE.

The actions of the PAD after the transmission of the character 0/8 (BS) is for further study.

Line folding also applies to *PAD service* signals and the echo of *PAD command* signals.

4.14 *Procedure for the start-stop mode DTE to indicate to the PAD a temporary inability to accept additional information*

The start-stop mode DTE, by means of parameter 12, will be able to select the use of X-ON and X-OFF characters to flow control the PAD.

If the value of parameter 12 is set to 1 and the interface is in the *data transfer* state the following procedure applies:

The start-stop mode DTE may indicate a temporary inability to receive additional characters from the PAD by transmitting the X-OFF character 1/3 (DC3).

Following transmission of the character 1/3 (DC3), the X-OFF condition will exist until the start-stop mode DTE indicates the ability to receive additional characters from the PAD by transmitting the X-ON character 1/1 (DC1).

While the X-OFF condition exists, the PAD will not transmit characters to the start-stop mode DTE.

The X-OFF condition is cancelled when the interface leaves the *data transfer* state, and does not exist when the interface enters the *data transfer* state.

The X-ON and X-OFF characters will not be echoed regardless of the value of parameter 2 and 20.

4.15 *Selection of linefeed insertion after carriage return*

The start-stop mode DTE, by means of parameter 13, will be able to select which procedure the PAD will perform during the *data transfer* state when it receives the character 0/13 (CR) to be transmitted to the start-stop mode DTE.

If parameter 13 is set to 0, the PAD takes no action.

If parameter 13 is set to 1, 5 or 7, the PAD will insert the character 0/10 (LF) after every character 0/13 (CR) in the data stream *to* the start-stop mode DTE.

If parameter 13 is set to 6 or 7, the PAD will insert the character 0/10 (LF) after every character 0/13 (CR) in the data stream *from* the start-stop mode DTE.

If parameter 13 is set to 4, 5, 6 or 7 (and parameter 2 is set to 1) the PAD will insert the character 0/10 (LF) after the echo of a character 0/13 (CR) to the start-stop mode DTE.

When this parameter includes the value 2, in combination with other optional values, then the LF inserted after CR in the data stream from the start-stop mode DTE will be placed in the editing buffer and may subsequently be edited, if parameter 15 is set to 1.

4.16 *Selection of padding characters to be inserted after the character 0/10 (LF)*

The start-stop mode DTE, by means of parameter 14, will be able to select the number of padding characters that will be inserted after each character 0/10 (LF) transmitted or echoed to it during the *data transfer* state. The value selected will not apply to the number of padding characters transmitted after the character 0/10 (LF) of the *format effector* as described in §§ 3.5.2 and 4.12 above.

4.17 *Editing of user data*

The editing functions described in § 3.6 above may also apply during the *data transfer* state. The start-stop mode DTE by means of parameter 15 may select whether or not to use the editing functions. The start-stop mode DTE may select, by using parameters 16, 17, 18 the character used for each editing function provided by the PAD and by use of parameter 19, select the response of the PAD to the editing characters (see Recommendation X.3).

4.18 *Page wait*

4.18.1 *General*

The start-stop mode DTE will be able to suspend the transmission of additional characters to the start-stop mode DTE after a specified number of linefeeds have been transmitted by the PAD as determined by the value of parameter 22 when the page wait condition occurs. The PAD will, if parameter 6 is not set to 0, send to the start-stop mode DTE a *page wait PAD service* signal. No further data will be sent until the page wait condition is cancelled. The standard format of the *page wait PAD service* signal is described in § 3.5.27.

4.18.2 *Page wait cancellation*

The PAD will cancel the page wait condition and after transmitting a format effector resume normal transmission when any of the following occur:

- on receipt of any condition that resets the count of linefeeds as described in § 4.18.3;
- on receipt of the page wait cancellation character (X-ON); or
- on resetting parameter 22 to zero.

4.18.3 *Page wait linefeed count reset*

The count of linefeed will be reset to zero by the PAD when any of the following occur:

- after the format effector following the page wait cancellation character;
- on receipt of all data forwarding conditions;
- on echoing linefeed in user input;
- after the *line deleted PAD service* signal (with all associated linefeeds) has been sent; or
- on leaving the *PAD command* state (state 6) after all associated linefeeds.

Other conditions for resetting the linefeed count are for further study.

4.19 *Interleaving of echo and output*

Character sent to start-stop DTE by the PAD are classified into *echo characters* and *output characters.* The *echo characters* are all characters contained in the following:

a) echoed received characters, either of a *PAD command* signal or of user input;

b) any line feed inserted after the echo of a carriage return, when Parameter 13 has value 4, 5, 6 or 7 (see § 4.15);

c) the *character deleted, line deleted* and *parity error PAD service* signals;

d) a *format effector* inserted as a result of line folding initiated by some other echoed character (see § 4.13);

e) all characters generated in response to the *line display* character (see § 3.6.2.3).

All other characters sent to the start-stop DTE by the PAD are *output characters.*

Echo and *output characters* shall be sent to the start-stop DTE by the PAD in accordance with either the *basic interleaving rules,* see § 4.19.1, or the *extended interleaving rules,* see § 4.19.2. The choice between rules is network dependent.

4.19.1 *Basic interleaving rules*

If any *echo character* is waiting to be sent to the start-stop DTE by the PAD, it shall be sent immediately.

If any *output character* is waiting to be sent to the start-stop DTE by the PAD, and if no *echo character* is waiting, the *output character* shall be sent immediately.

4.19.2 *Extended interleaving rules*

Characters sent to the start-stop DTE by the PAD are grouped into *interleaving units.* An *interleaving unit* either consists entirely of *echo characters* or consists entirely of *output characters.*

An interleaving unit of *echo characters* is terminated by any data forwarding condition, or by a *PAD command signal delimiter.*

A *PAD service* signal (which is not classified as echo), or a series of *PAD service* signals generated in response to a single PAD command, is an *interleaving unit.*

Each complete packet sequence sent from the Packet mode DTE is whole number of *interleaving units.* How a complete packet sequence is divided into one or more *interleaving units* is network dependent.

Note 1 – A preferred division rule is that any line feed or form feed should terminate an *interleaving unit* including any line feed inserted if the value of parameter 13 is odd.

Note 2 – If only part of an *interleaving unit* (output or echo) is sent to the start-stop mode DTE, characters of the other category (echo or output) may be delayed indefinitely. This may be avoided by the use of timers; details are for further study.

5 Formats of additional PAD command signals and PAD service signals available in the extended dialogue mode

In addition to the *PAD command* signals and *PAD service* signals defined above (see § 3.1.1 and § 3.5 above), some networks may support additional capabilities in the extended dialogue mode. Additional PAD command signal keywords, which are provisionally defined in Table 9/X.28, can be used instead of the corresponding standard keywords. Some networks may provide these keywords when the PAD is not in the extended dialogue mode.

Additional *PAD command* signals may be provided for:

a) requesting the action associated with the break signal (see § 5.1)

b) indicating a network user identifier prior to establishing calls, or terminating the use of a NUI (see § 5.2)

c) selecting a language for *PAD service* signals (see § 5.3)

d) requesting explanatory information on *PAD command* signals, PAD parameters, standard profiles, etc.
(Note: This function must be provided if extended dialogue mode is supported) (see § 5.4)

Additional *PAD service* signals may be provided for:

a) explanatory information as described above (see § 5.5)

b) prompting for additional information for certain *PAD command* signals. The formats and procedures are for further study.

When the PAD is in the extended dialogue mode, the parameter reference number of a PAD parameter in the *read, set, set and read, remote read* or *remote set and read PAD command* signals may be replaced by the abbreviated name shown in Table 8/X.28. The possible use of names to represent PAD parameter value is for further study.

TABLE 9/X.28

PAD command signal keywords for extended dialogue mode

Standard keyword	Extended dialogue mode keyword(s)	PAD command signal name
None	CALL	Selection
CLR	CLEAR	clear request
INT	INTERRUPT	interrupt
PROF	PROFILE	profile selection
PAR?	PAR PARAMETER READ	read
RESET	....	reset
SET	....	set
SET?	SETREAD	set and read
STAT	STATUS	status
....	BREAK	break
....	HELP	help
....	LANG LANGUAGE	language
....	NUI	nui
RPAR?	RREAD	remote read
ICLR	ICLEAR	invitation to clear
RSET?	RSETREAD	remote set and read

5.1 *Format of the break PAD command signal*

The *break PAD command* signal consists of the following elements:

<break PAD command signal> :: = <BREAK>

where

<BREAK> :: = 4/2 (B) 5/2 (R) 4/5 (E) 4/1 (A) 4/1 (K)

The *break PAD command* signal requests the PAD to act as if it had received the break signal from the start stop mode DTE. The action depends on the value of PAD parameter 7, as defined in § 4.11. However, the interface will enter the *PAD waiting* state or *data transfer* state as appropriate unless parameter 7 has the value 8 set, in which case the interface will reenter the *waiting for command* state.

Note – Escape from data transfer state is not possible by using this command.

5.2 *Format of the NUI ON and NUI OFF PAD command signals*

The NUI ON command signal consists of the following elements:

command signal> :: <ID> <NUI string>

where

<ID> :: = 4/9 (I) 4/4 (D)

<NUI string> is optional but if present is as defined in § 3.5.15.1.1.

The NUI ON PAD *command* signal identifies an individual terminal user to the PAD. This identification will apply for all subsequent calls until either the access path is disconnected or a *NUI OFF PAD command* signal is received by the PAD.

If the prompting facility is provided, then the PAD may request additional user input if required when the <NUI string> is omitted.

The NUI OFF PAD command signal consists of the following elements:

<NUI OFF PAD command signal> :: = <IDOFF>

where

<IDOFF> :: = 4/9 (I) 4/4 (D) 4/15 (0) 4/6 (F) 4/6 (F)

The *NUI OFF PAD command* signal indicates the termination of the use of the NUI.

5.3 *Format of the language PAD command signal*

The *language PAD command* signal consists of the following elements:

<language PAD command signal> :: = <LANG> <language string>

where

<LANG> :: = 4/12 (L) 4/1 (A) 4/14 (N) 4/7 (G)

<language string> :: = an appropriate identifier for a language or mode supported by the network for use in service signals.

The *language PAD command* may be provided to give a simpler way to set parameter 6 for a choice of language or mode.

If <language string> refers to a language which the network provides in extended dialogue mode, then the value of parameter 6 is set to the appropriate value (16 or greater). If <language string> refers to a language which the network provides in network dependent service signal formats, then the value of parameter 6 may be set to the appropriate value from 8 to 15.

The format of <language string> and the availability of more than one language is network dependent.

The need for selection of different languages for *PAD command* signals is for further study.

Note – If a network provides a language choice independent of extended dialogue mode, the format of <language string> should provide for identifying the mode and the language.

5.4 *Format of the help PAD command signal*

The *help PAD command* signal consists of the following elements:

<help PAD command signal> :: = <HELP> <help subject>

where

<HELP> :: = 4/8 (H) 4/5 (E) 4/12 (L) 5/0 (P)

<help subject> :: = identifier for the type of explanatory information requested, as defined in Table 10/X.28.

5.5 *Standard format of the help PAD service signal*

The *help PAD service* signal consists of the following elements:

<help PAD service signal> :: = <text>

where

<text> is network dependent and corresponds to the <help subject> requested in the *help PAD command* signal, as defined in Table 10/X.28.

TABLE 10/X.28

Help PAD command signal operands and results

<help subject> (Note 2)	service signal contents (Note 1)
none or HELP	description of help PAD command
LIST	list of available help subjects
COMMAND	list of PAD command signals
PARAMETER	list of PAD parameters
PARAMETER <reference>	description of referenced PAD parameter
PROFILES	list of available standard profiles
any PAD command	description of specified PAD command signal
PROFILE <reference>	name and parameter values of referenced standard profile

Note 1 – The actual contents of the help *PAD service* signal and the amount of detail presented are network dependent.

Note 2 – Some networks may provide help for additional subjects to those listed.

ANNEX A

(to Recommendation X.28)

PAD command signals and PAD service signals

TABLE A-1/X.28

PAD command signals

PAD command signal format		Function	PAD service signal sent in response (see note)
STAT		To request status information regarding a virtual call connected to the DTE	FREE or ENGAGED
CLR		To clear down a virtual call	CLR CONF or CLR ERR (in the case of local procedure error)
PAR?	List of parameter references	To request the current values of specified parameters	PAR (list of parameter with their current values or INV)
SET?	List of parameter references and corresponding values	To request changing or setting of the current values of the specified parameters and to request the current values of specified parameters	PAR (list of parameter with their current values or INV)
PROF	(identifier)	To give to PAD parameters a standard set of values	Acknowledgement
RESET		To reset the virtual call	Acknowledgement
INT		To transmit an *interrupt* packet	Acknowledgement
SET	List of parameters with requested values	To set or change parameter values	Acknowledgement or PAR (list of invalid parameter reference followed by INV)
Selection PAD command signal		To set up a virtual call	Acknowledgement
ICLR		To invite remote PAD to clear down a virtual call	CLR PAD
RPAR?	List of parameter references	To request the current values of specified parameters in remote PAD	RPAR (list of parameter references with their current values or INV)
RSET?	List of parameter references	To request changing or setting of the current values of the specified parameter(s) and to request the current value of specified parameters	RPAR (list of parameter references with their current values or INV)

Note – *PAD service* signals are not sent when parameter 6 is set to 0.

TABLE A-2/X.28

PAD service signals

Standard format of the PAD service signal		Explanation
RESET	DTE 1, 2 or 3 characters which represent the ERR décimal value of the diagnostic code NC (see Note 1) RPE	Indication that the remote DTE has reset the virtual call Indication of a reset of a virtual call due to local procedure error Indication of a reset of a virtual call due to network congestion Indication of a reset of a virtual call due to remote procedure error
CLR	See Table 6/X.28	Indication of clearing
CLR	CONF	Confirmation of clearing
See Note 7	–	Indication of call connected
	The characters to be sent are network dependent	PAD identification PAD service signal
ERR		Indication that a *PAD command signal* is in error
See Note 2		Indication of incoming call
XXX		Indication of line delete function completed for printing terminals (see Notes 3 and 4)
	See Note 8	Indication of character delete function completed for printing terminals
PAGE		Indication that a page wait condition has occurred
BS SP BS		Indication of character delete function completed for video terminals (see Note 4)
ENGAGED		Response to *status PAD command* signal when a call has been established
FREE		Response to *status PAD command* signal when a call is not established
PAR	Decimal value of parameter: Parameter value, INV, or list of invalid parameters	Response to *set and red PAD command* signal and to *set PAD command* signal if at least one parameter is invalid
*		*Prompt PAD service* signal

TABLE A-2/X.28 *(cont.)*

Standard format of the PAD service signal		Explanation
Format effector		*Acknowledgement PAD service* signal
TRANSFER TO	DTE address and facilities, See Notes 5 and 6	Indication that a called DTE reselection by the PAD is in progress
RPAR	Decimal value of parameter: parameter value, INV, or list of invalid parameters	Responses to remote set and red PAD command signal lecture

Note 1 – The diagnostic codes are specified in Recommendation X.25. Some networks may not provide these characters.

Note 2 – The standard format of the *incoming call PAD service* signal is given in § 3.5.22.

Note 3 – If echoing is required, the *line delete* character is echoed before the *line deleted PAD service* signal is transmitted.

Note 4 – The standard format of the indication of line delete function completed for video terminals is a repetition of the BS SP BS sequence.

Note 5 – The mentioned DTE address is the address of the DTE towards which the call is being transferred by the PAD.

Note 6 – The format of the facilities is identical to the one of the *incoming call PAD service* signal.

Note 7 – The standard format of the *connected PAD service* signal is given in § 3.5.21.

Note 8 – Altermatively the character 2/15 (/) may be used by some networks.

ANNEX B

(to Recommendation X.28)

PAD Time-outs

TABLE B-1/X.28

PAD time-outs

Time-out value (provi-sional)	Time-out number	Interface state	Started by	Normally terminated	Action to be taken when time-out expires	Remarks
Y	T10	State 1	Binary 1 is transmitted on both T and R	The PAD has received a valid *service request signal*	The PAD will disconnect the *information path*	
T = 60 s	T11	state 6	The PAD enters the *PAD waiting* state	The PAD has received the first character of a *PAD command* signal	The PAD clears in accordance with § 3.2.2.2	4 possible methods may be used. This time-out is not applicable in case of leased line access.
S > 60 s	T12	State 6	The PAD has received the first character of a *PAD command* signal	The PAD has received a complete *PAD command* signal	The PAD will transmit an *error PAD service* signal (when parameter 6 is not set to 0) and will return to the *PAD waiting* state of its action is for further study (when parameter 6 is set to 0)	The PAD will permit entry into the *PAD waiting* state N times before disconnecting the access information paths: this time out is not applicable in case of leased line access.
R > 60 s	T13	State 6	The PAD receives a graphic character other than 2/0, 2/11 or 7/15 after the DTE escapes from the *data transfer* state	Reception of a complete *PAD command* signal	The PAD will transmit an *error PAD service* signal and will return to the *data transfer* state (when parameter 6 is not set to 0) or the *PAD waiting* state of *data transfer* state as appropriate (when parameter 6 is set to 0)	This time-out is not applicable in the case of leased line access
V	T20	State 4	DTE transmits the *service request* signal	DTE has received a *PAD identification service*	DTE should retransmit the *service request* signal	When this time-out expires W times a fault should be reported

TABLE B-1/X.28 *(cont.)*

Time-out value (provisional)	Time-out number	Interface state	Started by	Normally terminated	Action to be taken when time-out expires	Remarks
B	T21	State 6	DTE transmits a *clear request PAD command* signal	The PAD has transmitted *clear confirmation PAD service* signal (when parameter 6 is not set to 0) or has disconnected the access information path (when parameter 6 is set to 0)	The DTE will disconnect the access information path (indeterminate result)	
X = 120 s	T30	–	Incoming call	PAD waiting state	The PAD will clear the virtual call	See § 3.2.1.7
Z	T31	–	Circuit 108/1 or 108/2 OFF	Circuit 108 ON	The access information path is disconnected	See § 1.1.3.2
P > 60 s	T14	State 10	The PAD is recalled from the connection in progress state	The PAD has received the first character of a PAD command signal	The PAD will transmit an error PAD service signal (when parameter 6 is not set to 0) and return to the connection in progress state	
Q > 60 s	T15	State 6	The PAD receives a graphic character other than 2/0, 2/11 or 7/15 after the DTE escape from the connection in progress state	Reception of a complete PAD command signal	(As for P above)	

ANNEX C

(to Recommendation X.28)

PAD service signals for extended dialogue mode

C.1 Possible PAD service signals text in Spanish for extended dialogue mode

1. ENGAGED – Comunicación establecida (§ 3.5.11/X.28).
2. FREE – Comunicación no establecida (§ 3.5.11/X.28).
3. *Reset PAD service* signal (Table 5/X.28).

   DTE – reiniciación por el dispositivo en el extremo distante, pueden perderse datos

   ERR – reiniciación por la red, error de procedimiento local, pueden perderse datos

   NC – reiniciación debido por problema en la red, pueden perderse datos

   RPE – reiniciación por la red, error de procedimiento en el extremo distante, pueden perderse datos

4. *Clear PAD service* signal (Table 6/X.28)

   OCC – liberación de la llamada, número ocupado

   NC – liberación de la llamada, problema temporal en la red

   INV – liberación de la llamada, petición de facilidad no válida

   NA – liberación de la llamada, acceso prohibido a este número

   ERR – liberación de la llamada, error de procedimiento local, identificado por la red

   RPE – liberación de la llamada, error de procedimiento en el extremo distante, identificado por la red

   NP – liberación de la llamada, número no asignado

   DER – liberación de la llamada, número fuera de servicio

   PAD – liberación de la llamada, petición distante

   DTE – liberación de la llamada, por el dispositivo en el extremo distante, pueden perderse datos

   RNA – liberación de la llamada, cobro revertido rechazado

   ID – liberación de la llamada, destino incompatibile

   SA – liberación de la llamada, barco ausente

   FNA – liberación de llamada, selección rápida rechazada

   ROO – liberación de llamada, no se puede encaminar según se ha pedido

5. *clear confirmation PAD service* signal (Table 7/X.28)

   CONF – liberación de llamada, confirmación

6. PAD parameter names (Table 8/X.28)

Parameter reference number	Parameter description
1	– rellamada al EDD utilizando un carácter
2	– eco
3	– elección de la señal de envió de datos
4	– elección de la duración de la temporización de reposo
5	– control de dispositivo auxiliar
6	– control de señales de servicio de EDD
7	– operación al recibir una señal de corte
8	– descartar salida
9	– relleno después del retroceso del carro
10	– delimitación de la línea
11	– velocidad binaria del ETD arrítmico
12	– control de flujo del EDD
13	– inserción de cambio de renglón después del retroceso del carro
14	– relleno después del cambio de renglón
15	– edición
16	– supresión de carácter
17	– supresión de línea
18	– visualización de línea
19	– señales de servicio de EDD de edición
20	– máscara de eco
21	– tratamiento de la paridad
22	– espera de página

C.2 Possible *PAD service* signals text in French for extended dialogue mode

1. ENGAGED – état occupé (§ 3.5.11/X.28).
2. FREE – état libre (§ 3.5.11/X.28).
3. *Reset PAD service* signal (Table 5/X.28).

DTE – réinitialisation par l'équipement distant, perte de données possibles

ERR – réinitialisation par le réseau, erreur de procédure locale, perte de données possibles

NC – réinitialisation en raison d'un dérangement momentané du réseau, perte de données possibles

RPE – réinitialisation par le réseau, erreur de procédure distante, perte de données possibles

4. *Clear PAD service* signal (Table 6/X.28)

OCC	–	communication libérée, numéro occupé
NC	–	communication libérée, encombrement momentané du réseau
INV	–	communication libérée, demande de service complémentaire non valable
NA	–	communication libérée, interdiction d'accès au numéro
ERR	–	communication libérée, erreur de procédure locale décelée par le réseau
RPE	–	communication libérée, erreur de procédure distante décelée par le réseau
NP	–	communication libérée, numéro non attribué
DER	–	communication libérée, numéro en dérangement
PAD	–	communication libérée, demande distante
DTE	–	communication libérée, par un équipement distant
RNA	–	communication libérée, taxation à l'arrivée refusée
ID	–	communication libérée, destination incompatible
SA	–	communication libérée, le navire ne peut être atteint
FNA	–	communication libérée, sélection rapide refusée
ROO	–	communication libérée, acheminement demandé impossible

5. *Clear confirmation PAD service* signal (Table 7/X.28)

CONF – communication libérée confirmation

6. PAD parameter names (Table 8/X.28)

Parameter reference number	Parameter description
1	– rappel de l'ADP au moyen d'un caractère
2	– renvoi en écho
3	– choix des caractères d'envoi de données
4	– choix du délai de temporisation de repos
5	– commande de dispositifs auxiliaires
6	– commande de signaux de service d'ADP
7	– fonctionnement à la réception du signal de coupure
8	– mise au rebut des données de sortie
9	– remplissage après retour du chariot
10	– retour à la ligne
11	– débit binaire de l'ETTD arythmique
12	– contrôle de flux de l'ADP
13	– insertion d'interligne après retour du chariot
14	– remplissage après interligne
15	– édition
16	– effacement de caractère
17	– effacement de ligne
18	– affichage de ligne
19	– signaux de service d'ADP d'édition
20	– gabarit d'écho
21	– traitement de parité
22	– attente de page

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

(provisional, Geneva, 1977; amended, Geneva, 1980, Malaga-Torremolinos, 1984 and Melbourne, 1988)

Preface

The establishment in various countries of public data networks providing packet-switched data transmission services creates a need to produce standards to facilitate international interworking.

The CCITT,

considering

(a) that Recommendations X.1 and X.2 define the user classes of service and facilities in a public data network, and Recommendation X.96 defines call progress signals;

(b) that Recommendation X.3 defines the PAD in a public data network;

(c) that Recommendation X.28 defines the DTE/DCE interface for a start-stop mode DTE accessing the PAD in a public data network;

(d) that Recommendation X.25 defines the interface between the DTE and the DCE for DTEs operating in the packet mode in public data networks;

(e) the need to allow interworking between a packet mode DTE and a non-packet mode DTE in the packet-switched transmission service;

(f) the urgent need to allow interworking between a start-stop mode DTE in a public switched telephone network, public switched data network or a leased line and a packet mode DTE using the virtual call facility of the packet-switched transmission service;

(g) the need to allow interworking between PADs;

(h) that the packet mode DTE shall not be obliged to use the control procedures for PAD functions, but that some packet mode DTEs may wish to control specific functions of the PAD,

unanimously recommends that

(1) the Recommendation X.29 procedures shall apply to the Recommendation X.25 interface between the DCE and the packet mode DTE;

(2) the Recommendation X.29 procedures may be applied for interworking between PADs;

(3) the procedures be as specified below in § 1 *Procedures for the exchange of PAD control information and user data*;

(4) the manner in which user data is transferred be as specified below in § 2 *User data transfer*;

(5) the procedures for the control of the PAD via PAD messages be as specified below in § 3 *Procedures for the use of PAD messages*;

(6) the formats of the data fields which are transferable on a virtual call be as specified below in § 4 *Formats.*

Note 1 – For ease of understanding, this Recommendation refers to specific packet types and procedures of Recommendation X.25. When PAD to PAD interworking is considered within a national network these packet types or procedures may have a different form from those used in Recommendation X.25 but will have the same operational meaning.

Note 2 – The following items are for further study:

- the use of the permanent virtual circuit service;
- interworking between DTEs having interfaces to different data transmission services;
- operation of non-packet mode DTEs in other than start-stop mode.

1 Procedures for the exchange of PAD control information and user data

1.1 The exchange of control information and user data between a PAD and a packet mode DTE or between PADs is performed by using user data fields defined in Recommendation X.25.

1.2 Annex A describes some of the characteristics of virtual calls as defined in Recommendation X.25, as related to the PAD representation of a start-stop mode DTE to a packet mode DTE. The characteristics described in Annex A also apply for interworking between PADs.

1.3 *Call user data*

The call user data field of *incoming call* or *call request* packets to or from the packet mode DTE or the PAD is comprised of two fields:

a) the protocol identifier field, and

b) the call data field.

The protocol identifier field is used for protocol identification purposes and the call data field contains user data.

A *call request* packet received by the PAD, containing no call user data field, will be accepted by the PAD.

If a call data field is present, the PAD will send it, unchanged, to the start-stop mode DTE, using the call data block of the *incoming call PAD service* signal (see § 3.5.22, Recommendation X.28).

1.4 *User sequences*

1.4.1 User sequences are used to exchange user data between the PAD and the packet mode DTE or a PAD.

1.4.2 User sequences are conveyed in the user data fields of complete packet sequences with Q = 0, and in both directions on a virtual call. (See Recommendation X.25.)

1.4.3 There will be only one user sequence in a complete packet sequence.

1.4.4 The PAD will transmit all *data* packets with the D bit set to 0.

On reception of a *data* packet with the D bit set to 1, the PAD will transmit the corresponding acknowledgement as soon as possible.

If the PAD does not support the D bit procedure, the PAD may reset the virtual call.

As no error correction procedure is in place from the PAD to the start-stop mode DTE, no guarantee of delivery can be implied from the acknowledgement.

1.5 *PAD messages*

1.5.1 *PAD* messages are used to exchange control information between the PAD and the packet mode DTE (or remote PAD). A *PAD* message consists of a control identifier field and a message code field possibly followed by a parameter field (see § 4.4 below).

1.5.2 *PAD* messages are conveyed in the user data fields of complete packet sequences with Q = 1 and in both directions on a virtual call. (See Recommendation X.25.)

1.5.3 There will be only one *PAD* message in a complete packet sequence.

1.5.4 The PAD will take into consideration a *PAD* message only when it has been completely received.

1.5.5 In the case where a parameter reference (see § 3 below) appears more than once in a *PAD* message, only the last appearance is taken into account.

1.5.6 The PAD will transmit all *data* packets with the D bit set to 0.

On reception of a *data* packet with both the Q bit and the D bit set to 1, the PAD will transmit the corresponding acknowledgement as soon as possible.

If the PAD does not support the D bit procedure, the PAD may reset the virtual call.

2 User data transfer

2.1 *Data* packets will be forwarded by the PAD when a *set*, *read*, or *set and read PAD* message is received, or under any of the other data forwarding conditions provided by the PAD (see Recommendation X.28, § 4.4).

2.2 The occurrence of a data forwarding condition will not cause the PAD to transmit empty data packets.

3 Procedures for the use of PAD messages

3.1 *Procedures for reading, setting, and reading and setting of PAD parameters*

3.1.1 The current values of PAD parameters may be changed and read by transmitting to the PAD a *set*, *read*, or *set and read PAD* message.

3.1.2 When the PAD receives a *set*, *read* or *set and read PAD* message, any data previously received will be delivered to the start-stop mode DTE before taking action on the *PAD* message. The PAD will also consider the arrival of such a *PAD* message as a data forwarding condition.

3.1.3 The PAD will respond to a valid *read* or *set and read PAD* message by transmitting a *parameter indication PAD* message. This *PAD* message will have a parameter field containing a list of parameter references and current values (after any necessary modification) of the PAD parameters to which the received *PAD* message referred.

3.1.4 The PAD will not return a *parameter indication PAD* message in response to a valid *set PAD* message received.

3.1.5 Table 1/X.29 specifies the PAD's response of the PAD to *set*, *set and read*, and *read PAD* messages.

3.1.6 If the function of a character is duplicated by the selection of parameter values by use of the *set* or *set and read PAD* message, the PAD will consider these parameter changes as valid, and will respond as described in this Recommendation. After these changes are invoked, the PAD will follow the procedure described in Recommendation X.28, § 3.3.2.

3.2 *Procedures for inviting the PAD to clear*

3.2.1 The *invitation to clear PAD* message is used to request that the PAD clears the virtual call, after transmission of all data previously transmitted to the start-stop mode DTE.

Note – The *clear indication* packet, which is transmitted by the PAD after delivery of the last character to the start-stop mode DTE, will have a clearing cause field set to *DTE clearing*.

3.3 *Interrupt and discard procedures*

3.3.1 If parameter 7 is set to 21, the PAD will transmit an *interrupt* packet with all bits of the interrupt user data field set to 0 followed by an *indication of break PAD* message to indicate that the PAD, at the request of the start-stop mode DTE, is discarding the user sequences received. The *PAD* message will contain an indication in its parameter field that parameter 8 has been set to 1 (*discard output*).

3.3.2 Before resuming data transmission to the PAD, the response to the *indication of break PAD* message shall be a *set* or *set and read PAD* message, indicating that parameter 8 should be set to 0 (*normal data delivery*).

Prior to sending this PAD message, any in-progress complete packet sequence being transmitted to the PAD must be terminated (with a packet that will be discarded by the PAD) in accordance with Recommendation X.25 procedures.

TABLE 1/X.29

PAD messages transmitted by the PAD in response to set, set and read, and read PAD messages

PAD message received by the PAD		Action upon PAD parameters	Corresponding *parameter indication PAD* message transmitted to the packet mode *DTE*
Type	Parameter field		
Set	None	Reset all implemented Recommendation X.3 parameters to their initial values corresponding to the initial profile	None
	List of selected parameters with the desired values	Set the selected parameters to the given values: a) if no error is encountered b) if the PAD fails to modify the values of some parameters	a) None b) List of these invalid parameters (see Note)
Set and read	None	Reset all implemented Recommendation X.3 parameters to their initial values corresponding to the initial profile	List all implemented Recommendation X.3 parameters, and their initial values
	List of selected parameters with the desired values	Set the selected parameters to the given values	List of these parameters with their new current values (see Note)
Read	None	None	List all implemented Recommendation X.3 parameters with their current values
	List of selected parameters	None	List of these parameters with their current values (see Note)

Note – If any of the parameters contain an error, then the error bit is set and the value field is coded as described in Table 3/X.29.

3.3.3 If a PAD receives an *indication of break PAD* message which contains a parameter field as described in § 3.3.1 above, it will respond by transmitting a *set PAD* message as described in § 3.3.2 above and will transmit a *break* signal to the start-stop mode DTE. If a PAD receives an *indication of break PAD* message which does not contain a parameter field, it will not respond to the packet mode DTE or PAD but it will transmit a *break* signal to the start-stop mode DTE.

3.3.4 When the PAD transmits an *interrupt* packet after the receipt from the start-stop mode DTE of an *interrupt PAD command* signal or a *break* signal, when parameter 7 is set to 1, the interrupt user data field is coded in bits 8 to 1 as 00000001.

3.3.5 If the PAD receives an *interrupt* packet it will confirm it in accordance with Recommendation X.25 procedures. The PAD will not transmit the contents of the interrupt user data field to the start-stop DTE. The PAD will ignore the values of the interrupt user data field. It is for further study whether the coding of this field given in § 3.3.4 above causes a different response.

3.3.6 If parameter 7 is set to 5, the PAD will transmit an *interrupt* packet with all bits of the *interrupt* packet set to 0, followed by an *indication of break PAD* message. The *PAD* message will not contain a parameter field as described in § 4.4.7.

3.3.7 Some PADs may always send the break signal to the start-stop mode DTE upon receipt of an *interrupt* packet rather than upon receipt of an *indication of break PAD* message.

3.4 *Procedure for resets*

Virtual calls may be reset according to the procedures defined in Recommendation X.25. The effect of the resetting procedure on the value of PAD parameter 8 is to reset its value to 0 (*normal data delivery*). The current values of all other PAD parameters are not affected.

3.5 *Error handling procedures by the PAD*

3.5.1 If the PAD receives a *set, read* or *set and read PAD* message containing an invalid reference to a PAD parameter, the parameter field within the *parameter indication PAD* message transmitted by the PAD will contain an indication that this has occurred. The remaining valid references to PAD parameters are processed by the PAD.

Possible reasons for an invalid access to a PAD parameter are:

a) the parameter reference has not been implemented in the PAD;

b) the parameter value has not been implemented in the PAD or cannot be altered from the current setting;

c) the parameter is a read-only one (*set* and *set and read PAD* messages only);

d) the parameter follows an invalid parameter separator (see § 4.4.5.4 below).

3.5.2 The PAD will transmit an *error PAD* message containing the message code of an invalid *PAD* message received under the following conditions:

a) if the PAD receives an unrecognizable message code;

b) if the parameter field following a recognizable message code is incorrect or incompatible with the message code;

c) if the parameter field following a recognizable message code has an invalid format;

d) if the PAD receives an unsolicited *parameter indication PAD* message;

e) if the PAD receives a PAD message that is too long.

3.5.3 The PAD will transmit an *error PAD* message if a *PAD* message containing less than 8 bits is received.

3.5.4 If the PAD receives an *error PAD* message it will not respond with a *PAD* message of any type. Subsequent action is for further study.

3.6 *Procedures for inviting the PAD to reselect the called DTE*

The *reselection or reselection with TOA/NPI PAD* message (Type of address/Numbering Plan Indicator) used by a packet mode DTE to request that the PAD clear the virtual call, after transmission to the start-stop mode DTE of all the previously transmitted data. Then, the PAD will establish a call to the reselected DTE.

Note – The TAO/NPI address subscription facility is designated in Recommendation X.2 for further study.

When the *reselection PAD message* is received, the PAD will transmit an *error PAD message* with an error type *unauthorized reselection PAD message* (00000110) under the following conditions:

a) the virtual call has been established by the packet-mode DTE;

b) the *called DTE reselection prevention facility* has been requested by the start-stop mode DTE;

c) the *reselection PAD message* has been already received more than N times (where N is for further study).

The format of the *reselection PAD* message is given in § 4.4.9 below. The format of the *reselection with TOA/NPI PAD* message is given in § 4.4.10 below. These messages contain the information needed by the PAD to establish the new virtual call.

Upon receipt of the *reselection* or *reselection with TOA/NPI PAD* message, the PAD will:

– transmit to the start-stop mode DTE all previously received data;

– clear the virtual call that is established;

– after having made the appropriate state changes as described in Recommendation X.28, § 3.2.5, establish a virtual call to the reselected DTE. The *call request packet* sent by the PAD, will contain only the facilities subscribed by the start-stop mode DTE and/or assigned by default. Any other facilities contained in the *reselection PAD message* will be ignored. In particular:

i) *Closed User Group Signals* – Independently by the CUG indicated in the *reselection PAD message*, the PAD will use the same CUG of the original call.

ii) *Reverse Charging* – If the start-stop mode DTE was not charged for the original call the reselected call will not be charged to the start-stop mode DTE, independently of the indication in the *reselection PAD message* (i.e., the PAD will use the *reverse charging* facility in the *call request packet*). If the start-stop mode DTE was charged for the original call, the reselected call will be charged to the reselected DTE if the *reselection PAD message* contains the *reverse charging* facility.

iii) *Charging information*:

– facility assigned for an agreed contractual period: The information will be sent to the start-stop mode DTE at the clearing of each call (original and reselected), or at the clearing of the last reselected call. If the later procedure was selected, the PAD will send the total charging information, without sending the charge of the individual calls (original and reselected).

– facility on a per call basis: The PAD follows the procedure indicated above, starting from the first *charging information facility request* (by the start-stop mode DTE or packet mode DTE).

iv) *RPOA selection:* for further study

Note – The other facilities indicated in Table 4/X.28 with *Note 2* are for further study.

Note – This procedure is an optional feature of the PAD. PADs which do not implement this feature will consider *reselection* and *reselection with TOA/NPI PAD* messages as invalid. PADs may implement this feature either by accepting (1) *reselection PAD* messages or (2) *reselection* and *reselection with TOA/NPI PAD* messages. The sending of *reselection or reselection with TOA/NPI PAD* messages by a PAD is for further study.

4 Formats

4.1 *Introduction*

Bits of octets are numbered 8 to 1 where bit 1 is the low order bit and is transmitted first. Octets of the call user data, of user sequences, of *PAD* messages and of interrupt user data are consecutively numbered starting from 1 and are transmitted in this order.

4.2 *Call user data format* (see Figure 1/X.29)

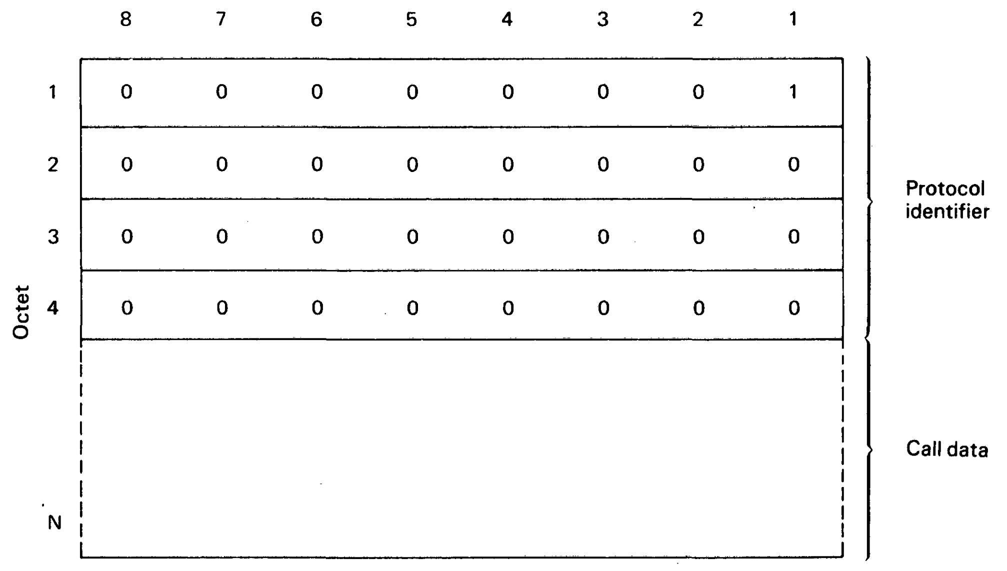
4.2.1 *Protocol identifier format*

The protocol identifier field standardized by CCITT consists of four octets.

The first octet is coded as follows:

bits 8 and 7 = 00 for CCITT use
= 01 for national use
= 10 reserved for international user bodies
= 11 for DTE-DTE use.

When bits 8 and 7 are equal to 00, bits 6 to 1 are equal to 000001 for indicating *PAD* messages relating to the *packet assembly/disassembly* facility for the start-stop mode DTE. Other coding of bits 6 to 1 is reserved for future standardization by the CCITT, subject to the rules of Recommendation X.244. All bits of octets 2, 3 and 4 are set to 0. These octets are reserved as a future mechanism for providing the called PAD or packet mode DTE with additional information pertinent to the calling party.



$4 < N < 16$ octets

FIGURE 1/X.29

Call user data field format

4.2.2 *Call data format*

Octets of the call data field will contain the user characters received by the PAD from the start-stop mode DTE during the call establishment phase. The coding of these octets is similar to that of user sequences (see § 4.3 below). The call data field is limited to 12 octets (see Figure 1/X.29).

4.3 *User sequence format*

4.3.1 The order of bit transmission from the PAD is the same as the order that bits are received from the start-stop mode DTE. The order of bit transmission to the start-stop mode DTE is the same as the order that bits are received.

4.3.2 No maximum is specified for the length of a user sequence.

4.4 *Control message format*

4.4.1 Bits 8, 7, 6, 5 of octet 1 of a user data field of complete packet sequences with Q = 1 are defined as the *control identifier field*, used to identify the facility, such as PAD, to be controlled. The control identifier field coding for *PAD* messages to control a PAD for a start-stop mode DTE is 0000. Other codings of the control identifier field are reserved for future standardization.

Note – The possibility of extending the control identifier field is for further study.

4.4.2 When the control identifier field (see § 4.4.1 above) is set to 0000, bits 4, 3, 2, 1 of octet 1 are defined as the message code field. The *message code* field is used to identify specific types of *PAD* messages, as given in Table 2/X.29.

TABLE 2/X.29

Type and coding of octet 1 of PAD messages

Type	Message code				
	Bits	4	3	2	1
Set PAD message		0	0	1	0
Read PAD message		0	1	0	0
Set and read PAD message		0	1	1	0
Parameter indication PAD message		0	0	0	0
Invitation to clear PAD message		0	0	0	1
Indication of break PAD message		0	0	1	1
Reselection PAD message		0	1	1	1
Error PAD message		0	1	0	1
Reselection with TOA/NPI		1	0	0	0

Note – The possibility of extending the message code field is for further study.

4.4.3 All *PAD* messages consist of a control identifier field (bits 8, 7, 6, 5 of octet 1 equal to 0000) and a message code field (bits 4, 3, 2, 1 of octet 1).

Set, read, set and read and *parameter indication PAD* messages consist of octet 1 which may be followed by one or more parameter fields. Each parameter field consists of a parameter reference octet and a parameter value octet.

The parameter value octets of the *read PAD* message contain the value 0.

The *error PAD* message consists of octet 1 and one or two octets giving the reason for the error.

The *indication of break PAD* message consists of octet 1 which may be followed by a parameter field.

The *invitation to clear PAD* message consists of octet 1 only.

4.4.4 The maximum length of PAD message is network dependent, but will be at least 128 octets.

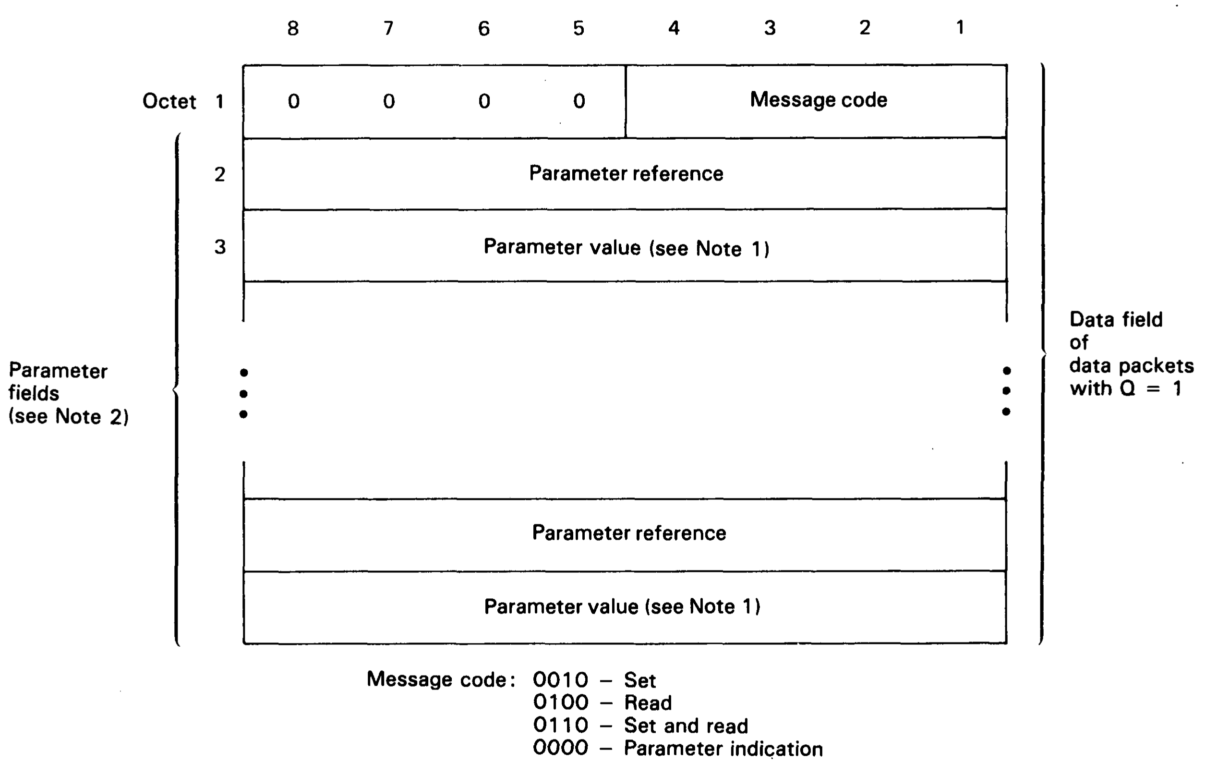
4.4.5 *Parameter field for set, read, set and read, and parameter indication PAD messages* (see Figure 2/X.29)

A parameter field contained in one of these *PAD* messages consists of a reference field and a value field. A parameter field is two octets in length, except when the extension mechanism is used (see § 4.4.5.1 below).

4.4.5.1 A reference field consists of a parameter reference, identified as a decimal number in Recommendation X.3, and is binary coded in bits 7 to 1, where bit 1 is the low order bit. Reference fields need not be ordered by increasing parameter reference numbers.

The code 1111111 (decimal 127) in bits 7 to 1 of the reference field will be used for the extension of this field. Such coding will indicate that there is another octet following. The following octet is coded with the parameter reference of Recommendation X.3 minus 127.

4.4.5.2 In *PAD* messages received by the PAD, bit 8 of each octet will be ignored. In *parameter indication PAD* messages, bit 8 of each reference field set to 1 will indicate an invalid access to the referred parameter as described in § 3.5 above.



Note 1 – These octets contain all 0s in read PAD messages.

Note 2 – Parameter field need not be present (see Table 1/X.29).

FIGURE 2/X.29

Set, read, set and read, and parameter indication PAD message format

4.4.5.3 A parameter value field consists of a value of the parameter reference, identified as a decimal number in Recommendation X.3, and is binary coded in bits 8 to 1, where bit 1 is the low order bit. Value fields in *read PAD* messages are coded as all binary 0s. In *set* and *set and read PAD* messages, they will indicate the requested values of parameters. In *parameter indication PAD* messages, they will indicate the current values of PAD parameters, after modification if any. If bit 8 (error bit) is set to 1 in the preceding octet (i.e. the parameter reference field), the parameter value field will indicate the reason for the error, as given in Table 3/X.29.

4.4.5.4 Parameters not standardized by CCITT may be supported. The parameter separator is used in PAD messages to indicate the separation between parameters specified in Recommendation X.3 and any others implemented nationally or locally.

The parameter separator consists of a parameter field which contains a reference field set to 00000000 and a value field set to 00000000.

When present, the parameter separator and the national or local parameter fields must be placed after any CCITT standardized parameter fields in PAD messages.

Note – It is recommended that only the parameters defined in Recommendation X.3 are used when communicating with a PAD in a different country or network.

TABLE 3/X.29

Coding of parameter value field in case of error

Error type	Parameter value field code								
	Bits								Decimal
	8	7	6	5	4	3	2	1	
No additional information	0	0	0	0	0	0	0	0	0
The parameter reference does not exist or has not been implemented in the PAD	0	0	0	0	0	0	0	1	1
The parameter value is invalid or has not been implemented in the PAD	0	0	0	0	0	0	1	0	2
The parameter value cannot be altered from the current setting	0	0	0	0	0	0	1	1	3
The parameter is read-only	0	0	0	0	0	1	0	0	4
The parameter follows an invalid parameter separator	0	0	0	0	0	1	0	1	5

Note – The value 0 is mandatory. Other values are optional.

4.4.6 *Format of error PAD messages* (see Figure 3/X.29)

Octet	8	7	6	5	4	3	2	1	
1	0	0	0	0	0	1	0	1	Data field of data packets with Q = 1
2	Error type (see Table 4/X.29)								
3	Invalid message code (see Note)								

Note – Does not occur for error type 00000000.

FIGURE 3/X.29

Error PAD message format

4.4.6.1 Octet 2 of the *error PAD* message will be coded as shown in Table 4/X.29.

4.4.6.2 In cases b, c, d, e and f in Table 4/X.29, octet 3 of an *error PAD* message will contain the message code of the received *PAD* message.

4.4.7 *Parameter field for indication of break PAD messages* (see Figure 4/X.29)

This *PAD* message may either not contain a parameter field, or contain a parameter field consisting of 2 octets (i.e. one reference field and one value field) coded as follows: the reference field will be coded 00001000 (indicating parameter 8) and the value field will be coded 00000001 (indicating decimal 1).

TABLE 4/X.29

Coding and meaning of octet 2 of error PAD messages

Case	Meaning	Coding								
		Bits	8	7	6	5	4	3	2	1
a	Received *PAD* message contained less than eight bits		0	0	0	0	0	0	0	0
b	Unrecognized message code in received *PAD* message		0	0	0	0	0	0	0	1
c	Parameter field format of received *PAD* message was incorrect or incompatible with message code		0	0	0	0	0	0	1	0
d	Received *PAD* message did not contain an integral number of octets		0	0	0	0	0	0	1	1
e	Received *parameter indication PAD* message was unsolicited		0	0	0	0	0	1	0	0
f	Received *PAD* message was too long		0	0	0	0	0	1	0	1
g	Unauthorized reselection *PAD* message		0	0	0	0	0	1	1	0

Octet	8	7	6	5	4	3	2	1	
1	0	0	0	0	0	0	1	1	Data field of data packets with Q = 1
2	Parameter reference								
3	Parameter value								

FIGURE 4/X.29

Indication of break PAD message format

4.4.8 *Parameter field for invitation to clear PAD message* (see Figure 5/X.29)

	8	7	6	5	4	3	2	1	
Octet 1	0	0	0	0	0	0	0	1	Data field of data packets with Q = 1

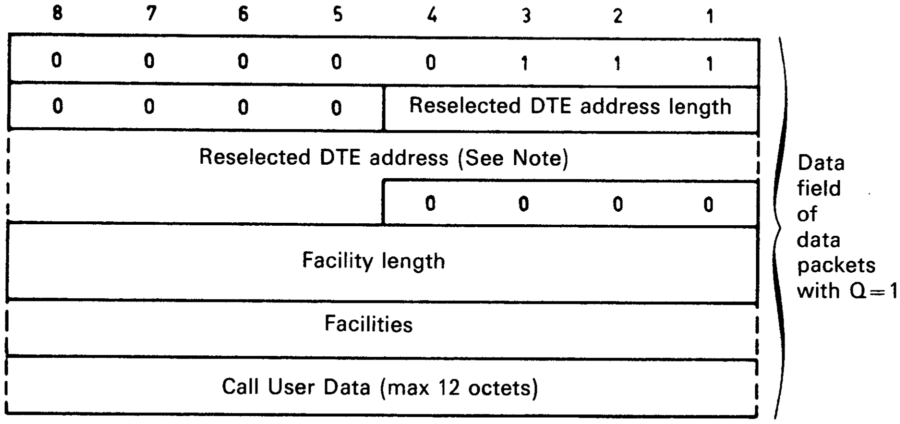
FIGURE 5/X.29

Invitation to clear PAD message format

This *PAD* message will not contain a parameter field.

4.4.9 *Reselection PAD message format*

The format of this message is given in Figure 6/X.29.



Note - The figure is drawn assuming that the DTE address consists of an odd number of digits.

FIGURE 6/X.29

Reselection PAD message format

4.4.9.1 *Reselected DTE address length field*

Bits 4, 3, 2 and 1 of the reselected DTE address length field indicate the length of the reselected DTE address in semi-octets. The address length is binary coded and bit 1 is the low order bit of the indicator.

4.4.9.2 *Address field*

Octet 3 and the following octets consist of the reselected DTE address. Each digit of the address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low order bit of the digit.

Starting from the high order digit, the address is coded in octet 3 and consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

The address field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field when necessary.

The reselected DTE address field should contain the *international data number* (DNIC + Network terminal number).

4.4.9.3 *Facility length field*

The octet following the reselected DTE address field indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

4.4.9.4 *Facility field*

The facility field is present only when optional user facilities are included by the DTE. This field indicates the facilities that must be included in the facility field of the *incoming call* packet received by the reselected DTE (see § 3.6).

The coding of the facility field is defined in § 7 of Recommendation X.25.

The facility field contains an integral number of octets, the maximum length of the complete PAD message is restricted, as described in § 4.4.4 above.

4.4.9.5 *Call user data field*

Following the facility field, the call user data field may be present and has a maximum length of 12 octets.

Call user data when present in the call user data field of the *reselection PAD* message is included in the call user data field of the *incoming call* packet received by the reselected DTE.

4.4.10 *Reselection with TOA/NPI PAD message format*

The format of this message is given in Figure 7/X.29.

Note – The TOA/NPI address subscription facility is designated in Recommendation X.2 for further study.

	7 6 5	4 3 2 1
1	0 0 0 0	1 0 0 0
2	Reselected DTE address length	
3	Reselected DTE address (see Note)	
		0 0 0 0
4	Facility length	
5	Facilities	
6	Call User Data (max 12 octets)	

Data field of data packets with Q = 1

T0706450-88

Note – The figure is drawn assuming that the number of semi-octets in the DTE address is odd.

FIGURE 7/X.29

Reselection with TOA/NPI PAD message format

4.4.10.1 *Reselected DTE address length field*

Octet 2 indicates the length of the reselected DTE address in semi-octets. The address length is binary coded and bit 1 is the low order bit of the indicator. The maximum value of the reselected DTE address length field is 17.

4.4.10.2 *Reselected DTE address field*

Octet 3 will consist of the TOA/NPI indication as described in Recommendation X.25. The following octets consist of the reselected DTE address. Each digit of the address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low order bit of the digit. Starting from the high order digit, the address digits are coded in consecutive semi-octets. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

4.4.10.3 *Facility length field*

The octet following the address field indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

4.4.10.4 *Facility field*

(See § 4.4.9.4.)

4.4.10.5 *Call user data field*

(See § 4.4.9.5.)

ANNEX A

(to Recommendation X.29)

Characteristics of virtual calls and Recommendation X.25 as related to the PAD representation of a start-stop mode DTE to a packet mode DTE

A.1 *General interface characteristics*

A.1.1 The mechanical, electrical, functional and procedural characteristics to activate, maintain and deactivate the physical access path between the DTE and the DCE will be in accordance with the physical level procedures of Recommendation X.25.

A.1.2 The link access procedure for data interchange across the link between the DTE and DCE will be in accordance with the link level procedures of Recommendation X.25.

A.1.3 The packet format and control procedures for the exchange of packets containing control information and user data between the DTE and the DCE will be in accordance with the packet level procedures of Recommendation X.25.

A.2 *Interface procedures for virtual call control*

A.2.1 Incoming calls are indicated to the packet mode DTE as specified in Recommendation X.25. Call requests are indicated by the packet mode DTE as specified in Recommendation X.25. Any use of optional user facilities are indicated in accordance with §§ 6 and 7 of Recommendation X.25.

A.2.2 The default throughput classes used by the PAD are determined by the data rates of the start-stop mode DTE (where exact correspondence is not obtained, the next higher throughput class is used).

A.2.3 The PAD and the packet mode DTE will use the clearing procedures specified in §§ 4.1.7, 4.1.8 and 4.1.9 of Recommendation X.25.

A.3 *Interface procedures for data transfer*

A.3.1 Data transfer on a virtual call can only take place in the *data transfer* state and when flow control permits (see § 4.4 of Recommendation X.25). The same is true for the transfer of *interrupt* packets (see § 4.3 of Recommendation X.25).

A.3.2 *Interrupt* packets transmitted by the packet mode DTE will be confirmed by the PAD following the procedures in Recommendation X.25.

A.3.3 The reset procedure may be used by the packet mode DTE or the PAD to re-initialize the virtual call and will conform to the procedures described in § 4.4.3 of Recommendation X.25.

A.3.4 A reset of the virtual call originated by the packet mode DTE or due to network congestion may be indicated by the PAD to the start-stop mode DTE.

A.3.5 A reset procedure initiated by the PAD may be due either to:

a) the receipt at the PAD of a request to reset from the non-packet mode DTE. The resetting cause contained in the *reset indication* packet will be *DTE reset*; or

b) a PAD or network failure.

A.3.6 For calls received by the PAD with bit 7 of octet 1 in the *incoming call* packet set to 0, the PAD will set bit 7 of octet 1 in the *call accepted* packet to 0 and will set the D bit in transmitted *data* packets to 0.

Pending further study, and in the absence of bilateral agreement between Administrations (used in conjunction with the D bit modification facility), the following applies:

If the *incoming call* packet received by the PAD has bit 7 of octet 1 set to 1, the PAD may set bit 7 of octet 1 of the *call accepted* packet to 1.

Calls originated by the PAD will set bit 7 of octet 1 in *call request* packets to 0. The called DTE can indicate if it requires the support of the D bit procedure by setting bit 7 of octet 1 of *call accepted* packets to 1.

PAD procedures associated with the Delivery Confirmation (D) bit in data packets (see § 4.3.3 of Recommendation X.25) are described in §§ 1.4.4 and 1.5.6.

A.4 *Virtual call characteristics*

A.4.1 *Resetting*

A.4.1.1 There may be a loss of data characters in any case of reset, as stated in Recommendation X.25. Characters generated by either of the DTEs prior to the *reset* indication or confirmation will not be delivered to the other DTE after the *reset* indication or confirmation.

A.4.2 *Interrupt transfer*

A.4.2.1 An *interrupt* packet is always delivered at or before the point in the data packet stream at which it was generated.

A.4.3 *Call clearing*

Data packets transmitted immediately before a *clear request* packet is sent, may be overtaken within the network by the *clear request* packet and subsequently be destroyed, as described in § 4.5 of Recommendation X.25.

Recommendation X.30 [1)]

SUPPORT OF X.21, X.21 *bis* AND X.20 *bis* BASED DATA TERMINAL EQUIPMENTS (DTEs) BY AN INTEGRATED SERVICES DIGITAL NETWORK (ISDN)

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

The CCITT,

considering

(a) that the Integrated Services Digital Network (ISDN) will offer the universal interfaces to connect subscriber terminals according to the reference configurations described in Recommendation I.411;

(b) that during the evolution of ISDN, however, there will exist for a considerable period DTEs conforming to Recommendations X.21, X.21 *bis* and X.20 *bis* which have to be connected to the ISDN;

(c) that the D-channel signalling protocol is described in Recommendations I.430, IQ.920, Q.921, Q.930 and Q.931;

(d) that the X.21 *bis* DTEs are an evolution of V series DTEs, which also provide interworking capability with X.21 DTEs over PDN services, and which use the network provided signal element timing and may have specific call control features to comply with the X.21 calling protocol [2)];

(e) that the X.20 *bis* based DTEs are an evolution of V series DTEs, which are operating in the asynchronous mode and which may have call control features to comply with the X.20 calling protocol,

unanimously declares

(1) that the scope of this Recommendation covers the connection of X.21 and X.21 *bis* based terminals of user classes of service 3 to 7 and 19 to the ISDN operating in accordance with circuit-switched or leased circuit services;

(2) that the scope of this Recommendation also covers the connection of X.20 *bis* based terminals of user classes of service 1 and 2 and of asynchronous data rates of 600, 1200, 2400, 4800 and 9600 to the ISDN operating in accordance with circuit-switched or leased circuit services;

1) This Recommendation is also included in the Recommendations of the I Series under the number I.461.

2) See Recommendation V.110.

(3) that the reference configurations of § 1 of this Recommendation shall apply;

(4) that the terminal adaptor (TA) functions to support X.21, X.21 *bis* and/or X.20 *bis* based DTEs including:

- rate adaption functions,
- call establishment functions,
- mapping functions,
- ready for data alignment,

shall be performed as outlined in § 2;

(5) that the scope of this Recommendation covers the rate adaption requirements which are caused by the connection of existing terminals to the ISDN user/network interface, but does not cover the requirements on bit rate conversion caused by the inter-operation of terminals with different bit rates (ISDN-CSPDN interworking).

CONTENTS

1 Reference configurations

Figures 1-1/X.30 and 1-2/X.30 show examples of possible configurations and are included simply as an aid to § 2 describing the TA functions.

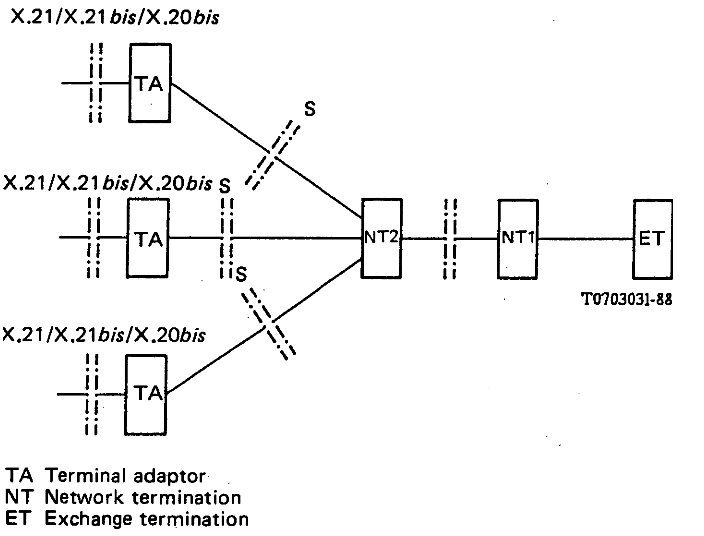
1.1 *Customer access configuration*

For the connection of X.21, X.21 *bis* or X.20 *bis* based DTEs to the ISDN, Figure 1-1/X.30 shows a possible reference configuration.

1.2 *Network configuration*

The specification of terminal adaption functions takes account of the network configuration and the end-to-end connection types shown in Figure 1-2/X.30 in which the associated terminal equipment TE1 and TE2 may be involved.

The TA functions for this scenario are described in § 2.



Note 1 – For ISDN reference configurations see Recommendation I.430.

Note 2 – The ISDN signalling protocol is described in Recommendations Q.921 and Q.931.

FIGURE 1-1/X.30

Customer access configuration example

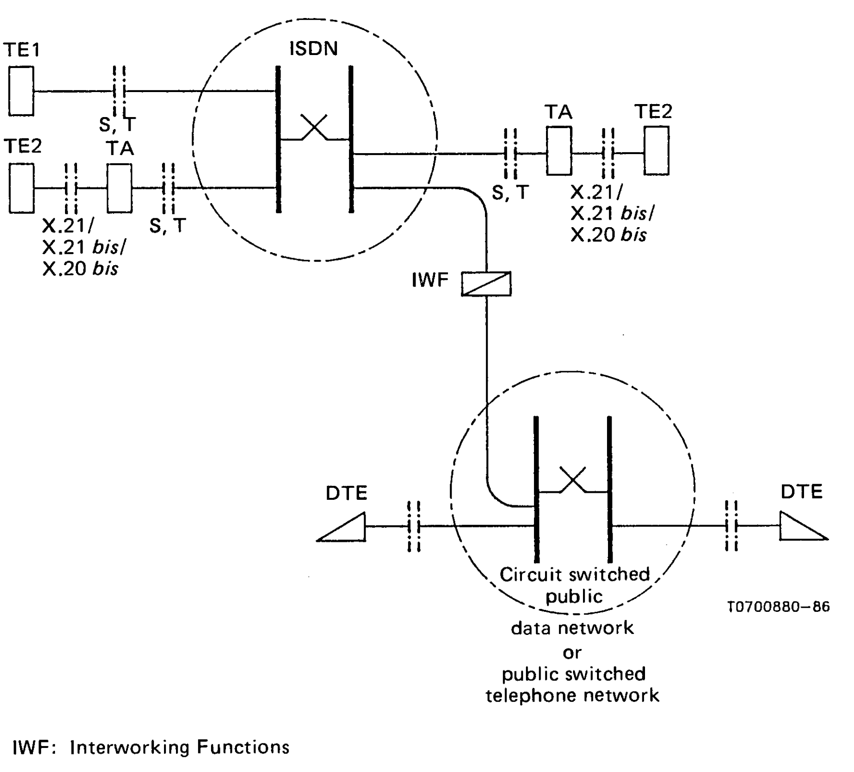


FIGURE 1-2/X.30

Network interworking configuration example

The terminals TE1 and TE2 are physically and logically connected to the ISDN where the call is handled.

The TA performs the necessary rate adaption, the signalling conversion from the X.21 signalling to the Q.931 signalling and vice-versa (X.21 mapping) and ready for data alignment. Interworking with dedicated networks, e.g. a CSPDN, will be provided on the basis of trunk lines interconnection by using Interworking Functions (IWF).

The following principles shall apply:

i) The non-voice services within the ISDN should basically not diverge from what is being developed in X Series Recommendations. This refers to the various aspects concerning quality of service, user facilities, call progress signals (see the X Series Recommendations, e.g., X.2 and X.96). However, existing features would be enhanced and additional features would also be developed if account were taken of the new ISDN customer capabilities (e.g., multi-terminal arrangement, user rate at 64 kbit/s simultaneous multi-media access as well as the possible solution of compatibility checking).

ii) Integration of X.21 based services into the ISDN is applicable to user classes of services 3 to 7, and 19. Integration of X.20 *bis* based services into the ISDN is applicable to user classes of service 1 and 2.

iii) Terminals TE1 and TE2 connected to an ISDN shall use the ISDN numbering scheme (see Recommendation E.164).

1.3 *Interworking situation*

Bearing in mind that this Recommendation defines the functions performed by the X.21 terminal adaptors (TA X.21) and X.21 *bis* terminal adaptors (TA X.20 *bis*) and X.20 *bis* terminal adaptors (TA X.20 *bis*), the following cases of interworking between these terminal adaptors and DTEs connected to CSPDN and PSTN may appear:

a) For user classes of service 3 to 7:

(1) TA X.21 - - - TA X.21

(2) TA X.21 - - - TA X.21 *bis*

(3) TA X.21 *bis* - - - TA X.21 *bis*

(4) TA X.21 - - - DTE X.21

(5) TA X.21 - - - DTE X.21 *bis*

(6) TA X.21 - - - V series DTE

(7) TA X.21 *bis* - - - DTE X.21

(8) TA X.21 *bis* - - - DTE X.21 *bis*

(9) TA X.21 *bis* - - - V series DTE

b) For user class of service 19:

(10) TA X.21 - - - TA X.21

(11) TA X.21 - - - TA X.21 *bis*

(12) TA X.21 *bis* - - - TA X.21 *bis*

(13) TA X.21 - - - TE1 (S/T reference point)

(14) TA X.21 *bis* - - - TE1 (S/T reference point)

c) For user classes of service 1 and 2:

(15) TA X.20 *bis* - - - TA X.20 *bis*

(16) TA X.20 *bis* - - - DTE X.20 *bis*

(17) TA X.20 *bis* - - - V series DTE

Note 1 – This Recommendation is intended to cover all TA-functions necessary to allow interworking as listed above. Currently, this Recommendation covers all TA-functions necessary to allow interworking between DTEs connected to ISDN and to CSPDN with the following exceptions:

1) for X.21 *bis* and X.20 *bis* only, the call control procedure with direct call has been explicitly covered, but other interface arrangements of X.21 *bis* and X.20 *bis* are not precluded;

2) for X.21 *bis*, the half-duplex mode of operation is for further study.

This applies to all the cases listed above, where at least one X.21 *bis* or X.20 *bis* terminal is involved. Alignment with the interworking functions may be necessary when the relevant Recommendations are available.

Note 2 – Within the interworking cases 1-17 mentioned above, the functions provided by TA X.21 *bis*, TA X.20 *bis* and the functions provided by TA V.110 should be compatible.

2 Terminal adaption functions

The terminal adaption functions to support X.21, X.21 *bis* and/or X.20 *bis* based DTEs can be subdivided into three areas, namely:

- rate adaption functions;
- X.21/Q.931 mapping functions for call control;
- ready for data alignment.

Some Administrations may provide separate TAs either for each Recommendation X.1 user class of service or for a group of user classes of service. Other Administrations may provide a universal TA for all user classes of service 3 to 7 or 19 or 1 and 2. Within the Recommendation only such functions are described which refer to single rate TAs. Additional functions necessary for universal TAs (e.g. user rate identification) are outlined in Appendix I.

2.1 *Terminal adaption functions for DTEs conforming to X.1 user classes of service 3 to 6*

2.1.1 *Rate adaption functions*

2.1.1.1 *General approach*

The rate adaption functions within the TA are shown in Figure 2-1/X.30. The function RA1 adapts the X.1 user rate to the next higher rate expressed by 2^k times 8 kbit/s (where $k = 0$ or 1). RA2 performs a second conversion to 64 kbit/s.

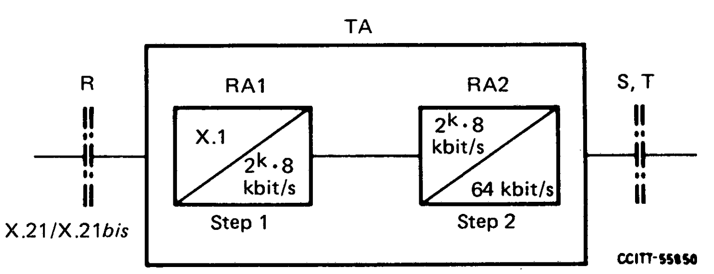


FIGURE 2-1/X.30

2.1.1.2 *First step of rate adaption (RA1) of X.1 rates to the intermediate rates of 8/16 kbit/s*

2.1.1.2.1 *Frame structure*

The conversion of the X.1 rates for user classes 3, 4 and 5 to 8 kbit/s, and for user class of service 6 to 16 kbit/s, shall be implemented by means of the 40 bit frame structure shown in Figure 2-2/X.30.

		Bit number							
		1	2	3	4	5	6	7	8
Octet 0	Odd frames –	0	0	0	0	0	0	0	0
	Even frames –	1	E1	E2	E3	E4	E5	E6	E7
Octet 1		1	P1	P2	P3	P4	P5	P6	SQ
Octet 2		1	P7	P8	Q1	Q2	Q3	Q4	X
Octet 3		1	Q5	Q6	Q7	Q8	R1	R2	SR
Octet 4		1	R3	R4	R5	R6	R7	R8	SP

Note – Bit X shall be set to "0" if not used for the optional flow control (see § 2.4.2), or for the indication of the far end synchronization loss (see Recommendation V.110).

FIGURE 2-2/X.30

Figure 2-2/X.30 shows that, in addition to the basic frame, a two frame multiframe is employed. In odd frames, octet 0 contains all zeros, whilst in even frames octet 0 consists of a one followed by seven E bits (see § 2.1.1.2.4). The order of bit transmission of the 40 bit frame is from left-to-right and from top-to-bottom.

2.1.1.2.2 *Frame synchronization*

The 17 bit frame alignment pattern consists of all 8 bits (set to zero) of octet 0 in odd frames and bit 1 (set to 1) of the following consecutive 9 octets of the 80 bit long multiframe (see also § 2.1.1.4.2). The first bit of octet 0 alternates between one and zero in consecutive frames and therefore provides a multiframe synchronization bit.

2.1.1.2.3 *Status bits SP, SQ, SR*

The bits SP, SQ and SR are used to convey channel associated status information. The mapping of the information on circuit C of the X.21 interface to the S bits and the circuit I in the distant interface should be done in such a way that the SP, SQ and SR bits are associated with the bit groups P, Q and R. To assure proper and secure operation the mapping scheme has to be consistent with Recommendations X.21 and X.24.

The mechanism for mapping is as follows:

– In all cases where X.21 byte timing interchange circuit B is not provided, the status bits SP, SQ and SR of the bit groups P, Q and R are evaluated by sampling the C lead in the middle of the 8th bit of the respective preceding bit group. On the other hand, the conditions of the status bits SP, SQ and SR are adopted by the I lead beginning with the transition of the respective 8th bit of a bit group R, P and Q to the 1st bit of the consecutive bit group P,Q and R on the R lead (see Figure 2-3/X.30).

– In the case where X.21-byte timing interchange circuit B is provided for character alignment, circuit C is sampled together with the bit 8 of the preceding character and circuit I is changing its state at the boundaries between old and new characters at circuit R. This operation is defined in Recommendation X.24.

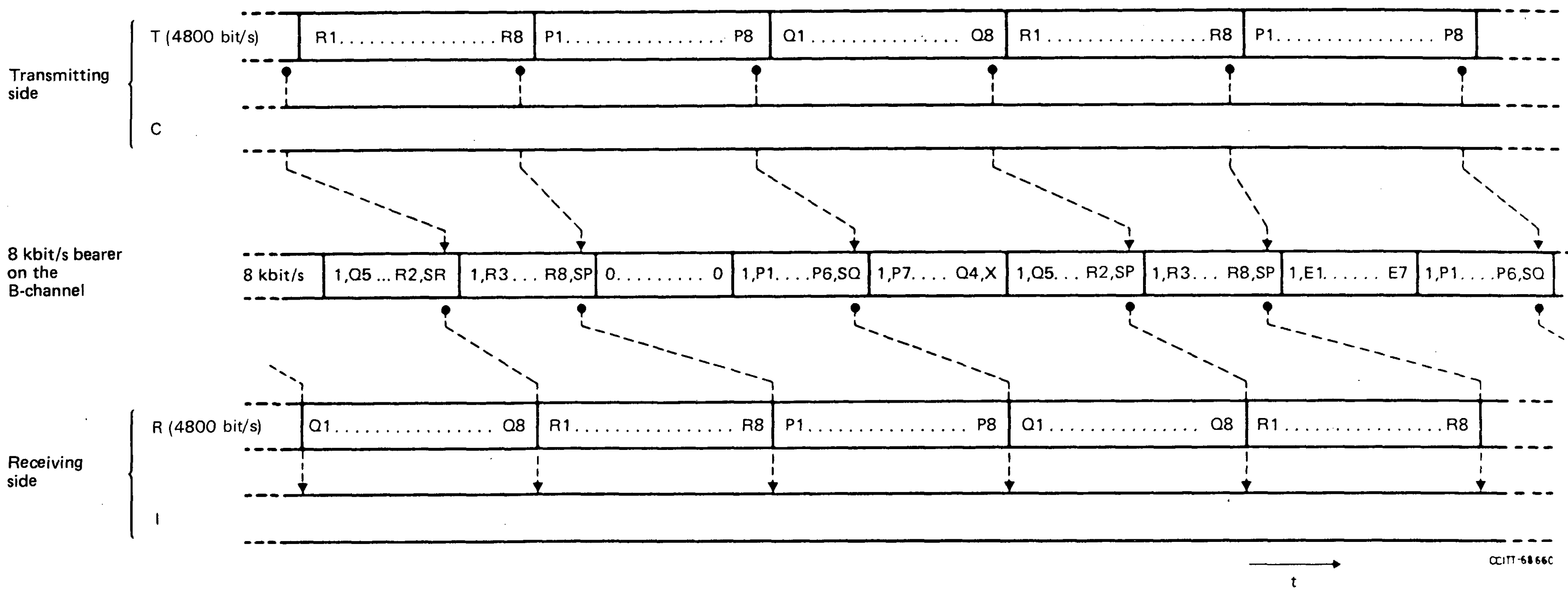


FIGURE 2-3/X.30

Mapping of status-information to the bitstream

Figure 2-3/X.30

In the sixth block of 8 kbit/s channel,

1, Q5........R2, SP	» should read: «	1, Q5........R2, SR	»

Note 1 – According to Recommendation X.21 the provision of the byte timing interchange circuit B is not mandatory.

Note 2 – The status bits may be used to transfer, during the data transfer phase, information for half-duplex operation between TA X.21 *bis* and TA X.21 or TA X.21 *bis* (i.e. mapping of the condition of the C lead of the TA X.21, of the 105 lead of the TA X.21 *bis*, to the condition on the 109 lead of the remote TA X.21 *bis*, and mapping of the condition of the 105 lead of the TA X.21 *bis* to the condition of the I lead on the remote TA X.21).

Note 3 – For bits SP, SQ, SR and X, a ZERO corresponds to the ON condition, a ONE to the OFF condition.

2.1.1.2.4 *Additional signalling capacity* (E bits)

The E bits provide the additional signalling capacity for the conveyance of information relating to the user rate. The coding of these bits is shown in Table 2-1/X.30.

TABLE 2-1/X.30

User rate (bit/s)	E1	E2	E3	E4	E5	E6	E7
600	1	0	0	X	X	X	0 or 1 (Note 1)
2400	1	1	0	X	X	X	X
4800	0	1	1	X	X	X	X
9600	0	1	1	X	X	X	X

X: Indicates spare bits which are reserved for future use and should be set to 1.

Note 1 – For the 600 bit/s user rate E7 is coded to enable the 8 × 40 bit frame group synchronization. To this aim, E7 in those 40 bit frames which terminate a frame group are set to zero (see § 2.1.1.2.6 and Figure 2-4a/X.30).

Note 2 – Different user rates with the same coding are distinct by different intermediate rates.

Note 3 – The coding of the user rates provides also for user rates specified for the TA recommended in Recommendation V.110.

Note 4 – It should be noted that bits E4 to E6 may be used in Recommendation V.110 for the transport of network independent clocking information.

Note 5 – Asynchronous rate information must be determined by the use of Q.931 signalling. Synchronous rate information may be determined by the use of E1, E2, E3 bit in conjunction with the intermediate rate.

2.1.1.2.5 *Data bits*

Data is conveyed in P, Q and R bits, i.e. 24 bits per frame.

2.1.1.2.6 *Repetition strategy*

For the adaption of user rates 600, 2400, 4800 bit/s to the 8 kbit/s intermediate rate and of the 9600 bit/s user rate to the 16 kbit/s intermediate rate, the sequence of even and odd octet 0 shall be maintained as defined in Figure 2-4/X.30. In order to achieve both short frame synchronization as well as short transfer delay times, a user-bit-repetition method is proposed. Figures 2-4a/X.30 and 2.4b/X.30 contain a scheme for the adaption of the 600 bit/s user rate and of the 2400 bit/s user rate respectively into the 8 kbit/s bearer rate. Figures 2-4c/X.30 and 2-4d/X.30 show the adaption of the 4800 bit/s user rate to the 8 kbit/s bearer rate and of the 9600 bit/s user rate to the 16 kbit/s bearer rate.

In the case of a 600 bit/s user rate, an explicit frame group synchronization pattern using bit E7 is provided to ensure preservation of user octet boundaries and associated status bit. The coding for the E7 bit shall be as follows:

... 1110111011101 ...

where the value 0 is marking the last 40 bit frame of each 8 × 40 bit frame group which contains three integer user octets.

0	0	0	0	0	0	0	0
1	P1	P1	P1	P1	P1	P1	SP
1	P1	P1	P2	P2	P2	P2	X
1	P2	P2	P2	P2	P3	P3	SP
1	P3	P3	P3	P3	P3	P3	SP
1	1	0	0	E4	E5	E6	1
1	P4	P4	P4	P4	P4	P4	SP
1	P4	P4	P5	P5	P5	P5	X
1	P5	P5	P5	P5	P6	P6	SP
1	P6	P6	P6	P6	P6	P6	SP
0	0	0	0	0	0	0	0
1	P7	P7	P7	P7	P7	P7	SP
1	P7	P7	P8	P8	P8	P8	X
1	P8	P8	P8	P8	Q1	Q1	SQ
1	Q1	Q1	Q1	Q1	Q1	Q1	SQ
1	1	0	0	E4	E5	E6	1
1	Q2	Q2	Q2	Q2	Q2	Q2	SQ
1	Q2	Q2	Q3	Q3	Q3	Q3	X
1	Q3	Q3	Q3	Q3	Q4	Q4	SQ
1	Q4	Q4	Q4	Q4	Q4	Q4	SQ
0	0	0	0	0	0	0	0
1	Q5	Q5	Q5	Q5	Q5	Q5	SQ
1	Q5	Q5	Q6	Q6	Q6	Q6	X
1	Q6	Q6	Q6	Q6	Q7	Q7	SQ
1	Q7	Q7	Q7	Q7	Q7	Q7	SQ
1	1	0	0	E4	E5	E6	1
1	Q8	Q8	Q8	Q8	Q8	Q8	SR
1	Q8	Q8	R1	R1	R1	R1	X
1	R1	R1	R1	R1	R2	R2	SR
1	R2	R2	R2	R2	R2	R2	SR
0	0	0	0	0	0	0	0
1	R3	R3	R3	R3	R3	R3	SR
1	R3	R3	R4	R4	R4	R4	X
1	R4	R4	R4	R4	R5	R5	SR
1	R5	R5	R5	R5	R5	R5	SR
1	1	0	0	E4	E5	E6	0
1	R6	R6	R6	R6	R6	R6	SR
1	R6	R6	R7	R7	R7	R7	X
1	R7	R7	R7	R7	R8	R8	SR
1	R8	R8	R8	R8	R8	R8	SP

FIGURE 2-4a/X.30

Adaption of the 600 bit/s user rate to the 8 kbit/s bearer rate

0	0	0	0	0	0	0	0
1	P1	P1	P2	P2	P3	P3	SP
1	P4	P4	P5	P5	P6	P6	X
1	P7	P7	P8	P8	Q1	Q1	SQ
1	Q2	Q2	Q3	Q3	Q4	Q4	SQ
1	1	1	0	E4	E5	E6	E7
1	Q5	Q5	Q6	Q6	Q7	Q7	SR
1	Q8	Q8	R1	R1	R2	R2	X
1	R3	R3	R4	R4	R5	R5	SR
1	R6	R6	R7	R7	R8	R8	SP

FIGURE 2-4b/X.30

Adaption of the 2400 bit/s user rate to the 8 kbit/s bearer rate

0	0	0	0	0	0	0	0
1	P1	P2	P3	P4	P5	P6	SQ
1	P7	P8	Q1	Q2	Q3	Q4	X
1	Q5	Q6	Q7	Q8	R1	R2	SR
1	R3	R4	R5	R6	R7	R8	SP
1	0	1	1	E4	E5	E6	E7
1	P1	P2	P3	P4	P5	P6	SQ
1	P7	P8	Q1	Q2	Q3	Q4	X
1	Q5	Q6	Q7	Q8	R1	R2	SR
1	R3	R4	R5	R6	R7	R8	SP

FIGURE 2-4c/X.30

Adaption of the 4800 bit/s user rate to the 8 kbit/s bearer rate

0	0	0	0	0	0	0	0
1	P1	P2	P3	P4	P5	P6	SQ
1	P7	P8	Q1	Q2	Q3	Q4	X
1	Q5	Q6	Q7	Q8	R1	R2	SR
1	R3	R4	R5	R6	R7	R8	SP
1	0	1	1	E4	E5	E6	E7
1	P1	P2	P3	P4	P5	P6	SQ
1	P7	P8	Q1	Q2	Q3	Q4	X
1	Q5	Q6	Q7	Q8	R1	R2	SR
1	R3	R4	R5	R6	R7	R8	SP

FIGURE 2-4d/X.30

Adaption of the 9600 bit/s user rate to the 16 kbit/s bearer rate

2.1.1.3 *Second step of rate adaption (RA2)*

As rate adaption of a single substream (8/16 kbit/s) to 64 kbit/s and multiplexing of several substreams to 64 kbit/s have to be compatible to enable interworking, a common approach is needed for second step rate adaption and for subchannel multiplexing. It is described in Recommendation I.460.

2.1.1.4 *Framing/reframing method and user rate identification*

For framing/reframing and user rate identification the following strategies shall be applied.

2.1.1.4.1 *Search for frame alignment*

The following 17 bit alignment pattern is searched for:

00000000	1XXXXXXX	1XXXXXXX	1XXXXXXX	1XXXXXXX
1XXXXXXX	1XXXXXXX	1XXXXXXX	1XXXXXXX	1XXXXXXX

No errors shall be tolerated in the defined bit positions (i.e. all bit positions excluding those denoted by "X").

It is assumed that the error rate will be sufficiently low to expect alignment following the detection of one 80 bit multiframe.

In the case of X.1 user class of service 3 (600 bit/s), a further search for the frame group synchronization pattern contained in bit position E7 shall be performed.

2.1.1.4.2 *Alignment monitoring/recovery*

The monitoring of the alignment shall be a continuous process. The alignment is assumed to be correct if there is no error in the 17 bit alignment pattern of the 80 bit multiframe.

Loss of alignment is assumed following the detection of N (provisional value: 3) consecutive multiframes each with at least one alignment bit error.

Following a loss of alignment the TA shall enter a recovery state, which is indicated at the X.21 interface by r = 1 and i = ON. In the transmitted frame, bit X, if used for the indication of the frame synchronizion to the far end, shall be set to OFF.

If the recovery of alignment is achieved, r and i present again the data and the status information respectively from the received frames. Bit X in the transmitted frames must be in the ON condition.

If recovery of alignment is not achieved within a fixed period, the TA shall indicate "DCE not ready" (state 22) by signalling r = 0, i = OFF. The duration of this period is network dependent (as in Recommendation X.21, § 2.6.2). In case of a circuit-switched service this leads to a clearing of the connection.

In the case of a X.21 *bis* TA, the signalling procedure in Recommendation V.110, § 4.1.5 should be used at the R-reference point.

2.1.1.4.3 *Identification of intermediate bit rate*

As a basic approach the intermediate bit rate is derived from the X.1 user rate contained in the Q.931 SETUP message.

As an alternative solution the intermediate bit rate may optionally be identified by relying solely on B-channel information (see Appendix II).

2.1.2 *X.21/X.21 bis to Q.931 protocol mapping*

The D-channel signalling capabilities of the ISDN-customer-access as defined in Recommendation Q.931 have to include the requirements arising from the mapping of the X.21 and X.21 *bis* interface signalling procedures to the Q.931 protocol at the S/T reference point.

The logical representation of these mapping functions is shown in Figure 2-5/X.30.

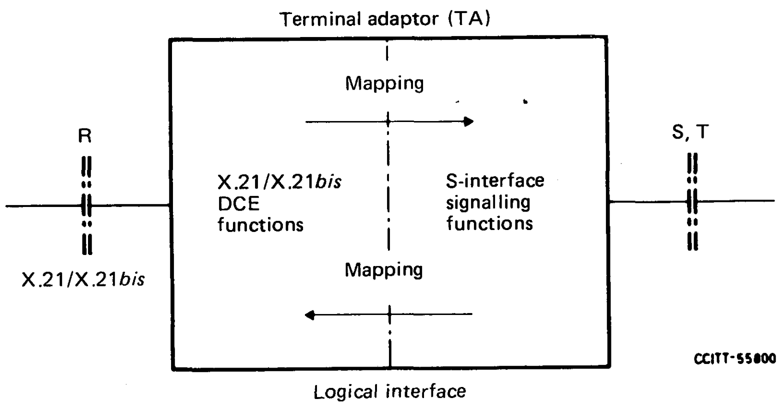


FIGURE 2-5/X.30

The D-channel signalling capabilities provided to X.21 and X.21 *bis* based terminals shall comprise the signalling messages as defined in Recommendation Q.931.

The following description and drawings depict examples of X.21 and X.21 *bis* mapping to the ISDN call control procedures. It is recognized that other possibilities and user options exist but this section is intended to provide general guidelines on X.21 and X.21 *bis* support. Only the normal call establishment and clearing procedures are shown.

Note 1 – Annex A contains an SDL description of the mapping of the procedures at the R-reference point to procedures at the S/T reference point and vice versa. However, the TA internal processes and states contained in the SDL diagrams are understood not to be binding for implementation.

Note 2 – Manual direct or address calls and manual disconnection from the TA should also be possible through the mapping of standard DTE/TA interface procedures with manual operations at the TA. In addition, automatic address calls may also be possible by the DTE employing a V.25 interface between the DTE and TA (see Recommendation V.110).

2.1.2.1 *Q.931/X.21 mapping* (see Figures 2-6/X.30 and 2-7/X.30)

The following sections are titled with the names of the Q.931 signalling messages at the S/T reference point.

2.1.2.1.1 *SETUP (from TA)*

In ready state (state 1) both DTE and TA transmit r = 1, i = OFF via the X.21 interface.

When the calling DTE indicates a call request (state 2, r = 0, i = ON) at the X.21 interface, the TA transmits a proceed to select signal to the DTE (state 3, +, OFF). The DTE begins to send selection signals to the TA (state 4, r = +, i = OFF).

When an end of selection signal (r = +, i = ON) is received at the X.21 interface, the TA transmits a SETUP message via the D-channel at the S/T reference point.

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 transfer 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 (e.g. LAPB) and layer 3 (e.g. X.25) information transfer protocols in the Low layer compatibility information element in the SETUP message. (See Q.931, annex entitled, "Low layer information coding principles").

The Called party address information element shall be encoded en-bloc i.e., with the complete address of the called party as received from the X.21 interface.

Afterwards, the state DCE waiting (state 6A, r = SYN, i = OFF) is entered at the X.21 interface.

2.1.2.1.2 *SETUP ACKNOWLEDGE/CALL PROCEEDING (from ET)*

The network reaction on the SETUP message received from the TA can be either:

a) sending of a CALL PROCEEDING message to the TA; when the CALL PROCEEDING message is received on the D-channel at the S/T reference point, the B-channel will be allocated and the TA transmits r = 1, i = OFF (within 80 bit multiframes in the case of user classes 3-6) via the B-channel at the S/T reference point; or

b) sending of a SETUP ACKNOWLEDGE message to the TA; when the SETUP ACKNOWLEDGE message is received on the D-channel at the S/T reference point, the B-channel will be allocated and and the TA transmits 1, OFF (within 80 bit multiframes in the case of user classes 3-6) via the B channel at the S/T reference point.

   In this case subsequent reception of CALL PROCEEDING does not entail any further actions in the TA.

2.1.2.1.3 *ALERTING (from ET)*

ALERTING message is only used with manual answering.

When an ALERTING message is received on the D-channel at the S/T reference point, the TA transmits the call progress signal (state 7, r = IA5, i = OFF) to the calling DTE.

Afterwards the state DCE waiting (state 6A, r = SYN, i = OFF) is entered at the X.21 interface.

2.1.2.1.4 *CONNECT (from ET)*

When a CONNECT is received on the D-channel at the S/T reference point, the TA transmits any DCE provided information (state 10, r = IA5, i = OFF) to the calling DTE. Afterwards the state connection in progress (state 11) is entered at the X.21 interface.

When the frame alignment pattern of the 80 bit multiframe (in the case of Recommendation X.1 user classes 3-6) is received on the B-channel at the S/T reference point, the TA performs switch-through.

When the calling DTE receives (1, ON) via the through-connected B-channel at the X.21 interface, the calling DTE enters the state ready for data (state 12) and data transfer (state 13) can begin.

2.1.2.1.5 *SETUP (from ET)*

The TA shall not accept a SETUP message unless the X.21 interface is in the ready state (state 1). When a SETUP message is received on the D-channel at the S/T reference point, the TA shall follow the procedures for determining compatibility checking (e.g., data signalling rate) found in Recommendation Q.931. If the TA determines that it can respond to the incoming call, it follows the procedures of Recommendation Q.931. It is expected that ALERTING message would only be used with terminals that answer manually.

The TA transmits an incoming call (r = Bell, i = OFF) via the X.21 interface to the called DTE, and the incoming call state (state 8, r = BEL, i = OFF) entered.

Call offering procedure in a multiterminal configuration is described in § 2.1.3.

2.1.2.1.6 *CONNECT (from TA)*

When a call accepted (state 9, t = 1, c = ON) is received from the called DTE, the TA transmits a CONNECT message via the D-channel of the S-interface.

2.1.2.1.7 *CONNECT ACKNOWLEDGE (from ET)*

When a CONNECT ACKNOWLEDGE message is received on the D-channel at the reference point, the TA, selected by this message, transmits 1/OFF via the allocated B-channel and signals connection in progress (state 11, r = 1, i = OFF) to the DTE after delivering DCE provided information if any.

The TA performs switch-through after the frame alignment pattern (80 bit multiframe in the case of user classes 3-6) has been received via the B-channel at the S/T reference point.

When the called DTE receives 1, ON via the switched through B-channel on the X.21 interface, the ready for data state (state 12, r = 1, i = ON) is entered and data transfer (state 13, r = D, i = ON) can begin.

2.1.2.1.8 *RELEASE (from ET)*

In the case of a multiterminal configuration, the exchange termination sends a RELEASE message to each TA that had signalled CALL PROCEEDING, ALERTING or CONNECT but which was not selected for the call. Subsequently the TA performs the DCE clear indication procedure at the X.21 interface and sends a RELEASE COMPLETE message to the exchange.

2.1.2.1.9 *DISCONNECT (from TA)*

A DTE clear request (state 16, t = 0, c = OFF) is transmitted via the B-channel from the clearing to the cleared DTE.

The TA at the clearing DTE recognizes the state 16 at the X.21-interface, separates the R- and I-leads from the B-channel and transmits a DCE clear confirmation (state 17 = 0, OFF) to the clearing DTE. It transmits also a DISCONNECT message via the D-channel of the S/T reference point (see Figure 2-6/X.30).

After reception of the RELEASE message on the D-channel, the TA tears down the B-channel, sends RELEASE COMPLETE to the exchange, transmits DCE ready (r = 1, i = OFF) to the DTE, and the DTE enters the state DTE ready (state 1, t = 1, c = OFF).

2.1.2.1.10 *DISCONNECT (between TA)*

When the DTE initiates DTE clear request (t = 0, c = OFF) this status is transmitted inslot within the B-channel and received as DCE clear indication (r = 0, i = OFF) in the DTE (see Figure 2-7/X.30).

The TA recognizes the clear request received inslot via the B-channel at the S/T reference point, separates the R- and I-leads from the B-channel and transmits a DCE clear indication (state 19 = 0, OFF) to the DTE to be cleared.

After the TA to be cleared has received DTE clear confirmation (t = 0, c = OFF) from the DTE, it transmits the DISCONNECT message via the D-channel, and clears the B-channel.

After reception of a RELEASE message on the D-channel, the TA releases the call reference, sends RELEASE COMPLETE message to the exchange, transmits DCE ready (state 2, r = 1, i = OFF) to the DTE, and the DTE enters the state DTE ready (t = 1, c = OFF).

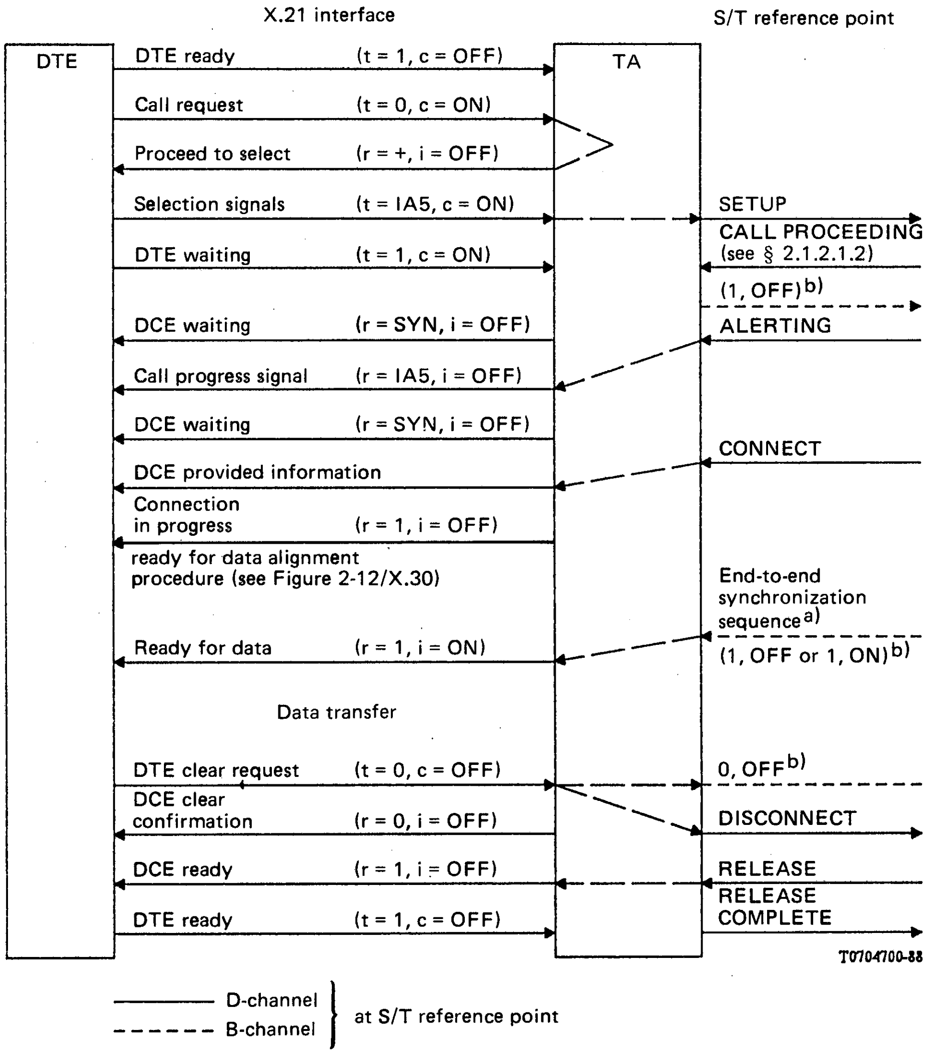
2.1.2.1.11 *DISCONNECT (from ET)*

In the case of clearing by the network, the local exchange transmits the DISCONNECT message via the D-channel to the terminal which has to be cleared. After reception of the DISCONNECT message in the TA, the TA transmits a RELEASE message on the D-channel to the exchange.

If the X.21 interface is in the call establishment phase and has not yet reached state 11 or 12, and if the DISCONNECT message contains the reasons for clearing, the TA moves to state 7 and transmits the corresponding call progress signal prior to signalling the DCE clear indication (see § 2.1.5).

Otherwise the TA transmits the state r = 0, i = OFF (DCE clear indication) via the X.21 interface to the DTE, which sends back to the TA the state t = 0, c = OFF (DTE clear confirmation).

The procedure described above is not shown in the Figures 2-6/X.30 and 2-7/X.30.



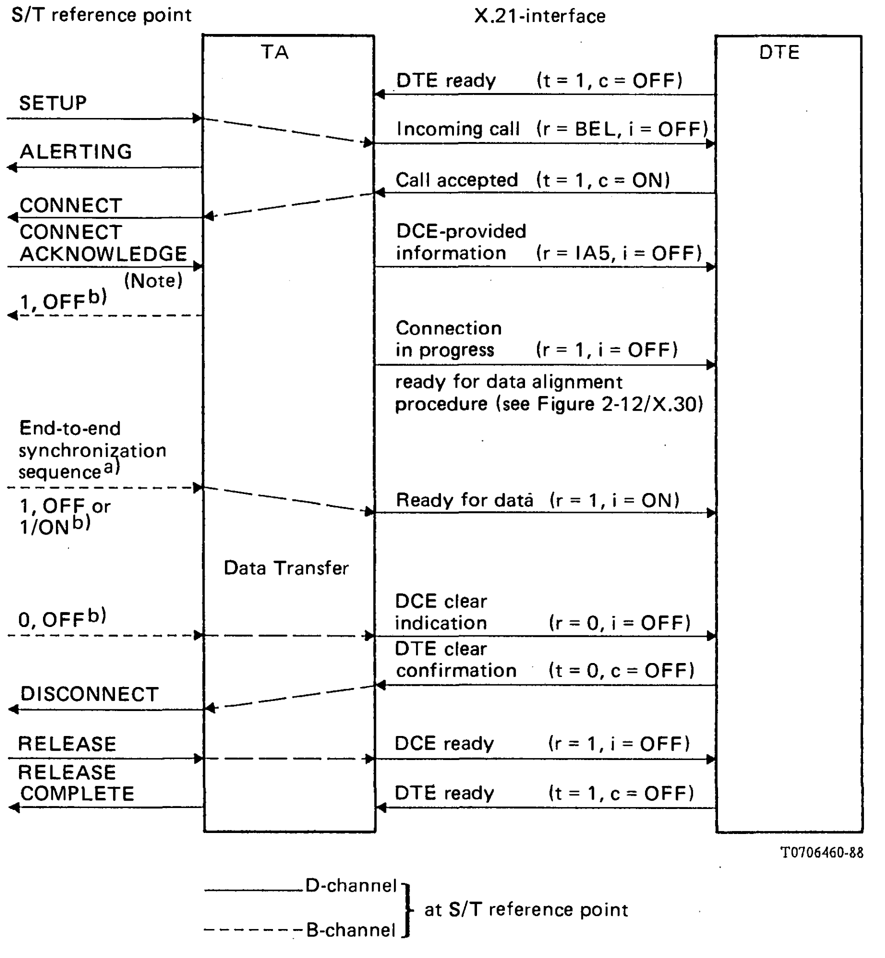
[a] For user class 19, see Figure 2-13/X.30.

[b] Not applicable for user class 19.

Note – The case of outgoing/incoming call collision is described in § 2.1.6.

FIGURE 2-6/X.30

X.21 – Example of DTE call establishment and clearing



a) For user class 19, see Figure 2-13/X.30.

b) Not applicable for user class 19.

Note – In the case of a multi-terminal configuration, the exchange sends a RELEASE message to each TA that had signalled CALL PROCEEDING, ALERTING or CONNECT, but which was not selected for the call.

FIGURE 2-7/X.30

X.21 – Example of DTE call which is established and cleared

2.1.2.1.12 *RELEASE COMPLETE (from ET)*

When the RELEASE COMPLETE message is received via the D-channel at the S/T reference point in the TA of the cleared DTE, the DCE ready state (state 21 = 1, OFF) and the DTE ready state (state 1 = 1, OFF) are entered.

2.1.2.2 *X.21 bis (direct call)*

See Figures 2-8/X.30 and 2-9/X.30.

Note – The Figures 2-8/X.30 and 2-9/X.30 depict some examples of X.21 *bis* support. Only the conditions on principal interchange circuits have been shown and options such as the use of circuits 105/109, 108.2, etc., have not been included. X.21 *bis*/Q.931 mapping is for further study.

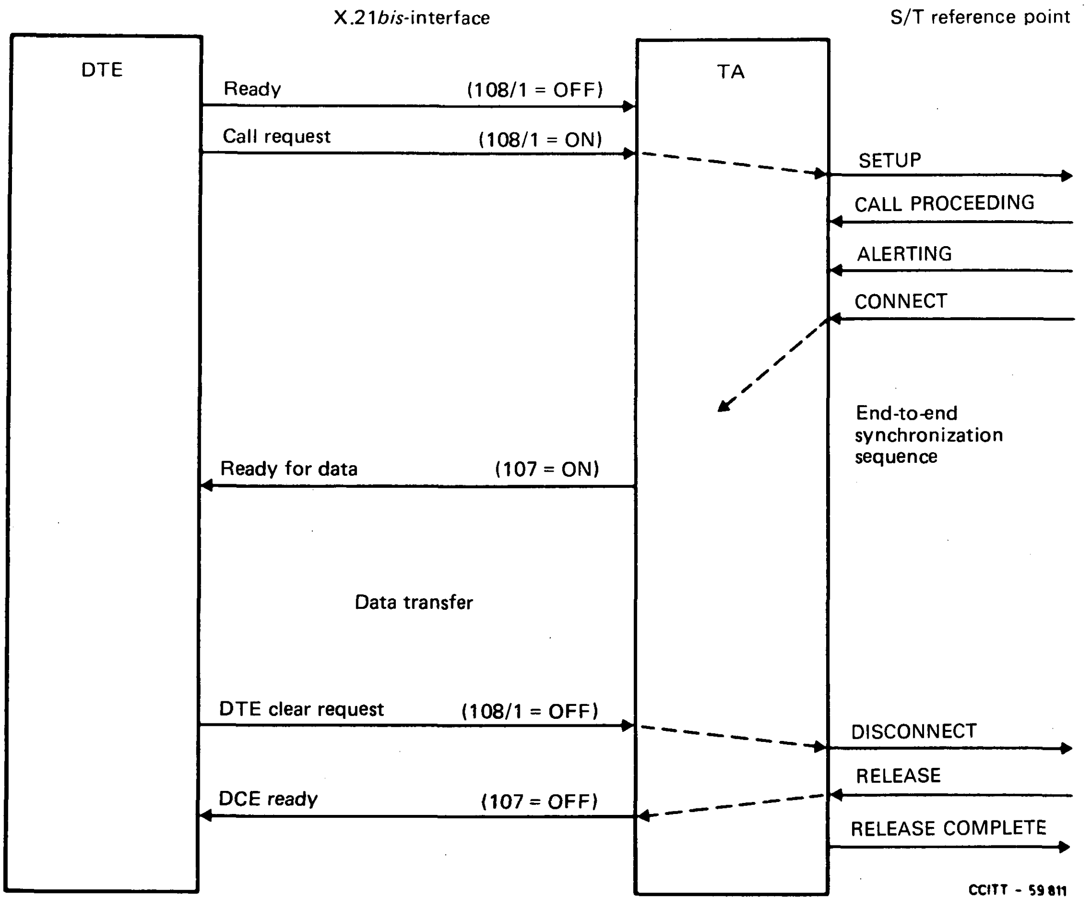
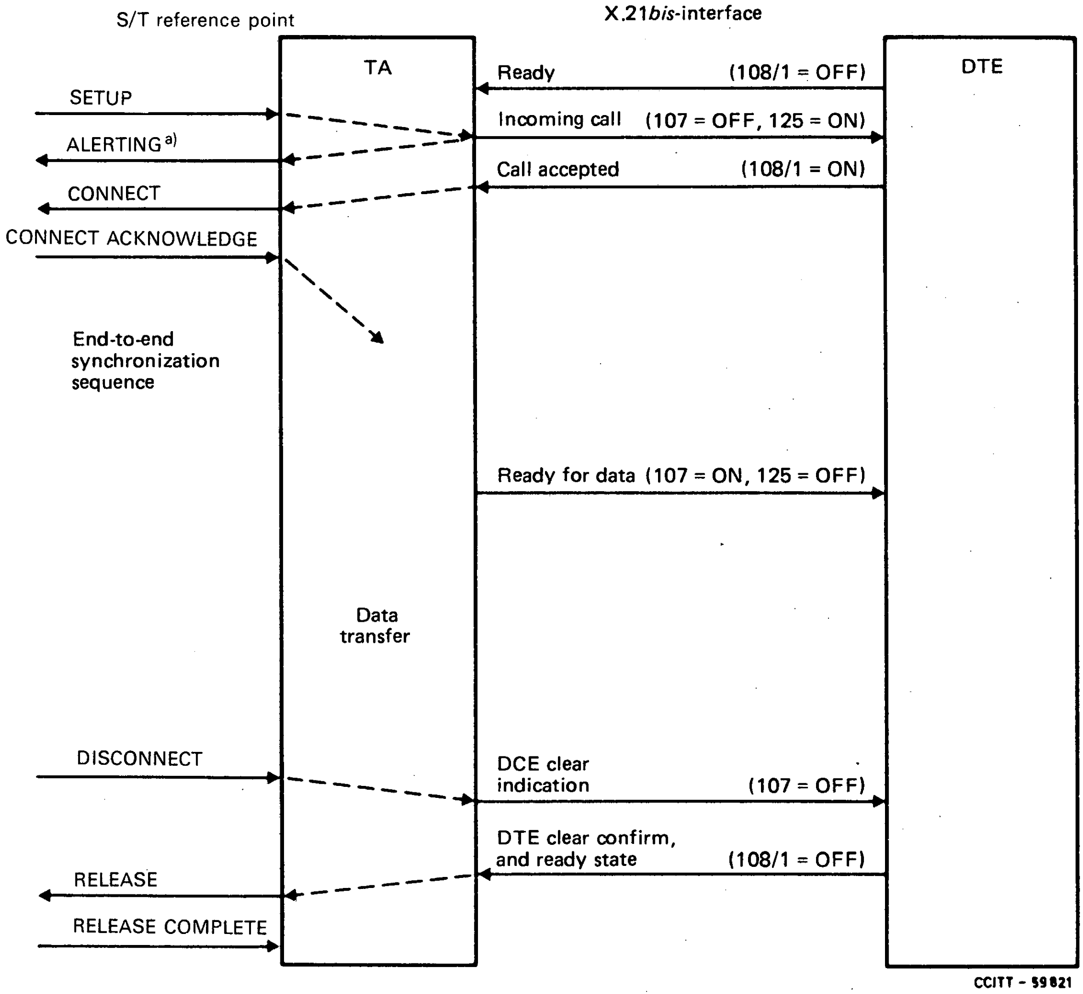


FIGURE 2-8/X.30

X.21bis – Example of DTE call establishment and clearing



a) Use only with manual answering.

FIGURE 2-9/X.30

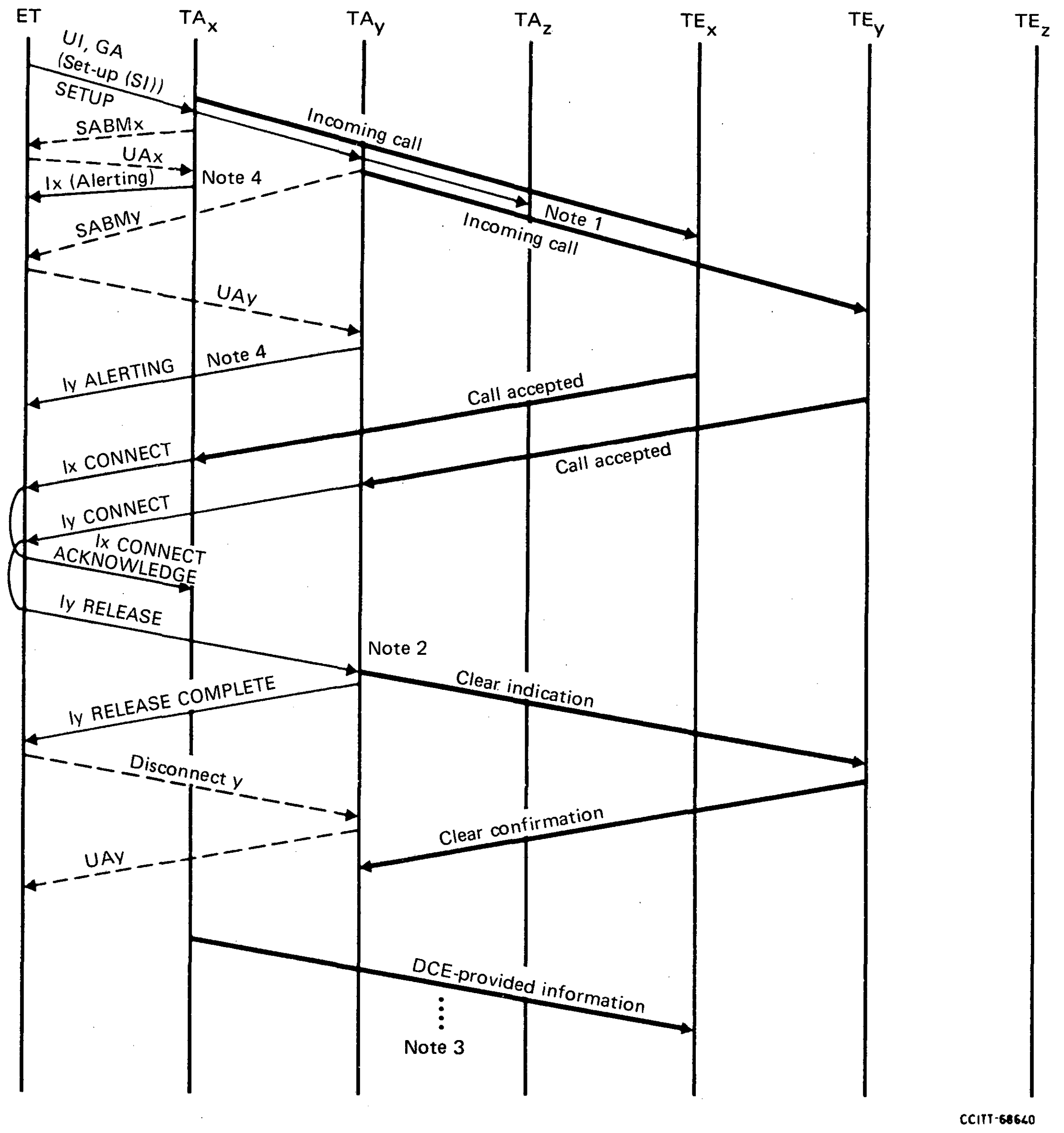
X.21bis – Example of DTE call which is established and cleared

2.1.3 *Call offering procedure in a multiterminal configuration*

For a call offering procedure in a multiterminal configuration, the following general description applies:

In case of a multiterminal configuration, an incoming call (SETUP message containing appropriate service indication information) is offered according to Recommendation Q.931.

When a SETUP mesage is received on the D-channel of the S/T reference point the TA shall follow the procedures for determining compatibility checking (e.g. data signalling rate) found in Recommendation Q.931. If the TA determines that it can respond to the incoming call, it follows the procedures or Recommendation Q.931. It is expected that the ALTERTING message would only be used by terminals that answer manually.



---- D-channel protocol (layer 2): LAP-D

——— D-channel protocol (layer 3)

——— X.21

GA Global address

Note 1 – TAz does not respond to the SETUP message because it is supporting a terminal which is not compatible with the calling terminal. However, TAz may alternatively respond with a RELEASE COMPLETE message with the cause "incompatible destination" (# 88).

Note 2 – The TAs which had sent an ALERTING or CONNECT message but were not selected for the call by the exchange are notified by a RELEASE message.

Note 3 – For further mapping of X.21 to D-Channel protocol refer to Figure 2-7/X.30.

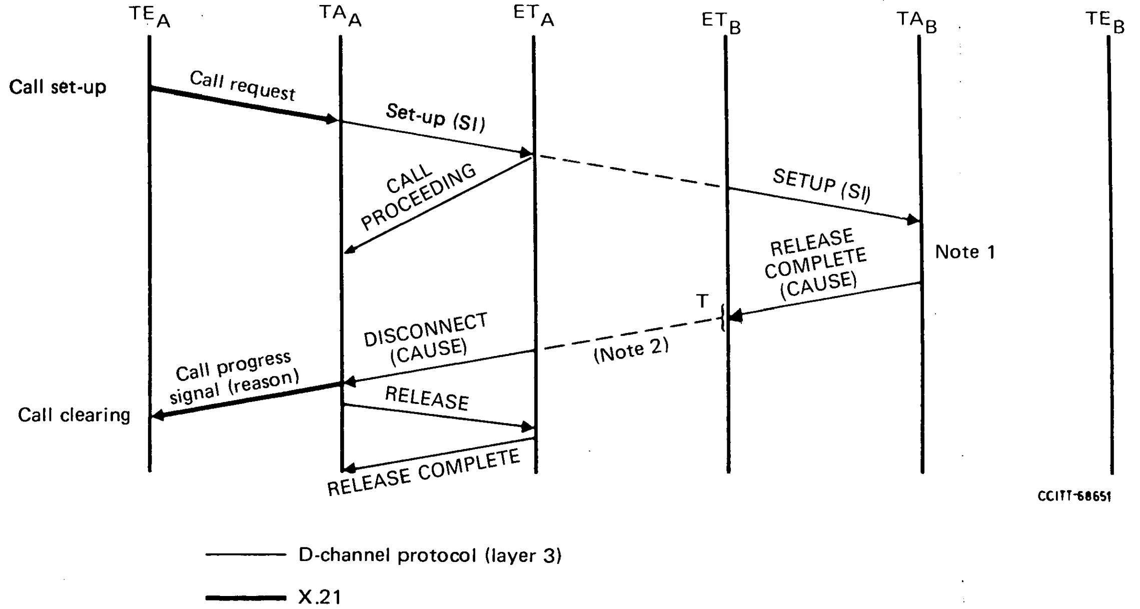
Note 4 – ALERTING messages are only used for the manual answering case.

FIGURE 2-10/X.30

Call offering procedure in a multiterminal configuration (example)

If the TA supports a compatible terminal, but cannot accept the call, because the terminal is not in the ready state, a RELEASE COMPLETE message has to be returned by the TA (see Figure 2-11/X.30). If the state of the terminal is:

a) controlled not ready, then the RELEASE COMPLETE message has cause 21, "call rejected";
b) uncontrolled not ready, then the RELEASE COMPLETE message has cause 27, "destination out of order";
c) busy, then the RELEASE COMPLETE message has cause 17, "user busy"



Note 1 – RELEASE COMPLETE message including the appropriate case code, is sent by a TA supporting a terminal which is compatible with information contained in the SETUP message, to indicate that the call cannot be accepted at this time for the following reasons: controlled not ready, uncontrolled not ready, busy condition of the called terminal, etc.

Note 2 – ET_B will follow the procedures of Recommendation Q.931, giving priority to causes as follows (as defined in Q.931):

1) cause # 17, "user busy";
2) cause # 21, "call rejected";
3) any other cause.

FIGURE 2-11/X.30

Negative response to incoming call (example)

This message is forwarded to the calling side to provide the appropriate X.21 call progress signals. Its mapping in the calling TA is described in § 2.1.5.

If more than one TA has responded, the message to be forwarded, including the cause to be indicated, is derived according to the priority rules of Recommendation Q.931.

In case several TAs have accepted the incoming call by returning a CONNECT message, the TA selected by the network receives the CONNECT ACKNOWLEDGE message. The TAs not selected for the call are cleared by the network by means of a RELEASE message

In a multiterminal configuration, a number of terminals and terminal adaptors can be contending for access to the D-channel. The contention resolution mechanism may result in delays of the outgoing signalling messages and could therefore affect the call set-up time. Call failure information transmission to the calling side may be delayed also by the priority rule procedure mentioned above.

2.1.4 *Ready for data alignment*

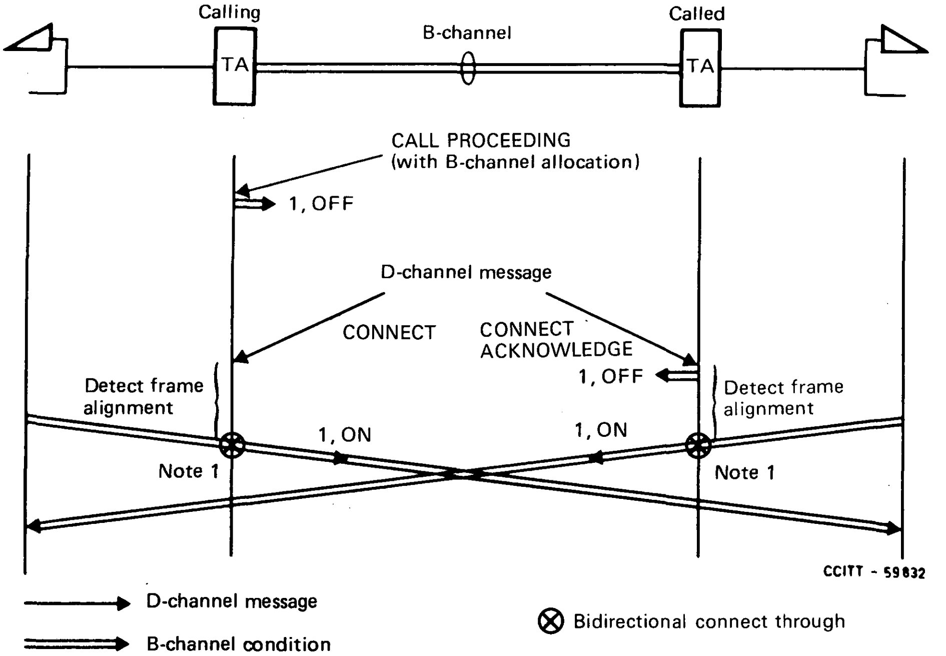
The task of synchronizing the entry to and exit from the data transfer phase between two subscriber terminals shall be performed by the terminal adaptors and subscriber terminals. For this purpose the X.21 procedure with inslot handshaking shall be used.

Two cases exist, one where the called TA supports only one data user rate and the other where the called TA will adapt to the data user rate of the calling TA.

In the following only the case of single rate TA is described.

The functions necessary for multiple rate TA (universal TA) are described in Appendix I.

For a single rate TA a symmetrical procedure is performed (see Figure 2-12/X.30):



Note 1 – The TA will perform connect-through after detecting frame alignment and completing delivery to the terminal of any DCE-provided information. To guarantee the correct ready for data alignment, through-connection must be performed immediately before the C lead is scanned.

Note 2 – Only those conditions necessary to effect ready for data alignment are shown.

Note 3 – The bidirectional switch through in the TA can also be performed in transition of state 12 to 13 in Recommendation X.21, if the TA is transmitting 1, ON during state 12.

FIGURE 2-12/X.30

Single rate TA operation to effect ready for data alignment at rates < 64 kbit/s

Both TAs shall check the signal of their receive B-channel for the frame alignment bit pattern.

After frame alignment detection in the B-channel, the TA shall connect the B-channel through to its terminal (DTE) immediately before the C-lead is scanned. From this point onwards the 1/ON condition from the DTE will be transmitted towards the distant DTE. Depending on the state of the distant end, either 1/OFF is received from the distant TA or 1/ON from the distant DTE. Reception of r = 1, i = OFF denotes the state "connection in progress" (state 11), reception of r = 1, i = ON denotes the state "ready for data" (state 12).

After switching through the B-channel by the TA, transmission of data and status in the data phase is continued and clearing down can be synchronized between the subscriber terminals by means of clear request.

2.1.5 *Mapping of Q.931 causes to X.21 call progress signals*

In several cases it will be necessary to map causes from Q.931 to X.21. The TA shall use Table 2-2/X.30 to map the causes from Q.931 messages to X.21 call progress signals.

Note – Since one-to-one mapping of Q.931 causes and X.21 call progress signals is not possible in all cases, some of the entries in Table 2-2/X.30 may not convey exactly the same meaning.

2.1.6 *Additional information for handling of exception situations*

When the call is cleared prematurely or a call failure occurs, the rules of Section 5.8 of Recommendation Q.931 and of Recommendation X.21 apply. The following procedures are derived for the mutual mapping between the R and the S/T reference points.

TABLE 2-2/X.30

Mapping of Q.931 cause fields to X.21 call progress signals

Item	Q.931 cause	Code	X.21 call progress signal significance	Code
1	Unassigned or unallocated number	1	Not obtainable	43
2	No route to destination	3	Not obtainable	43
3	Channel unacceptable	6	Not obtainable	43
4	Normal clearing	16	Not applicable	
5	User busy	17	Number busy	21
6	No user responding	18	No connection	20
7	User alerting, no answer	19	No connection	20
8	Call rejected	21	Controlled not ready	45
9	Number changed	22	Changed number	42
10	Destination out of order	27	Uncontrolled not ready	46
11	Invalid number format (Incomplete number)	28	Selection signals procedure error	22
12	Normal, unspecified	31	Not applicable	
13	No circuit/channel available	34	No connection	20
14	Network out of order	38	Out of order	44
15	Temporary failure	41	Out of order	44
16	Switching equipment congestion	42	Network congestion	61
17	Requested circuit or channel not available	44	No connection	20
18	Resources unavailable, unspecified	47	Network congestion	61
19	Quality of service unavailable	49	Not applicable	
20	Bearer capability not authorized	57	Incompatible user class of service	52
21	Bearer capability not presently available	58	Network congestion	61
22	Service or option not available, unspecified	63	No connection	20
23	Bearer service not implemented	65	Invalid facility request	48
24	Channel type not implemented	66	Invalid facility request	48
25	Service or option not implemented, unspecified	79	Invalid facility request	48
26	Invalid call reference value	81	Not obtainable	43
27	Identified channel does not exist	82	Not obtainable	43

TABLE 2-2/X.30 *(cont.)*

Item	Q.931 cause	Code	X.21 call progress signal significance	Code
28	Incompatible destination	88	Not obtainable	43
29	Invalid message	95	Selection signal transmission error	23
30	Mandatory information element is missing	96	Selection signal procedure error	22
31	Message type non existent or not implemented	97	Selection signal procedure error	22
32	Message not compatible with call state, message type non existent or not implemented	98	Selection signal procedure error	22
33	Information element non existent, not implemented	99	Selection signal procedure error	22
34	Invalid information element contents	100	Selection signal transmission error	23
35	Message not compatible with call state	101	Selection signal procedure error	22
36	Recovery on timer expiry	102	Not obtainable	43
37	Protocol error, unspecified	111	Selection signal procedure error	42
38	Interworking, unspecified	127	RPOA out of order	72

2.1.6.1 *Call collision*

Call collision may occur at both sides of the TA, at the X.21 interface and at the S/T reference point.

Note – Call collision for the X.21 *bis* and X.20 *bis* interfaces is for further study.

2.1.6.1.1 *Call collision at the X.21 interface*

The TA shall accept an incoming SETUP message when the X.21 interface is in the READY state.

When at the X.21 interface a call collision is detected (TA sends incoming call, X.21 DTE sends call request) the TA will indicate proceed-to-select and cancel the incoming call.

Note – As an alternative the TA may send a DCE clear indication and when in the READY state resend the incoming call.

2.1.6.1.2 *Call collision at the S/T reference point*

In the event of call collision at the S/T reference point the procedures defined in Q.931 shall apply.

2.1.6.2 *No channel available*

If no channel including no B-channel at the S/T reference point is available for connection establishment, an outgoing SETUP message is answered from the ET by a RELEASE COMPLETE message with the cause 34 = no channel available. This is mapped at the X.21 interface into the call progress signal 20 = no connection, followed by DCE clear indication.

2.1.6.3 *Premature clearing*

A DTE may initiate the clearing procedure at any time by transmitting a DTE clear request at the X.21 interface, as described in § 2.1.2.1.9. If no connection exists between DTEs, at the distant station, the procedure described in § 2.1.2.1.11 will apply.

2.1.6.4 *No answer to outgoing SETUP*

If an outgoing SETUP is not answered by the ET, the DTE will, after the time-out of timer T2 (20 s), initiate the clearing procedure by transmitting DTE clear request. The TA, in its S/T reference point, will send a RELEASE COMPLETE message (cause code 31: normal, unspecified). On its X.21 interface, it will transmit DCE clear confirmation.

On the other hand, if a TA is provided with the optional timer T303 (Q.931) it may start the clearing procedure at the S/T reference point as above by transmitting RELEASE COMPLETE (cause code 102: recovery on timer expiry). At the X.21 interface, the TA sends the call progress signal 43 = not obtainable, followed by DCE clear indication.

2.2 *Terminal adaption functions for DTEs conforming to X.1 user class of service 7*

2.2.1 *Rate adaption functions*

For rate adaption from X.1 user classes of services 3-6 to 64 kbit/s a 40 bit frame has been adopted (see Figure 2-2/X.30). Within this frame 24 data bits can be transmitted which may be allocated to three bit groups P, Q and R each bit group containing 8 bits.

An equivalent approach, with the optional possibility of character alignment also for the X.1 user rate of 48 kbit/s, shall be used. To implement this approach an appropriate frame structure for this rate is defined. Table 2-3/X.30 shows this frame which contains the octets 1, 2, 3 and 4 (framing of 24 data bits).

Octet alignment is performed by means of the 8 kHz timing.

TABLE 2-3/X.30

	Bit number							
	1	2	3	4	5	6	7	8
Octet 1	1	P1	P2	P3	P4	P5	P6	SQ
Octet 2	0	P7	P8	Q1	Q2	Q3	Q4	X
Octet 3	1	Q5	Q6	Q7	Q8	R1	R2	SR
Octet 4	1	R3	R4	R5	R6	R7	R8	SP

The frame alignment pattern consists of 10111011 in bit 1 of consecutive octets which are received from the 64 kbit/s stream. This frame alignment pattern also will be used for *ready for data* alignment (see § 2.1.4) and for user rate identification (see Appendix II).

For user rate identification the following algorithm shall apply (see also Recommendation V.110):

- search for the bit pattern ... 10111011 ... in bit 1 of consecutive octets which are received from the 64 kbit/s stream;
- if this search is successful then the user rate is 48 kbit/s.

Note – For international interworking, bit X must be set to 1. This bit may be used for other purposes in a national network.

2.2.2 *X.21/X.21 bis to D-channel protocol mapping*

The X.21/X.21 *bis* mapping functions are given in § 2.1.2.

2.2.3 *Call offering procedure in a multiterminal configuration*

As per § 2.1.3.

2.2.4 *Ready for data alignment*

As per § 2.1.4.

2.2.5 *Mapping of Q.931 causes to X.21 call progress signals*

As per § 2.1.4.

2.2.6 *Additional information for handling of exception situations*

As per § 2.1.6.

2.3 *Terminal adaption functions for DTEs conforming to X.1 user class of service 19*

2.3.1 *Rate adaptation functions*

It is assumed that in the case of a TA supporting only 64 kbit/s, no rate adaptation and no user rate identification is necessary. The procedure in the case of a universal TA is for further study (see Appendix I).

Note – It is recognized that the *all ones* condition could be produced by the alarm indication signal (AIS). The implication of this on D-channel signalling requires further study.

2.3.2 *X.21/X.21 bis to D-channel protocol mapping* (see Figure 2-6/X.30 and 2-7/X.30)

The following sections are titled with the names of the Q.931 signalling messages at the S/T reference point.

2.3.2.1 *SETUP (from TA)*

In *ready* state (state 1) both DTE and TA transmit (1, OFF) via the X.21-interface.

When the calling DTE indicates a *call request* (state 2, r = 0, i = ON) at the X.21-interface, the TA transmits a *proceed to select* signal (state 3) to the DTE (r = +, i = OFF) . The DTE begins to send *selection* signals to the TA (state 4).

When an *end of selection* (r = +, i = ON) is received at the R-interface, the TA transmits a SETUP message via the D-channel of the S-interface.

2.3.2.2 *CALL PROCEEDING/SETUP ACKNOWLEDGE*

When the CALL PROCEEDING or SETUP ACKNOWLEDGED message is received on the D-channel of the S-interface, the B-channel will be allocated and the TA transmits all zeros via the B-channel at the S/T reference point.

2.3.2.3 *ALERTING (from ET)*

ALERTING is generally used with manual answering.

When an ALERTING message is received on the D-channel of the S-interface, the TA transmits *call progress* signals (state 7) to the calling DTE.

Afterwards the state DCE waiting (state 6A, r = SYN, i = OFF) is entered at the X.21-interface.

2.3.2.4 *CONNECT (from ET)*

When a CONNECT message is received on the D-channel at the S/T reference point, the TA may transmit *DCE-provided information* (state 10) to the calling DTE. Afterwards the state *connection in progress* (state 11) is entered at the X.21-interface.

The alignment pattern procedure is entered as described in § 2.3.4.1.

2.3.2.5 *SETUP (from ET)*

The TA shall not accept a SETUP message unless the X.21-interface is in the ready state (state 1).

When a SETUP message is received on the D-channel of the S-interface, the TA shall follow the procedures for determining compatibility checking (e.g. data signalling rate) found in Recommendation Q.931. If the TA determines that it can respond to the incoming call, it follows the procedures of Recommendation Q.931. It is expected that the ALERTING message would only be used by terminals that answer manually.

The TA transmits an incoming call (BEL, OFF) via the X.21-interface to the called DTE, and the *incoming call* state (state 8) is entered.

In the case of a multiterminal configuration the incoming call point-to-multipoint operation is described in § 2.1.3.

2.3.2.6 *CONNECT (from TA)*

When a *call accepted* (state 9 = 1, ON) is received from the called DTE, the TA transmits a CONNECT message via the D-channel at the S/T reference point.

2.3.2.7 *CONNECT ACKNOWLEDGE (from ET)*

When a CONNECT ACKNOWLEDGE message is received on the D-channel of the S reference point the TA, selected by this message, signals *connection in progress* (1, OFF, state 11) to the DTE after delivering DCE-provided information if any.

The alignment pattern procedure is entered as described in § 2.3.4.1.

2.3.2.8 *RELEASE (from ET)*

In the case of a multiterminal configuration the exchange sends the *RELEASE* message to each TA that had signalled CALL PROCEEDING, ALERTING or CONNECT but which was not selected for the call. Subsequently the TA performs the *DCE clear indication* procedure at the X.21-interface and sends a RELEASE COMPLETE message to the exchange.

2.3.2.9 *DISCONNECT (from TA)*

When a DTE indicates *DTE clear request* (r = 0, i = OFF, state 16), the TA transmits *DCE clear confirmation* (r = 0, i = OFF, state 17) via the X.21-interface and transmits a DISCONNECT message via the D-channel of the S-interface and tears down the B-channel.

After reception of RELEASE on the D-channel, the TA releases the call reference, sends RELEASE ACKNOWLEDGE to the exchange on the D-channel and transmits *DCE ready* (r = 1, i = OFF) to the DTE. The DTE then enters the *DTE ready* state (t = 1, c = OFF).

2.3.2.10 *DISCONNECT (from ET)*

In the case of clearing by the network the local exchange transmits the DISCONNECT message via the D-channel to the terminal which has to be cleared. After reception of the DISCONNECT message in the TA, the TA transmits a RELEASE message on the D-channel to the exchange.

On the other hand the TA transmits the state 19, r = 0, i = OFF (*DCE clear indication*) via the X.21-interface to the DTE, which sends back to the TA the state 20, t = 0, c = OFF (*DTE clear confirmation*).

2.3.2.11 *RELEASE COMPLETE (from ET)*

When the RELEASE COMPLETE message is received via the D-channel of the S/T reference point in the TA, the *DCE ready* state (state 21 = 1, OFF) and the *DTE ready* state (state 1, r = 1, i = OFF) is entered.

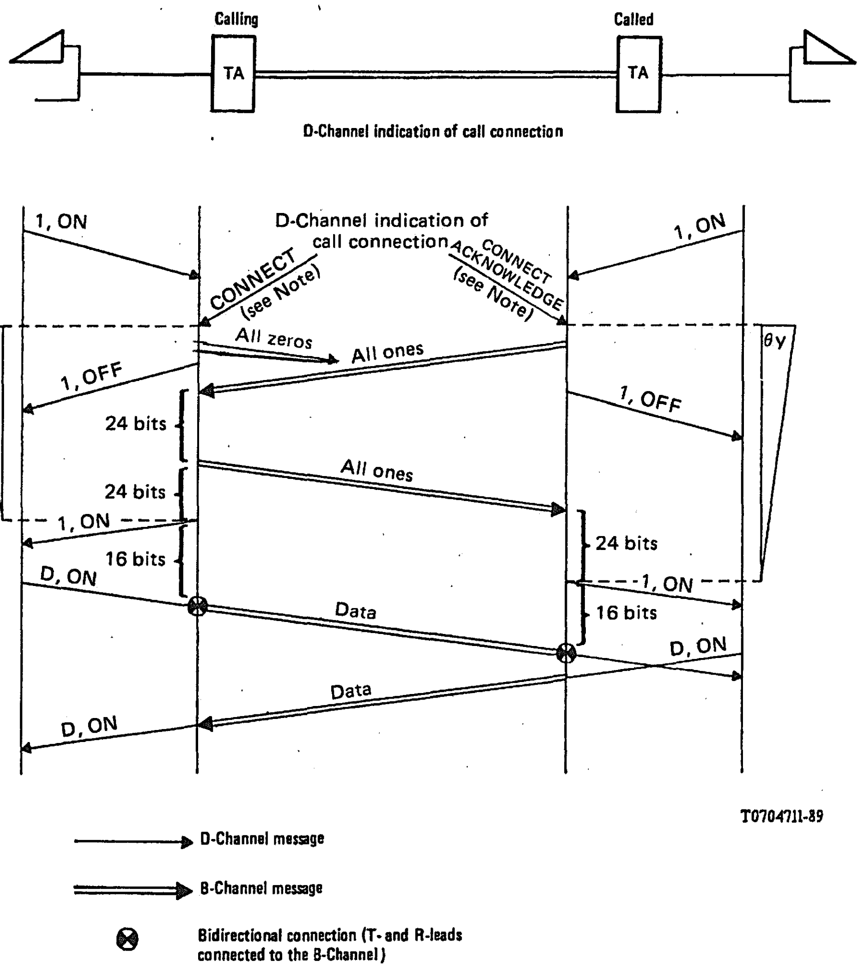
The procedure described above is not shown in Figures 2-6/X.30 and 2-7/X.30.

2.3.3 *Call offering procedure in a multiterminal configuration*

As per § 2.1.3.

2.3.4 *Ready for data alignment*

For *ready for data* alignment on entering and leaving the *data transfer* phase between two terminals operating at 64 kbit/s the following procedure shall apply (see Figure 2-13/X.30).



Note – The TA will only indicate ready for data after completing delivery to the DTE of any DCE provided information.

The receipt of a CONNECT message by the calling TA may occur before or after the receipt of a CONNECT ACKNOWLEDGE message by the called TA.

FIGURE 2-13/X.30

The operational sequence to effect ready for data alignment at a user rate of 64 kbit/s

2.3.4.1 *Entering the data transfer phase*

At the time the called TA has received the CONNECT ACKNOWLEDGE message and delivered the DCE provided information, if any, the called terminal is in the state 11 (*connection in progress*). The *ready for data* alignment procedure begins by continuous sending of the alignment pattern *all ones* at the called side.

All zeros should be returned via the allocated B-channel to the calling party while DCE provided information is sent to the called party. Following the completion of DCE provided information the all ones signals should be transmitt ed via the B-channel.

After the calling adaptor has received a CONNECT mesage and delivered the DCE provided information to the calling DTE, if any, the X.21-interface is in the state connection in progress (state 11). If the calling adaptor now has recognized 24 bits of the alignment pattern, it knows that the through-connections are established in the network and it sends the same pattern in the forward direction. After 24 bits have been sent, the calling TA indicates *ready for data* (state 12 r = 1, i = ON) for exact 16 bits, then performs the connection of the B-channel to the T- and R-leads.

When the called adaptor, while sending the alignment pattern, has recognized 24 bits of the alignment pattern from the calling adaptor, it indicates to the DTE *ready for data* (state 12 = 1, ON) for exact 16 bits, then performs the connection of the B-channel to the T- and R-leads.

When the byte timing is provided at the X.21 interface, the transition from OFF to ON on the I-lead is performed on an octet boundary, complying with Recommendation X.24.

If the alignment pattern has not been received by the calling adaptor before end of time-out θ_x the calling adaptor indicates *ready for data* (r = 1, i = ON) for exact 16 bits, then performs the connection of the B-channel to T- and R-leads.

If the alignment pattern has not been received by the called adaptor before end of time-out θ_y the called adaptor indicates *ready for data* (r = 1, i = ON) for exact 16 bits, then performs the connection of the B-channel to T- and R-leads.

The values of θ_x (provisional value 1 s) and θ_y (provisional value 2 s) should cater for time propagation delays on the longest hypothetical reference connection and require further study.

Optionally, earlier switch-through may occur in the TAs (i.e. the TA does not wait for the expiry of time outs θ_x and θ_y). In this case DTE information sent after the *ready for data* on the X.21 interface may be lost due to the lack of end-to-end alignment. Since no *ready for data* alignment takes place after the connect-through in the TAs, a DTE to DTE synchronization must be performed by an end-to-end procedure between the two DTEs at higher layers.

2.3.4.2 *Leaving the data transfer phase*

It is not possible to leave the data transfer phase using the synchronization method, because transparency is needed. The cleared terminal should see the end of its communication before the *clear* message is received. However, anything it sends at this stage would be ignored. Higher level protocols are necessary to resolve these problems.

2.3.5 *Mapping of Q.931 causes to X.21 call progress signals*

As per § 2.1.5.

2.3.6 *Additional Information for handling of exception*

Situations as per § 2.1.6 , § 2.1.6.3 "premature clearing".

2.4 *Terminal adaption functions for DTEs conforming to X.1 user classes of service 1 and 2 (asynchronous operation)*

2.4.1 *Rate adaption functions*

2.4.1.1 *General approach*

The rate adaption functions within the TA are shown in Figure 2-14/X.30. A three-stage method is employed with the functional blocks RA0, RA1 and RA2. The RA0 function is an asynchronous-to-synchronous conversion stage using the same technique as defined in Recommendation V.14 for support of X.1 user rates. It produces a synchronous bit stream defined by 2^n times 600 bit/s (where n = 0 to 4). The function RA1 adapts the intermediate RA0 user rate to the next higher rate expressed by 2^k times 8 kbit/s (where k = 0 or 1). RA2 performs a second conversion to 64 kbit/s.

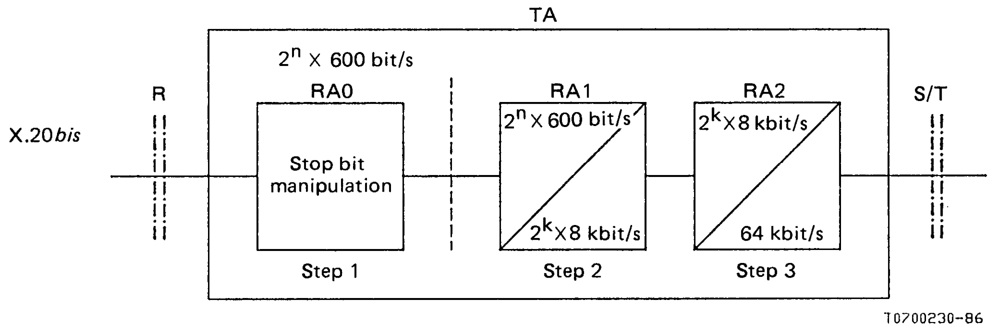


FIGURE 2-14/X.30

2.4.1.2 *Supported asynchronous user rates*

TABLE 2-4/X.30

Asynchronous user rates

User class of service	Data rate bit/s	Rate tolerance in %	No. of data bits [b]	No. of stop bits	RA0/RA1 rate (bit/s)	RA1/RA2 rate (kbit/s)
2	50	+/−2.5	5	1.5	600	8
	75	+/−2.5	5, 7 or 8	1, 1.5 or 2	600	8
	110	+/−2.5	7 or 8	1 or 2	600	8
	150	+/−2.5	7 or 8	1 or 2	600	8
	200	+/−2.5	7 or 8	1 or 2	600	8
1	300 [a]	+/−2.5	7 or 8	1 or 2	600	8
Note 1	600 [a]	+1/−2.5	7 or 8	1 or 2	600	8
	1200 [a]	+1/−2.5	7 or 8	1 or 2	1200	8
	2400 [a]	+1/−2.5	7 or 8	1 or 2	2400	8
	4800 [a]	+1/−2.5	7 or 8	1 or 2	4800	8
	9600 [a]	+1/−2.5	7 or 8	1 or 2	9600	16

[a] Implies that these data rates should be supported by an Universel TA.

[b] Number of data bits includes possible parity bits.

Note 1 – The use of asynchronous data rates of 600, 1200, 2400, 4800 and 9600 bit/s is in accordance with Recommendation X.1.

2.4.1.3 *Asynchronous-to-synchronous conversion (RA0)*

The RA0 function is only used with asynchronous V-series (X.20 *bis*) interfaces. Incoming asynchronous data is padded by the addition of stop elements to fit the nearest channel defined by 2^n times 600 bit/s. Thus a 300 bit/s user data signalling rate shall be adapted to a synchronous 600 bit/s stream. The resultant synchronous stream is fed to RA1.

2.4.1.4 2nd step, RA1: Adaption of RA0 to the intermediate rates at 8/16 kbit/s, see § 2.1.1.2.

3rd step, RA2: Adaption of intermediate rate, to the bearer rate 64 kbit/s, see § 2.1.1.3.

2.4.1.5 *Break signal*

The terminal adaptor shall detect and transmit the break signal in the following fashion:

If the convertor detects M to 2M+3 bit/s, all of Start polarity, where M is the number of bits per character in the selected format including Start and Stop bits, the converter shall transmit 2M+3 bits of Start polarity.

If the convertor detects more than 2M + 3 bits all of Start polarity, the converter shall transmit all these bits as Start polarity.

The 2M + 3 or more bits of Start polarity received from the transmitting side shall be output to the receiving terminal.

The terminal must transmit on Circuit 103 at least 2M bits Stop polarity after the Start polarity break signal before sending further data characters. The convertor shall then regain character synchronism from the following Stop to Start transition.

2.4.1.6 *Overspeed/Underspeed*

A Terminal Adaptor shall insert additional Stop elements when its associated terminal is transmitting with a lower than nominal character rate. If the terminal is transmitting characters with an overspeed of up to 1% (or 2.5% in the case of nominal speeds lower than 600 bit/s), the asynchronous-synchronous converter may delete Stop elements as often as is necessary to a maximum of one for every eight characters at 1% overspeed. The converter on the receiving side shall detect the deleted Stop elements and re-insert them in the received data stream (Circuit 104).

The nominal length of the Start and Data elements shall be the same for all characters. The length of the Stop elements may be reduced by as much as 12.5% for nominal speeds exceeding 300 bit/s to allow for overspeed in the transmitting terminal. For nominal speeds less than or equal to 300 bit/s a 25% reduction in Stop element is allowed.

2.4.1.7 *Parity bits*

Possible parity bits included in the user data are considered as data bits by the RA0 function.

2.4.2 *Flow control*

A flow control option, for use with TA supporting asynchronous DTEs, is described in this section. Flow control allows the connection of asynchronous DTEs operating at different user data rates by reducing the character output of the faster to that of the slower. Support of flow control will require the use of the end-to-end (TA-to-TA) protocol defined in § 2.4.2.2 and an incoming line (from network) buffer in addition to a selected local protocol employed. There will also be a requirement for character buffering from the DTE interface. The size of this buffer is not defined in this Recommendation because it is dependent upon implementation.

Local flow control of the DTE interface is required where the DTE operates at a rate higher than the synchronous rate established between TAs. End-to-end flow control is required where the synchronous rate established between TAs is consistent with the operating rate of one DTE (or interworking function) and higher than the synchronous rate consistent with the operating rate of the other DTE (or interworking function). Both local and end-to-end flow control could be required in some applications.

2.4.2.1 *Local flow control: TA to DTE*

Connection may be made between TAs connected to asynchronous DTEs operating at two different speeds. It is the responsibility of the TA connected to the faster DTE to execute a Local Flow Control protocol to reduce the character rate to that of the slower DTE. This operation will require some buffer storage in the TA. A TA may support several different Local Flow Control protocols, although only one will be selected at any one time. There are a number of such protocols in use, some of which are detailed in the following text.

2.4.2.1.1 105/106 *operation*

This is an out-of-band Flow Control mechanism, utilizing two of the interchange Circuits specified in V.24. If a DTE requires to transmit a character, it turns ON Circuit 105 (request to send). The DTE can only begin transmission when it receives in return Circuit 106 ON (ready for sending). If, during transmission of a block of characters Circuit 106 goes OFF, the DTE must cease transmission (after completing the transmission of any character of which transmission has started) until Circuit 106 turns ON again.

2.4.2.1.2 XON/XOFF *operation*

This is an inband Flow Control mechanism using two characters of the IA5 set for XON and XOFF operation. If a DTE receives an XOFF character, it must cease transmission. When it receives an XON character, it may resume transmission. The characters typically used for XON and XOFF are DC1 and DC3 (bit combination 1/1 and 1/3 in Recommendation T.50) respectively, although alternative bit-combinations can be used.

2.4.2.1.3 *Other methods*

Alternative and non-standard methods of asynchronous flow control are in use, and these may be mapped onto the TA flow control protocol.

2.4.2.2 *End-to-end (TA to TA) flow control:*

Matching (by reduction) of the transmitted character rate of the DTE to the rate of the TA is not sufficient in all cases to guarantee correct operation, and end-to-end flow control may be required.

The X bit is used to carry Flow Control information. A TA will buffer incoming characters. When the number of buffered characters exceeds a threshold TH1, depending upon implementation, the TA will set the X bit of its outgoing frames to OFF.

Upon receipt of a frame containing an X bit set to OFF, a TA will execute its selected Local Flow Control procedure indicating that the attached DTE must stop sending characters, and cease the transmission of data after transmitting completely the characters in progress by setting the data bits in the outgoing frames to ones.

When the buffer contents of a TA which has initiated an end-to-end Flow Control drops below threshold TH2, the TA will reset the outgoing X bit to ON.

When the far end TA receives a frame with the X bit set to ON, it will recommence data transmission, and, by use of the Local Flow Control procedure, indicate to the attached DTE that it may continue.

Note – There may be a delay between initiation of the end-to-end Flow Control Protocol and termination of the incoming character stream. The characters arriving during this time must be buffered, and the total buffer size will depend upon the character rate, round trip delay and the buffer threshold.

2.4.2.3 *Use of channel capacity*

Upon accepting a call from a TA supporting Flow Control and operating at a different user rate and/or intermediate rate, the called TA will adopt the identical intermediate rate and bit repetition factor. This will override the parameters normally selected. In such cases, the TA connected to the faster DTE will execute a Local Flow Control procedure to reduce the character rate to that of the slower DTE.

Thus, if a faster DTE calls a slower DTE, the faster intermediate channel rate and bit repetition factor will be adopted by the TAs on both ends. To reduce the character rate received by the slower DTE, its TA will exercise end-to-end Flow Control and cause the TA on the calling side to utilize Local Flow Control.

If a slower DTE calls a faster DTE, the slower intermediate channel rate and bit repetition factor will be adopted by the TAs on both ends. To reduce the character rate transmitted by the faster DTE, its TA will exercise Local Flow Control.

If the called TA does not implement the intermediate rate and bit repetition factor used by the calling TA, the call shall be rejected.

2.4.2.4 *Requirements of a TA supporting Flow Control*

The following are general requirements for a TA supporting Flow Control:

i) A TA supporting Flow Control shall be capable of operating with an intermediate rate and bit repetition factor that is independent of the asynchronous speed used at its DTE interface.

ii) A TA supporting Flow Control shall be capable of recognizing the intermediate rate and bit repetition factor required for an incoming call, and adopting it. User rate information will be obtained from signalling.

iii) A TA supporting Flow Control shall be capable of executing a Local Flow Control protocol to reduce the character rate to that of the far-end DTE.

iv) A TA supporting Flow Control will support the use of end-to-end (TA-to-NA) Flow Control using the X bit, and will contain a character buffer.

2.4.3 *Ready for data alignment*

The adaption functions relevant to bit rate adaption for steps RA1 and RA2 and the READY FOR DATA ALIGNMENT remain as described in § 2.1.4.

3 **Test loops**

The maintenance concept of the X.30 TA shall comply with the maintenance concept of the ISDN subscriber access and subscriber installation as defined in Recommendations of the I.600-series and in Recommendation I.430 on ISDN subscriber access and installation maintenance. The Test loops are specified in those Recommendations.

The ISDN communication architecture enables communication of maintenance information over bearer connections between network service access points (NSAPs). Accordingly, a bearer service may be used on either a B or 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 OSI application layer protocol. The specification of these management capabilities to be supported by TAs is for further study. The following concepts shall apply:

3.1 *Test loop reference configuration*

Figure 3-1/X.30 shows the location of test loops within the TA.

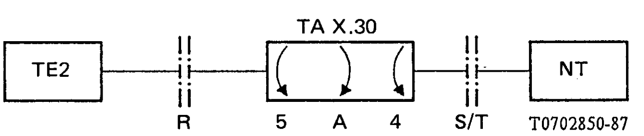


FIGURE 3-1/X.30

Location of Test Loops

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

3.2 *Test loop characteristics*

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

3.3 *Loop activation/deactivation mechanism*

(i) *Test loop 4*

Test loop 4 being controlled from the network side of the TA is activated either via a layer 3 message on the D-channel or via a layer 1 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.

When the loop is established the following states shall apply at the R-reference point:

- for the X.21 interface towards the terminal

  R = 0/1 ..., i = OFF (DCE controlled not ready) shall apply;

- for the X.21 *bis* interface towards the terminal,
  - circuit 104 is placed in the binary 1 condition,
  - circuit 106, 107, 109 and 125 are placed in the OFF condition,
  - circuit 142 is placed in the ON condition.
  - timing information is placed on circuits 114 and 115.

(ii) *Test loop 5*

For activation/deactivation of test loop 5, the definitions as under (i) apply. Since the loop 5 is close to the R-reference point, the loop point is located within the R-interface 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 interface. At the loop point, however, the incoming and outgoing (logged) bitstreams are identical.

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

iii) *Test loop A*

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

Note – Since selection of a specific B-channel is not specified in Recommendation X.21/X.21 bis, the subject of B-channel selection within test loop A, if required, remains for further study.

Note – Loop activation/deactivation (for the above 3 test loops) can optionally as an alternative be provided manually.

3.4 *Coding of activation/deactivation control message*

- loop 4 control via B- or D-channel application layer protocol: for further study;
- loop 4 control via B-channel layer 1 mesage: 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*.

Note – The protocols and procedures for communicating between the two system management application processes (SMAPs) are for further study.

ANNEX A

(to Recommendation X.30)

SDL diagrams

A.1 *General*

In order to provide a clear and unambiguous understanding of the protocol mapping in the TA (X.21 procedures to the ISDN signalling procedures) a formal method is used. This annex presents a formal description using SDL (specification and description language) which is recommended by CCITT (Recommendations Z.101-Z.104).

The description supplements Figures 8/X.30 and 9/X.30.

A.2 *Some remarks about the formal description*

a) Because of fundamental differences in the formal description techniques used in Recommendation X.21 (Annex A) and the one used to describe the X.21 TA it was not possible to realize a one-to-one translation of the "states" as described in Recommendation X.21 into the "states" as described in the X.21 TA.

However, as SDL is a method recommended by CCITT, it is still felt appropriate to use this language.

Corresponding states from Recommendation X.21 are indicated as comment in the X.21 TA description.

b) Only the regular *call control* phase and the *clearing* phase of the X.21 TA are described. No time-outs, etc. are included.

c) The following tasks are not shown in detail in the SDL diagrams:

- switch-through at the R-side of the TA (on the R-interface, data is internally mapped to the B-channel handler),
- end-to-end synchronization,
- the rate adaption and frame/envelope (dis)assembly processes.

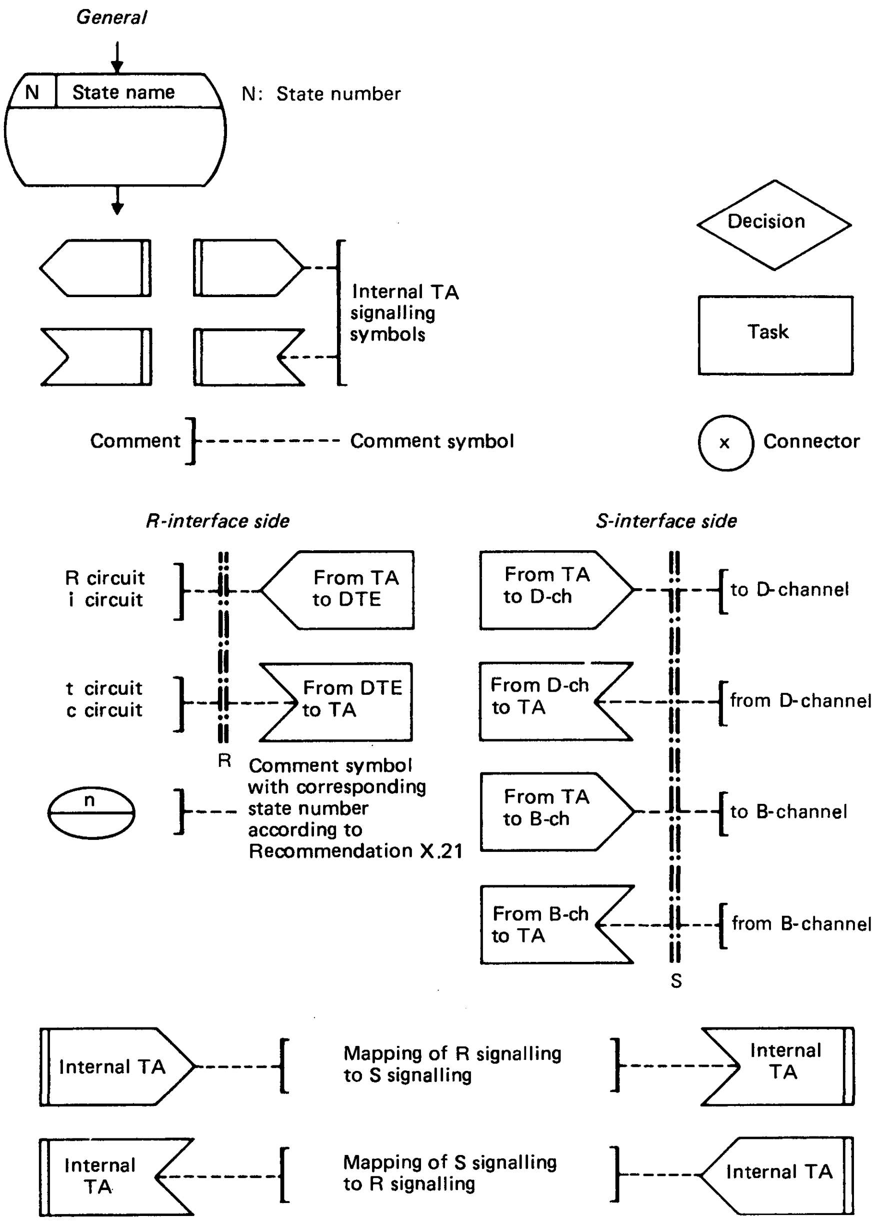
d) In order to describe the TA, the TA is divided in three parts, which can act simultaneously:

- the R-interface side
- the D-channel handler on the S-interface side
- the B-channel handler on the S-interface side

The (ordering of the) interacting signals between R-side and S-side represent the actual mapping of the R-interface procedures to the S-interface procedures.

An explanation of the symbols used in the SDL diagrams is given in Figure A-1/X.30.

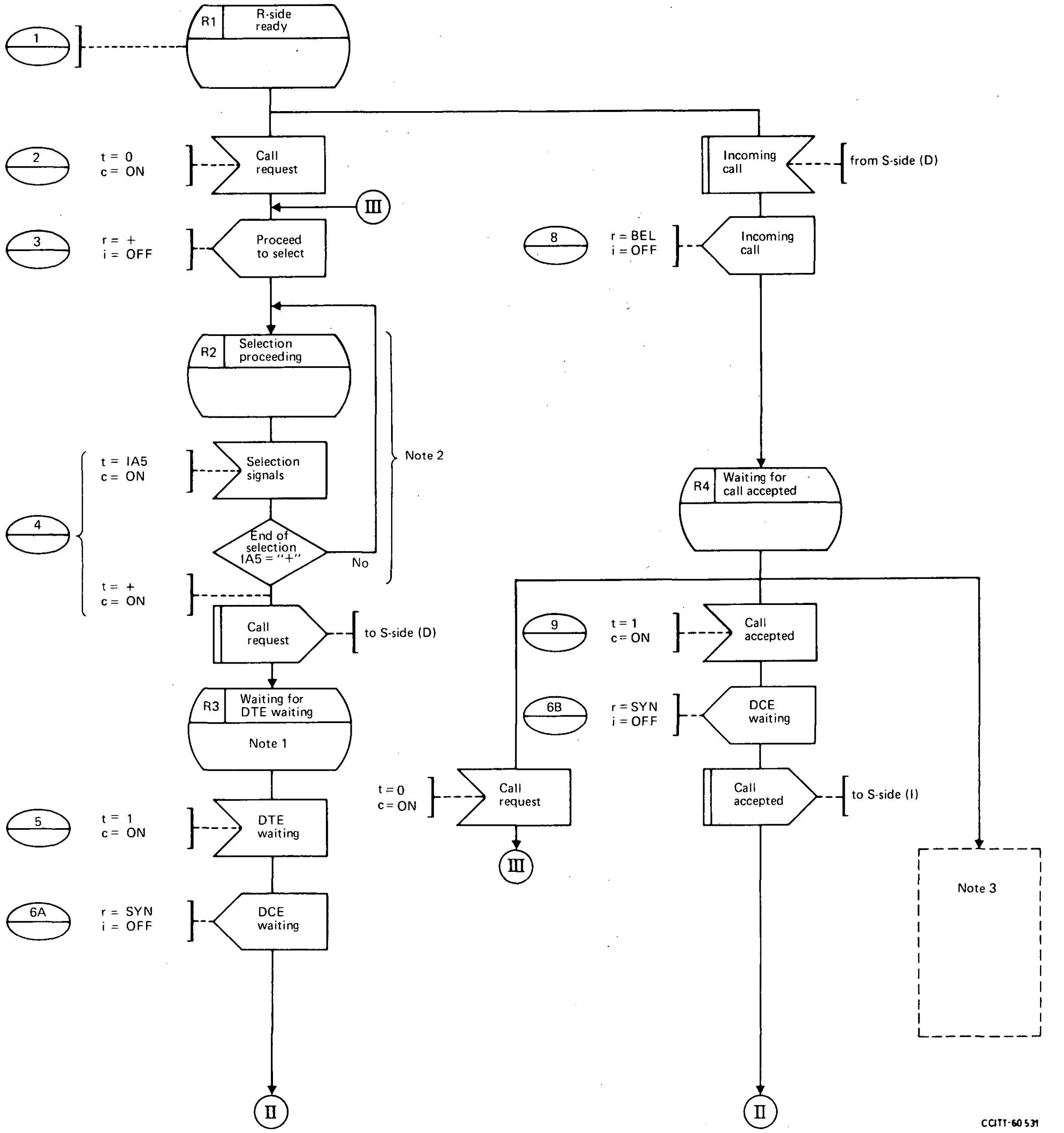
The protocol mapping of the X.21 TA is given in Figures A-2/X.30 to A-6/X.30.



Note – Two-process representation at R-interface side and S-interface side employed in the following figures does not imply two-process implementation.

FIGURE A-1/X.30

Use of symbols in SDL diagrams for X.21 terminal adapter (TA) signalling [1]



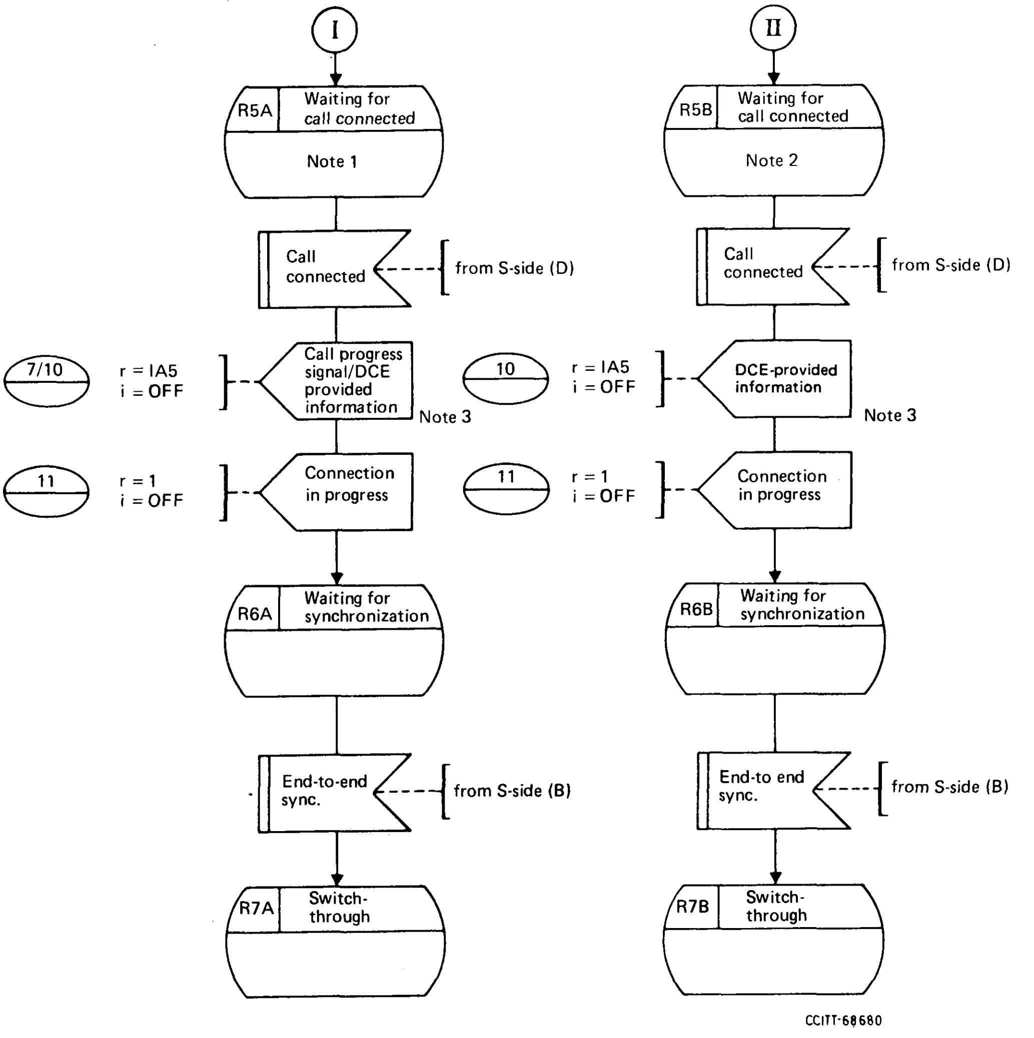
Note 1 – Manual answering terminals are not considered in this figure.

Note 2 – If an internal *incoming call* signal is received while in this state, it should be ignored by the R-side.

Note 3 – X.21 extended address procedure is left for further study.

FIGURE A-2/X.30 (sheet 1 of 2)

R-interface side of the X.21 TA ; call control phase



Note 1 – If an internal *incoming call* signal is received while in this state, it should be ignored by the R-side.

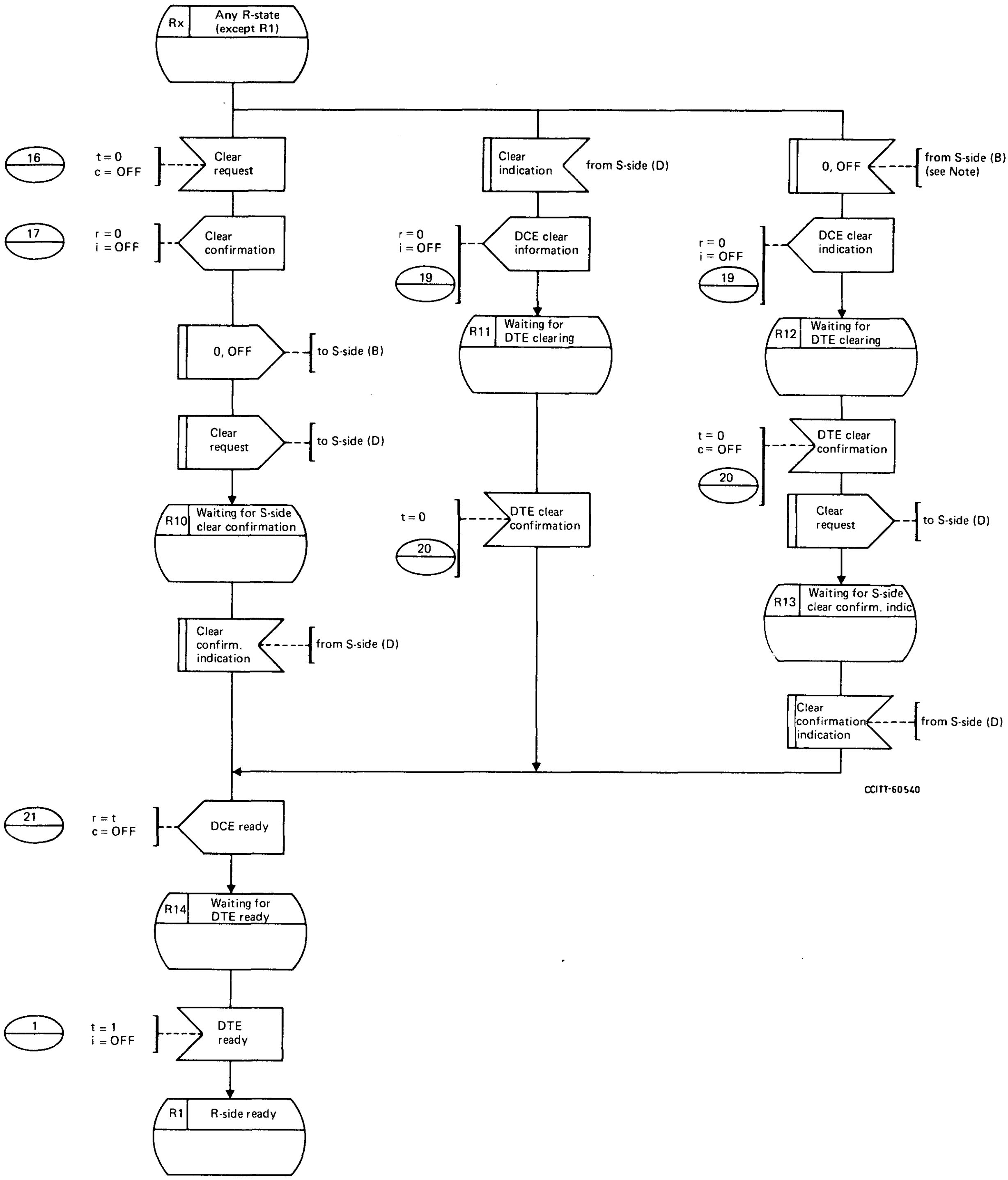
Note 2 – X.21 extended address procedure is left for further study.

Note 3 – DCE waiting states (6A or 6B; see Recommendation X.21, Figure A-2/X.21) may be bypassed.

Note 4 – The X.21 states *controlled* and *uncontrolled not ready* are not shown in these diagrams. However, if an internal incoming call is received from the S-side during these states, the R-side will respond with an internal *clear request* to the S-side with the appropriate reason.

FIGURE A-2/X.30 (sheet 2 of 2)

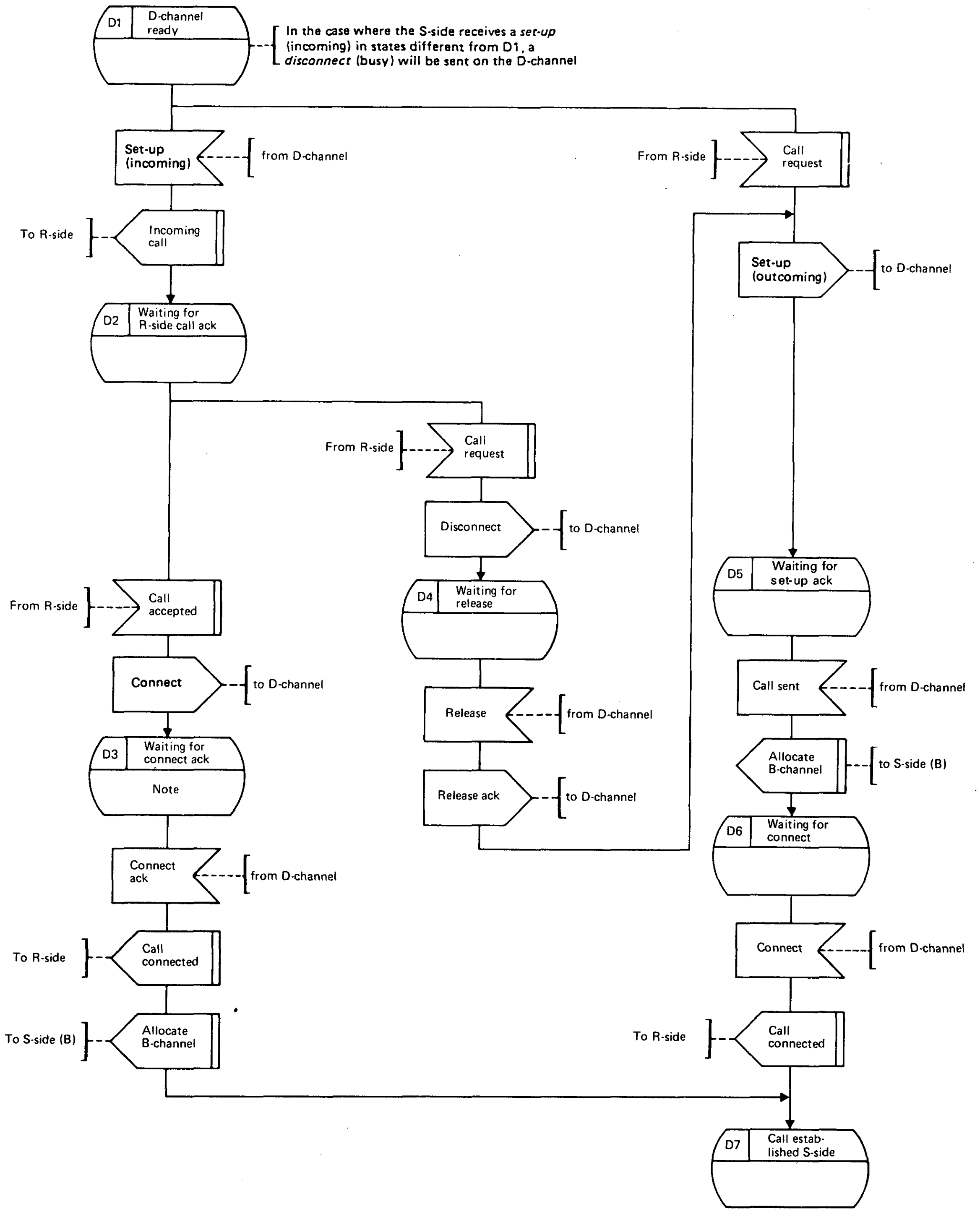
R-interface side of the X.21 TA; call control phase



Note – In the case of 64 kbit/s, the 0, OFF signal is not defined on the B-channel.

FIGURE A-3/X.30

R-interface side of the X.21 TA; clearing phase



Note – In the case of point-to-multipoint configuration, a *disconnect* message is received for such terminals which are not allocated the call.

FIGURE A-4/X.30

S-interface side of the X.21 TA; call control phase of the D-channel handler

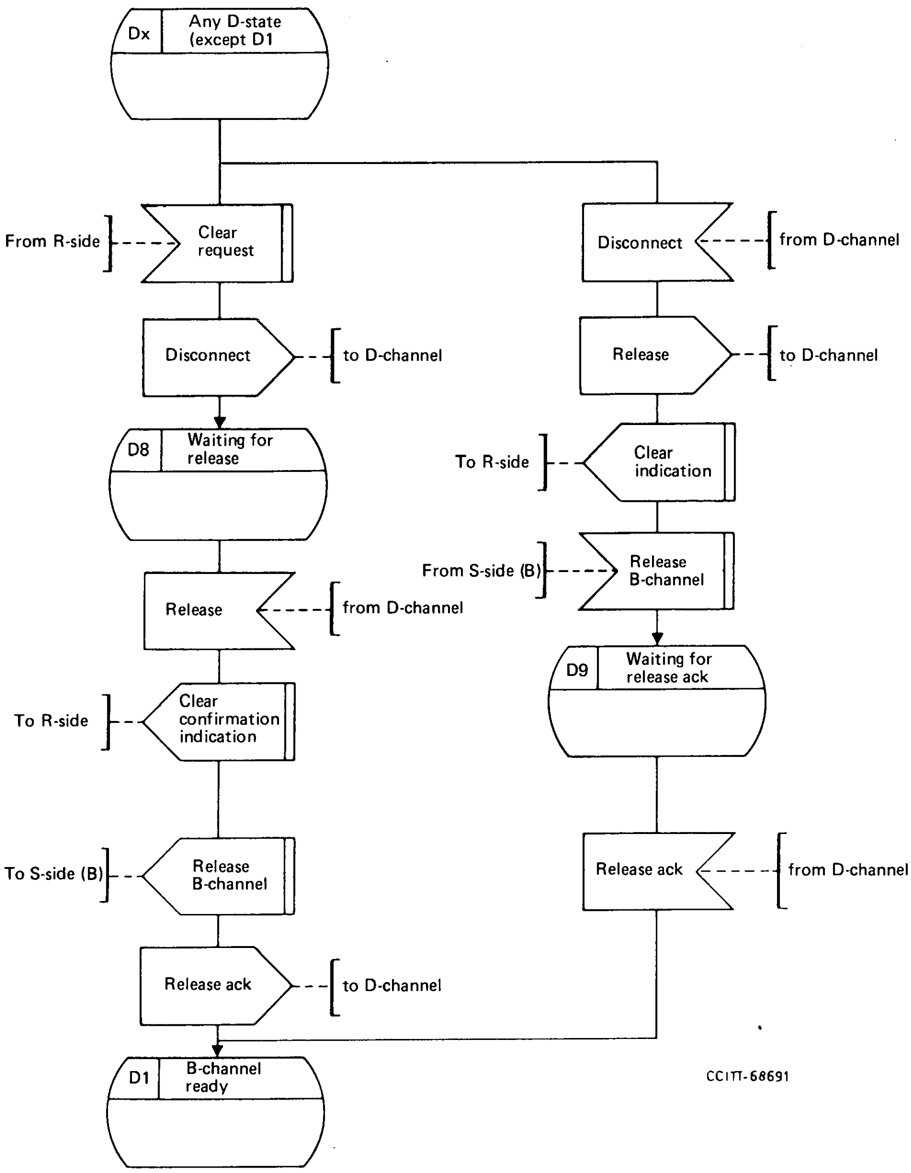
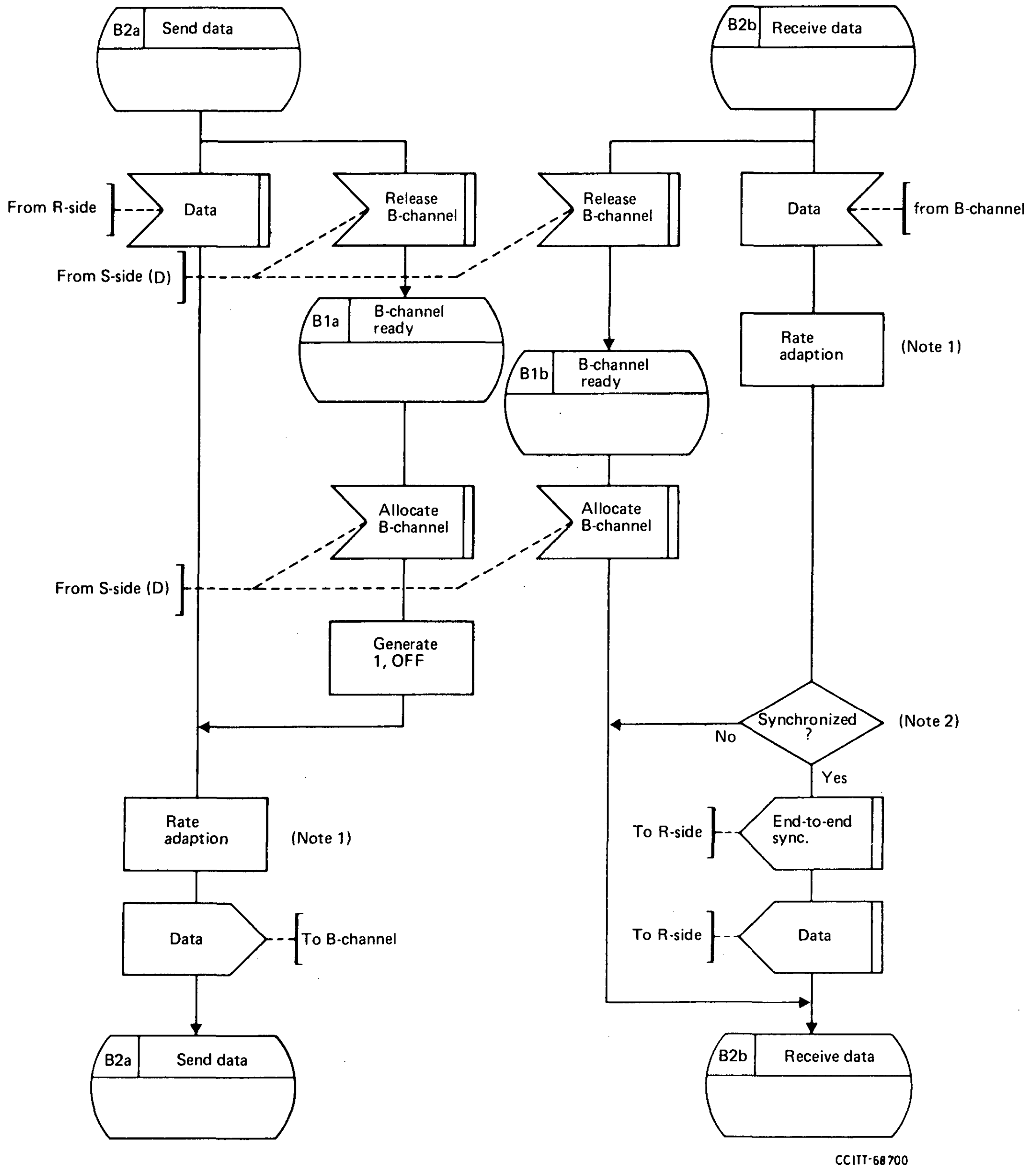


FIGURE A-5/X.30

S-interface side of the X.21 TA; clearing phase of the D-channel handler



Note 1 – Only required for user classes 3 to 7.

Note 2 – See §§ 2.1.4, 2.2.4 and 2.3.4.

FIGURE A-6/X.30

S-interface side of the X.21 TA; B-channel handler

APPENDIX I

(to Recommendation X.30)

Universal terminal adaptor

Some Administrations may provide universal TAs for all user rates from 600 bit/s to 64 kbit/s. In this case the called TA will adapt to the data user rate of the calling TA.

I.1 *User rate identification*

I.1.1 Search for the bit pattern ... 10111011 ... in bit 1 of successive octets which are received from the 64 kbit/s stream.

If the search is positive, then the user rate is 48 kbit/s.

I.1.2 *Identification of intermediate rate*

See Appendix II, § II.1.

I.1.3 *User rate identification at rates less than 48 kbit/s*

See Appendix II, § II.3.

I.1.4 The procedures for detection of a 64 kbit/s unstructured path by a universal TA requires further study. However, it is recognised that in the case of a TA supporting only 64 kbit/s, such a procedure is not needed.

Note 1 – Operations I.1.1, I.1.2 and I.1.3 may be performed in parallel.

Note 2 – The procedure to be undertaken if user rate detections is not successful requires further study.

I.2 Search for frame alignment at user rates less than 48 kbit/s, after restitution of the intermediate rate, using the following strategy:

Look for the following 17 bit alignment pattern:

00000000	1XXXXXXX	1XXXXXXX	1XXXXXXX	1XXXXXXX
1XXXXXXX	1XXXXXXX	1XXXXXXX	1XXXXXXX	1XXXXXXX

No errors will be tolerated in the defined bit position shown above. (*Note* – "X" indicates that the condition of this bit position has no significance for the purpose of alignment.)

It is assumed that the error rate will be sufficiently low to expect alignment following the detection of one 80 bit multiframe.

In the case of X.1 user class of service 3 (600 bit/s) a further search for the multiframe synchronization pattern contained in bit position E7 shall be performed.

I.3 *Loss of alignment/recovery*

Loss of alignment will be assumed following the detection of *N* (provisional value: 3) consecutive frames, each with at least one alignment bit error.

The monitoring of the alignment signal shall be a continuous process using the same procedure as for initial alignment detection.

Following loss of the alignment, the TA shall enter a recovery state.

If the recovery of alignment is not achieved within a fixed period, the TA shall indicate *DCE not ready* by signalling r = 0, i = OFF. The duration of this period is network dependent (as in Recommendation X.21, § 2.6.2).

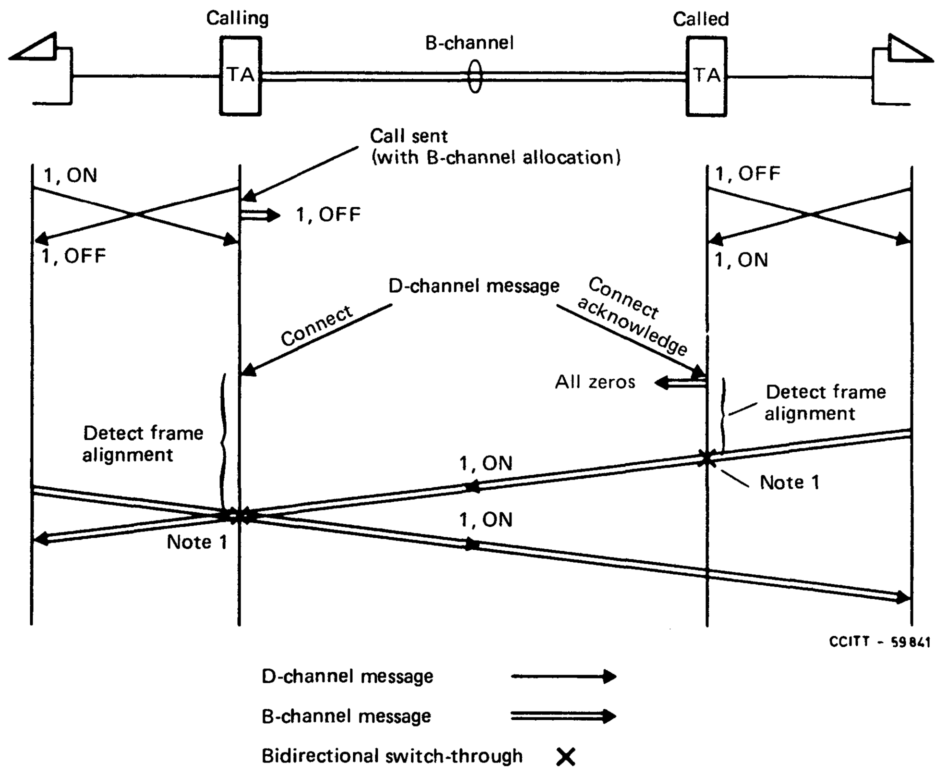
If recovery is not successful further maintenance procedures might be used.

Note 1 – The implication of a user rate changing during a call requires further study, particularly since it is not currently accommodated by Recommendation X.21.

Note 2 – It is recognized that procedures for universal TA operation cannot be implemented without a change to Recommendation X.21.

I.4 *Ready for data alignment*

The called TA transmits *all zeros* until it has identified the user rate of the calling DTE (see Figure I-1/X.30). Thus a handshaking procedure is performed where the calling TA will be the last to switch through. After switching through of the calling TA, both X.21 terminals enter the *ready for data* state.



Note 1 – The TA shall perform connect-through after detecting frame alignment and completing delivery to the terminal of any DCE-provided information.

Note 2 – Only those conditions necessary to effect *ready for data* alignment are shown.

FIGURE I-1/X.30

Universal TA operation to effect ready for data alignment at rates < 64 kbit/s

APPENDIX II

(to Recommendation X.30)

Inslot identification of intermediate bit rate

II.1 *Identification of intermediate rate*

The intermediate rate (16 or 8 kbit/s) is identified by inspecting the bit sequence of position 1 and the bit sequence of position 2 of the 64 kbit/s octets.

If the bit sequence of position 1 contains strings of 8 to 15 continuous 0-bits and the bit sequence of position 2 contains no 0-bits, the intermediate bit rate is 8 kbit/s.

If the bit sequences of positions 1 and 2 both contain strings of continuous 0-bits with lengths of 4 or more bits, the intermediate bit rate is 16 kbit/s.

Irrelevant of the intermediate bit rate, positions 3 to 8 of the 64 kbit/s octets must contain only 1-bits.

II.2 *Restitution of the intermediate rate*

The 16 kbit/s intermediate rate can be restituted by mapping the bits of positions 1 and 2 of each 64 kbit/s octet onto two subsequent bits of the 16 kbit/s intermediate rate.

The 8 kbit/s intermediate rate can be restituted by mapping the first bit of each 64 kbit/s octet onto one bit of the 8 kbit/s rate.

II.3 *User rate identification*

For an intermediate bit rate of 16 kbit/s the user rate is 9.6 kbit/s.

For an intermediate rate of 8 kbit/s the user rate is identified by the coding of the E-bit pattern (see § 2.1.1.2.4).

Reference

[1] CCITT Recommendations Z.101-Z.104 *Functional specification and description language (SDL).*

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;

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

(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.

CONTENTS

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.

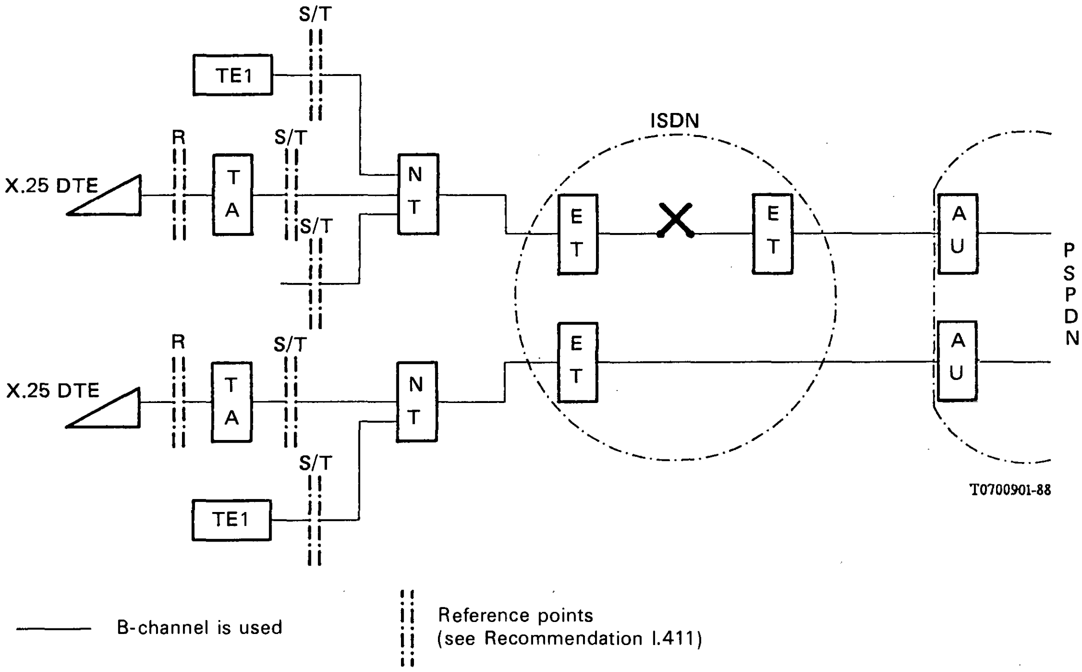
Note – Multiplexing at layer 2 within a B-channel is for further study.

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.



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

Note 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.

Note 2 – See Recommendation X.325 for interworking guidelines.

FIGURE 2-1/X.31

Configuration when accessing PSPDN services

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.

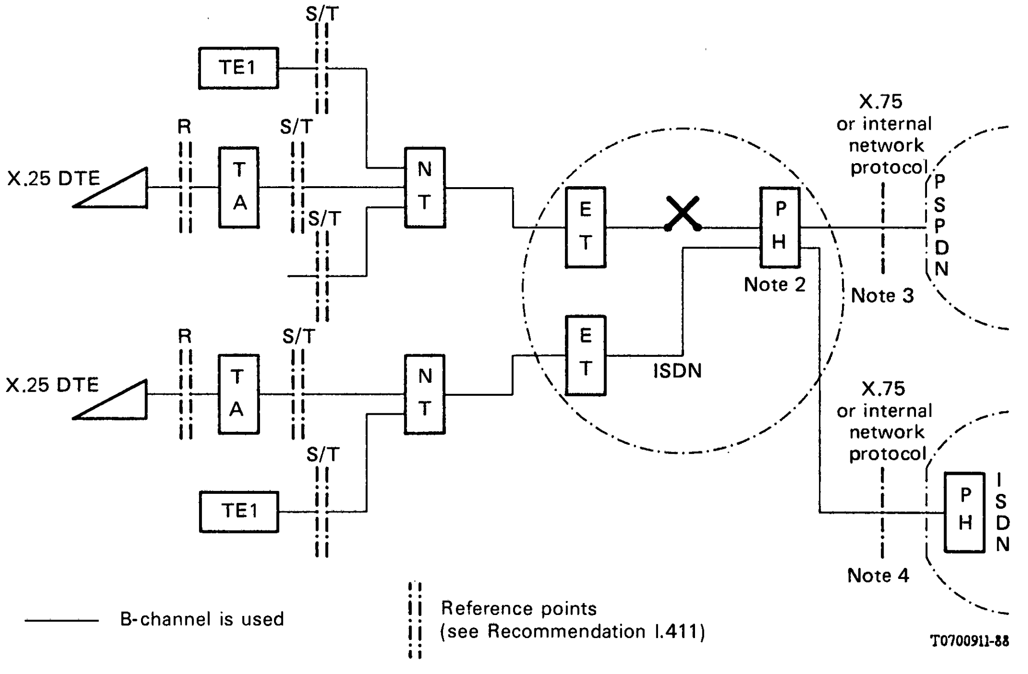
When needed, DTE identification may be provided to the PSPDN by using the call establishment signalling protocols in Recommendation Q.931. Furthermore, DCE identification may be provided to the DTE, when needed, by using the same protocols.

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.



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

Note 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.

Note 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.

Note 3 – See Recommendation X.325.

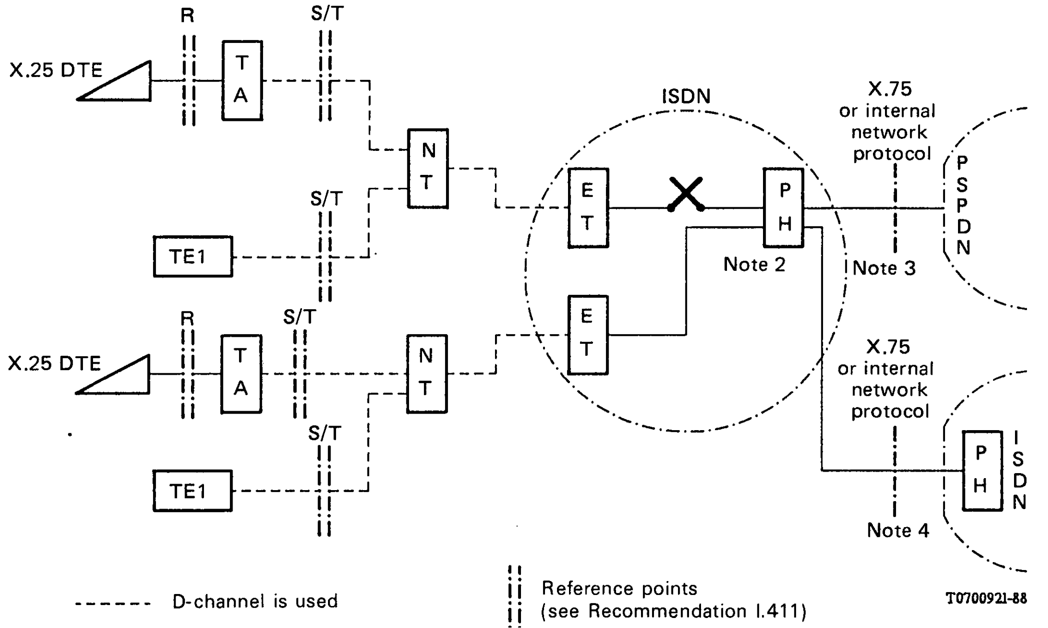
Note 4 – See Recommendation X.320.

FIGURE 2-2/X.31

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

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.



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

Note 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.

Note 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.

Note 3 – See Recommendation X.325.

Note 4 – See Recommendation X.320.

FIGURE 2-3/X.31

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

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 network to user direction			Allowable user response user-network
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 network to user direction			Allowable user response user-network
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

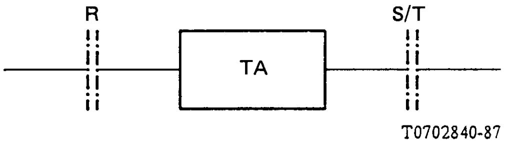
	X.25 cause in clear indication packet				Q.931 error condition		
Item	X.25/X.96 cause	Code	Diagnostic	Code	Q.931 cause	Code	Diagnostic
1	DTE originated	0	No additional information	0	Normal call clearing	16	(None)
		1XX	DTE specified	XX			
2	Network congestion	5	No additional information	0	Switching equipment 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).



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

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.

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).

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	Rec. X.25, § 1.1
		X.21 *bis*	DTE sets circuit 108 = ON	Rec. X.25, § 1.2
		V-Series interfaces	DTE sets circuit 108 = ON	Rec. X.25, § 1.3
	X.21 circuit-switched		DTE signals direct call	Rec. X.21, § 4.4
	X.21 *bis* direct call		DTE signals direct call	Rec. X.21 *bis*, § 2.3.1
	V.25 *bis* direct call		DTE uses direct call mode (Note)	Rec. V.25 *bis*, § 5
Full circuit-switched access	X.21 addressed call		DTE enters call control phase	Rec. X.21, § 4
	X.21 *bis* addressed call		DTE performs automatic address call	Rec. X.21 *bis*, § 2.3.2 iii)
	V.25 *bis* addressed call		DTE uses address call mode	Rec. V.25 *bis*, § 4

Note – The difference between the V.25 *bis* direct call mode and operation according to § 1.3 (V-Series interfaces) is for further study.

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 § 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 the 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 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 address information is therefore required by the TA. When the DTE presents the call request, the TA attempts to establih a B-channel. When the B-channel is completely set-up, the TA signals ready for data at the R reference point.

7.3.3.2 *Incoming call*

7.3.3.2.1 Q.931 *Call offering*

The 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 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 I).

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 poin,
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 these conditions occur, 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 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.

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 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/X.31 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.

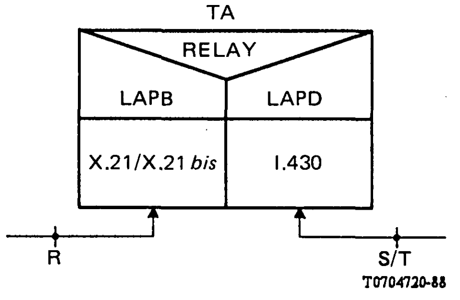


FIGURE 7-2/X.31

Architecture of the mapping function

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.

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:

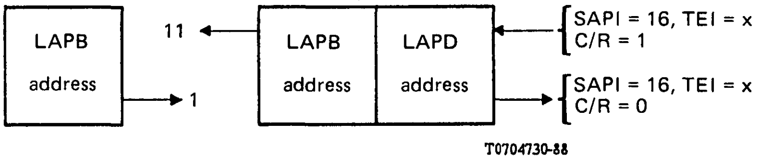
- Address field mapping
- Control field mapping
- Frame check sequence recalculation

These functions are subject to the following sections.

7.4.2.1.1 *Information frame address field mapping*

The LAPB address length is 1 octet.

The LAPD address length is 2 octets.



where x = TEI value assigned to the TA

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 *call request* packet

Note – Alternatively, initiation of a 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 *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 § 7.4.3.1.1. The establishment of the D-channel link is in accordance with the procedures described in § 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 *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 level 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 an 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* interface; the TA has to respond with an ON to OFF transition on circuit 107.

7.5 *Access through the B and D channel*

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 *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 resquest 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 *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 sections (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 Recommendation of the I.600 Series 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/X.31 shows the location of test loops within the TA.

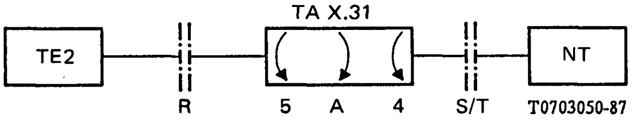


FIGURE 7-4/X.31

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 Recommendation I.430 and the I.600 Series.

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 1 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 = 0/1 . . ., 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.*

Note 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.

Note 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/X21 *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 layers 2 and 3 of X.25

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 only on layers 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 of this Recommendation.

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.1 *Call control*

In this appendix, the following call phases are specified:

– idle phase,

– establishment phase,

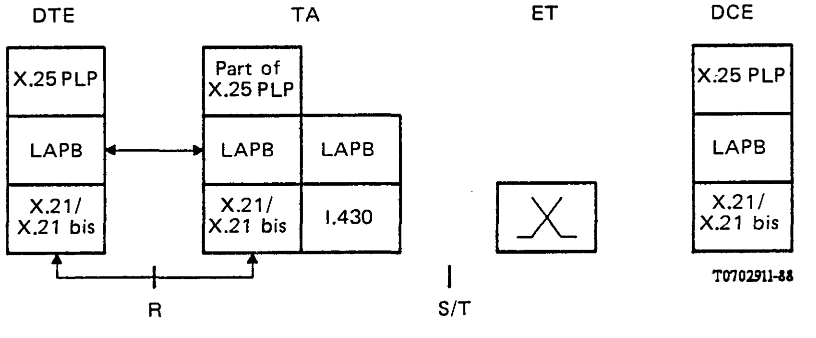
– data transfer phase,

– 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 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.



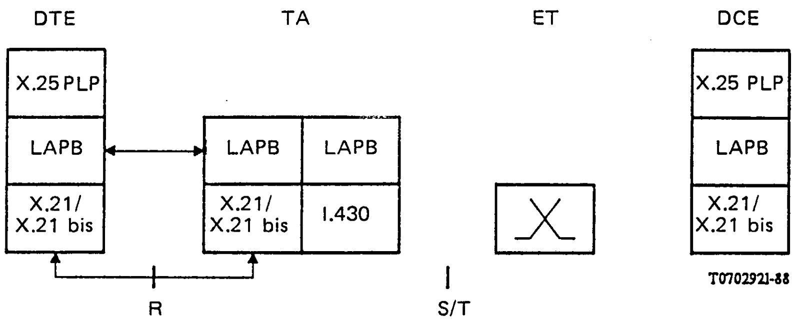
Note – Events and protocols on the D-channel are not shown in this Figure.

FIGURE I-1/X.31

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

In the idle phase, the TA acts on the R-reference point as X.25 DCE (Figure I-1/X.31). All X.25 layer 2 procedures are supported. Some layer 3 procedures, for instance the restart procedures, may be supported too.

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/X.31).



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.2.1.1 *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.

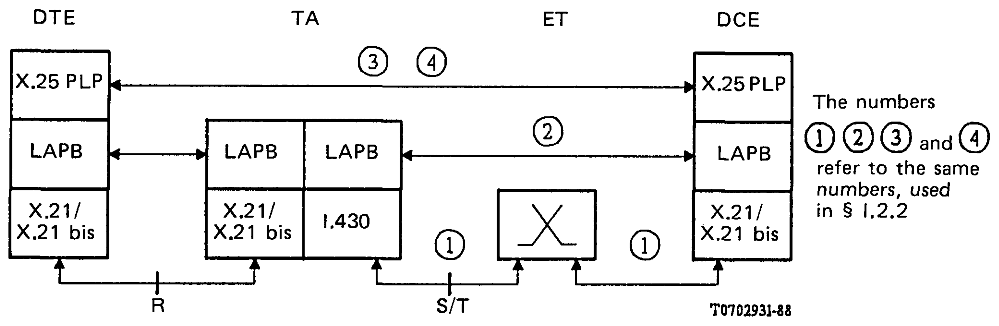
I.2.2 *Establishment phase*

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 layer 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 I-3/X.31). Only layer 3 dedicated procedures apply.

Figure I-4/X.31 gives an example of the message sequence for the establishment phase.



Note – Events and protocols on the D-channel are not shown in this Figure.

FIGURE I-3/X.31

Active layers in the establishment phase

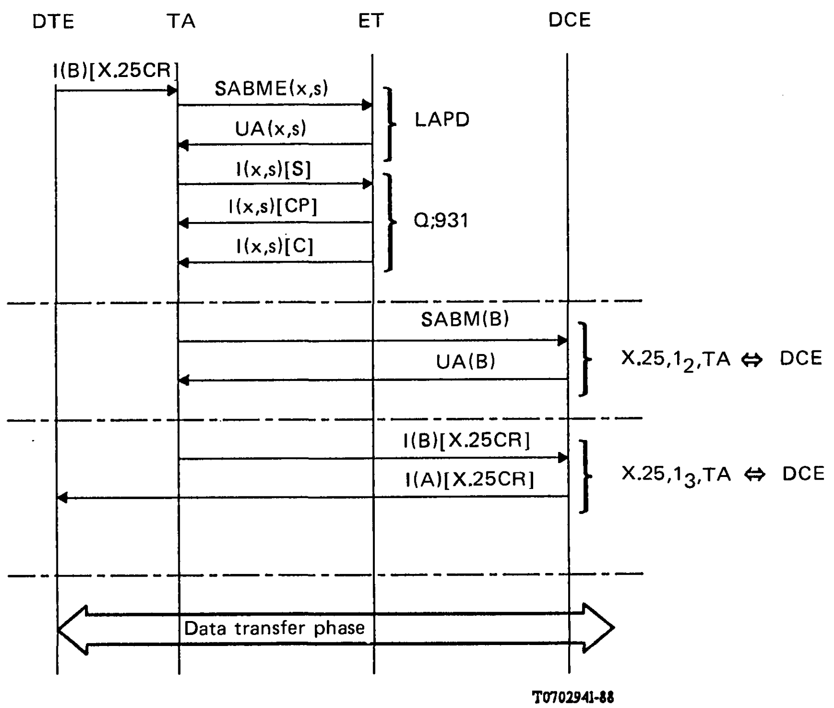


FIGURE I-4/X.31

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

I.2.2.1 *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 may be reset by means of a restart procedure. The buffered *call request* packet is sent to the DCE in the PH/AU. At the acknowledgement of the correct reception of the *call request* packet, the TA changes to the data transfer phase following the procedures of § I.2.2.3 of this appendix.

I.2.2.2 *Incoming call*

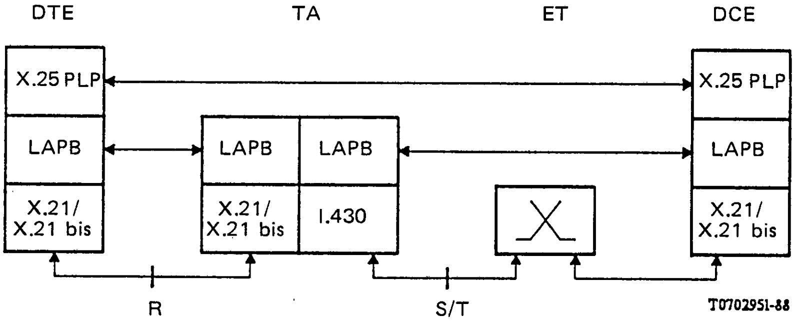
At the reception of an incoming call, the procedures of § 6.2 of this Recommendation apply for the allocation of a B-channel. After allocation of a B-channel, a link is established between the DCE in the PH/AU and the TA according to the layer 2 procedures of Recommendation X.25. Layer 3 of the X.25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

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/X.31).



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,

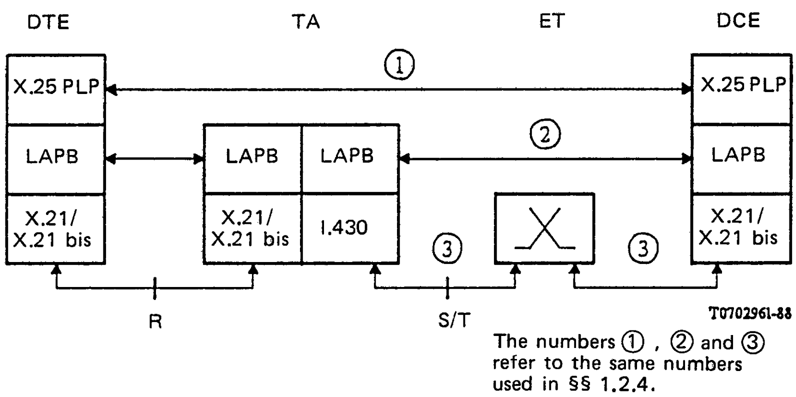
– the user (manually).

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/X.31.

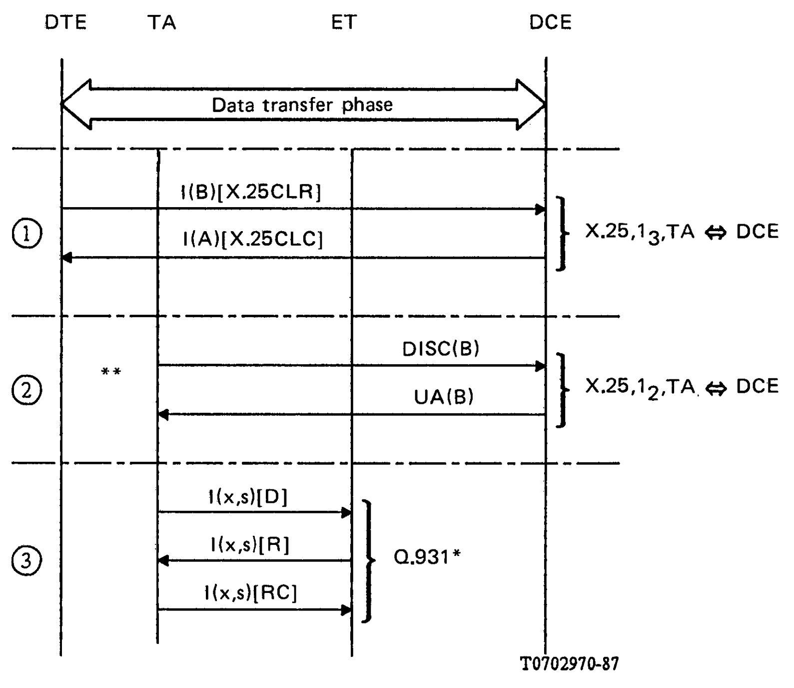


Note – Events and protocols on the D-channel are not shown in this Figure.

FIGURE I-6/X.31

Active layers in the clearing phase

Figure I-7/X.31 gives an example of the message sequence for the clearing phase.



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

** 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

I.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 of this Recommendation 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 of this Recommendation 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

When two packet mode TE2s are interconnected by an ISDN circuit-mode connection, they will make use of TAs as shown in Figure II-1/X.31.

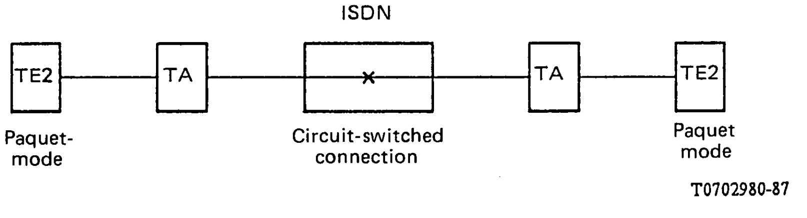


FIGURE II-1/X.31

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

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/X.31 to III-7/X.31. 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*).

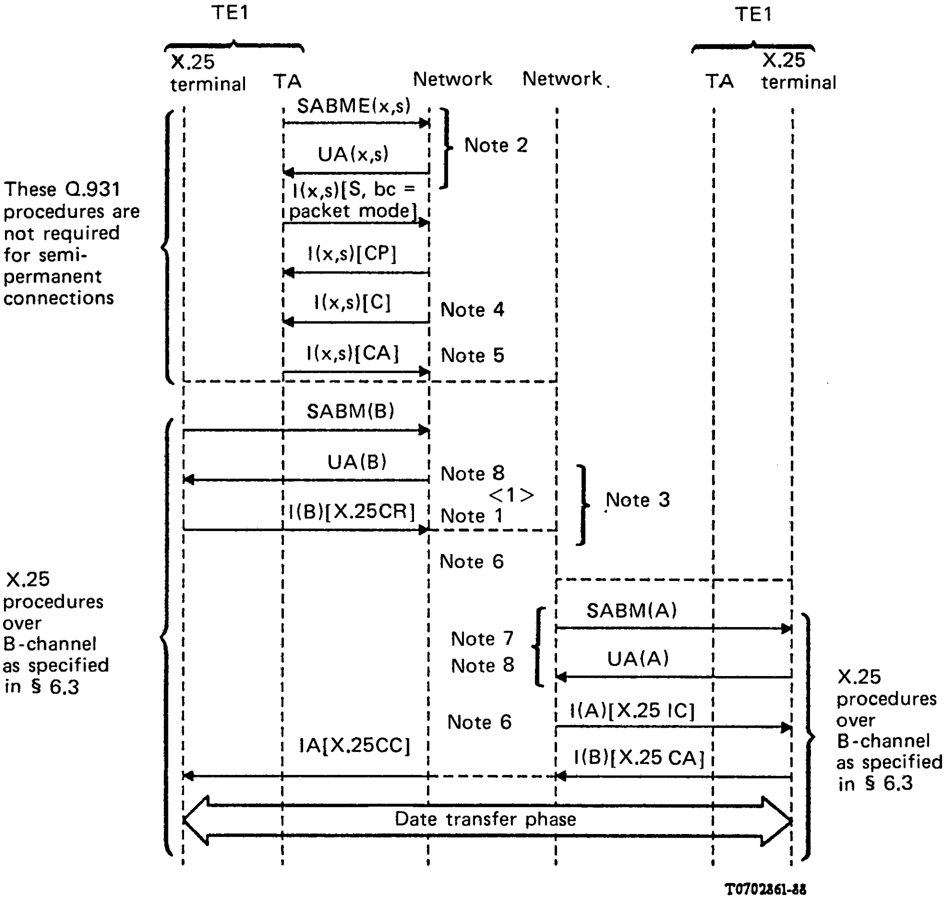
CA	–	*call accepted*
CC	–	*call connected*
CLC	–	*clear confirmation*
CLI	–	*clear indication*
CLR	–	*clear request*
CR	–	*call request*
IC	–	*incoming call*

Layer 2 frames

( )	–	*Layer 2*
GTEI	–	*Group TEI (127)*
A. B	–	*X.25 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*



Note 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/X.31.

Note 2 – If signalling link is not already established.

Note 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/X.31 and III-6/X.31.

Note 4 – The network starts timer T320, if implemented.

Note 5 – This message is optional.

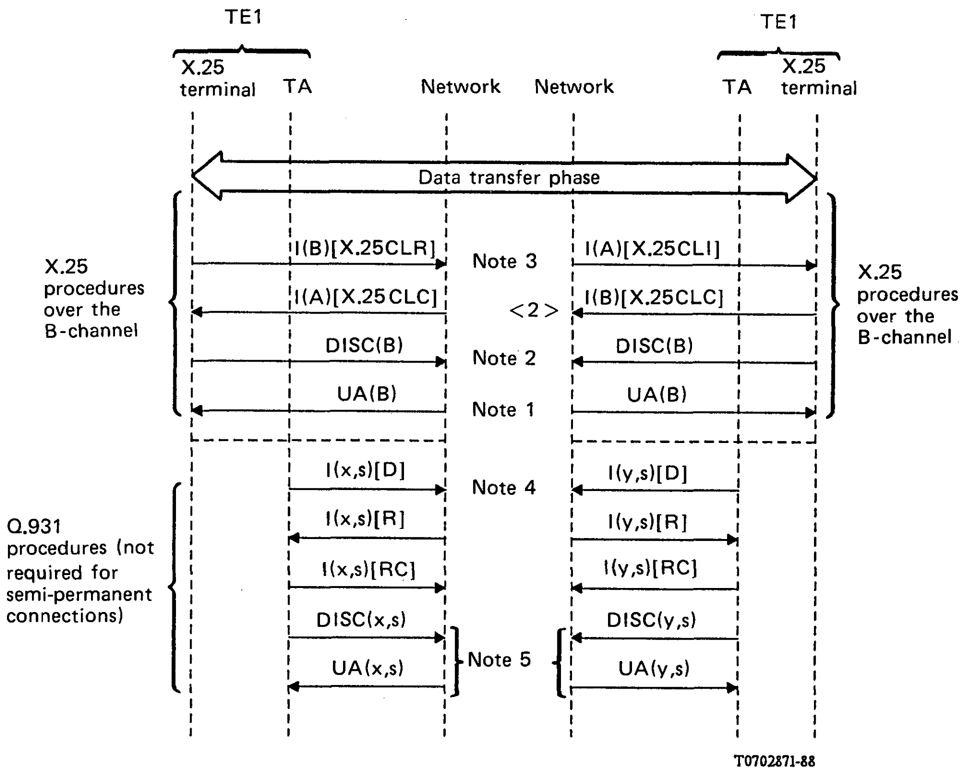
Note 6 – The network cancels timer T320, if implemented and running.

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

Note 8 – Not shown in the diagram is a possible X.25 restart procedure performed after link set up.

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



Note 1 – When the cleared side has set up the call using D-channel access, the message sequence at the cleared side will be as from point <4> in Figure III-4/X.31.

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

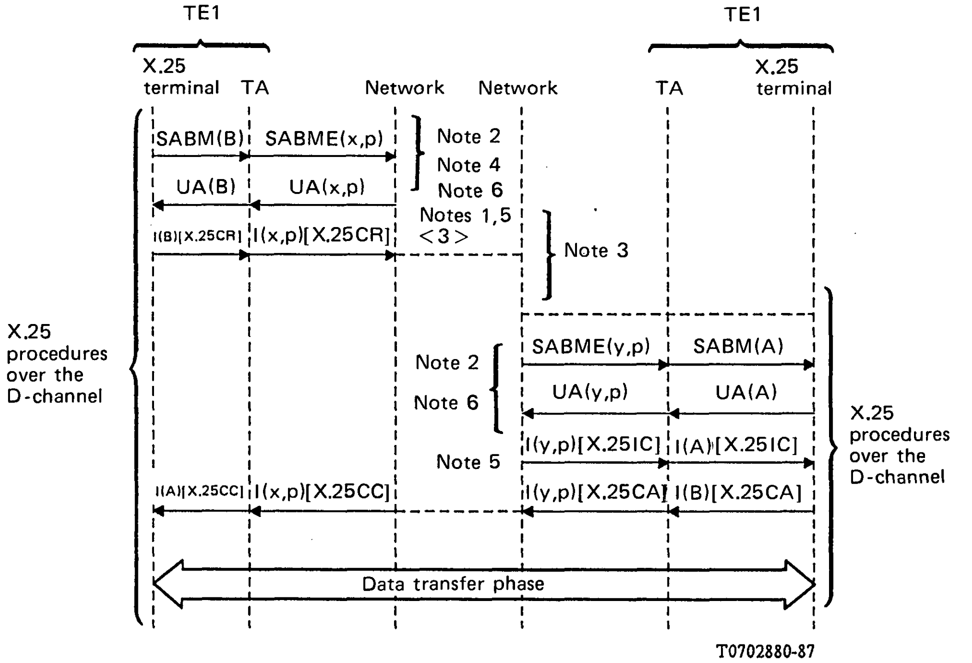
Note 3 – The network starts timer T320, if implemented.

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

Note 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



Note 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/X.31.

Note 2 – If SAPI = 16 link is not already established.

Note 3 – The incoming call may be offered to the TA using the procedures shown in Figure III-7/X.31.

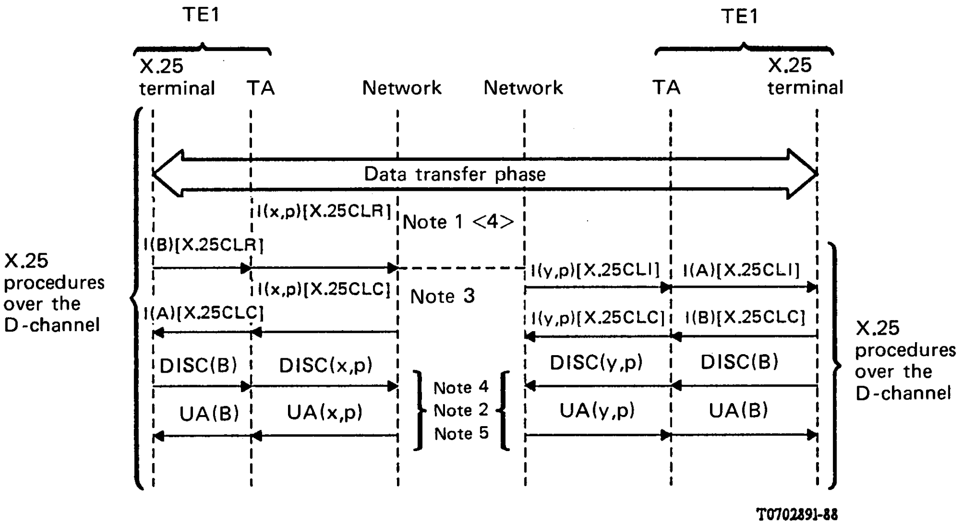
Note 4 – The network starts timer T320, if implemented.

Note 5 – The network stops timer T320, if implemented and running.

Note 6 – Not shown in the diagram is a possible X.25 restart procedure performed after link set up.

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



Note 1 – When the cleared side has set up the call using B-channel access, the message sequence at the cleared side will be as from point <2> in Figure III-2/X.31.

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

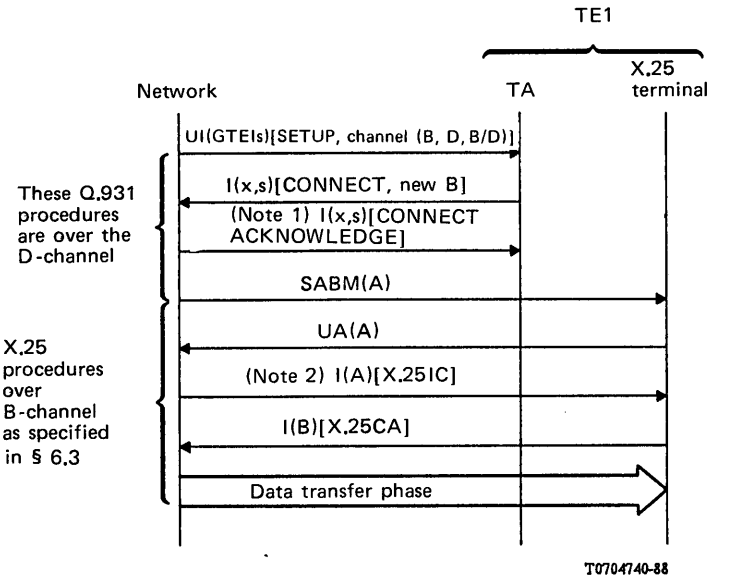
Note 3 – The network starts timer T320, if implemented.

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

Note 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

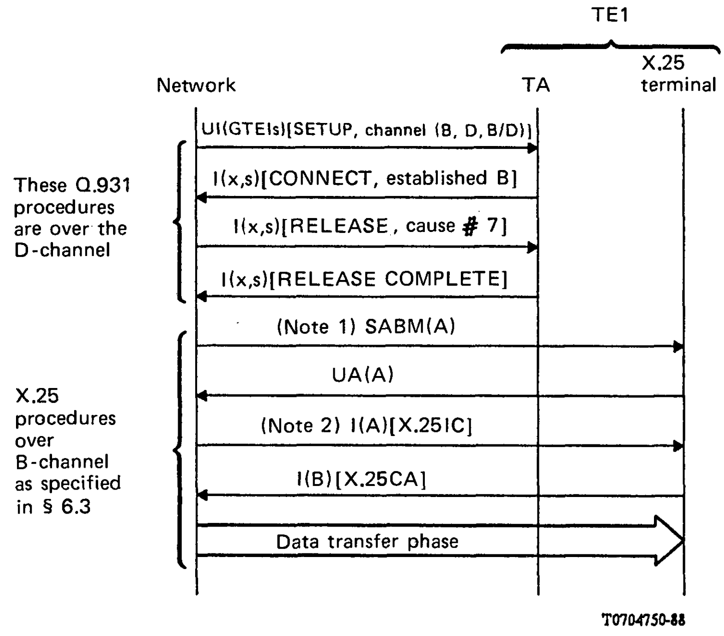


Note 1 – The network starts timer T320, if implemented.

Note 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

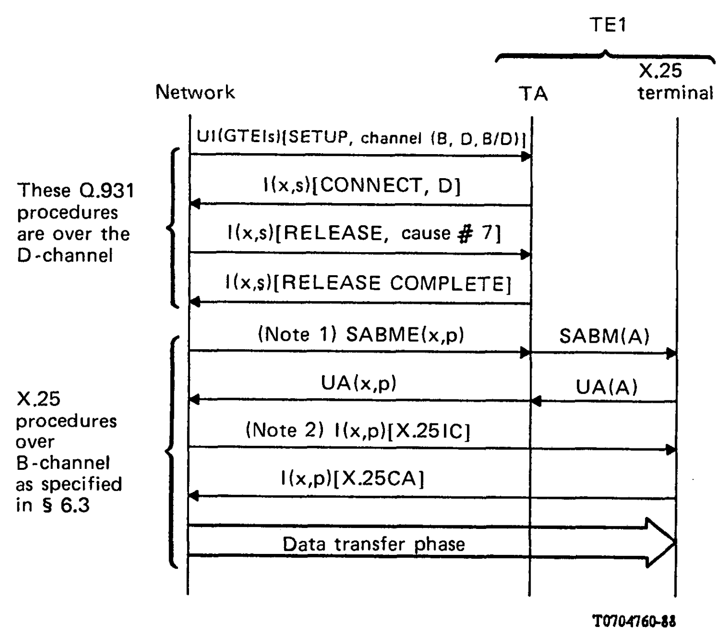


Note 1 — The network establishes the link layer in the B-channel if it is not already established. See § 6.3.

Note 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



Note 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.

Note 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/X.31 through III-16/X.31 show example conditions when cause mappings would be utilized between Q.931 and X.26 messages and utilize the specific mappings of Table 6-5/X.31 and Table 6-6/X.31 as shown below:

Figure	*Reference Table*	*Note*
***** Q.931 failures during call establishment *****		
III-8	Table 6-5/X.31	
III-9	Table 6-5/X.31	
III-10	Table 6-5/X.31	
III-11	Table 6-5/X.31	
III-12	Table 6-5/X.31	
***** User side failures during X.25 data transfer phase *****		
III-13	Table 6-5/X.31	1
III-14	Table 6-5/X.31	2
***** Network side premature clearing *****		
III-15	Table 6-6/X.31	
III-16	Table 6-6/X.31	

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

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

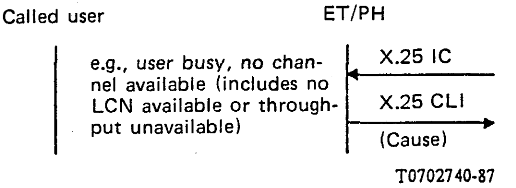
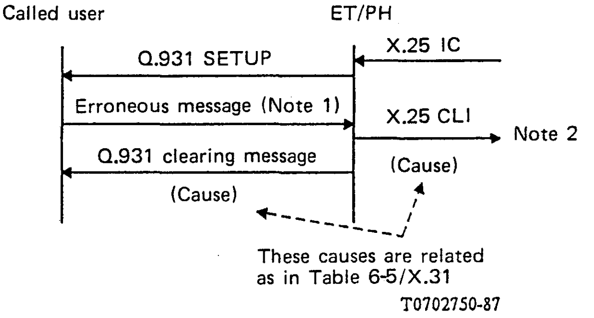


FIGURE III-8/X.31

Undeliverable call

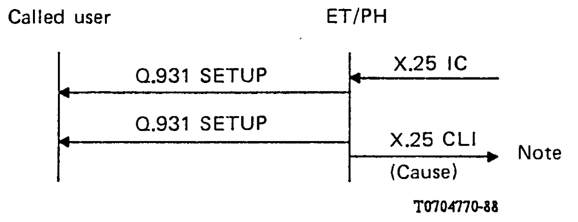


Note 1 – This figure only applies to the case where the erroneous message results in a Q.931 clearing message. See § 6.4.3 for more information.

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

FIGURE III-9/X.31

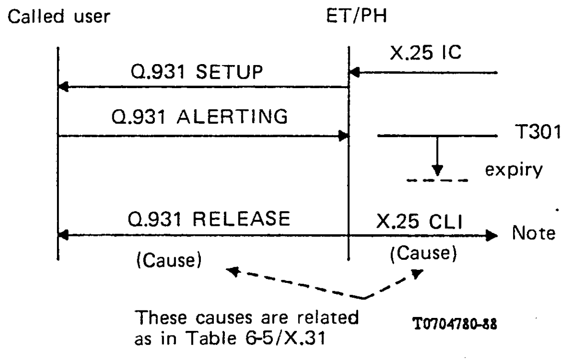
Erroneous message (e.g., format error)



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

FIGURE III-10/X.31

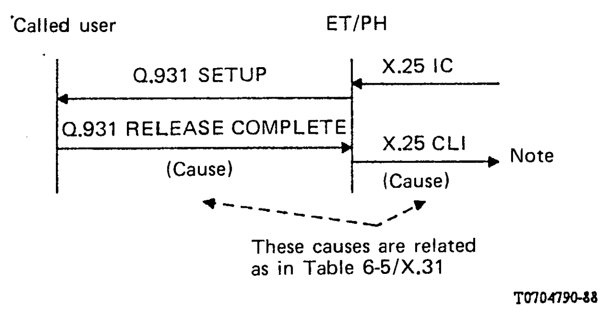
No responding user



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

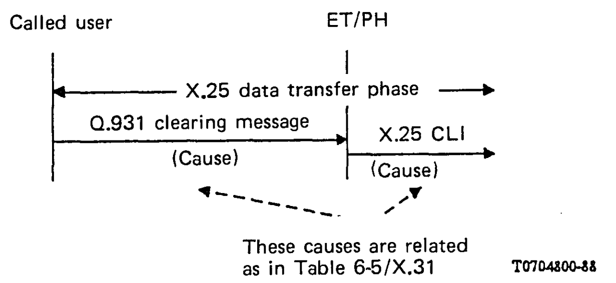
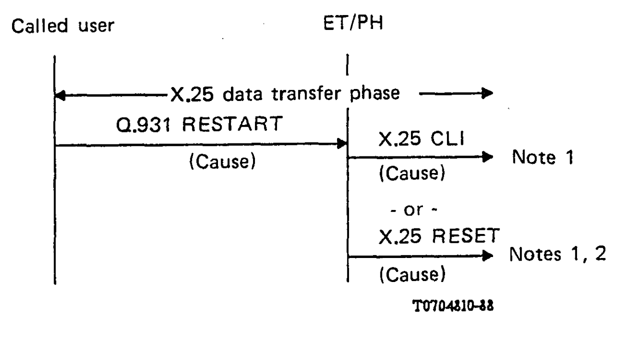


FIGURE III-13/X.31

Q.931 clearing during X.25 data transfer phase



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

Note 2 – For permanent virtual circuits only.

FIGURE III-14/X.31

Q.931 RESTART during X.25 date transfer phase

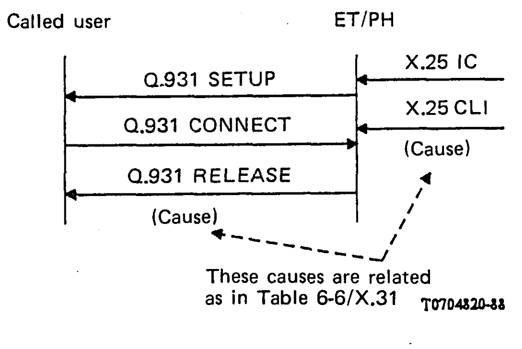
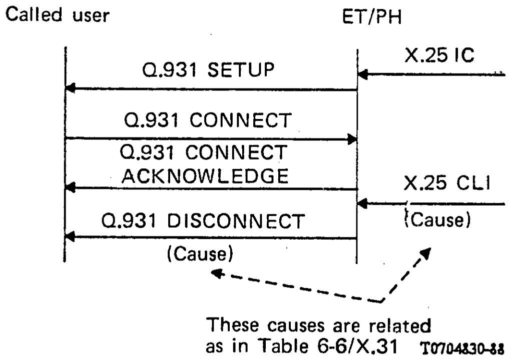


FIGURE III-15/X.31

Premature clearing of the virtual circuit
(e.g., expiry of X.25 timer T21)



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 circuit

APPENDIX IV

(to Recommendation X.31)

D-channel TAs requiring full protocol terminal in the TA

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 of this Recommendation.

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/X.31). All X.25 layer 2 procedures are supported by the TA. Some layer 3 procedures, for instance the restart procedures, may be supported too.

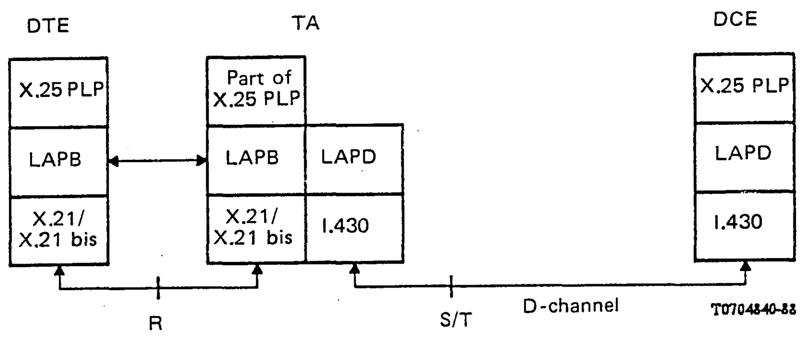


FIGURE IV-1/X.31

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/X.31 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.

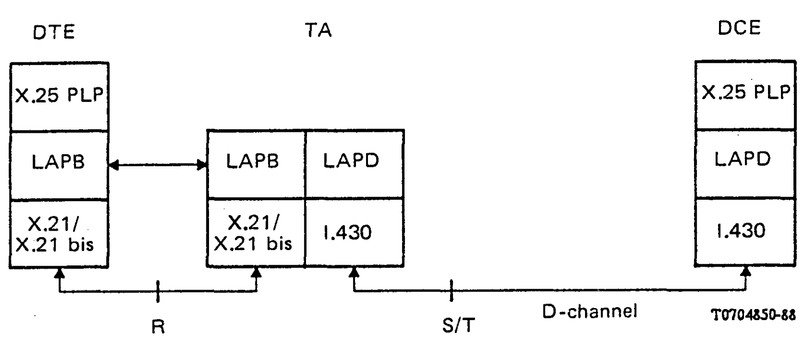


FIGURE IV-2/X.31

Example configuration in the idle phase, transparent at layer 3

IV.2.1.1 *Transferring to the establishment phase*

The TA transmits to the establishment phase at:

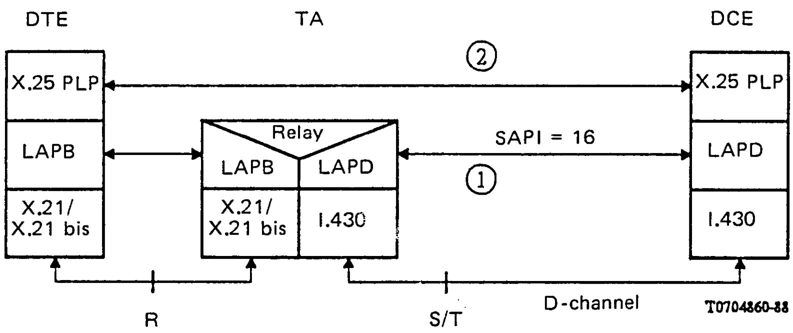
– the detection of an outgoing call. Outgoing calls are detected by the receipt of an X.25 *call request* packet or via the human/machine interface of the TA, or by the receipt of an I frame (see § IV.2.2.1).

– 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:

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 section.

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 may be reset 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/X.31 gives an example of the message sequence for establishment phase.

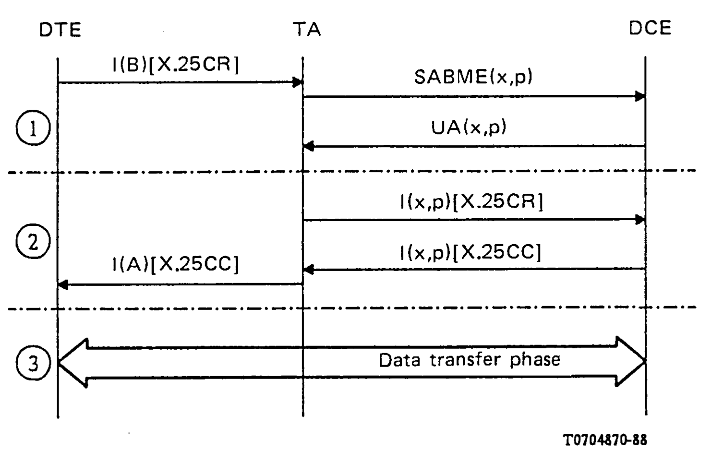


FIGURE IV-4/X.31

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

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 may be reset by means of the restart procedure.

The TA then proceeds to the data transfer phase.

IV.2.2.2 *Incoming call*

At the reception of an incoming call, the procedures of § 6.2.2 of this Recommendation 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/X.31). The mapping is described in § 7.4.2 of this Recommendation.

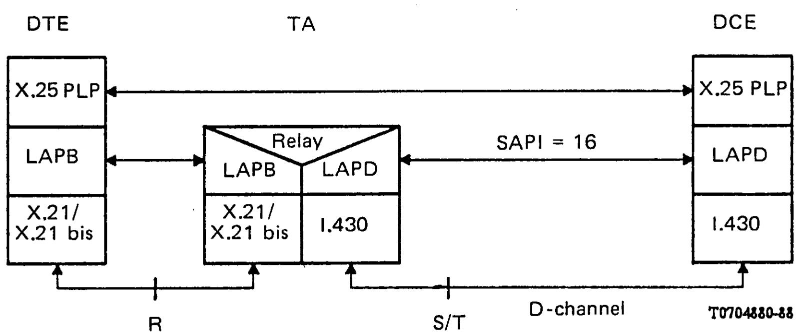


FIGURE IV-5/X.31

Example configuration in 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 any more. This detection will be done by the PH (see § IV.2.4).

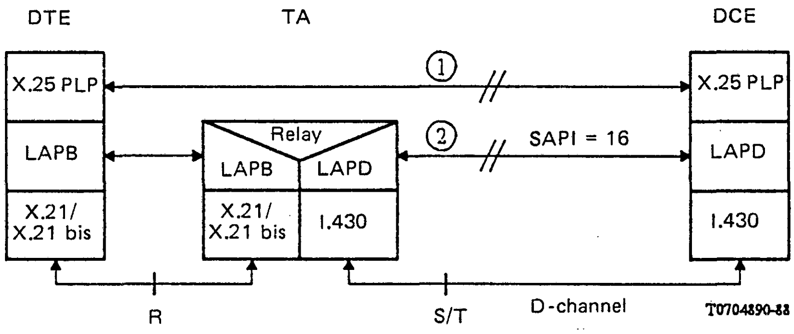
Note 1 – Alternatively, this detection is done by the user, e.g., notification via a push button on the TA.

Note 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/X.31):

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 section.

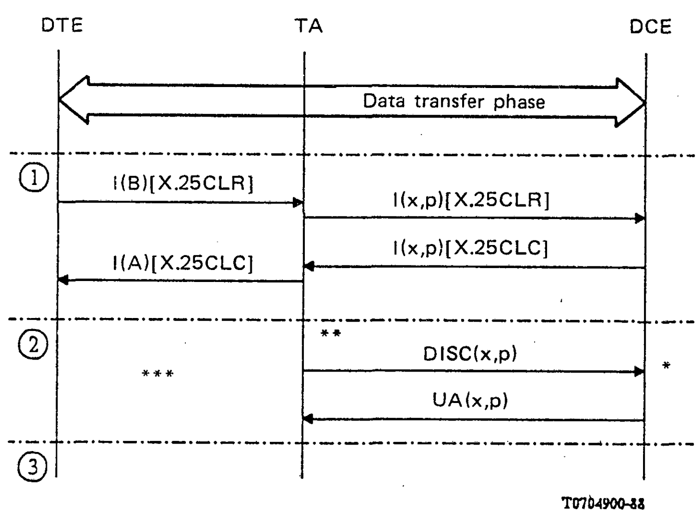
FIGURE IV-6/X.31

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/X.31 gives an example of the message sequence for the clearing phase.



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

** Manual notification by the user is supposed.

*** 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)

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.

APPENDIX V

(to Recommendation X.31)

References

X.1	International user classes of service in 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 network
X.10	Categories of access for data terminal equipment (DTE) to public data transmission services
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 an isochronous 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 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 V.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

Recommendation 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

(Malaga-Torremolinos, 1984, amended at Melbourne, 1988)

Preface

The establishment in various countries of packet switched public data networks (PSPDN) providing data services creates the need to produce Recommendations to facilitate access to the PSPDN through a public switched telephone network (PSTN) or an integrated services digital network (ISDN) or a circuit switched public data network (CSPDN).

The CCITT,

considering:

(a) that Recommendation X.1 specifies the user classes of service for DTEs operating in the packet mode, that Recommendation X.2 defines user facilities provided by public data networks, that Recommendation X.10 defines categories of access, that Recommendations X.21 and X.21 *bis* define DTE/DCE physical level interface characteristics, that Recommendation X.25 defines the interface between the DTE and the DCE for terminals operating in the packet mode and connected to public data networks by dedicated lines, that Recommendation X.31 defines the support of packet mode terminal equipment by an ISDN, that Recommendation X.121 defines the international numbering plan for public data networks (PDNs), that Recommendation X.300 defines the principles and arrangements for interworking between PDNs and other public networks;

(b) that the V-Series Recommendations define modem and interface characteristics for use of data services on the PSTN;

(c) that Recommendation T.70 defines the procedures and interfaces to be used by telematic terminals, that Recommendation T.71 defines the extension of Link Access Procedure Balanced (LAPB) procedure to be used in half-duplex transmission facilities (LAPX);

(d) that a need has been identified to access a PSPDN through a PSTN, or an ISDN, or CSPDN, because a dedicated circuit to the PSPDN is not justified, or because global service availability is required with back-up network access via public switched networks; however permanent virtual circuits are not available in the types of access covered in this Recommendation;

(e) that some Administrations have considered the provision of Telematic services in different types of networks, e.g. PSPDN, PSTN, ISDN and CSPDN;

(f) that, when this Recommendation is used to provide the Network Service defined in Recommendation X.213, the physical, link and packet layers correspond to the Physical, Data link and Network layers respectively, as defined in Recommendation X.200,

(unanimously) recommends

that the functional and procedural aspects of packet mode DTEs accessing a PSPDN through a PSTN or an ISDN circuit switched bearer service, or CSPDN, are as specified in this Recommendation.

Note – Packet mode terminal (TE 1 or TE 2) conforming to the I-Series Recommendations may access a PSPDN through an ISDN circuit switched bearer service. In this case the functional and procedural aspects related to layer 2 and layer 3 in the B-channel are as specified in this Recommendation.

CONTENTS

1 Scope

This Recommendation defines the functional and procedural aspects of the DTE/DCE interface for packet mode user classes of service DTEs as defined in Recommendations X.1 and X.10, for DTEs that access a PSPDN via public switched networks. In this Recommendation, a public switched network (PSN) is either a public switched telephone network (PSTN) or an integrated services digital network (ISDN) providing circuit switched bearer service or a circuit switched public data network (CSPDN).

Note – The ISDN interface specification for transparent circuit connection is described in Recommendation X.31. In this Recommendation only the DTE functionalities for the access to a PSPDN service through an ISDN are considered.

In the PSTN case, the X.32 DTE/DCE interface coincides with the interface between the DTE and the modem. In the ISDN case, the X.32 interface coincides with the R reference point (see Figure 1/X.32). In the CSPDN case, the X.32 DTE/DCE interface coincides with the X.21 or X.21 *bis* interface. This definition applies whether or not the Administration provides the DCE and regardless of how the interface is physically realized (e.g., whether or not the DTE and DCE are contained within the same enclosure). In either case the PSN is involved only:

a) in the establishment of the switched access path;

b) to provide a transmission medium; and

c) optionally, to provide a PSN number for purposes of identification and addressing.

Administrations may offer one or more of the following physical layer interfaces:

1) for access by way of a CSPDN, either Recommendation X.21 or Recommendation X.21*bis* will be used, as described in §§ 4.1 or 4.2, respectively;

2) for access by way of a PSTN, appropriate V-Series Recommendations will be used as described in § 4.3;

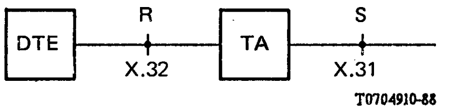
3) for access by way of an ISDN, refer to Recommendation X.31.

The exact use of the relevant points in these Recommendations is given in § 4.

The transmission facility is duplex or, optionally, half-duplex. Specific procedures are defined in § 5.6 of this Recommendation for operation over a half-duplex transmission facility.

At the link layer, the LAPB link access procedure of Recommendation X.25 is used over a single switched physical circuit. The LAPB formats and procedures shall be in accordance with §§ 2.2, 2.3 and 2.4 of Recommendation X.25, with additions as noted in § 5 of this Recommendation.

The formats and the procedures at the packet layer shall be in accordance with §§ 3, 4, 5, 6 and 7 of Recommendation X.25 with the additions noted in § 6 of this Recommendation.



Note – The DTE and TA functionalities may be implemented in the same piece of equipement in the case of a TE1 terminal. In this case this Recommendation covers layers 2 and 3 operation in the B-channel while the S reference point procedures are described in Recommendation X.31.

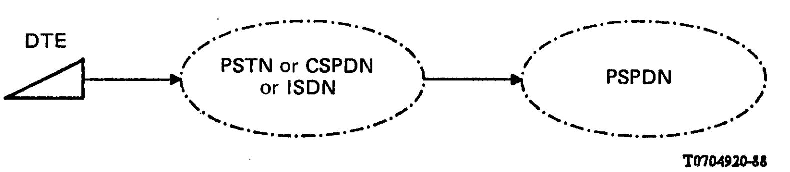
FIGURE 1/X.32

ISDN reference point

2 Functional aspects

2.1 *Dial-in and dial-out considerations*

Dial-in operation allows a packet-mode DTE to access a PSPDN by means of selection procedures on a PSTN or CSPDN or ISDN (see Figure 2/X.32). This operation is termed "dial-in-by-the-DTE" within this Recommendation.



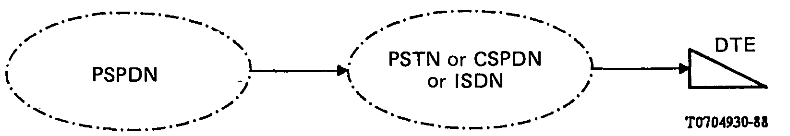
Note – In the ISDN case, the ISDN is accessed via TA functions that may be implemented in separate equipment (DTE and TA case) or in the same piece of equipment (TE1 case) as the DTE functions.

FIGURE 2/X.32

Dial-in-by-the-DTE operation

For performing this operation, the DTE may use an automatic or manual calling procedure.

Dial-out operation allows a PSPDN to access a packet-mode DTE by means of selection procedures on a PSTN or CSPDN or ISDN (see Figure 3/X.32). This operation is termed "dial-out-by-the-PSPDN" within this Recommendation.



Note – In the ISDN case, the ISDN is accessed via TA functions that may be implemented in separate equipment (DTE and TA) or in the same piece of equipment (TE1) case as the DTE functions.

FIGURE 3/X.32

Dial-out-by-the-PSPDN operation

For dial-out-by-the-PSPDN operation, the DTE should use the automatic answering procedure but may use manual answering.

Virtual call origination is independent of dial-in-by-the-DTE and dial-out-by-the-PSPDN operations. That is, a DTE that has been involved in a dial-in-by-the-DTE or dial-out-by-the-PSPDN operation may then initiate or receive virtual calls, subject to the limitations in specific situations as described in § 3.

2.2 *Identification*

2.2.1 *DTE identity*

When a DTE accesses a PSPDN through a PSN (dial-in-by-the-DTE) or when a DTE is accessed by a PSPDN through a PSN (dial-out-by-the-PSPDN), there may be a requirement for identification of the DTE to the DCE.

The DTE "identity" is a means of referring to the DTE. The DTE identity is either explicitly agreed to between the DTE and the Administration or is implicitly acceptable to the Administration through agreements with other Administrations, organizations or authorities. It may be composed of different elements such as a number from a numbering plan, identification of the DTE service and authority, validity dates and period, public keys used for authentication, etc.

The characteristics of the service which a DTE obtains via dial-in-by-the-DTE or dial-out-by-the-PSPDN access depend upon whether the PSPDN considers the DTE identified for each particular switched access connection or virtual call. If the DTE is identified, then the PSPDN has a way to accrue charges to be paid on behalf of the DTE. That is, either the DTE or some other party is billable.

Two components are required in order for a DTE to be considered identified:

a) the DTE is administratively registered either:
   1) through direct arrangement with the PSPDN (i.e. explicitly), or
   2) through pre-arrangement between the PSPDN and a PSN or another authority, and direct arrangement between the DTE and that authority (i.e. not explicitly),
b) the DTE identity is made known to the DCE during the switched access connection using one of the methods described in § 2.4.

A DTE may incur charges even if not identified because some Administrations collect charges via the PSTN, ISDN or CSPDN.

In any case, DTE identification is used for billing and accounting purposes. In addition to this basic function, DTE identification may optionally be used for one or both of the following purposes:

a) enabling the PSPDN to provide a calling DTE address to a called DTE, or
b) enabling the DTE to obtain a different service than that offered to DTEs which do not establish an identity (see § 2.3).

2.2.2 *DCE identity*

When a network supports dial-out-by-the-PSPDN access to DTEs, there may be a requirement for identification of the network (i.e. DCE) to the DTE. In the case of dial-in-by-the-DTE access, although the identity of the DCE may already be known by the DTE (as the DTE originated the switched access connection), there may also be a DTE requirement for identification of the network. The identification of the DCE to the DTE may be used for different purposes, such as:

a) to enable the DTE to select the specific security related information (e.g. encrypted key, password, etc.) appropriate to that network for use in exchanges with the DCE;

b) to enable the DTE to select different parameters, procedures or profiles appropriate to that network;

c) to enable a DTE to ascertain by which PSPDN the switched access has been established, thus enabling proper operation of the optional *closed user group* facility and of the conveyance of the appropriate calling DTE address provided by the PSPDN, if applicable.

For each dial-in-by-the-DTE or dial-out-by-the-PSPDN access, the DCE may establish its identity by successfully completing one of the methods for DCE identification described in § 2.5. The DCE identity is composed of the network's Data Network Identification Code (DNIC), and optionally, a DTE profile designator (see § 3.1.11), except when the identity is provided by the PSN (see § 2.5.1.1); in the latter case the identity is a number of the PSN numbering plan.

2.3 *Service aspects*

The switched access service given to a particular DTE is dependent upon:

a) the PSPDN;

b) the use/non-use of DTE identification, and

c) the DTE service available to and chosen by the DTE.

Three DTE service types are defined in this Recommendation (see § 2.3.2). One of the DTE service types (*nonidentified*) is independent of the specific DTE identity. One service type (*identified*) may or may not be independent of the specific DTE identity. The third type (*customized*) is related to the specific DTE identity in order to provide customization of some service aspects.

The types of DTE service are further distinguished by whether there is a number assigned by the network to be used to represent the DTE identity in the address fields of *call set-up* packets. This number is called a "DTE address" and is defined in § 3.1.3.

2.3.1 *Service attributes*

"Attributes" are defined to describe each aspect of switched access service. However, the values of the attributes do not necessarily include all capabilities offered to PSPDN users that access the PSPDN via a leased line. The attributes are:

a) DTE identity;

b) DTE identification method;

c) DTE address;

d) registered address;

e) registered PSN number;

f) X.25 subscription set;

g) logical channels assignment;

h) dial-out-by-the-PSPDN availability;

i) dial-out access type;

j) X.32 optional user facilities;

k) DCE identity presentation, and

l) link layer address assignment.

For each DTE service, each attribute is either provided or not provided; if it is provided it is either:

1) set to a default value specified by the network (Network Default) or

2) set to a value selected by the user from a set of values provided by the network (User Selectable). (*Note* - A network may define a default value for the attribute).

A *DTE profile* is the set of values of the Network Default and User Selectable attributes that have been selected for a particular DTE identity.

Note – The *DTE profile* need not be stored in the PSPDN.

Some networks may allow a subscriber to arrange for more than one *DTE profile* to meet different requirements for switched access service. Each *DTE profile* is independent. A "DTE profile designator" is used to differentiate the multiple profiles of the DTE.

2.3.2 *DTE services*

Some networks may offer service to unidentified DTEs, that is, to DTEs for which no identification is provided to the DCE.

Some networks may offer service to identified DTEs, that is, to DTEs for which an implicit or explicit *DTE identity* is provided to the DCE via one of the methods specified in § 2.4. Different types of service are defined for use in different situations. The network may offer one or more of these services.

The three types of service defined in this Recommendation are called DTE services. One is a service for unidentified DTEs. The other two are services for identified DTEs. The three DTE services are:

a) nonidentified,

b) identified, and

c) customized.

2.3.2.1 *Service for unidentified DTEs*

The service offered to unidentified DTEs is called *nonidentified* DTE service and is detailed in § 3.3. This DTE service may be offered as part of dial-in-by-the-DTE or dial-out-by-the-PSPDN operation or both.

For a dial-out-by-the-PSPDN operation, the lifetime of a switched access path corresponds to the lifetime of the virtual call. That is, at the completion of the clearing procedures for the virtual call, the DCE initiates those procedures necessary to disconnect the switched access path.

For a dial-in-by-the-DTE operation, the switched access path shall not be disconnected for a period of time (T14) even in the absence of any virtual calls. This allows users a period of time to reestablish a virtual call (see § 7.5).

For dial-in-by-the-DTE operation, the PSPDN may limit the number of unsuccessful attempts to establish a virtual call.

When a DTE uses the *nonidentified* DTE service:

a) it is not required to use any optional procedures;

b) it is able to operate with different networks without having to subscribe to any of them (i.e. not administratively registered and/or assigned an identity with any PSPDN); and

c) it should not be permitted to make paid calls or receive reverse-charged calls (i.e. the *local charging prevention* facility is set by the network), thus allowing the Administration to guarantee collection of charges. However, some Administrations may permit nonidentified DTEs to make free calls or may use other methods to collect charges (e.g. via the PSTN, ISDN or CSPDN).

2.3.2.2 *Services for identified DTEs*

The services offered to identified DTEs provide a set of capabilities/facilities different from and/or enhanced beyond the *nonidentified* DTE service. In particular, on those networks which allow only identified DTEs to accrue charges, it is possible for DTEs to:

a) make calls for which the calling DTE assumes responsibility for the charges, and/or

b) receive reverse-charged calls.

2.3.2.2.1 *Identified DTE service*

The PSPDN may offer the *identified* DTE service in which:

a) the *DTE identity* has not been explicitly agreed to with the Administration, or

the *DTE identity* has been explicitly agreed to. In this case, allocation of *registered addresses*, to some DTEs, by the Administration is a network option;

b) the other attributes have the values set by the network as specified in § 3.4.

The effect of the *identified* DTE service is that this DTE is billable but the service is otherwise similar to the *nonidentified* DTE service. Note that the use of the *network user identification* (NUI) *subscription* facility provides a *DTE identity* used for billing purposes and may, in conjunction with the *NUI override* facility (§ 6.3), override, for the specific virtual call, the default set of X.25 subscription facilities. However, when using the *NUI override* facility feature, overridding the facilities is performed only when a Call Request is made by the switched access DTE and not for an Incoming Call to the switched access DTE.

The *identified* DTE service may be offered as part of dial-in-by-the-DTE or dial-out-by-the-PSPDN operation or both.

2.3.2.2.2 *Customized DTE service*

The PSPDN may offer the *customized* DTE service in which the *DTE identity* has been explicitly agreed to with the Administration, a *registered address* has been allocated and the other attributes are set according to the DTE profile which has been customized for the DTE according to the capabilities supported by the network as permitted within the specification given in § 3.5. The effect is that this DTE is billable, has an X.121 address registered with the PSPDN, and is provided a service tailored in many aspects to its requirements. This DTE service may be offered as part of dial-in-by-the-DTE or dial-out-by-the-PSPDN operation or both.

2.4 *DTE identification methods*

This Recommendation provides four distinct methods for DTE identification. These methods are:

a) identification provided by the public switched network,

b) identification by means of a link layer Exchange Identification (XID) procedure,

c) identification by means of a packet layer registration procedure,

d) identification by means of the *NUI selection* facility in *call set-up* packets.

(*Note* – For an interim period, support of the use of a DTE identification method by means of the calling address field in *call request* packets is a national matter. It should be remembered that the use of the calling address field for conveying identification conflicts with the use of this field for addressing, and problems can arise if both uses are needed.)

A network may support any, all or none of these methods in conjunction with the DTE services offered (see § 2.7).

The mechanisms in b), c) and d) may be used by some networks to offer functions other than, or in addition to, DTE identification.

The identity of the DTE becomes known to the network via one of the identification procedures at either or both of the following times:

1) prior to any virtual call establishment (see § 2.4.1), or

2) on a per virtual call basis (see § 2.4.2).

It is considered vital that a reasonable degree of protection be achieved in the DTE identification procedure so that Administrations and subscribers can prevent fraudulent DTE identification. Therefore, the identification procedure includes the capabilities to verify and/or authenticate the correctness of the DTE identification. The XID and registration methods obey an "identification protocol" that has been defined in §§ 2.9 and 7.1 for conveying the information necessary for the DCE to receive the DTE identity, verify it to the proper degree of authenticity, and to report on the success of the procedure. Two grades of security are defined in the identification protocol. Identification provided by the public switched network and the X.25 *NUI selection* facility do not use an explicit identification protocol. However, the success of authentication is implicit in the reception by the DTE of a *call connected* packet.

DCE identification may be achieved by using the identification protocol while it is simultaneously being used for DTE identification, but as an independent invocation of the protocol.

Networks may choose to offer "secure dial-back" as an additional means for authentication of the DTE identity. Secure dial-back, as specified in § 7.2.1, uses physical location as a basis for DTE authentication by combining dial-in-by-the-DTE, dial-out-by-the-PSPDN, and DTE identification prior to virtual call establishment.

2.4.1 *Identification prior to virtual call establishment*

There are three methods by which the identity of the DTE can be determined by the DCE prior to the establishment of any virtual call. These methods are described in the following three subsections. All three methods apply to both dial-in-by-the-DTE and dial-out-by-the-PSPDN operation.

The service that a DTE which is identified prior to virtual call establishment obtains is either the *identified* or the *customized* DTE service.

If the service obtained is the *customized* DTE service and includes customized values for link layer options and system parameters, the DTE identification must be performed at the link level (see § 2.4.1.2) or be provided by the public switched network (see § 2.4.1.1).

The DTE identification that is determined by any of the prior-to-virtual-call-establishment methods remains in effect even in the absence of any virtual calls.

2.4.1.1 *Identity provided by the public switched network*

In the case of dial-in-by-the-DTE operation, the *DTE identity* may be provided by the public switched network (i.e. PSTN, ISDN or CSPDN) to the PSPDN during the PSN connection establishment stage.

Note – The administrative arrangements described in § 2.2.1 are necessary for the calling line identification to be used by the PSPDN as a *DTE identity.*

The DTE is a subscriber of the PSTN, ISDN or CSPDN network, and, therefore, the PSTN number, the ISDN number or the CSPDN number (as well as some additional management information in some circumstances) may be available and will be signalled to the PSPDN.

In the case of dial-out-by-the-PSPDN, the PSPDN uses, as the DTE identification, the information which has been provided to the PSN in order to do the dial-out-by-the-PSPDN operation.

Note – This method of identification may be used in the case of dial-out-by-the-PSPDN operation even when the PSN does not provide calling line identification.

As the PSN is providing the identification information, the DTE is not required to use any optional user procedures in order to accomplish DTE identification.

The DTE identification determined by means of this method remains in effect until the switched access path is disconnected.

Note – Although the operational requirements for a DTE which is not identified or which is identified via the "provided-by-public-switched-network" method are the same, the capabilities/facilities available to DTEs using these methods can be very different. This may result in differences in general DTE operation, especially in regard to reverse charging. In particular, the differences are those between the *nonidentified* DTE service and the *identified* or *customized* DTE services.

2.4.1.2 *Identity provided by means of the link layer XID procedure*

Identification of the DTE may be provided by a link layer procedure, as described in §§ 5 and 7, based on exchanges of XID frames between the DTE and the DCE before the logical link is established (*disconnected* phase of Recommendation X.25).

This procedure may be optionally offered by networks depending, in part, on the offering by the network of the optional frames that this procedure uses. When it is offered by the network, use of this identification procedure by DTEs is optional.

The XID frame used in this method may also be used for other link layer functions.

The DTE identification determined by means of this method remains in effect until the switched access path is disconnected or the link layer has left the information transfer phase and has entered the *disconnected* phase.

2.4.1.3 *Identity provided by means of the packet layer registration procedure*

Identification of the DTE may be provided by means of a packet layer procedure described in §§ 6 and 7. This procedure is based on one or more exchanges of *registration request* packets (from DTE to DCE) and *registration confirmation* packets (from DCE to DTE) and is always initiated by the DTE. (These packets are described in § 5.7.2 of Recommendation X.25). The DTE may initiate this procedure (for purposes of identification) once at the beginning of the existence of the switched access path, i.e. before any virtual calls are made in which the *nonidentified* DTE service is obtained or in which a per- virtual-call-DTE identification method is used. The DTE identification determined by means of this method remains in effect until the switched access path is disconnected or the link layer has entered the *disconnected* phase. Also, the receipt of a *restart indication* packet by the DTE may mean that DTE identification has been lost (see § 6.1 of Recommendation X.25 and §§ 6 and 7 of this Recommendation).

This procedure may be optionally offered by networks depending, in part, on the offering by the network of the optional *registration* packets that this procedure uses. When it is offered by the network, use of this identification procedure by DTEs is optional.

The *registration* packets used in this method are also used by those networks which offer the optional *on-line facility registration* facility.

2.4.2 *Identification per virtual call by means of network user identification facility*

There is a method, using the *network user identification selection* facility, by which the identity of the DTE can be determined on a per-virtual-call basis.

The identification of the DTE is provided in the facility field of the *call request* packet via the use of the optional *NUI selection* facility. Use of NUI in the facility field in a *call accepted* packet allows a modification of billing (e.g. subaccount billing) to be carried out and has no effect on the values of the *DTE profile* in use for this DTE.

This procedure may be optionally offered by networks depending, in part, on the offering by the network of the optional *NUI selection* facility that this procedure uses. When it is offered by the network, use of this identification procedure by DTEs is optional.

The identification established by this method is accomplished at the same time as virtual call set-up and remains in effect until the virtual call is cleared.

The *NUI selection* facility may also be used when a prior-to-virtual-call-establishment identification method has been used. In this case, the service obtained by the DTE using the *NUI selection* facility in a *call request* packet is detailed in § 6.3 concerning operation of the *NUI selection* facility.

The service that a DTE using the NUI method obtains is the *identified* DTE service. Upon termination of the virtual call:

a) if no prior-to-virtual-call-establishment DTE identification had been accomplished, the logical channel is usable again for a *nonidentified* call or a DTE-identification-via-NUI call, or

b) if a prior-to-virtual-call-establishment DTE identification had been accomplished, the logical channel is usable again under the conditions of the DTE service that the prior-to-virtual-call *DTE identity* had invoked.

2.5 *DCE identification methods*

This Recommendation provides three distinct methods for DCE identification. These methods are:

a) identification provided by the public switched network,

b) identification by means of a link layer XID procedure, and

c) identification by means of a packet layer registration procedure.

When a network provides dial-in-by-the-DTE access and/or dial-out-by-the-PSPDN access, it need not provide the DCE identification to the DTE. Some networks may not provide the DCE identification to the DTE regardless of the approach used for the DTE identification.

However, for the networks that choose to provide the DCE identification to the DTE using one of the optional identification procedures, it is possible that the DTE may not use that optional identification procedure and, therefore, may not recognize the DCE identification. Additionally, networks are not required to provide DCE identification on dial-in-by-the-DTE operation.

There is a need to provide a reasonable degree of protection in the identification procedure so that Administrations and subscribers can prevent inaccurate DCE identification. Therefore, the identification procedure incorporates the functions of authentication and verification of the DCE's identity. The XID and registration methods of DCE identification obey an "identification protocol" that has been defined in §§ 2.9 and 7.1 for conveying the information necessary for the DTE to recognize the DCE identity, including verifying the identity to the proper degree of authenticity and reporting on the success of the procedure.

When no DCE identification is received by the DTE, it is the responsibility of the DTE to decide if the level of security is sufficient to continue operation.

DTE identification may be achieved by using the identification protocol while it is simultaneously being used for DCE identification, but as an independent invocation of the protocol.

2.5.1 *Identification prior to virtual call establishment*

2.5.1.1 *Identity provided by the public switched network*

In the case of dial-out-by-the-PSPDN, the PSTN number, the ISDN number or the CSPDN number identifying the DCE may be provided by the public switched network (as well as some additional network management information from the PSPDN in some circumstances).

When identification is provided by the PSN, the DCE is not required to use any optional packet/frame types or any optional packet/frame fields defined in §§ 5, 6 or 7 or in Recommendation X.25.

2.5.1.2 *Identity provided by means of the link layer XID procedure*

DCE identification can be optionally provided to the DTE by means of the exchange of XID frames prior to the link set-up. The detailed procedure to provide such information is the identification protocol given in §§ 2.9 and 7.1.

2.5.1.3 *Identity provided by means of the packet layer registration*

DCE identification can be optionally provided to the DTE using the *registration* packets. The exact process is the identification protocol given in §§ 2.9 and 7.1.

2.5.2 *Identification per virtual call*

Identification of the DCE to the DTE on a per-virtual-call basis is currently not provided. The need for such a capability has been left for further study.

2.6 *Dial-in-by-the-DTE and dial-out-by-the-PSPDN operation*

All PSPDNs conforming to this Recommendation shall provide dial-in-by-the-DTE operation. Provision of dial-out-by-the-PSPDN operation is optional.

2.7 *DTE service requirement*

To provide a switched access service to DTEs, without introducing additional procedures, all PSPDNs conforming to this Recommendation shall offer the *nonidentified* DTE service and/or support use of the provided-by-the-PSN DTE identification method.

Networks may also provide access to and/or from DTEs through a PSN, with the DTE being identified to the network using one of the optional identification procedures (see §§ 2.4.1.2, 2.4.1.3 and 2.4.2).

2.8 *Duplex and half-duplex operation*

If CSPDN access is used, the transmission facility is duplex. If PSTN access is used, the transmission facility operation is duplex, or, optionally, some networks may also provide for half-duplex operation. The additional procedures necessary for half-duplex operation are described in § 5.6. If an ISDN transparent circuit connection is used, the transmission facility is duplex.

2.9 *Identification protocol*

The elements of protocol which are used in performing DTE or DCE identification by either the XID or registration methods are independent of the procedure (the vehicle) used to transfer these elements between DTE and DCE (i.e. either XID frames or *registration* packets).

The "identification protocol" consists of exchanges between the "challenged" party and the "questioning" party. The "challenged" party provides and, optionally, certifies its identity and the "questioning" party checks and authenticates this identity.

The DTE and DCE, either calling or called, may be questioning, challenged, or both questioning and challenged. This is the result of the identification protocol being used independently for DTE identification and DCE identification, possibly simultaneously.

The identification protocol provides two grades of security characterized by how many operations are needed and which elements are needed in each direction.

The operational details of the identification protocol are given in § 7.1.

2.10 *Negotiation of values*

Negotiation of link layer parameters is left for further study. Presently, DCE parameters are set to specific values according to the *DTE profile* as outlined in §§ 2.3 and 3.

Some networks may provide the capability for negotiation of packet layer facilities by means of the *on-line facility registration* facility. When provided, this negotiation takes as a starting point the values established in the *DTE profile* and, as a result, may override them.

Packet layer facilities may also be overridden by using the *NUI selection* facility when the *NUI override* facility is in effect.

3 DTE service descriptions

3.1 *DTE service attributes*

3.1.1 *DTE identity*

The *DTE identity* attribute, when provided, defines the identity of the DTE.

3.1.2 *DTE identification method*

The *DTE identification method* attribute, when provided, defines the DTE identification method used for establishing the *DTE identity* (see § 2.4). The method is the same for dial-in-by-the-DTE and dial-out-by-the-PSPDN operation unless the provided-by-PSN method is selected for one operation, in which case the methods may be different.

3.1.3 *DTE address*

When this attribute is provided a *DTE address* is assigned by the network for a given DTE identity.

The *DTE address* can be derived and validated from the identification method.

This *DTE address* may be, as a network option, either an X.121 number from the PSPDN numbering plan (see § 2.3 of Recommendation X.121) or a number in the X.121 format from the PSN numbering plan. The number in the X.121 format from the PSN numbering plan for CSPDN is according to § 2.3 of Recommendation X.121. The number in the X.121 format from the PSN numbering for PSTN and for ISDN is either according to § 2.2.1.3 of Recommendation X.121 or to § 2.6 of Recommendation X.121. The possible formats of the DTE address are given in § 6.6 of Recommendation X.301.

Note – The inclusion or application of the TOA/NP1 address format to Recommendation X.32 as defined in Recommendation X.25 requires further study.

3.1.3.1 *DTE address not provided*

In the case of dial-in-by-the-DTE, when the DTE makes a call request, the contents of the calling address field in the corresponding *incoming call* packet are either:

a) incomplete X.121 PSN format; this means the contents of the calling address field are not valid with respect to the definition of a "valid number" in the various Recommendations (e.g. a four digit number representing a DNIC that is assigned to a PSN; a number in the form 0 + CC; and a number in the form 9 + TCC are not valid numbers as defined in Recommendations X.121, E.164 and E.163 respectively); or

b) temporary number from the PSPDN numbering plan; this means the contents of the calling address field, although valid with respect to the definition of a "valid number" in the various Recommendations, is not a number permanently attributed to the DTE. It may be, as an example, attributed to the dial-in port used for a particular call.

Note – If the temporary number is used, the called DTE must be made aware that the contents of the calling address field is not a DTE address. The means to convey this information are for further study. Pending the results of such a study, this option may be used nationally, but such a temporary number shall not be carried on international interconnections.

Moreover, when the PSN implements calling line identification but there is no arrangement between the PSN and PSPDN to use the number provided by the PSN as DTE identification and when no other DTE identification method is used, the PSPDN may include the PSN-provided number in the calling address field of the *incoming call* packet.

3.1.3.2 *DTE address provided*

When an identified DTE makes a call request, the contents of the calling DTE address field in the *incoming call* packet given to the called DTE is the *DTE address.* This applies even if the *temporary location* facility has been used to change the *registered PSN number* (see § 7.2).

3.1.4 *Registered address*

This attribute, when provided, permits the DCE to be aware of a possible already established PSN connection with the DTE. The value of the *registered address* is always identical to the value of the *DTE address.*

3.1.4.1 *Registered address not provided*

If the called DTE address field in a *call request* packet contains an X.121 number from the PSN numbering plan which is not a registered address, then a dial-out-by-the-PSPDN call is made to that PSN number without checking if a switched connection already exists with the DTE. If a switched connection already exists, a subsequent dial-out-by-the-PSPDN operation will result in a busy signal. Therefore, the incoming virtual call is cleared.

3.1.4.2 *Registered address provided*

Upon receiving a call request with a called DTE address, that is the *registered address,* the PSPDN needs to determine whether or not to perform a dial-out-by-the-PSPDN operation. If there is a switched connection in existence on which the *DTE identity* that corresponds to the *registered address* has been established, that switched connection will be used by the PSPDN. Otherwise, the PSPDN will perform the dial-out-by-the-PSPDN operation.

Note – This dial-out-by-the-PSPDN will not be successful if there is already a switched connection to the DTE when there has not been an establishment of a *DTE identity* or there has been a *DTE identity* established that does not correspond to the *registered address.*

The PSN number used for the dial-out-by-PSPDN is the *registered PSN number.*

Note – In some networks, if the called address used in a Call Request packet to call a switched access DTE is not the *registered address* for a *DTE identity* but is a *registered PSN number,* the PSPDN will not recognize this as a *registered address* and may treat the call according to the *nonidentified* DTE service (see §§ 3.5 and 3.3).

3.1.5 *Registered PSN number*

When the *registered PSN number* attribute is provided, its value is used by the PSPDN for dialing out to that DTE. If a *call request* packet contains a *registered address* which is not X.121 PSN number, the PSPDN uses the *registered PSN number* in order to perform the dial-out-by-the-PSPDN operation. If the *registered address* is an X.121 PSN number, then it is considered to be the *registered PSN* number.

If a DTE does not have a *registered address,* then the *registered PSN number* attribute does not apply.

3.1.6 *X.25 subscription set*

The *X.25 subscription set* attribute defines values for the X.25 link layer options and system parameters and the X.25 packet layer subscription-time optional user facilities which apply to switched access operation. Networks are not required to support all of the link layer options and packet layer subscription-time facilities, except as required in Recommendation X.2. The list of link layer options and system parameters and packet layer optional user facilities in the *X.25 subscription set* is given in Table 3/X.32 (see § 3.3).

Note – As defined in Recommendation X.25, the throughput class value is, at most, the speed of the access line (see the *dial-out access type* attribute, § 3.1.9). However, in the case of a modem with automatic fall-back capability, the DCE shall set the default throughput class value to the maximum signalling rate of the modem used, unless the user has selected a lower value for the *default throughput classes assignment* facility. Some networks may take into account the signalling rate selected by the modems in fixing the default throughput class.

3.1.6.1 *Network default*

When the *X.25 subscription set* is specified as network default, the value of each of the options, parameters and facilities is a default value that is set by the PSPDN. Different defaults may apply according to the DTE service invoked.

The value of the *local charging prevention* facility is closely related to the policy of the PSPDN regarding accrual of charges by a nonidentified DTE (see § 3.3).

3.1.6.2 *User selectable*

When the *X.25 subscription set* is specified as user selectable, the value of each of the options, parameters, and facilities is available for customization by the user to a value from the set of values offered by the PSPDN.

3.1.7 *Logical channels assignment*

The logical channels assignment attribute defines the number of logical channels of each type assigned for a particular DTE.

There is a default value assigned by the PSPDN for nonidentified DTEs (see below). A different default value may be set by the PSPDN for use in cases where the *DTE identity* is established.

3.1.7.1 *Network default*

When the *logical channels assignment* is specified as network default, there is one virtual call logical channel with dial-out-by-the-PSPDN operation and there may be one or more virtual call logical channels with dial-in-by-the-DTE operation; the specific number is a network option. The direction of virtual call placement that is allowed on the logical channel(s) is governed by the direction of the dial operation as shown in Table 1/X.32.

TABLE 1/X.32

Direction of virtual call placement allowed as related to direction of the dial operation when logical channels assignment is by network default

Dial operation	Capabilities for DTE originating/receiving virtual calls	Equivalent X.25 optional user facilities (see Note)
Dial-in-by-the-DTE	Originating virtual calls	– Incoming calls barred – 1-way logical channel outgoing
Dial-out-by-the-PSPDN	Receiving virtual calls	– Outgoing calls barred – 1-way logical channel incoming

Note – The association of the dial operation with one or both of the optional user facilities is network-dependent.

3.1.7.2 *User selectable*

When the *logical channels assignment* is specified as user selectable, the number of logical channels of each type is set by the user, for the particular *DTE identity*, from the values supported by the network. This may include the assignment of channels for permanent virtual circuits.

3.1.8 *Dial-out-by-the-PSPDN availability*

The *dial-out-by-the-PSPDN availability* attribute allows the use of dial-out-by-the-PSPDN operation.

3.1.8.1 *Network default*

When the *dial-out-by-the-PSPDN availability* is specified as network default, the network chooses whether or not to offer dial-out-by-the-PSPDN operation. When dial-out-by-the-PSPDN operation is offered, the PSPDN attempts to establish a switched access path to the PSN number given in a *call request* packet.

3.1.8.2 *User selectable*

When the *dial-out-by-the-PSPDN availability* is specified as user selectable, the capability to have dial-out-by-the-PSPDN availability operation with a particular DTE is chosen by the user. When the *dial-out-by-the-PSPDN availability* is selected, the *registered PSN number* attribute must also be selected. Then the network dials out to the DTE whenever the *registered address* is used in a *call request* packet and there is not already a switched access path.

3.1.9 *Dial-out access type*

The *dial-out access type* attribute applies to dial-out-by-the-PSPDN operation and allows a DTE to choose modem characteristics or a user class of service or characteristics of an ISDN connection, possibly other than the national default, from those offered by the network. *Dial-out access type* refers to the modem characteristics (in the case of the PSTN) or the X.1 user class (in the case of the CSPDN) or the characteristics of an ISDN connection (in the case of ISDN) that are used for switched access line operation at the physical layer, see § 4. A national default dial-out access type is made by the PSPDN for each PSN through which access is permitted.

Note that for dial-in-by-the-DTE through the PSTN, the modem characteristics of the PSPDN port dialled into are used. For dial-in-by-the-DTE through the CSPDN, the X.1 user class of the PSPDN port called is used.

Note 1 – Some networks may use the procedures of Recommendation V.100 to perform modem selection.

Note 2 – The modem used determines whether the transmission facility is full or half duplex. Therefore, there is no attribute for the type of transmission facility operation.

3.1.9.1 *Network default*

When the *dial-out access type* is specified as network default, the national default modem characteristics are used for dial-out-by-the-PSPDN through the PSTN. For dial-out-by-the-PSPDN through the CSPDN, the national default X.1 user class is used. For dial-out-by-the-PSPDN through an ISDN, the national default for rate adaption method is used, see Recommendation X.31 for the applicable method.

3.1.9.2 *User selectable*

When the *dial-out access type* is specified as user selectable, the modem characteristics selected for this *DTE identity*, from those offered by the network, are used for dial-out-by-the-PSPDN through the PSTN. For dial-out-by-the-PSPDN through the CSPDN, the X.1 user class, selected for this *DTE identity* from those offered by the network, is used. For dial-out-by-the-PSPDN through an ISDN, the X.1 user class, selected for this *DTE identity* from those offered by the network, is used.

3.1.10 *X.32 optional user facilities*

Two X.32 optional user facilities, *temporary location* and *secure dial-back* are included within this attribute. Both of these optional user facilities are defined in § 7.2. It is optional for the PSPDN to offer these facilities.

3.1.11 *DCE identity presentation*

The PSPDN chooses whether or not to offer DCE identity presentation. When DCE identity presentation is offered, the *DCE identity presentation* attribute defines the DCE identification method used by the PSPDN. The PSPDN may choose to use a DCE identification method for both dial-in-by-the-DTE operation and dial-out-by-the-PSPDN operation or for only dial-out-by-the-DTE operation. When the DCE identification is done for both operations, the method is the same for dial-in-by-the-DTE operation and dial-out-by-the-PSPDN operation. The PSPDN selects one of the DCE identification methods given in § 2.5.

Some networks may include a DTE profile designator as part of the DCE identity in order to inform the DTE of the *DTE profile* applicable to the DTE/DCE interface during this instance of switched access. The DTE profile designator is a string of octets that may be assigned by the PSPDN to the *DTE identity* as a name for the specific *DTE profile.*

3.1.12 *Link layer address assignment*

The *link layer address assignment* attribute defines the mechanism used to determine the link layer addresses.

Note – Other methods of link layer address assignment than those described below are for further study.

3.1.12.1 *Network default*

When the *link layer address assignment* is specified as network default, the link level addresses are assigned depending on the direction of the switched access call as defined in § 5.2 (same as Recommendation T.70).

Alternatively, *link layer address assignment* that is dependent on the roles of the equipment as DTE and DCE, as defined in § 5.2 (same as § 2.4.2 of Recommendation X.25), may be provided by some networks.

Note 1 – The dial-out-by-the-PSPDN operation will only operate properly when the DTE and the PSPDN implement the same *link layer address assignment* method.

Note 2 – Assigning the link layer addresses according to the roles of the equipment as DTE and DCE does not allow for two DTEs to interoperate directly without an intervening PSPDN.

3.1.12.2 *User selectable*

When the *link layer address assignment* is specified as user selectable, the user designates whether the link level addresses are assigned depending on the direction of the switched access call or depending on the roles of the equipment as DTE and DCE (see § 5.2).

3.2 *Summary of DTE services*

The type of each attribute is given for the three DTE services in Table 2/X.32.

TABLE 2/X.32

Summary of DTE services

Attributes \ Services	Nonidentified	Identified	Customized
DTE identity	– – –	Yes	Yes
DTE identification method	– – –	Any (ND)	Prior to virtual circuit establishment (ND)
DTE address	– – –	Note 4	Yes
Registered address	– – –	Note 1	Yes
Registered PSN number	– – –	– – –	User selectable
X.25 subscription set	ND	Note 2	User selectable
Logical channel assignment	ND	ND	User selectable
Dial-out-by-the-PSPDN availability	ND	Note 1	User selectable
Dial-out access type	ND	ND	User selectable
X.32 optional user facilities	– – –	– – –	User selectable
DCE identity presentation	ND	ND	ND
Link layer address assignment	ND	ND	User selection Note 3

– – – not provided
ND network default
Yes provided

Note 1 – In this DTE service, the use of *registered addresses* for some DTEs is a network option. When the DTE is assigned a *registered address*, the value of the *dial-out-by-the-PSPDN availability* attribute is user selectable. Otherwise, (if no *registered address* is assigned to the DTE), the availability of dial-out-by-the-PSPDN operation is by network default.

Note 2 – ND or, if *NUI override* is in effect, user selectable packet layer facility values (Annex H/X.25).

Note 3 – In the case of dial-in-by-the-DTE operation, the link layer address values assigned are the same for both assignment methods and, therefore, the values are not dependent on the assignment method selected by the user.

Note 4 – In this DTE service, the use of *DTE addresses* for some DTEs is a network option.

3.3 *Nonidentified DTE service*

The values of the attributes for the *nonidentified* DTE service defined in § 2.3.2.1 are shown in the "nonidentified" column of Table 2/X.32:

- no *DTE identity* is established;
- no *DTE identification* method is used.

Generally, no optional user facilities are available except those governing the direction of virtual call placement (i.e. incoming calls barred, outgoing calls barred, one-way logical channel outgoing, and one-way logical channel incoming) and those that can be used on a per-virtual-call basis without prior subscription. In addition, some networks may allow the use of:

a) some subscription-time optional user facilities without prior subscription. (The network may make these known by publication or through the use of the *on-line facility registration* facility; in such cases, a PSPDN should consider making its identity known nonidentified DTEs), and

b) some subscription-time optional user facilities that must be requested by the DTE through the use of the *on-line facility registration* facility.

The X.25 link layer options and system parameters and the X.25 subscription-time optional user facilities are categorized for dial-in-by-the-DTE and dial-out-by-the-PSPDN operation in Table 3/X.32 as:

- an "AVAIL-NS" link layer system parameter, which is set by the network on all networks offering *nonidentified* DTE service;
- an "AVAIL-BAS" optional user facility or link layer option, which is available on all networks offering *nonidentified* DTE service. This facility is in effect even if not requested;
- an "AVAIL-OPT" optional user facility, which is available on some networks offering the *nonidentified* DTE service and the availability of which is made known through either publication or use of the *on-line facility registration* facility. These facilities can be used without further request when operating on these networks;
- an "AVAIL-RQ" optional user facility, which is available on some networks offering the *nonidentified* DTE service and the use of which must be requested through the *on-line facility registration* facility; or
- a "NO" optional user facility or line level option, which is not available on any network offering *nonidentified* DTE service.

The DTE may use any per-call X.25 facility that is supported by the PSPDN and that does not require prior subscription.

3.4 *Identified DTE service*

The values of the attributes for the *identified* DTE service (defined in § 2.3.2.2) are shown in the "identified" column of Table 2/X.32.

- A *DTE identity* that has been agreed to explicitly or implicitly is provided to the nework.
- The *X.25 subscription* set is the same as in the *nonidentified* DTE service except that:
  a) for dial-in-by-the-DTE operation, in which the *NUI override* facility is in effect at the DTE/DCE interface, the *NUI selection* facility, as defined in Recommendation X.25, can be used to invoke user selected packet layer facility values (see § 6.3 and Annex H/X.25), and
  b) the *local charging prevention* facility is not in effect.

The DTE may use any per-call X.25 facility which is supported by the PSPDN and which does not require prior subscription.

TABLE 3/X.32

Availability of link level options and system parameters and packet level subscription-time facilities in the nonidentified DTE service

Option, parameter or facility (applicable to all assigned logical channels)	Available with Dial-in-by-the-DTE operation	Available with Dial-out-by-the-PSPDN operation
Link layer		
K	AVAIL-NS	AVAIL-NS
T1	AVAIL-NS	AVAIL-NS
T2	AVAIL-NS	AVAIL-NS
T3	AVAIL-NS	AVAIL-NS
N1	AVAIL-NS	AVAIL-NS
N2	AVAIL-NS	AVAIL-NS
Multilink	NO	NO
MT1	NO	NO
MT2	NO	NO
MT3	NO	NO
Extended frame sequence numbering	NO	NO
Packet layer		
On-line facility registration	AVAIL-OPT	AVAIL-OPT
Extended packet sequence numbering	AVAIL-RQ (Note 1)	AVAIL-RQ
D-bit Modification	AVAIL-RQ	AVAIL-RQ
Packet retransmission	AVAIL-OPT	AVAIL-OPT
Incoming calls barred	AVAIL-BAS	NO
Outgoing calls barrred	NO	AVAIL-BAS
One-way logical channel outgoing	AVAIL-BAS	NO
One-way logical channel incoming	NO	AVAIL-BAS
Nonstandard default packet sizes	AVAIL-RQ	AVAIL-RQ
Nonstandard default window sizes	AVAIL-RQ (Note 2)	AVAIL-RQ (Note 2)
Default throughput classes assignment	AVAIL-RQ	AVAIL-RQ
Flow control parameter negotiation	AVAIL-RQ (Note 1)	AVAIL-RQ
Throughput class negotiation	AVAIL-RQ (Note 1)	AVAIL-RQ

TABLE 3/X.32 *(cont.)*

Availability of link level options and system parameters and packet level subscription-time facilities in the nonidentified DTE service

Option, parameter or facility (applicable to all assigned logical channels)	Available with Dial-in-by-the-DTE operation	Available with Dial-out-by-the-PSPDN operation
Packet layer *(cont.)*		
Closed user group related facilities – Closed user group – Closed user group with outgoing access – Closed user group with incoming access – Incoming calls barred within a closed user group – Outgoing calls barred within a closed user group	 NO NO NO NO NO	 NO NO NO NO NO
Bilateral closed user group related facilities – Bilateral closed user group – Bilateral closed user group with outgoing access	 NO NO	 NO NO
Fast select acceptance	NO	AVAIL-RQ
Reverse charging acceptance	NO	NO
Local charging prevention (Note 3)	Yes	Yes
Network user identification subscription	NO	NO
NUI override	NO	NO
Charging information subscription	NO	NO
RPOA subscription	NO	NO
Hunt group	NO	NO
Call redirection	NO	NO
Call deflection subscription	NO	NO

Note 1 – Further study is required to determine whether subscription should be equivalent to use in a *call set-up* packet (either in the general format identifier for the *extended packet sequence numbering* facility or in the facility field for other facilities) under the *nonidentified* DTE service.

Note 2 – Some networks offering half-duplex operation as part of the *nonidentified* DTE service may set the default window size to a single nonstandard default window size value.

Note 3 – The *local charging prevention* facility is in effect unless the PSPDN permits unidentified DTEs to accrue charges.

3.5 *Customized DTE service*

The values of the attributes for the *customized* DTE service (defined in § 2.3.2.2) are shown in the "customized" column in Table 2/X.32.

Note – If a public port is used, the values in the customized *DTE profile* may not all be supported. (The characteristics available may vary from public port to public port). The result may be service according to network default values or refusal of service.

A *DTE identity* that has been explicitly agreed to with the PSPDN for obtaining the *customized* DTE service is provided to the PSPDN.

The availability for customization of each X.25 link layer option and system parameter and X.25 packet layer subscription-time facility is given in Table 4/X.32.

The DTE may use any per-call X.25 facility which is supported by the PSPDN and which does not require prior subscription.

The DTE may use any per-call X.25 facility which is supported by the PSPDN and which requires a corresponding subscription-time facility to be selected, provided that the corresponding subscription-time facility has been selected.

4 Interface characteristics (physical layer)

Administrations may offer one or more of the physical layer interfaces specified below.

For a description of the physical layer interface for the case of ISDN transparent circuit connection, see Recommendation X.31.

4.1 *X.21 interface*

For establishment, maintenance, and disestablishment of a switched access path between a DTE and a PSPDN by way of a CSPDN, the interface at the physical layer shall be in accordance with Recommendation X.21, as described in the following sections.

4.1.1 *DTE/DCE physical interface elements*

The DTE/DCE physical interface elements shall be according to §§ 2.1 through 2.5 of Recommendation X.21.

4.1.2 *Alignment of call control characters and error checking*

Alignment of call control characters and error checking shall be in accordance with § 3 of Recommendation X.21.

4.1.3 *Procedures for entering operational phases*

The *call control* phase shall be required prior to entering the operational phases and shall be in accordance with § 4 of Recommendation X.21.

After a call is established within the CSPDN, the physical layer interface will enter the *data transfer* phase, as described in § 5.1 of Recommendation X.21. While in the *data transfer* phase (state 13), data exchanged on circuits T and R will be as described in subsequent sections of this Recommendation.

The *Not ready* states given in § 2.5 of Recommendation X.21 are considered to be non-operational states, and may be considered by higher layers to be out-of-order states.

4.1.4 *Clearing procedures*

Clearing procedures shall be according to § 6 of Recommendation X.21.

TABLE 4/X.32

Availability for customization in the customized DTE service of the X.25 link level options and system parameters and the X.25 subscription-time facilities

Option, parameter or facility	Customization available
Link layer	
K	CUSTOM
T1	CUSTOM
T2	CUSTOM
T3	CUSTOM
N1	CUSTOM
N2	CUSTOM
Multilink	(Note 1)
MT1	(Note 1)
MT2	(Note 1)
MT3	(Note 1)
Extended frame sequence numbering	CUSTOM
Packet layer	
On-line facility registration	CUSTOM
Extended packet sequence numbering	CUSTOM
D-bit modification	CUSTOM
Packet retransmission	CUSTOM
Incoming calls barred	CUSTOM
Outgoing calls barred	CUSTOM
One-way logical channel outgoing	CUSTOM
One-way logical channel incoming	CUSTOM
Nonstandard default packet sizes	CUSTOM
Nonstandard default window sizes	CUSTOM
Default throughput classes assignment	CUSTOM
Flow control parameter negotiation	CUSTOM
Throughput class negotiation	CUSTOM

TABLE 4/X.32 *(cont.)*

Availability for customization in the customized DTE service of the X.25 link level options and system parameters and the X.25 subscription-time facilities

Option, parameter or facility	Customization available
Packet layer *(cont.)*	
Closed user group related facilities – Closed user group – Closed user group with outgoing access – Closed user group with incoming access – Incoming calls barred within a closed user group – Outgoing calls barred within a closed user group	 CUSTOM CUSTOM CUSTOM CUSTOM CUSTOM
Bilateral closed user group related facilities – Bilateral closed user group – Bilateral closed user group with outgoing access	 CUSTOM CUSTOM
Fast select acceptance	CUSTOM
Reverse charging acceptance	CUSTOM
Local charging prevention	CUSTOM
Network user identification subscription	CUSTOM
NUI override	CUSTOM
Charging information subscription	CUSTOM
RPOA subscription	CUSTOM
Hunt group	CUSTOM
Call redirection	CUSTOM (see Note 2)
Call deflection subscriptions	

CUSTOM can be chosen or set to a nondefault value by the DTE, if suported by the PSPDN

Note 1 – The need for multilink procedures over switched access paths is left for further study.

Note 2 – The criteria for determining that the DTE is out of order (for the purposes of call redirection) have been left for further study.

4.1.5 *Failure detection principles and test loops*

Failure detection principles shall be according to §§ 2.6.1 and 2.6.2 of Recommendation X.21.

The definitions of test loops and the principles of maintenance testing using test loops are provided in Recommendation X.150.

A description of the test loops and the procedures for their use are given in § 7 of Recommendation X.21.

Automatic activation by a DTE of test loop 2 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2 at the local data switching exchange (DSE) to verify the operation of the subscriber line, the switched access path and all or part of the DCE or line terminating equipment. Subscriber control of the loop, if provided, may be manual or automatic as described in Recommendations X.150 and X.21, respectively.

4.1.6 *Signal element timing*

The signal element timing shall be in accordance with § 2.6.3 of Recommendation X.21.

4.2 *X.21 bis interface*

For establishment, maintenance, and disestablishment of a switched access path between a DTE and a PSPDN by way of a CSPDN, the interface at the physical layer shall be in accordance with Recommendation X.21 *bis*, as described in the following sections.

4.2.1 *DTE/DCE physical interface elements*

The DTE/DCE physical interface elements shall be in accordance with § 1.2 of Recommendation X.21 *bis*.

4.2.2 *Procedures for entering operational phases*

The procedures for entering operational phases shall be in accordance with § 2 of Recommendation X.21 *bis*. When circuit 107 is in the ON condition, and when circuits 105, 106, 108, and 109, if provided, are in the ON condition, data exchange on circuits 103 and 104 will be as described in subsequent sections of this Recommendation.

When circuit 107 is in the OFF condition, or any of circuits 105, 106, 108 or 109, if provided, is in the OFF condition, the interface is considered to be in a non-operational state and may be considered by the higher layers to be in an out-of-order state.

4.2.3 *Failure detection and test loops*

Failure detection principles, the description of the test loops and the procedures for their use are given in §§ 3.1 through 3.3 of Recommendation X.21 *bis*.

Automatic activation by a DTE of test loop 2 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2 at the local DSE to verify the operation of the subscriber line, the switched access path, and all or part of the DCE or line terminating equipment. Subscriber control of the loop, if provided, may be manual or automatic as described in Recommendations X.150 and X.21 *bis*, respectively.

4.2.4 *Signal element timing*

Signal element timing shall be in accordance with § 3.4 of Recommendation X.21 *bis*.

4.3 *V-series interface*

For establishment, maintenance, and disestablishment of a switched access path between a DTE and a PSPDN by way of a PSTN, the physical layer interface shall be as described in the following sections.

4.3.1 *Modem characteristics*

Administrations may choose to offer modem characteristics in accordance with any or all of the following:

a)	1200 bit/s	V.22, Alternatives A, B or C, Mode i)
b)	2400/1200 bit/s	V.22 *bis*, Modes i) or iii), or V.26 *ter*, Mode i) or iii)
c)	9600/4800 bit/s	V.32

In addition, those Administrations which offer half-duplex operation may choose to offer modem characteristics in accordance with any or all of the following:

d)	2400 bit/s	V.26 *bis*, Alternative B
e)	4800/2400 bit/s	V.27 *ter*

Note – In the future it is desirable that one modem characteristic should be available in all network implementations of this Recommendation. However, for the time being, it has not been possible to select a single modem type.

Other modem characteristics are left for further study or are a national matter.

Use of the backward channel, if allowed, is outside the scope of this Recommendation.

4.3.2 *Procedures for full duplex operational phases*

When circuit 107 is in the ON condition, and when circuits 105, 106, 108 and 109, if provided, are in the ON condition, data exchanged on circuits 103 and 104 will be as described in subsequent sections of this Recommendation.

Circuits 106 and 109 may enter the OFF condition due to momentary transmission failures of modem retraining. Higher layers should delay for several seconds before considering the interface to be non-operational.

4.3.3 *Procedures for half duplex operational phases*

The states of circuits 103, 104, 105, 106 and 107 shall be according to § 5.6.8, below.

4.3.4 *Origination procedures*

DTEs may use either:

a) the automatic origination procedures described in § 3 of Recommendation V.25;

b) the automatic origination procedures described in §§ 4 or 5 of Recommendation V.25 *bis*;

c) the manual origination procedures of § 6 of Recommendation V.25.

Networks will use automatic origination procedures only.

Note – Other origination procedures may be used provided that no special requirements are placed on DTEs (including DTEs having integral modems and diallers) using only V.25 or V.25 *bis* procedures.

4.3.5 *Answering procedures*

For dial-out-by-the-PSPDN procedures, DTEs should use the automatic answering procedures of Recommendations V.25 and V.25 *bis.* Some Administrations may also allow use of manual answering procedures, provided that doing so does not affect DTEs using automatic answering procedures.

For dial-in-by-the-DTE, networks will use automatic answering procedures only.

4.3.6 *Disconnection procedures*

DTEs and networks shall use the disconnection procedures specified in Recommendation V.24.

4.3.7 *Test loops*

The definitions of test loops and the principles of maintenance testing using test loops are provided in Recommendation V.54.

Descriptions of the test loops and the procedures for their use are given in the appropriate modem Recommendations. It should be noted that the procedures for loop testing vary among the several modem Recommendations.

Automatic activation by a DTE of test loops 2 and 4 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2 or 4 at the local DSE to verify the operation of the subscriber line, the switched access path, and all or part of the DCE or line terminating equipment. Subscriber control of the loop, if provided, may be manual or automatic as described in Recommendation V.54 and the appropriate modem Recommendations, respectively.

5 **Link access procedure across the DTE/DCE interface**

5.1 *Introduction*

This section specifies the mandatory and optional link layer procedures that are employed to support switched access data interchange between a DCE and a DTE.

5.1.1 *Compatibility with the ISO balanced classes of procedure*

The switched access link layer procedures defined in this Recommendation use the principles and terminology of the High-level Data Link Control (HDLC) procedures specified by the International Organization for Standardization.

DCE compatibility of operation with the ISO balanced classes of procedure (Class BA with options 2 and 8 and Class BA with options 2, 8 and 10) is achieved using the LAPB procedure described in §§ 2.2, 2.3, and 2.4 of Recommendation X.25. Class BA with options 2 and 8 (LAPB modulo 8) is available in all networks for switched access.

Class BA with options 2, 8 and 10 (LAPB modulo 128) may also be offered for switched access by some networks.

Note – The operating conditions under which modulo 128 sequence numbering applies are left for further study.

Class BA 1, 2 8 and Class BA 1, 2, 8, 10 provide for the additional use of the unnumbered format Exchange Identification (XID) command and response. This additional capability may be used in the performance of DTE/DCE identification and authentication and in the selection of X.32 optional user facilities (see § 7.2) by the application of the proposed HDLC standard – General purpose XID frame information field content and format (Draft ISO International Standard 8885).

5.1.2 *Underlying transmission facility*

The underlying transmission facility is duplex or, optionally, half-duplex (see § 2.8). Specific procedures are defined in § 5.6 for operation over a half-duplex transmission facility.

5.2 *Link layer address assignment*

Two alternative mechanisms for assigning the link layer addresses are included in the procedures of this Recommendation. The conditions under which each mechanism applies are specified in the *link layer address assignment* attribute (see § 3.1.12).

It should be noted that the alternative mechanisms result in the assignment of identical values in dial-in-by-the-DTE operation.

5.2.1 *Assignment depending on switched access call direction*

In accordance with Recommendation T.70, link layer address assignment for dial-in-by-the-DTE and dial-out-by-the-PSPDN operation depends on the direction of the switched access call as specified in Table 5/X.32.

The DCE is always aware of whether the switched access path is established by the DTE (dial-in-by-the-DTE) or the DCE (dial-out-by-the-PSPDN). The DTEs that are not or cannot be aware of this situation shall initiate the appropriate address resolution procedures to determine the individual address of the DCE. These procedures are left for further study. However, it is intended that these procedures will not affect DTEs using the link level address assignment described in Table 5/X.32.

TABLE 5/X.32

Link layer address assignment

Station 1 Link layer address assignment		
	Calling A	Called B
Command	B	A
Response	A	B

Note – For dial-in-by-the-DTE, the DTE is calling A; for dial-out-by-the-PSPDN, the DCE is calling A.

5.2.2 *Assignment depending on roles of equipment as DTE and DCE*

In accordance with the specifications in § 2.4.2 of Recommendation X.25, the link layer address assignment depends on the roles of the equipment as DTE and DCE such that the DCE transmits to the DTE the address A in command frames and the address B in response frames and the DTE does the opposite (i.e. transmits to the DCE address B in command frames and address A in response frames).

5.3 *Use of exchange identification (XID) frames*

5.3.1 *General*

XID frames may be used by the DCE and DTE in the performance of either DTE or DCE identification and authentication, and/or by the DTE and DCE to convey X.32 optional user facilities (see § 7.2).

Note – The use of the XID command/response for address negotiation and the negotiation of link layer parameters is left for further study.

5.3.1.1 *XID command*

The XID command is used by the DTE/DCE to cause the DCE/DTE to identify itself, and, optionally, to provide DTE/DCE identification and/or characteristics to the DCE/DTE. An information field is optional with the XID command.

5.3.1.2 *XID response*

The XID response is used by the DTE/DCE to reply to a XID command. An information field containing the DTE/DCE identification and/or characteristics may be optionally present in the XID response.

5.3.2 *Format of XID frame*

The format of the address field of the XID frame is as defined in § 5.2 above.

The format of the control field of the XID frame is given in Table 6/X.32.

Note – The first bit transmitted is bit 1, the low order bit.

TABLE 6/X.32

XID command and response control field bit encoding

Format	Command	Response	Encoding 1 2	3 4	5	6 7 8
Unnumbered	XID	XID	1 1	1 1	P/F	1 0 1

After the XID control field there may be an XID information field. The general format of the XID information field, when present, is shown in Figure 4/X.32.

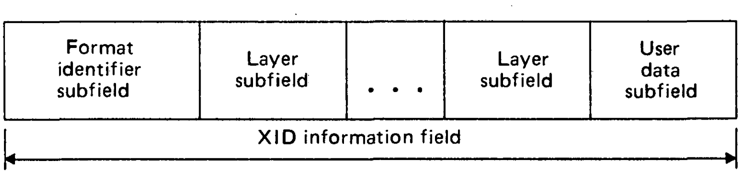


FIGURE 4/X.32

General structure of the XID information field

The XID information field is composed of a number of subfields. These subfields are a format identifier (FI) subfield, several layer subfields, and a user data subfield.

The FI subfield is a fixed one-octet field. This field is encoded to have a capacity of designating 128 different ISO standardized formats and 128 different user-defined formats. The format identifier in this Recommendation is one of the ISO standardized format identifiers. The FI subfield is present if there is a layer subfield and/or a user data subfield present. The FI subfield need not be present if there is no layer subfield or data user subfield present. The format identifier is encoded as shown in Figure 5/X.32.

Bits

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

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FIGURE 5/X.32

XID format identifier subfield

The layer subfields are permitted to be present in the information field of either XID command or XID response frames for the purposes of link layer address resolution and link level parameter negotiation. The use of these subfields within the scope of this Recommendation is left for further study.

The user data subfield contains data link user information to be transferred during XID interchange. This data link user information is transported transparently across the data link and passed to the user of the data link. The user data subfield is composed of the two elements illustrated in Figure 6/X.32.

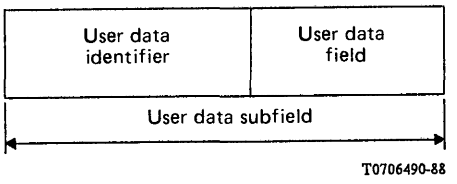

FIGURE 6/X.32

User data subfield

The user data identifier element identifies the subfield as the user data subfield. Its encoding is shown in Figure 7/X.32.

Bits

1	2	3	4	5	6	7	8
1	1	1	1	1	1	1	1

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FIGURE 7/X.32

User data identifier element

The length of the user data field is the number of octets between the user data identifier and the frame check sequence of the XID frame. The user data field element contains the X.32 identification protocol elements or X.32 optional user facilities which are described in § 7 (see Table 9/X.32).

In the scope of this Recommendation, the user data subfield should only be used in XID command frames, and while in the disconnected phase.

Since the use of layer subfields is for further study within the scope of this Recommendation, the format of the information field of the XID command frames is summarized in Figure 8/X.32.

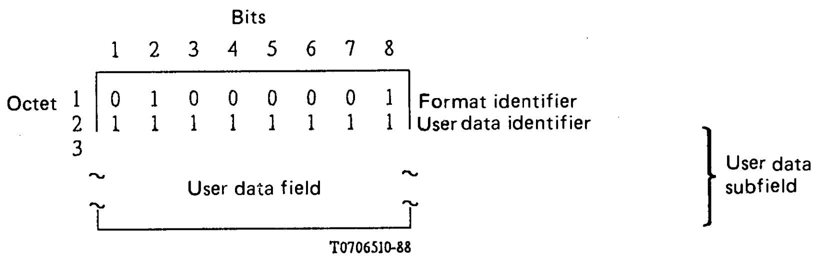


FIGURE 8/X.32

XID information field format

5.3.3 *XID procedures for identification and X.32 optional user facilities*

5.3.3.1 *General*

When a DTE/DCE determines that it is not able to act upon a received XID command, it will consider this XID command as not implemented and will act as specified in Recommendation X.25 (see Recommendation X.25, § 2.4.4.4.1 for the *disconnected* phase, and Recommendation X.25, § 2.4.6.1 for the *information transfer* phase).

When a DTE/DCE determines that it is able to act upon a received XID command, it shall process this command and acknowledge it by transmitting an XID response with the F bit set to the value of the P bit received in the XID command in any phase (*disconnected* phase or *information transfer* phase). The DCE shall and the DTE should set the P bit to 1 in the XID command frame.

For purposes of this Recommendation, the user data subfield shall only be used in XID command and while in the disconnected phase. A user data subfield will be ignored by the DCE when received in an XID response and/or while in the *information transfer* phase.

When transmitting an XID command, the DTE/DCE shall start timer T1. Timer T1 is stopped upon reception of the XID response with the F bit set to the value of the P bit sent in the XID command.

If timer T1 expires before the XID response (which has the F bit set to the value of the P bit sent in the XID command) is received by the DTE/DCE, the DTE/DCE retransmits the XID command and restarts timer T1. The maximum number of attempts made by the DTE or DCE to complete successful transmission of the XID command is defined by N2.

5.3.3.2 *Identification, authentication and selection of X.32 optional user facilities using XID frames*

The reception of an XID response by the DTE/DCE only means that the corresponding XID command has been correctly received by the DCE/DTE. If the DCE/DTE needs to transmit an identification protocol element or an X.32 facility element to the DTE/DCE, it shall transmit the element in an XID command.

Following successful identification/authentication and/or selection of X.32 optional user facilities using an XID exchange(s), the data link will be established under normal LAPB procedures (see § 5.4.1). If these procedures are not successful, the switched access path is disconnected (see § 5.4.2).

The identification of the DTE and/or DCE remains in effect until the link layer or the switched access path is disconnected.

5.4 *Link set-up disconnection*

5.4.1 *Link set-up*

The initiative of the link set-up is in the charge of the DTE in dial-in-by-the-DTE operation and of the DCE in dial-out-by-the-PSPDN operation. The DCE may also initiate link set-up in the case of dial-in-by-the-DTE operation; likewise, the DTE may also initiate link set-up in the case of dial-out-by-the-PSPDN operation.

When receiving a Set Asynchronous Balanced Mode (SABM) or Set Asynchronous Balanced Mode Exteded (SABME) (if supported) command during the identification procedure with XID frames, the DCE/DTE shall consider that the DTE/DCE does not want to complete the identification procedure. The DTE/DCE may then accept the link set-up initiation or may disconnect the link and the switched access path, depending on whether or not the DCE/DTE considers the completion of the identification process as mandatory.

During the period between transmitting an SABM/SABME command and receiving the UA response, the DCE/DTE shall discard any frame (including XID) except SABM/SABME, Disconnect (DISC), Unnumbered Acknowledge (UA) and Disconnected Mode (DM) as specified in § 2.4.4.1 of Recommendation X.25.

5.4.2 *Disconnection*

Whenever the DCE needs to disconnect the switched access path and the link is not already in the *disconnected* phase, it should first disconnect the link.

5.5. *Multilink*

The need for multilink procedures over switched access paths is left for further study.

5.6 *Half-duplex operation*

Figure 9/X.32 shows the half-duplex transmission module (HDTM) for extending LAPB for operation over the PSTN where half-duplex circuits are used. The signals which the two LAPX modules use in controlling the direction of the line are described.

Before the HDTM begins operation the physical circuit must be established by the appropriate PSTN call control procedures. The HDTM in the DTE or DCE which has established the switched access path will initially have the right to transmit. The DTE or DCE which originated the switched access path is the "calling DTE/DCE". The other DTE or DCE is the "called DTE/DCE".

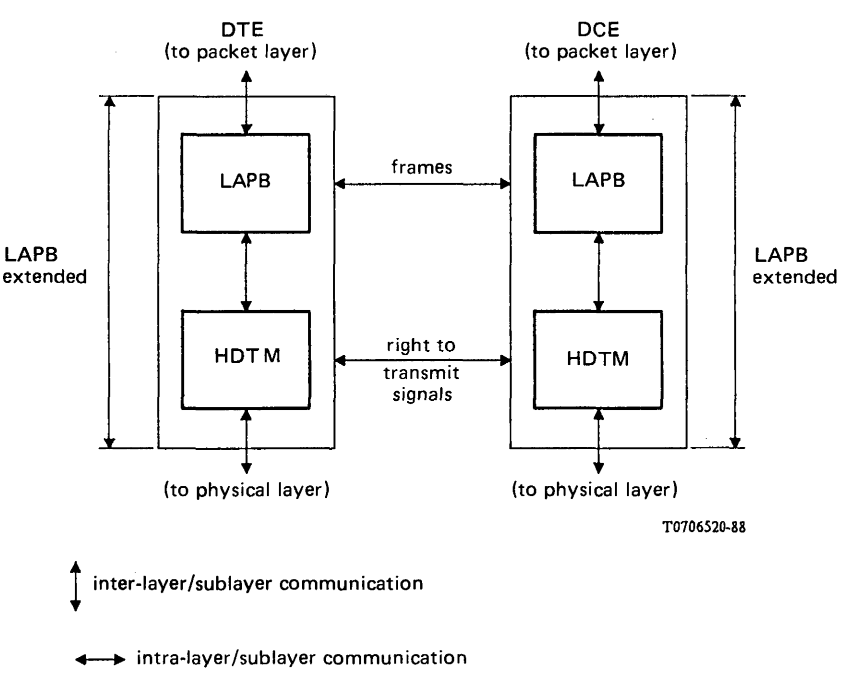


FIGURE 9/X.32

Link layer for PSTN access based on LAPB plus the HDTM

5.6.1 *Right to transmit*

The purpose of the HDTM is to coordinate the use of the half-duplex line between the DTE and DCE. It must exchange signals with the remote HDTM, interact with LAPB, and direct the physical level. The HDTM has the responsibility for deciding when to give up the right to transmit.

The right to transmit is exchanged between the DTE and DCE by using the idle channel state condition and flags as signals. Initially, the DTE or DCE which initiated establishing the physical connection has the right to transmit. That DTE or DCE sends the idle channel state condition when it has finished transmitting frames. After the line has been turned around, the other DTE/DCE sends flags to confirm the exchange of the right to transmit, until it has a frame to send. If the confirmation is not received in a certain amount of time, the DTE or DCE which gave up the right to transmit may take it again by sending flags.

Note – If no frame is sent, at least five flags must be sent as the minimum signal between receiving the right to transmit and relinquishing it again.

The meaning of the idle channel state condition in this Recommendation is different from that of Recommendation X.25. As a result, the T3 timer does not apply to half-duplex operation.

An optional alternative to the detection of the idle channel state condition is to use the detection of the carrier going OFF as the signal that the sending device is giving up the right to transmit. Also, an optional alternative to the detection of flags is to use the detection of the carrier going ON as the signal that the remote device has accepted the right to transmit. This alternative behavior should only be used with modems that give substantial protection from transient errors on the line.

In those situations where the physical layer cannot detect that the connection has been cut-off, an optional procedure, which detects the absence of any activity over a period of time and then disconnects the link, should be used.

5.6.2 *Layer relationships*

In adapting LAPB for half-duplex operation, modifications have been kept to a minimum. However, there is a functional requirement that the HDTM inhibit LAPB from sending frames during certain phases of the half-duplex procedure. The means of accomplishing this functional requirement are not defined in this Recommendation. Some considerations in implementing the HDTM are discussed in Appendix I.

The logical relationships among LAPB, the HDTM, and the physical layer are as shown in Figure 10/X.32.

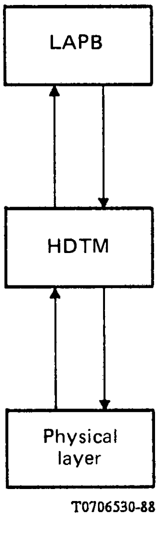


FIGURE 10/X.32

Layer relationships

5.6.3 *State definitions*

Five states of the HDTM are defined for describing the procedure used to keep track of the right to transmit.

5.6.3.1 *Idle state (state 0)*

The DTE/DCE is in an inactive state. This is the initial state prior to the establishment of the switched access path and the final state after termination of the switched access path.

5.6.3.2 *Half-duplex sending state (state 1)*

The DTE/DCE is in a half-duplex sending state, so that all signals generated by LAPB are passed to the physical layer. The calling DTE/DCE enters this state upon establishment of the switched access path.

5.6.3.3 *Wait for receiving state (state 2)*

The DTE/DCE is waiting for an indication that the remote DTE/DCE has entered the half-duplex sending state. No signals generated by LAPB are passed to the physical layer.

5.6.3.4 *Half-duplex receiving state (state 3)*

The DTE/DCE is in a half-duplex receiving state, so that no signals generated by LAPB are passed to the physical layer. The remote DCE/DTE is considered to be in the half-duplex sending state. The called DTE/DCE enters this state upon establishment of the switched access path.

5.6.3.5 *Wait for sending state (state 4)*

The DTE/DCE is awaiting indication of the availability of the physical layer for transmission of frames to the remote DCE/DTE. Flag, idle channel state condition, and abort signals are passed to the physical layer, but sending of frames is inhibited.

5.6.4 *Timer XT1*

A timer, XT1, is defined for use in recovering from an apparent failure of the remote DTE/DCE to take the right to transmit. To avoid a contention condition during this recovery process, different values of timer XT1 are to be used by the called and calling DTE/DCE. A calling DTE/DCE uses the value XT1 a, and a called DTE/DCE uses the value XT1 b.

The values of XT1a and XT1b are system parameters and have been left for further study.

5.6.5 *Counter XC1*

An optional counter, XC1, is defined for use in determining that the connection has been cut-off. It is incremented when the DTE or DCE is given the right to transmit or seizes the right to transmit and has not received a frame or at least five continuous flags. This counter is decremented if its value is greater than zero and the flags or a frame have been received. If the counter reaches a certain level, the switched call is assumed to be cut-off. The minimum value of this cut-off level is four.

5.6.6 *State diagram and descriptions*

The state diagram shown in Figure 11/X.32 describes the procedure used by the HDTM for controlling the right to transmit. The number in each ellipse is the state reference number. The transitions are caused by interactions between LAPB and the HDTM, interactions between the HDTM and the physical layer, signals from the remote HDTM, and timer expiration within the HDTM.

5.6.7 *State definitions expressed in terms applicable to a modem interface*

Taking the use of the HDTM with a V-series modem interface as an example, the following expressions of the state definitions can be made:

5.6.7.1 *Idle state (state 0)*

Circuit 107 is OFF. Circuit 105 is OFF. LAPB is inhibited from sending frames and is disconnected from circuit 103.

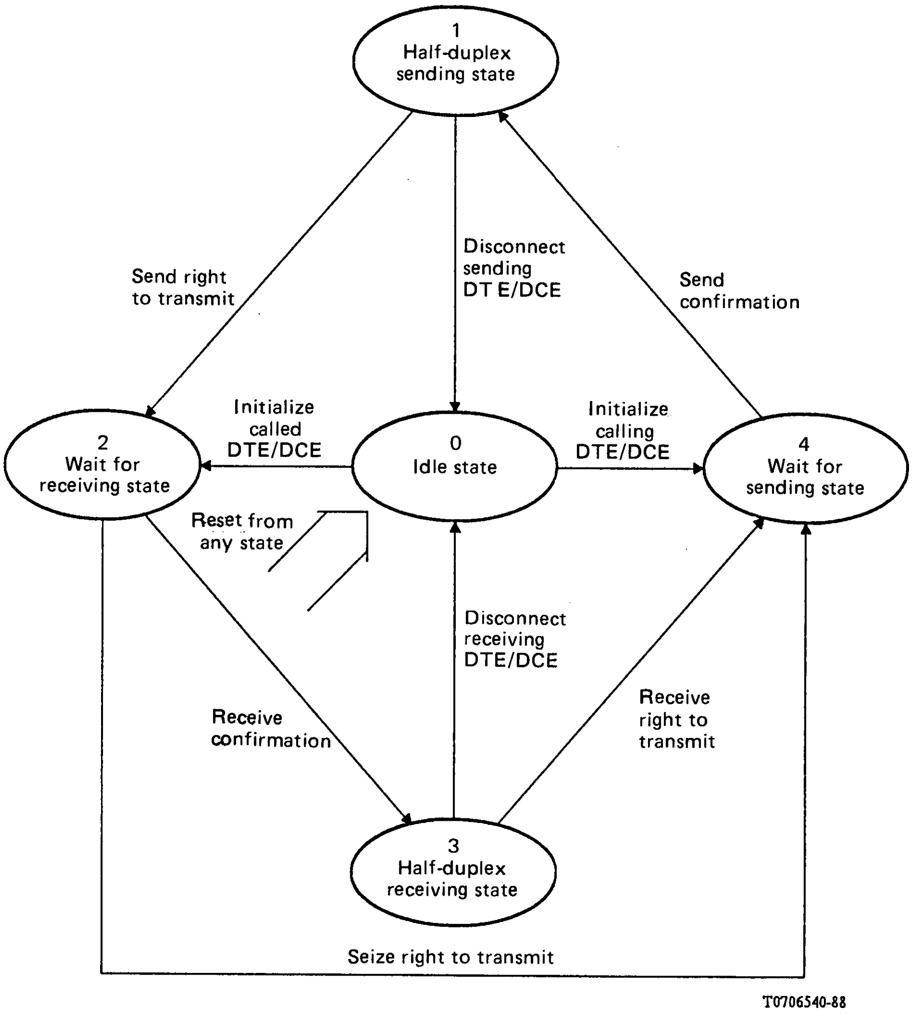


FIGURE 11/X.32

State diagram

5.6.7.2 *Half-duplex sending state (state 1)*

Circuit 105, circuit 106 and circuit 107 are ON. LAPB is connected to circuit 103 and enabled to send frames.

5.6.7.3 *Wait for receiving state (state 2)*

Circuit 107 is ON, circuit 105 is OFF. LAPB is inhibited from sending frames and disconnected from circuit 103, which is held in the binary 1 condition. Timer XT1 is running.

5.6.7.4 *Half-duplex receiving state (state 3)*

Circuit 107 is ON, circuit 105 is OFF. LAPB is inhibited from sending frames and disconnected from circuit 103, which is held in the binary 1 condition.

5.6.7.5 *Wait for sending state (state 4)*

Circuit 105 and circuit 107 are ON, and circuit 106 is OFF. LAPB is connected to circuit 103 but is inhibited from sending frames.

5.6.8 *Table of transitions between states expressed in terms applicable to a modem interface*

Continuing the example, Table 7/X.32 shows, in terms of a V-series modem interface, the events that cause a state transition and the resulting action(s).

TABLE 7/X.32

Description of state transitions in terms of a V-series modem interface

Present state	Transition name		New state
	Event	Action	
0	Initialize calling DTE/DCE		4
Idle state	Calling DTE/DCE: circuit 107 ON	Turn circuit 105 ON. Connect LAPB to circuit 103.	Wait for sending state
0	Initialize called DTE/DCE		2
Idle state	Called DTE/DCE: circuit 107 ON	Start timer XT1.	Wait for receiving state
1	Send right to transmit		2
Half-duplex sending state	Transmission concluded (see Note 1)	Inhibit sending of LAPB frames. Disconnect LAPB from circuit 103. Hold circuit 103 in the binary 1 condition. Turn circuit 105 OFF (see Note 2). Start timer XT1.	Wait for receiving state
1	Disconnect sending DTE/DCE		0
Half-duplex sending state	LAPB has entered a disconnected phase	Turn circuits 105 and 107 OFF.	Idle state
2	Receive confirmation		3
Wait for receiving state	Reception of a flag or detection of carrier ON (see Note 3)	Stop timer XT1.	Half-duplex receiving state
2	Seize right to transmit		4
Wait for receiving state	Expiry of timer XT1	Turn circuit 105 ON. Release circuit 103 from binary 1 condition. Connect LAPB to circuit 103.	Wait for sending state
3	Receive right to transmit		4
Half-duplex receiving state	Reception of 15 continuous 1 bits or detection of carrier OFF (see Note 4 and 5)	Turn circuit 105 ON. Release circuit 103 from binary 1 condition. Connect LAPB to circuit 103.	Wait for sending state

TABLE 7/X.32 *(cont.)*

Description of state transitions in terms of a V-series modem interface

Present state	Transition name		New state
	Event	Action	
3	Disconnect receiving DTE/DCE		0
Half-duplex receiving state	LAPB has entered a disconnected phase	Turn circuit 107 OFF.	Idle state
4	Send confirmation		1
Wait for sending state	Circuit 106 ON	Enable sending of LAPB frames (see Note 6).	Half-duplex sending state
Any	Reset from any state		0
	Circuit 107 OFF	Inhibit sending of LAPB frames. (Turn circuit 105 OFF.)	Idle state

Note 1 – The HDTM may determine that a transmission by the LAPB module has been concluded by either of the following:

– counting a sequence of continuous flags on circuit 103 while in state 1;

– a time-out;

– a signal from another source, e.g. from a higher level.

However, if no frame is transmitted while in state 1, not less than five continuous flags shall be sent in state 1 before entry into state 2.

Note 2 – It is recommended that circuit 105 not be turned OFF until 15 bit times after the binary 1 condition is established on circuit 103. This will assure transmission of an idle sequence to the remote DTE/DCE.

Note 3 – It is understood that circuit 109 will go ON. Entry into state 3 may be dependent on this condition as an implementation option.

Note 4 – It is recognized that whether or not an idle channel state condition sequence is sent by the remote DTE/DCE, the DTE/DCE will detect an idle channel state condition after circuit 109 goes OFF, since according to Recommendation V.24, § 4.3, this will hold circuit 104 in the binary 1 condition.

Note 5 – It is understood that circuit 109 will go OFF. Entry into state 4 may be made dependent on this OFF condition as an implementation option.

Note 6 – It is necessary to ensure that at least one full flag is transmitted after circuit 106 comes ON. This flag may be the opening flag of the first frame.

5.6.9 *Turnaround checkpoint retransmission*

In order to improve the efficiency of the LAPB procedure when using half-duplex circuits, it is highly recommended that an additional mechanism be implemented. It is called "turnaround checkpoint retransmission" and is described as follows:

- before a DTE/DCE gives the turn back (i.e. goes from state 1 to state 2 of Figure 11/X.32), it acknowledges all frames that were received and accepted during the time it was in state 3 (*Half-duplex receiving* state) before it got the turn;
- if a DTE/DCE gets the turn (i.e. transition from state 3 to state 4) or takes the turn (i.e. transition from state 2 to state 4 of Figure 11/X.32) then this DTE/DCE will first retransmit all I-frames that have not been acknowledged.

5.6.10 *Interworking with a DTE/DCE without turnaround checkpoint additional procedures*

The above procedure allows for interworking between a DTE/DCE having implemented the above additional mechanisms and a DCE/DTE not having implemented them.

In order to improve the efficiency of the procedure in such a case:

- a DTE/DCE having implemented the *turnaround checkpoint retransmission* is advised to replace the last RR frame of the transmit sequence, if any, by a REJ frame carrying the appropriate N(R).
- a DTE/DCE not having implemented *turnaround checkpoint retransmission* nevertheless acknowledges during a turn all frames which have been correctly received during the previous turn.

6 Packet layer

6.1 *Scope and field of application*

The formats and the procedures at the packet layer shall be in accordance with §§ 3, 4, 5, 6 and 7 of Recommendation X.25 with additions as noted in this section and in § 7 of this Recommendation.

If identification and authentication are done at the packet layer, identification and authentication of the identity of both the DTE and DCE will cease to apply when a failure on the physical layer and/or link layer is detected.

Some DTEs may choose to use the registration procedure for *on-line facility registration* immediately after the switched access path has been established and the link has been set up.

6.2 *Use of registration packets for identification of DTE and/or DCE and for conveyance of X.32 optional user facilities*

The registration procedure can be used for DTE and DCE identification at the packet layer. The *registration request* packet is used to convey identification protocol elements from the DTE to the DCE. The *registration confirmation* packet is used to convey identification protocol elements from the DCE to the DTE.

When using *registration* packets for DCE identification, it is necessary for the DTE to send a *registration request* packet in order to give the DCE an opportunity to identify itself.

Whenever DCE identification is being done via the registration procedure, a *registration confirmation* packet must be sent after the identification protocol has been completed in order for the registration procedure to be completed. If the DCE identification was not successful, this packet may contain identification protocol elements to begin the DCE identification procedure again, if allowed.

The identification protocol may be used for DTE identification and DCE identification at the same time. When this occurs, a registration packet may carry elements for both directions of identification simultaneously.

A DTE may specify X.32 optional user facilities in registration packets.

Descriptions of the identification protocol elements and X.32 facilities are listed in § 7.2.

When the *registration request* or the *registration confirmation* packet is used for identification and/or the conveyance of X.32 optional user facilities, the elements and/or facilities (see § 7.3) are carried in the registration field.

Registration packets may be used to perform identification, conveyance of X.32 facilities, and on-line facilities negotiation in the same packets, subject to the restriction of § 7.1.2, below (see § 7.3 of Recommendation X.25).

6.3 *Identification and authentication of the DTE using the NUI selection facility in call set-up packets*

The *NUI selection* facility in *call set-up* packets can be used for DTE identification on a per virtual call basis. It can also be used in addition to one of the prior-to-virtual-call DTE identification methods. This NUI identification remains in effect for the lifetime of the virtual call and is independent of any previous NUI identification on the interface. Subsequent call requests on the switched access path will either revert to the prior DTE service on the interface or receive a DTE service associated with a NUI.

The *NUI selection* facility parameter may contain as the *DTE identity* either a user identifier plus a password assigned by the network to the DTE, or only a password assigned by the network to the DTE. The formats of the user identifier and the password are national matters. The following cases describe the operation of the *NUI selection* facility:

1) When a *DTE identity* has been established using a prior-to-virtual-call DTE identification method, the *NUI selection* facility may be used if the *NUI subscription* and/or the *NUI override* facilities are set by the network. In this case, the *NUI selection* facility applies conforming to the procedures described in Recommendation X.25 (see § 6.21/X.25).

2) When a *DTE identity* has not been established using a prior-to-virtual-call identification method and the *NUI selection* facility is used, the *identified DTE* service (see § 3.4) is selected (when supported by the network). Two subcases are possible:

   a) *NUI override* facility is set by the network when a *call request* packet containing a valid NUI is sent, the features subscribed to by the DTE identified by that NUI and associated with that NUI apply to the virtual call;

   b) *NUI override* facility is not set by the network when a *call request* packet containing a valid NUI is sent, the default *X.25 subscription set* applies to the virtual call.

In both cases a) and b), the NUI remains in effect only for the lifetime of the virtual call.

7 **X.32 procedures, formats and facilities**

7.1 *Identification protocol*

7.1.1 *Protocol elements*

The identification protocol is for exchanging identification and authentication information in one or more pairs of messages. The two parties involved in this protocol are called the questioning party and the challenged party.

Two security options are defined: the basic option described as *security grade 1* and an enhanced option described as *security grade 2.* The identification and authentication information are encoded in the following protocol elements:

a) The identity element (ID) is a string of octets representing the DTE or DCE identity (see §§ 2.2.1 and 2.2.2, respectively) of the challenged party.

b) The signature element (SIG) of the identity is a string of octets associated with the identity and used for authentication of the identity. It is assigned for a period of time by the authority that assigns the identity and may be changed from time to time. For example, the SIG may be a password or the result of an encryption process applied to the identity element (ID) of the challenged party.

c) The random number element (RAND) is a string of octets which is unpredictable for each identification exchange. It is used only in the security grade 2 option.

d) The signed response element (SRES) of the challenged party is the reply to the RAND protocol element by the questioning party. It is used only in the security grade 2 option.

e) The diagnostic element (DIAG) is the result of the identification process and is transmitted by the questioning party at the end of the process.

The format of these elements is shown in § 7.3.

The sizes of values of the identity, signature and random number elements are a national matter and depend on a number of factors including:

a) whether the authentication is of DTE identity or DCE identity,

b) the grade of security,

c) the method of identification,

d) the possibilities of future improvements in computational techniques, and

e) whether the PSPDN directly assigns DTE identities or adopts, through pre-arrangement, the DTE identities assigned by the PSN or another authority.

7.1.2 *Identification protocol procedure*

The first message of a pair is transmitted by the challenged party. The second message of the pair is transmitted by the questioning party. Security grade 1 provides a single exchange of elements ID [, SIG], and DIAG, whereas security grade 2 uses an additional exchange of RAND and SRES elements to provide a greater degree of security.

Note – In both security grades 1 and 2, SIG may be omitted if not required by the questioning party. If it is not required, its presence is not considered in error.

The identification protocol elements are passed between the parties in either a sequence of XID command frames or registration packets. Networks may offer either or both methods of security exchange, but an entire identification exchange must be done entirely with only one method.

The identification protocol may be used for DTE identification simultaneously but independently of its use for DCE identification. When this occurs, a registration packet or XID frame may carry elements for both directions of identification simultaneously.

The identification established using the identification protocol applies for the duration of the switched access. That is, once the DIAG element indicating acceptance of the DTE/DCE identity has been sent, the switched access path must be disconnected before another attempt to use the identification protocol to identify that challenged party can be made.

If the identification protocol is not successful, that is, the DIAG element indicates refusal of the DTE/DCE identity, the questioning party should disconnect the switched access path. In the case of security grade 1, a network may allow up to three retries of the identification protocol (i.e., the DIAG element indicates refusal of the DTE/DCE identity) before the switched access path is disconnected when the network is the questioning party. For security grade 2, only one attempt to perform the identification protocol is permitted when the network is the questioning party.

The actions of the DCE when acting as the challenged or questioning party are further described by the state diagrams and tables in Annex A.

The security grade applied on a particular switched connection is determined by the subscription of the DTE with the Administration. It is not negotiable on a per call basis. Not all networks will offer both security grade options. The use of certain optional features may be restricted to a particular security grade. A positive and secure DTE identification is limited to the security of the switched access path, particularly in dial-out-by-the-PSPDN operation.

In order to avoid situations in which both parties are waiting for the other to identify first, these principles will be followed:

a) Each party should send its identity, if capable and willing, at the earliest opportunity. However, the called party is not required to send its own identity before complete identification of the calling party.

b) If the calling party does not send its identity, the called party has a choice of operating a service not requiring identification or disconnecting the switched connection.

Security grade 1 involves a single pair of messages as shown in Figure 12/X.32. First, the challenged party sends its identity (ID) and, if required, its signature (SIG). The questioning party responds with the diagnostic (DIAG).

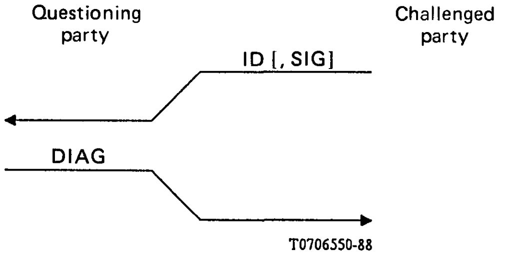


FIGURE 12/X.32

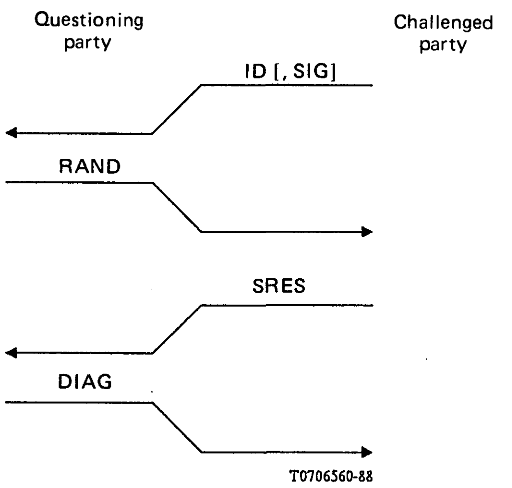
Security grade 1

As shown in Figure 13/X.32, security grade 2 involves an additional authentication exchange if the initial response (ID [, SIG]) of the challenged party is valid. If ID is an identity unknown to the questioning party or if the SIG element is required by the questioning party but either it is not present or is inconsistent with the claimed identity, then an error diagnostic (DIAG) is issued and the access path is disconnected. Otherwise, the questioning party will generate and send a random number (RAND) which the challenged party will encrypt and return as its signed response (SRES). The questioning party will then decrypt SRES and, if this operation results in a value identical to RAND, the appropriate diagnostic (DIAG) is sent to the challenged party and the identification process is successfully completed. Otherwise, an error diagnostic (DIAG) is returned and the access path is disconnected.

Note 1 – It is left for further study whether or not to define, as a mechanism for protecting against specific forms of intrusion, that the value of RAND is odd or even depending on the direction of the switched access call.

Note 2 – If the network does not store the public keys of DTEs, the SIG can be used to convey the public key and other information characteristics of the DTE (e.g., indication of security level two is to be used). Private keys of the DTE, if any, are not included in the SIG information. In order to add to the protection, this information can be encrypted via the private key of the network.

If on-line facility registration is done simultaneously with identification, the DTE shall do so only in the packet containing SRES. If on-line facility registration is attempted prior to SRES, it will be refused by the network with a cause code value of *local procedure error.*



Note – The exchange depicted illustrates the case where the initial ID [, SIG] message was valid.

FIGURE 13/X.32

Security grade 2

7.1.3 *Identification protocol formats*

The formats for the identification protocol elements are defined in § 7.3 of this Recommendation in accordance with §§ 6 and 7 of Recommendation X.25. The elements are coded identically in registration packets and XID frames.

7.2 *Procedures for X.32 optional user facilities*

7.2.1 *Secure dial-back facility*

Networks that implement both the dial-in-by-the-DTE and dial-out-by-the-PSPDN operations may provide, as an optional user facility agreed for a period of time, a dial-back procedure. This facility, if subscribed to, combines the dial-in-by-the-DTE operation with the dial-out-by-the-PSPDN operation to offer additional protection when the identity of the DTE becomes known to the network. This procedure allows, in the *customized* DTE service, a DTE to use the dial-in-by-the-DTE operation, identity itself, and disconnect. Security is achieved in using the *identity element* of the identification protocol and a dial-out-by-the-PSPDN to the *registered PSN number.* The network uses the dial-out-by-the-PSPDN operation to dial back the DTE using the *registered PSN number.* The DCE identifies itself and the DTE identifies itself again. Some networks may offer the additional feature of limiting the use of the *secure dial-back* facility to specific hours of operation of the DTE.

The grade of security for *secure dial-back* is not negotiable per switched access call. It is one aspect of the identity and its value is set when pre-registering to the authority that defines the identity.

After the DTE has correctly identified itself to the DCE during dial-in-by-the-DTE, the DCE sends a *request for dial-back confirmed* via the *diagnostic element* of the identification protocol. Then the DTE and network should disconnect the link, if necessary, and then the switched access path as soon as possible. The network should then initiate the dial-back to the DTE as soon as possible by using dial-out-by-the-PSPDN.

If, during the dial-in-by-the-DTE operation, the DCE is aware that it cannot perform the dial-back, the DCE will indicate to the DTE that dial-back is not possible. This indication is given via the *diagnostic element* of the identification protocol.

When the DCE disconnects the switched access path on the dial-in-by-the-DTE it starts DCE timer T15. The DCE then attempts the dial-out-by-the-PSPDN operation as soon as possible. The period of timer T15, at the end of which the DCE abandons the attempt to dial out to the DTE, is a system parameter agreed for a period of time with the Administration.

When the network dials out, the DCE includes a "dial-back indication" to the DTE via the *diagnostic element* of the identification protocol.

If the DTE receives an unsolicited dial-back from the DCE, the switched access path may be disconnected.

Note – As some PSTN networks implement *calling party clear,* a PSPDN may wish to restrict dial-back to an outgoing only PSTN port.

7.2.2 *Temporary location facility*

Temporary location is an optional user facility that applies to the DTE/DCE interface for registered DTEs that accept dial-out calls from the PSPDN.

This facility can be used to substitute a different switched access number for dial-out-by-the-PSPDN to the DTE other than the *registered PSN number.* The switched access number specified is an X.121 number from the PSN numbering plan.

Note – Extension of a switched access number to accommodate additional digits, secondary digits, secondary dial tone, or dialling delays as allowed by V.25 and/or X.24 is left for further study.

In addition, a DTE may specify, by means of this facility, the periods of time during which it may be reached at a valid number for the PSN.

During those periods not identified by this facility, the number used to reach the DTE will be its *registered PSN number.*

The substitute number goes into effect at the "stay initiation" date and time. The substitute number is no longer in effect at the "stay termination" date and time.

At the expiration of the time given in the *temporary location* facility, the number used for dial-out-by-the-PSPDN reverts to the *registered PSN number.*

Use of the *temporary location* facility by the called DTE will not cause the *called line address modified notification* facility to be inserted in the *Call Connected* packet. However, the *called line address modified notification* facility will appear in the *Call Connected* packet according to normal conditions of Recommendation X.25.

7.3 *Coding of the identification protocol elements and X.32 facilities*

7.3.1 *General*

The general principles for coding of the identification protocol elements and X.32 facilities are the same as the ones specified for the registration field in § 7.1 of Recommendation X.25. The statements of § 7.1 of Recommendation X.25 concerning facilities do not apply to this section. The statements of § 7.1 of Recommendation X.25 concerning registration elements apply to the identification protocol elements and X.32 facilities in this section.

7.3.2 *Coding of the identification protocol element and X.32 facility code fields*

Table 8/X.32 gives the list of the identification protocol element and X.32 facility codes, the coding for each, and, where applicable, whether this code may be sent by the challenged or the questioning party.

TABLE 8/X.32

Identification protocol element and X.32 facility codes

Identification element or facility code	May be sent by		Bits							
	challenged party	questioning party	8	7	6	5	4	3	2	1
Identity element	X		1	1	0	0	1	1	0	0
Signature element	X		1	1	0	0	1	1	0	1
Random number element		X	1	1	0	0	1	1	1	0
Signed response element	X		1	1	0	0	1	1	1	1
Diagnostic element		X	0	0	0	0	0	1	1	1
Temporary location			1	1	0	1	0	0	0	0

7.3.3 *Coding of the identification protocol element and X.32 facility parameter fields*

7.3.3.1 *Identity element*

The octet following the code field indicates the length, in octets, of the parameter field. The following octets contain the string of octets composing the identity.

7.3.3.2 *Signature element*

The octet following the code field indicates the length, in octets, of the parameter field. The following octets contain the string of octets composing the signature.

7.3.3.3 *Random number element*

The octet following the code field indicates the length, in octets, of the parameter field. The following octets contain the string of octets composing the number which is the random number element. It is binary coded with bit 8 of the first octet following the parameter length being the high order bit and bit 1 of the last octet being the low order bit. If the number of significant bits of the random number is not octet-aligned, then zeroes precede the most significant bit to make it octet-aligned.

7.3.3.4 *Signed response element*

The octet following the code field indicates the length, in octets, of the parameter field. The following octets contain the string of octets composing the number which is the signed response. It is binary coded with bit 8 of the first octet following the facility parameter length being the high order bit and bit 1 of the last octet being the low order bit. If the number of significant bits of the signed response is not octet-aligned, then zeroes precede the most significant bit to make it octet-aligned.

7.3.3.5 *Diagnostic element*

The coding of the parameter field for the *diagnostic element* is shown in Table 9/X.32.

TABLE 9/X.32

Coding of the parameter field for the diagnostic element

	Bits							
	8	7	6	5	4	3	2	1
Identification/authentication confirmed	0	1	1	1	1	1	1	1
Identification or authentication failed (Note 1)								
– general	1	0	0	0	0	0	0	0
– additional	1	X	X	X	X	X	X	X
Network congestion (Note 2)	0	0	0	0	0	1	0	1
Identification in use (Note 3)	0	0	0	1	0	1	1	1
Dial-back indication (Note 4)	0	0	1	1	1	1	1	1
Network congestion for dial-back (Note 4)	0	0	0	1	1	0	1	1
Request for dial-back confirmed (Note 4)	0	0	0	1	1	1	1	1

Note 1 – Bits 7 to 1 are for maintenance purposes and are a national matter. Complete specification and provision of this information to a user represents a possible compromise of security by providing details of authentication failure.

Note 2 – Replacement of this *call progress* signal is for further study in close liaison with the revision of Recommendation X.96.

Note 3 – Whether multiple switched connections can be simultaneously active using the same *DTE identity* is for further study.

Note 4 – Used only in conjunction with the *secure dial-back* facility (see § 7.2.1).

7.3.3.6 *Temporary location facility*

The octet following the code field indicates the length, in octets, of the parameter field.

The parameter field consists of one or more instances of temporary location requested by the DTE.

For each instance of temporary location, the first 5 octets indicate the date and time of the stay initiation. The next 5 octets indicate the date and time of the stay termination. The octet following the stay termination indicates the number of semi-octets in the switched access number and is binary encoded. The following octets contain the switched access number.

Date and time of initiation/termination is a string of 10 decimal digits expressing the coordinated universal time (UTC) and has the form YYMMDDhhmm. YY is the two low-order digits of the Christian era year, and MM, DD, hh, and mm are the month, day, hour, and minute, respectively. The 10 decimal digits are BCD encoded in 5 octets with the first digit of the year encoded into bits 8 to 5 of the first octet and the last digit of the minute encoded into bits 4 to 1 of the fifth octet.

A value of all zeros for stay initiation will indicate the DTE's desire for immediate initiation.

A value of all zeros for stay termination will indicate the DTE's desire for the switched number to remain in effect until subsequent replacement (i.e., permanently).

Note – Some networks may only permit the stay termination and/or stay initiation fields to contain all zeros. In that case, the number of instances of temporary location is limited to one.

The switched access number is coded as a series of semi-octets. Each semi-octet contains either a digit in binary coded decimal or a special value in the range 1010-1111 binary.

Note – The special values may be used to accommodate the capabilities of V.25 and/or X.24, particularly in specifying secondary dial tone and dialling delays. Such use is left for further study.

If the switched access number contains an odd number of semi-octets, it is followed by a semi-octet containing zeros.

A switched number length of zero will indicate that the DTE is unavailable.

7.4 *Security grade 2 method*

The authentication method in security grade 2 provides for the use of encryption to prevent unauthorized access subject to the constraints of unit cost and computation time. One example of a public key encryption technique which could be used for this purpose is given in Appendix II. The selection and use of security grade 2 algorithms is a national matter.

Note – Further study, in close cooperation with ISO/TC 97/SC 20, will define the characteristics and length constraints of the various numbers and parameters to be used in security grade 2 algorithms. The definition of the parameters of an algorithm should strike a balance between the cost and the complexity of the algorithm, and the value of that which is protected. The goal is to make the cost of breaking the code exceed the cost of obtaining the network resources by authorized means.

7.5 *DCE timer T14*

The DCE may support a timer T14, the value of which should be made known to the DTE.

At the expiration of timer T14, the DCE will disconnect the link, if connected, then the switched access path.

Timer T14 is started whenever a switched access path is established. Timer T14 is stopped when either the *DTE identity* is established or a virtual call(s) is established which is not to be charged to the local DTE. In the latter case, timer T14 will be restarted when no assigned logical channels are active.

The relationships of timer T14 to the different methods of DTE identification are illustrated in Appendix III.

The period of timer T14 shall be network dependent.

7.6 *DCE timer T15*

Timer T15 is used in conjunction with the secure *dial-back* facility (see § 7.2.1).

The period of timer T15 is left for further study.

ANNEX A

(to Recommendation X.32)

Actions taken by the DCE in the roles of questioning and challenged parties for security grade 1 and security grade 2 identifications

A.1 *Introduction*

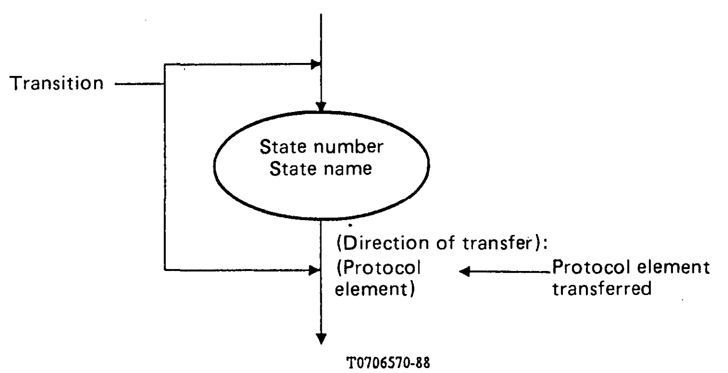
This annex specifies the actions taken by the DCE when it acts as the questioning and challenged parties for security grade 1 and security grade 2 identifications. When performing the identification procedure described in § 7.1.2, the DCE shall act as described in this annex.

Note – As the identification protocol is symmetrical and should be used by the DTE in the same manner as the DCE, the actions of the DTE should correspond directly to the actions defined for the DCE.

The identification protocol is presented as a succession of state diagrams and corresponding tables.

In this annex, a DIAG element is considered as positive when its parameter field means *identification/authentication confirmed, request for dial-back confirmed,* or *dial-back indicator* (see § 7.3.3.5). It is considered as negative in other cases.

A.1.1 *Symbol definition of state diagrams*



Note 1 – Each state is represented by an ellipse wherein the state name and number are indicated.

Note 2 – Each state transition is represented by an arrow. The direction of transfer and the protocol element that has been transferred are indicated beside that arrow.

A.1.2 *Definition of actions*

In each table, the actions taken by the DCE as the questioning party or the challenged party are indicated in the following way:

NORMAL:	Normal event; protocol elements received are handled as described in § 7.1.2.
DISCARD:	Received message is discarded.
RAND:	RAND transmitted.
Positive DIAG:	Positive DIAG transmitted.
Negative DIAG:	Negative DIAG transmitted.
ID [, SIG]:	ID [, SIG] transmittted.
SRES:	SRES transmitted.

Each entry in the tables in this annex gives, first, the action taken, if any, then an arrow indicating the transition, and finally, the state that the DCE as the questioning or challenged party will enter.

A.2 *Security grade 1 identification*

A.2.1 *DCE acting as the questioning party*

The DCE acts as the questioning party for security grade 1 when it offers *identified* or *customized* DTE service via the XID or registration DTE identification method with grade 1 authentication. Four states are defined for describing the procedures the DCE uses:

a) *q11 – Waiting for ID [, SIG] (grade 1)*

This is the initial state of the DTE identification process. It is entered after the switched connection is established and, when the registration procedure DTE identification method is used, after the link layer is set up. In this state, the DCE expects to receive the ID (and possibly SIG) element(s) from the DTE. If the DCE allows retrying the identification protocol, this state is also entered when a DTE identification attempt has failed and the limit of retries has not been exhausted.

b) *q12 – Evaluating ID [, SIG] (grade 1)*

In this state, the DCE determines whether or not the DTE identity that was presented in the ID (and possibly SIG) element(s) is acceptable. The result is the transmission by the DCE to the DTE of the DIAG element, which has as its value the success or not of the acceptability evaluation.

c) *q13 – DTE identification successful (grade 1)*

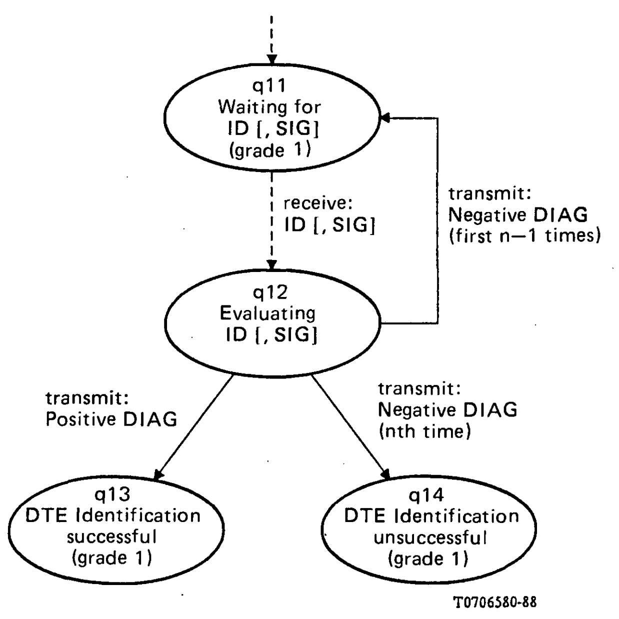
In this state, the DCE provides the *identified* or *customized* DTE service to the identified DTE. The DCE remains in this state until the switched connection is disconnected.

d) *q14 – DTE identification unsuccessful (grade 1)*

In this state, the DCE does not provide the *identified* or *customized* DTE service (unless NUI is used on a per virtual call basis for the *Identified* DTE service) but may provide the *Nonidentified* DTE service if it is supported. The DCE enters this state when the last DTE identification attempt allowed by the retry limit has failed. The DCE remains in this state until the switched connection is disconnected.

Figure A-1/X.32 provides the state diagram for the DCE acting as the questioning party in the case of security grade 1 identification.

The actions to be taken by the DCE acting as the questioning party for security grade 1 identification, when one of the listed events occurs, are indicated in Table A-1/X.32.



n = number of DTE identification attempts permitted

FIGURE A-1/X.32

Diagram of states for DCE acting as questioning party for security grade 1 identification

TABLE A-1/X.32

Actions taken by the DCE as the questioning party (security grade 1)

State of the DCE acting as the questioning party / Protocol element received by the DCE or decision by the DCE	q11 Waiting for ID [, SIG] (grade 1)	q12 Evaluating ID [, SIG] (grade 1)	q13 Identification successful (grade 1)	q14 DTE identification unsuccessful (grade 1) (see Note 1)
ID [, SIG]	NORMAL → q12	DISCARD → q12	DISCARD → q13	DISCARD → q14
DCE checking of the ID [, SIG] is complete	////////////////	Positive DIAG → q13 or negative DIAG → q14 or → q11 (see Note 2)	////////////////	////////////////

Note 1 – When in this state, the DCE should disconnect the switched access path when it is sure that the DIAG element has been received by the challenged party or the challenged party is out-of-order.

Note 2 – Depending on whether or not ID and/or SIG are recognized as correct by the DCE. When negative DIAG, go to q11 until the retry limit has been reached.

A.2.2 *DCE acting as the challenged party*

The DCE acts as the challenged party for security grade 1 when it identifies itself to the DTE via the XID or registration DCE identification method with grade 1 authentication. Four states are defined for describing the procedures the DCE uses:

a) *c11 – Initial challenged (grade 1)*

This is the initial state of the DCE identification process. It is entered after the switched connection is established, and, when the registration procedure DCE identification method is used, after the link layer is set up. In this state, the DCE transmits the ID (and possibly SIG) element(s) to the DTE.

b) *c12 – Waiting for DIAG (grade 1)*

In this state, the DCE expects to receive the DIAG element which has as its value the acceptability or not of the DCE identity.

c) *c13 – DCE Identification successful (grade 1)*

In this state, the DCE has completed its identification successfully. The DCE remains in this state until the switched connection is disconnected.

d) *c14 – DCE Identification unsuccessful (grade 1)*

The DCE enters this state when the DCE identification attempt has failed. The DCE remains in this state until the switched connection is disconnected.

Figure A-2/X.32 provides the state diagram for the DCE acting as the challenged party in the case of security grade 1 identification.

The actions to be taken by the DCE as the challenged party for security grade 1 identification, when one of the listed events occurs, are indicated in Table A-2/X.32.

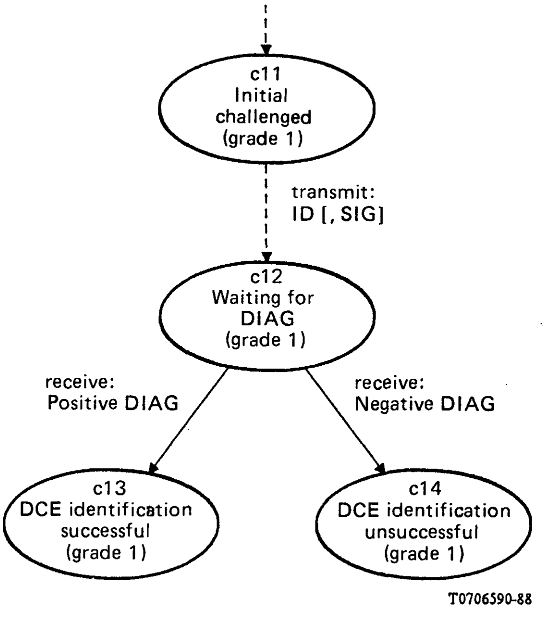


FIGURE A-2/X.32

Diagram of states for DCE acting as challenged party for security grade 1 identification

TABLE A-2/X.32

Actions taken by the DCE as the challenged party (security grade 1)

State of the DCE acting as the challenged party / Protocol element received by the DCE or decision by the DCE	c11 Initial challenged (grade 1)	c12 Waiting for DIAG (grade 1)	c13 Identification successful (grade 1)	c14 Identification unsuccessful (grade 1) (see Note 1)
DCE decides it wants to be identified	ID [, SIG] → c12	//////////////// ////////////////	//////////////// ////////////////	//////////////// ////////////////
Positive DIAG	NORMAL → c13 or c14 (see Note 2)	NORMAL → c13	DISCARD → c13	DISCARD → c14
Negative DIAG	NORMAL → c14	NORMAL → c14	DISCARD → c13	DISCARD → c14

Note 1 – In this state, the DCE shall disconnect the switched access path.

Note 2 – c13 or c14 depending on whether or not the DCE wants to be identified.

A.3 *Security grade 2 identification*

A.3.1 *DCE acting as the questioning party*

The DCE acts as the questioning party for security grade 2 when it offers *identified* or *customized* DTE service via the XID or registration DTE identification method with grade 2 authentication. Six states are defined for describing the procedures the DCE uses:

a) *q21 – Waiting for ID [, SIG] (grade 2)*

This is the initial state of the DTE identification process. It is entered after the switched connection is established and, when the registration procedure DTE identification method is used, after the link layer is set up. In this state, the DCE expects to receive the ID (and possibly SIG) element(s) from the DTE.

b) *q22 – Evaluating ID [, SIG] (grade 2)*

In this state, the DCE begins determining whether or not the DTE identity that was presented in the ID (and possibly SIG) element(s) is acceptable. If the DTE identity is acceptable or the acceptability is not fully determined in this state, the DCE generates the value for the RAND element and transmits it to the DTE. If the DTE identity is unacceptable, the DCE transmits to the DTE the DIAG element with a negative value.

c) *q23 – Waiting for SRES*

In this state, the DCE expects to receive the SRES element from the DTE. The DCE may continue to evaluate the ID (and possibly SIG) element(s) and, if the DTE identity is unacceptable, the DCE transmits to the DTE the DIAG element with a negative value.

d) *q24 – Evaluating SRES*

In this state, the DCE determines if the value presented in the SRES element is correct for the DTE identity. If the evaluation of the ID [, SIG] element(s) has not already been completed, it is completed in this state. The results of the SRES check (and the last of the ID [, SIG] check) is transmitted by the DCE to the DTE as the value of the DIAG element.

e) *q25 – DTE identification successful (grade 2)*

In this state, the DCE provides the *identified* or *customized* DTE service to the identified DTE. The DCE remains in this state until the switched connection is disconnected.

f) *q26 – DTE identification unsuccessful (grade 2)*

In this state, the DCE does not provide the *identified* or *customized* DTE service (unless NUI is used on a per virtual call basis for the *identified* DTE service) but may provide the *nonidentified* DTE service if it is supported. The DCE remains in this state until the switched connection is disconnected.

Figure A-3/X.32 provides a state diagram for the DCE acting as the questioning party in case of security grade 2 identification.

The actions to be taken by the DCE as the questioning party for security grade 2 identification, when one of the listed events occurs, are indicated in Table A-3/X.32.

A.3.2 *DCE acting as the challenged party*

The DCE acts as the challenged party for security grade 2 when it identifies itself to the DTE via the XID or registration DCE identification method with grade 2 authentication. Six states are defined for describing the procedures the DCE uses:

a) *c21 – Initial challenged (grade 2)*

This is the initial state of the DCE identification process. It is entered after the switched connection is established, and, when the registration procedure DCE identification method is used, after the link layer is set up. In this state, the DCE transmits the ID (and possibly SIG) element(s) to the DTE.

b) *c22 – Waiting for RAND*

In this state, the DCE expects to receive the RAND element. If the ID (and possible SIG) are not acceptable to the DTE, the DCE may receive the DIAG element with a negative value.

c) *c23 – Calculating SRES*

Using the value of the RAND element, the DCE calculates the value for the SRES element and transmits it to the DTE. If the DTE has continued to evaluate the ID (and possibly SIG) and determined that it is not acceptable, the DCE may receive the DIAG element with a negative value.

d) *c24 – Waiting for DIAG (grade 2)*

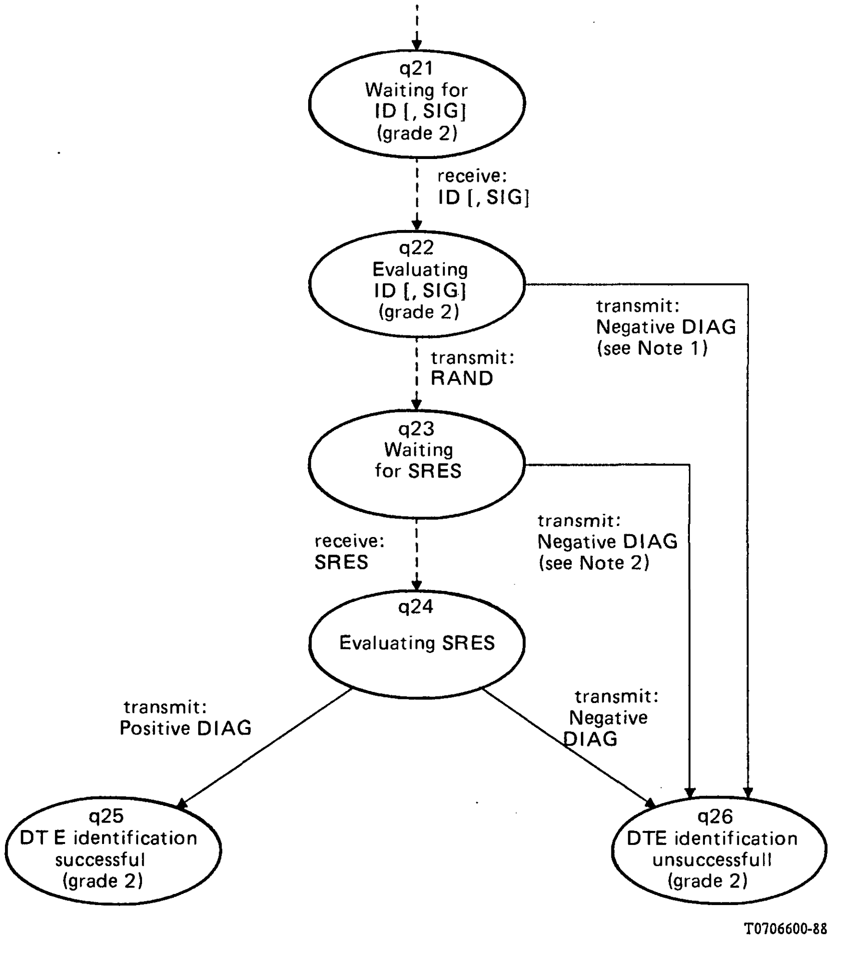
In this state, the DCE expects to receive the DIAG element which has as its value the acceptability or not of the DCE identity and SRES value.

e) *c25 – DCE identification successful (grade 2)*

In this state, the DCE has completed its identification successfully. The DCE remains in this state until the switched connection is disconnected.

f) *c26 – DCE identification unsuccessful (grade 2)*

The DCE enters this state when the DCE identification attempt has failed. The DCE remains in this state until the switched connection is disconnected.



Note 1 – If an error in the ID and/or SIG is found before RAND is transmitted.

Note 2 – If an error in the ID and/or SIG is found after RAND is transmitted.

FIGURE A-3/X.32

Diagram of states for DCE acting as the questioning party for security grade 2 identification

TABLE A-3/X.32

Actions taken by the DCE as the questioning party (security grade 2)

State of the DCE acting as the questioning party / Protocol element received by the DCE or decision by the DCE	q21 Waiting for ID [, SIG] (grade 2)	q22 Evaluating ID [, SIG] (grade 2)	q23 Waiting for SRES	q24 Evaluating SRES	q25 DTE identification successful (grade 2)	q26 DTE identification unsuccessful (grade 2) (see Note 1)
ID [, SIG]	NORMAL → q22	DISCARD → q22	DISCARD → q23	DISCARD → q24	DISCARD → q25	DISCARD → q26
At least initial DCE checking of the ID [, SIG] is complete	//////////////	RAND → q23 or Negative DIAG → q26 (see Note 2)	//////////////	//////////////	//////////////	//////////////
Further DCE checking (if any) of the ID [, SIG] is complete	//////////////	//////////////	NORMAL → q23 or Negative DIAG → q26 (see Note 3)	//////////////	//////////////	//////////////
SRES	Negative DIAG→ q26	Negative DIAG→ q26	NORMAL → q24	DISCARD → q24	DISCARD → q25	DISCARD → q26
DCE checking of the SRES is complete	//////////////	//////////////	//////////////	Positive DIAG → q25 or Negative DIAG → q26 (see Note 4)	//////////////	//////////////

Note 1 – When in this state, the DCE should disconnect the switched access path when it is sure that the DIAG element has been received by the challenged party, or the challenged party is out-of-order.

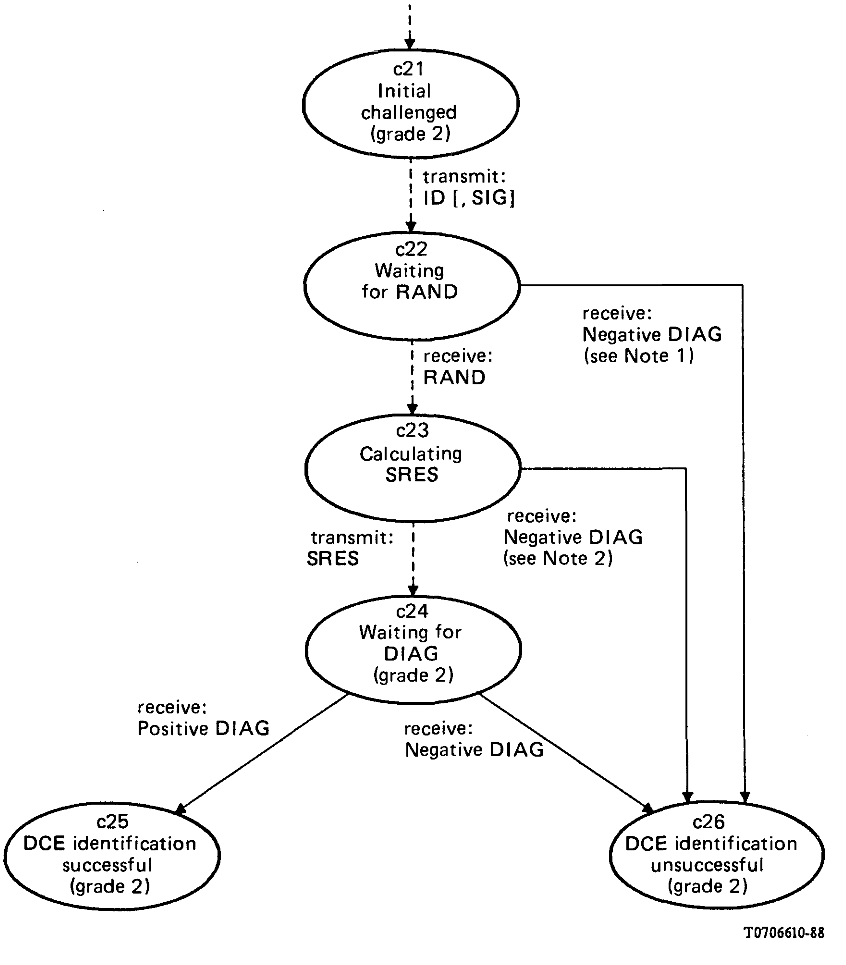
Note 2 – As negative DIAG is sent if the DCE has detected ID [, SIG] as incorrect. RAND is sent if the DCE has detected ID [, SIG] as correct or if it has not yet checked ID [, SIG].

Note 3 – After having transmitted RAND, if the DCE detects that the ID [, SIG] received when in state q21 was incorrect, it transmits a negative DIAG and goes into state q26. Otherwise, the DCE continues with the normal process of waiting to receive the SRES element.

Note 4 – q25 ou q26 depending on whether or not the SRES is recognized as correct by the DCE.

Figure A-4/X.32 provides a state diagram for the DCE acting as the challenging party in case of security grade 2 identification.

The actions to be taken by the DCE for security grade 2 identification, when one of the listed events occurs, are indicated in Table A-4/X.32.



Note 1 – If an error in the ID and/or SIG is found before RAND is transmitted.

Note 2 – If an error in the ID and/or SIG is found after RAND is transmitted.

FIGURE A-4/X.32

Diagram of states for DCE acting as the challenged party for security grade 2 identification

TABLE A-4/X.32

Actions taken by the DCE as the challenged party (security grade 2)

State of the DCE acting as the challenged party / Protocol element received by the DCE or decision by the DCE	c21 Initial challenged (grade 2)	c22 Waiting for RAND	c23 Calculating SRES	c24 Waiting for DIAG (grade 2)	c25 DCE Identification successful (grade 2)	c26 DCE Identification unsuccessful (grade 2) (see Note 1)
DCE decides it wants to be identified	ID [, SIG] → c22	//////////////	//////////////	//////////////	//////////////	//////////////
RAND	DISCARD → c26	NORMAL → c23	DISCARD → c23	DISCARD → c24	DISCARD → c25	DISCARD → c26
DCE calculation of SRES from RAND is complete	//////////////	//////////////	SRES → c24	//////////////	//////////////	//////////////
Positive DIAG	DISCARD → c26	NORMAL → c25 or c26 (see Note 2)	DISCARD → c26	NORMAL → c25	DISCARD → c25	DISCARD → c26
Negative DIAG	DISCARD → c26	NORMAL → c26	NORMAL → c26	NORMAL → c26	DISCARD → c25	DISCARD → c26

Note 1 – In this state, the DCE shall disconnect the switched access path.

Note 2 – c25 or c26 depending on whether or not the DCE wants to be identified.

ANNEX B

(to Recommendation X.32)

Abbreviations

ADM	Asynchronous disconnected mode
AVAIL-BAS	Available on all networks
AVAIL-NS	Available and selected by the network
AVAIL-OPT	Available on some networks
AVAIL-RQ	Available on some networks and must be requested
BA	Class of HDLC
CSPDN	Circuit switched public data network

CUSTOM	Customized
DCE	Data circuit-terminating equipment
DIAG	Diagnostic element
DISC	Disconnect
DM	Disconnected mode
DNIC	Data network identification code
DSE	Data switching equipment
DTE	Data terminal equipment
FI	Format identifier
HDLC	High-level data link control
HDTM	Half-duplex transmission module
ID	Identity element
ISDN	Integrated services digital network
ISO	International organization for standardization
k	Number of outstanding I frames
LAPB	Link access procedure B
LAPX	Link access procedure – Half-duplex
MT...	Parameter...
N...	Parameter...
ND	Network default
NN	National number
NTN	Network terminal number
NUI	Network user identification
PDN	Public data network
PSN	Public switched network
PSPDN	Packet switched public data network
PSTN	Public switched telephone network
RAND	Random number element
REJ	Reject
RPOA	Recognized private operating agency
RR	Receive ready
RSA	Rivest, Shamir, Adleman algorithm
SABM	Set asynchronous balanced mode
SABME	Set asynchronous balanced mode extended
SIG	Signature element
SRES	Signed response element
TCC	Telephone country code
T...	Timer...
UA	Unnumbered acknowledge
UTC	Coordinated universal time
XC	Counter...
XID	Exchange identification (Unnumbered Format)
XT...	Timer...

APPENDIX I

(to Recommendation X.32)

Implementation of LAPX

I.1 *Introduction*

Considerations are given here for defining the signals needed between the HDTM and the LAPB and physical layer modules in implementing LAPX.

I.2 *Control and status functions*

The following logical functions describe interactions between LAPB and the HDTM:

- *control [TERM]*
  LAPB has entered the disconnected phase.
- *control [CONCLUDE]*
  LAPB has finished transmitting one or more frames.
- *status [OP-T]*
  Enable LAPB to send frames.
- *status [INOP-T]*
  Inhibit LAPB from sending frames.

If the idle channel state condition detection mechanism of LAPB is not disabled, then the HDTM needs to protect LAPB from the use of idle channel state condition in turning around the line. This protection is done by having the HDTM present constant flags to LAPB except in the *Half-duplex receiving* state (state 3). It may be desirable to define additional logical functions in doing this.

The following logical functions describe interactions between the HDTM and the physical layer:

- *control [SEIZE]*
  The HDTM has stopped waiting for data to be received and is waiting to transmit data.
- *control [RELEASE]*
  The HDTM has stopped sending data and is requesting the physical layer to release the right to transmit.
- *control [DISCON]*
  The HDTM is requesting the physical layer to disconnect the physical connection because LAPB is disconnected.
- *status [CALLING]*
  The physical connection originated by this DTE/DCE is established.
- *status [CALLED]*
  The physical connection originated by the other DTE/DCE is established.
- *status [UNCON]*
  There is no physical connection.
- *status [XMT]*
  The physical connection is able to transmit data.
- *status [REMOTE]*
  This is an optional function used if the physical layer, instead of the HDTM, detects the indication that the remote DTE/DCE accepts the right to transmit (remote is in the *Half-duplex sending* state).
- *status [LOCAL]*
  This is an optional function used if the physical layer, instead of the HDTM, detects the request for change in the direction of transmission that gives the local DTE/DCE the right to transmit (remote is in the *Wait or receiving* state).

The forms of these interactions are not defined. However, an example of the HDTM physical layer interactions is given in §§ 5.6.7 and 5.6.8.

I.3 *Table of transitions between states*

Table I-1/X.32 shows the events that cause a state transition and the resulting action(s). This provides a generalized description of operation of the HDTM.

TABLE I-1/X.32

Description of state transitions

Present state	Transition name		New state
	Event	Action	
0	Initialize calling DTE/DCE		4
Idle state	Calling DTE/DCE: data circuit established (e.g. data set ready, ready for data) (i.e. status [CALLING])	Do function control [SEIZE]	Wait for sending state
0	Initialize called DTE/DCE		2
Idle state	Called DTE/DCE: data circuit established (e.g. data set ready, ready for data) (i.e. status [CALLED])	Start timer XT1	Wait for receiving state
1	Send right to transmit		2
Half-duplex sending state	Conclusion of transmission (i.e. control [CONCLUDE])	Send request that remote DTE/DCE enter the half-duplex sending state (see Note 1). Start timer TX1. Do function status [INOP-T] (see Note 2). Do function control [RELEASE]	Wait for receiving state
1	Disconnect sending DTE/DCE		0
Half-duplex sending state	LAPB has entered a disconnected phase (i.e. control [TERM]) (see Note 3)	Do function control [DISCON]	Idle state
2	Receive confirmation		3
Wait for receiving state	Reception of indication that the remote DTC/DCE has entered the half-duplex sending state (see Note 4) (i.e. status [REMOTE])	Stop timer XT1	Half-duplex receiving state
2	Seize right to transmit		4
Wait for receiving state	Expiry of timer XT1 or has frame to send (i.e. a LAPB/HDTM transmit data function) (see Note 5)	Do function control [SEIZE]	Wait for sending state

TABLE I-1/X.32 *(continued)*

Description of state transitions

Present state	Transition name		New state
	Event	Action	
3	Receive right to transmit		4
Half-duplex receiving state	Reception of notification that the remote DTE/DCE is requesting a change in the direction of transmission (i.e. status [LOCAL]) (see Note 6)	Do function control [SEIZE]	Wait for sending state
3	Receive right to transmit		2
Half-duplex receiving state	Reception of notification that the remote DTE/DCE is requesting a change in the direction of transmission (i.e. status [LOCAL]) (see Note 6)	Start timer XT1	Wait for receiving state
3	Disconnect receiving DTE/DCE		0
Half-duplex receiving state	LAPB has entered a disconnected phase (i.e. control [TERM]) (see Note 3)	Do function control [DISCON]	Idle state
4	Send confirmation		1
Wait for sending state	Indication of availability of the physical layer for transmission (i.e. status [XMT])	Send indication to the remote DTE/DCE that the half-duplex sending state has been entered. Do function status [OP-T] (see Note 7)	Half-duplex sending state
Any	Reset from any state		0
	Physical layer has no circuit to a remote DTE/DCE (i.e. status [UNCON])	Do function status [INOP-T]	Idle state

Note 1 – HDTM uses the idle data link channel state indication (at least 15 continuous 1's) for requesting that the remote DTE enter the *half-duplex sending* state.

Note 2 – Status [INOP-T] indicates to LAPB that the sending of frames is inhibited.

Note 3 – Control [TERM] indicates that LAPB has entered the disconnected phase (equivalent to ADM of HDLC).

Note 4 – Reception of a flag or detection of carrier ON (circuit109 = 1) is this indication.

Note 5 – One timer XT1 expiration must occur before a frame may be sent.

Note 6 – HDTM uses the idle data link channel state indication (at least 15 continuous 1's) or detection of carrier OFF (CIRCUIT 109 = 0) for detecting that the remote DTE is requesting a change in the direction of transmission.

Note 7 – Status [OP-T] indicates to LAPB that the sending of frame is enabled.

I.4 *HDTM/physical layer control and status functions expressed in terms applicable to a modem interface*

Continuing the example of § 5.6.7, the HDTM/physical layer logical functions may be described as shown below as they apply to the use of the HDTM with a V-series modem interface:

- *control [SEIZE]*

  Request turning circuit 105 ON and, if necessary, releasing circuit 103 from binary 1 condition.
- *control [RELEASE]*

  Request holding circuit 103 in the binary 1 condition and turning circuit 105 OFF.
- *control [DISCON]*

  Request turning circuit 107 OFF and, if necessary, turning circuit 105 OFF.
- *status [CALLING]*

  As the calling DTE/DCE, report circuit 107 ON.
- *status [CALLED]*

  As the called DTE/DCE, report circuit 107 ON.
- *status [UNCON]*

  Report circuit 107 OFF.
- *status [XMT]*

  Report circuit 106 ON.
- *status [REMOTE]*

  Report carrier ON.
- *status [LOCAL]*

  Report carrier OFF.

APPENDIX II

(to Recommendation X.32)

RSA public key algorithm

The Rivest, Shamir, Adleman (RSA) algorithm defines a public key cryptography system. Each subscriber to an RSA cryptosystem generates a public modulo key (n), a public exponential key (e), and a secret exponential key (d) which conform to certain consistency rules to be subsequently described. The subscriber can publish and disclose its public keys (n, e) but it will never reveal its secret exponential key (d). The exchange of information via the RSA algorithm involves the successive transformations and decryption. The form of encryption and decryption transformations are mathematically identical but differ only in the values of the exponential keys used. Each RSA transformation is of the form:

$$X' = X^k \text{ (modulo } n)$$

where

X is the integer to be transformed

X' is the transformed integer

n is the public modulo key

k is the exponential key which is either the public exponential key e, or the secret exponential key d.

The RSA keys for a subscriber are generated subject to the following two constraints:

$n = p \cdot q$ (p and q are large prime numbers)

$(d \cdot e)$ modulo $[(p - 1) \cdot (q - 1)] = 1$

The encryption operation can use either e or d as the exponential key. However, the decryption operation must use the exponential key (d or e) that was *not* used in the encryption process. Both processes must use the same modulo key, n.

As applied to the security grade 2 identification process described in § 7.1.2, the challenged party will generate SRES by encrypting RAND using its secret exponential key, d, so that the questioning party can decrypt SRES using the public keys of the challenged party (e and n).

APPENDIX III

(to Recommendation X.32)

Relationship of timer T14 to the different methods of DTE identification

Figure III-1/X.32 illustrates the points in the general sequence of events defined in this Recommendation at which timer T14 is started or stopped.

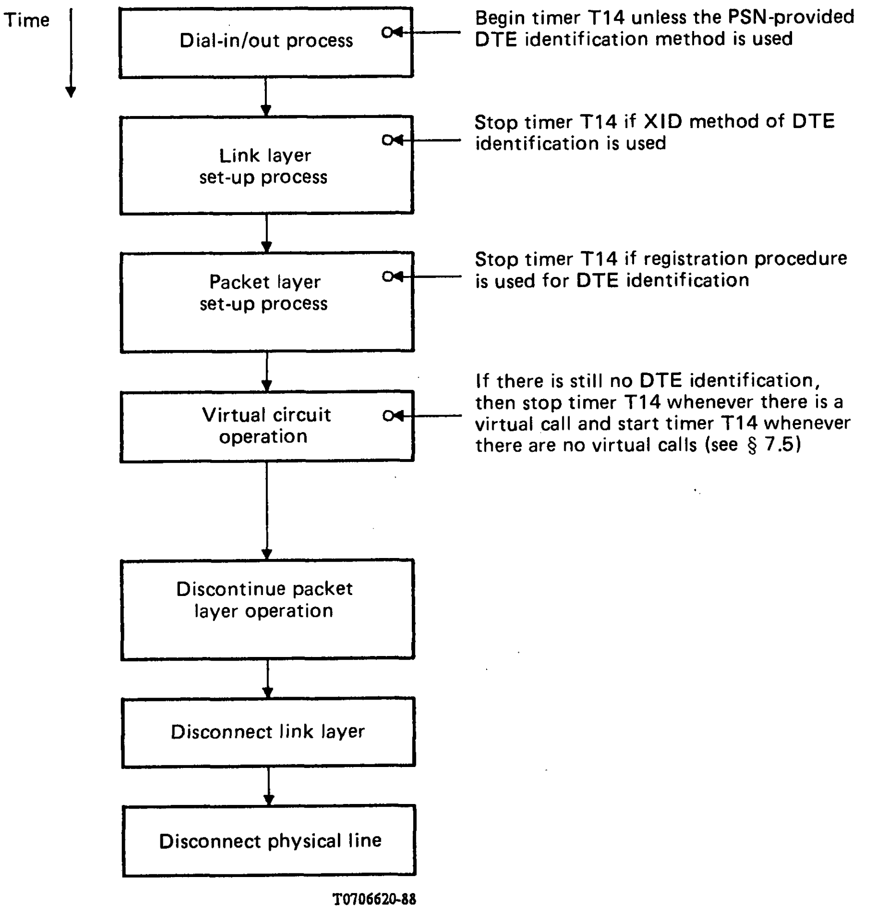


FIGURE III-1/X.32

Relationship between timer T14 and DTE identification methods

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